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Deliverable D 2.1

Delphi Study and paper

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1 Executive Summary

The present document describes the objectives, methodology and findings of Task 2.1 of the Shift2Rail CSA (Coordination and Support Action) TER4RAIL, which was supported by ERRAC, and is exploring research activities among different actors that are beneficial for railways.

This study was undertaken to determine if the rail stakeholders believed in the Rail Vision 2050 document and specifically agreed with the statements contained within the document. This was important as the next generation of this document is intended to be the basis of a Strategic Research and Innovation Agenda (SRIA) for Rail. A Delphi survey revealed the consensus and the dissent in relation to the statements. The methodology is presented along with the results.

We have used both the areas of consensus and also of dissent to develop a narrative to inform the future road-mapping of the EU rail sector and in particular the strategic rail agenda, the STRIA.

The narrative reports that:
There are issues with rail freight;
There is a clarity that rail and public transport are the optimal solutions to provide mobility for passengers;
That by 2050 rail will still the safest mode with zero casualties and will be recognised and valued by European citizens;
Rail will be the backbone of urban mobility with rail considered the mass transit solution;
There will be new energy-efficient station designs in cities;
Data must be shared across the European rail stakeholders, preserving the requirements of privacy;
Native speakers in urban areas across Europe will have easy tailored access to mobility services but not necessarily non-native speakers.

The common themes were:

- Market orientation;
- Cost, competition and efficiency;
- Leadership, political issues, lobbying, government intervention for good or ill;
- Lack of seamlessness for many reasons;
- Inadequate speed of reaction/investments compared to Asian competitors;
- Lacking technical/technological innovations and skills;
- Language barriers;
- Different regulations barriers in EU rail space;
- Info, data availability sharing and management;
- Safety and security issues;
- Accessibility and capacity;
- A limiting of scope from universal visions to
    - Urban,

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- Native,
- Backbone.

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2 Abbreviations and acronyms

Abbreviation / Acronyms	Description
ACARE	Advisory Council for Aviation Research and Innovation in Europe
ADAS	Advanced Driver-Assistance Systems
AEA	Association Europe Airlines
AEI	Automatic Equipment Identification
AGV	Automatic Guided Vehicle
AI	Artificial Intelligence
AI	Artificial Intelligence
ALICE	Alliance for Logistics Innovation through Collaboration
APMO	Average Percent of Majority Opinion
ARE	Association for Research and Enlightenment
ATO	Automated Train Operation
ATO	Automatic Train Operations
ATP	Automatic Train Protection System
B2B	Business-to- Business
B2B	Business To Business
B2C	Business -to-Costumers
B2C	Business To consumer
BOP	Booking Optimization Platform
BSS	Business Support System
BU	Business Unit
CAGR	Compounded Annual Growth Rate
CAS	Collision Avoidance Systems
CCAM	Cooperative Connected and Automated mobility
CCS	Command and Control System
CEF	Connecting Europe Facilities
CER	European Centre for Research
CO2	Carbon dioxide
CSI	Common Systems Interconnect
CT	Combined Transport
CTO	Carrier and Terminal Operator
CTS	Centre For Transportations
CV	Choice variable

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CV-US	User Choice Variable by user segment
D	deliverable
DG MOVE	Directorate-General for Mobility and Transport
DI	Disruptive innovation
DRTS	Demand Responsive Transport Services
EC	European Commission
ECMT	European Conference of Ministers of Transport
EDR	Event Data Recorders
EEA	European Economic Area
EFTA	European Free Trade Association
EPoSS	European Technology Platform on Smart Systems Integration
ERP	Enterprise Resource Planning
ERRAC	European Rail Research Advisory Council
ERTMS	European Rail Traffic Management System
ERTRAC	European Road Transport Research Advisory Council
ETA	Estimated Time of Arrival
ETCS	European Train Control System
ETCS	European Train Control System
ETIP SNET	European Technology & Innovation Platforms Smart Networks for Energy Transition
ETP	European Technology Platforms
EU	European Union
EU	European Union
FP7	Seventh Framework Programme of the European Union
FTL	Full Truck Load
GDP	Gross Domestic Product
GDP	Gross Domestic Product
GHG	Green House Gases
GHG	Greenhouse Gas
GHG	Greenhouse Gases
GNP	Gross National Product
GPS	Global Positioning System
GPS	Global Positioning Systems
GSM	Global System for Mobile
GVA	Gross Value Added
HGV	Heavy Goods Vehicles

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HOG	House of quality
HSL	High Speed Lines
HSR	High Speed Railways
HSR	High speed rail
HVLDG	High Value Low Density Goods
I2V	Infrastructure-to-Vehicles
IaaS	Infrastructure as a Service
IC	Innovation Capability
ICE	Intercity-Express
ICT	Information Communication Technology
ICT	Information and Communications Technology
ICT	Information and Communications Technology
IM	Infrastructure Manager(s)
IOT	Internet Of Things
IoT	Internet of Things
IP	Innovation Programme
ISO	International Standards Organization
ISO	International Organization for Standardization
ITMMA	Institute of Transport and Maritime Management
ITU	Intermodal Transport Unit
JIT	Just In Time
KCV	Key choice variable
KPI	Key Performance Indicator
LCC	Life Cycle Cost
LCL	Less Container Load
LD	Long Distance
LDC	Long Distance Commuting
LEZ	Low Emission Zones
LRT	Light Rail Transportation
LRV	Light Rail Vehicle
LTC	Less than Truck Load
LU	Loading Unit
M&A	Merger and Acquisition
MA	Modal alignment
MAAP	Multi-Annual Action Plan
MaaS	Mobility-as-a-Service

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MAAS	Mobility as a Service
MPI	Market Performance Indicator
MS	Market segment
NDTAC	Noise Differentiated Track Access Charges
NOX	Nitrogen Oxide
NUTS	Nomenclature of Territorial Units for Statistics
OBU	On Board Units
OD	Origin-Destination
OEM	Original Equipment Manufacturer
OEM	Original Equipment Manufacturer
OSS	One-Stop Shops
PAG	Permanent Advisory Group
PI	Physical Internet
PKM	Passenger Kilometre
PPP	Public Private Partnership
PSO	Public Service Contract
PT	Public Transport
PT	Public transport
QFD	Quality function deployment
R&D	Research and Development
R&I	Research and Innovation
RC	Rail system change
RFID	Radio-Frequency Identification
RMMS	Rail Market Monitoring Scheme
RO	Railway Operator
ROW	Right-of-Way
RPG	Rail Performance Gaps
RPK	Revenue Passenger Km
RSE	Rail system efficiency
RT	Reduced travel
RU	Railway Undertaking
S2R	Shift2Rail
S2R JU	Shift 2 Rail Joint Undertaking
SCM	Supply Chain Management
SCS	Supply Chain Specialist
SERA	Single European Rail Area

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SME	Small Medium Enterprises
SO	Shunting Operator
SP	Service Provider
SPD	System Platform Demonstrator
SR	Sustainable rail
STRIA	Strategic Transport Research and Innovation Agenda
SWL	Single Wagon Load
TD	Technical demonstrator
TEN-T	Trans European Network
TEU	Twenty foot Equivalent Unit
TKM	Tonnes Kilometre
TMS	Traffic Management System
TPS	Train Planning System
TSI	Technical Specifications for Interoperability
TSI	Technical Specifications for Interoperability
UCC	User comfort and convenience
UCC	Urban Consolidation Centre
UCD	User-centred design
UIC	International Union of Railways
UIC	International Union of Railways
UIC RICG	International Union of Railways Research and Innovation Coordination group
UIRR	International Union for road-Rail combined transport
UK	the United Kingdom
UNIFE	Community of European Railway and Infrastructure Companies
US	User segment
V2I	Vehicles To Transport Infrastructure
V2I	Vehicle-to-Infrastructure
V2V	Vehicles to Vehicles
V2V	Vehicle-to-Vehicle
V2X	Vehicles To many other resources
V2X	Vehicle-to-Everything
VAT	Value Added Tax
VOIP	Voice Over Internet Protocol
WLAN	Wireless Local Area Network
WP	Work Package

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WP	Work Package
WW	Worldwide
ZTL	Zone with Limited Traffic

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3 Background

Road-mapping is a powerful technique that has become integral to the creation and delivery of strategies and innovation in numerous sectors. It can deliver alignment and dialogue between functions within one sector and across sectors, such as road-rail, air-rail, and so on.

A technology roadmap implies a flexible planning technique to drive strategic and long-range technological planning, by matching short-term, medium-term, and long-term goals with a commonly agreed vision that includes specific technological solutions. Operational and organisational road-mapping are just as important: the determined operational goals can be delivered by the organisations that are most suited to deliver.

The rail sector is presently at the stage of following and reinforcing the extant roadmaps. The work of TER4RAIL entails reviewing and supporting the roadmaps' progression and identifying gaps in these roadmaps for the next major phase of the revision. This work is performed with desktop research, interviews with major stakeholders at the TER4RAIL events, webinars to present the research, and by seeking updates from invited experts from within and outside the sector. The inter-relationships between the rail sector and other modes is quite important, and therefore, cross checking with the holders of the roadmaps from the other ETPs and the S2R JU is extremely crucial.

Alongside this, a Delphi study is conducted to evaluate the assumptions and state-of-the-art underlying the current roadmaps, with a view to provide core evidence-based updates for the subsequent round of road-mapping. The Delphi technique can be applied for both quantitative and qualitative data and forms an appropriate technique to collect, aggregate, and analyse the informed judgements of a group or panel of experts on previously identified issues. The technique provides unbiased input, as the researcher and experts never meet face to face, thus eliminating the negative effects of group dynamics and peer pressure. One of the major objectives for using a Delphi study is to achieve consensus on some formerly recognised issues. Regarding consensus, Stuter (1998) contends that "The Delphi Technique and consensus building are both founded in the same principle - the Hegelian dialectic of thesis, antithesis, and synthesis, with synthesis becoming the new thesis. The goal is a continual evolution to 'oneness of mind' (consensus means solidarity of belief) – collective mind, the holistic society, the holistic earth etc" (p.1). Thus, achieving a consensus is an important criterion for a Delphi study, although Saldanha and Gray (2002) assert that the result of a Delphi study does not necessarily entail consensus. They do agree, however, that such a consensus serves as a useful measure for agreement between the panellists in policy-related areas.

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4 Objective/Aim

Workpackage 2 reviewed, supported, and improved the sector roadmaps in order to prepare for the subsequent iterations of the road-mapping process.

Road-mapping in the rail sector can be considered to be primarily contained in the Shift2Rail Multi Annual Action Plan, the ERRAC Strategic Rail R&I Agenda(s), the subsequent RAIL VISION 2050 document, as well as the ERRAC/ERTAC Integrated Urban Mobility Roadmap, among others. In addition, the work completed under SETRIS for the development of cross-modal roadmaps between the ETPs for transport represents the broader context of rail road-mapping.

Task 2.1 comprised work as follows:

A Delphi Study in 2–3 rounds over 18 months to utilise expert knowledge across the EU and beyond: identifying challenges and exploring the rail and intermodal roadmaps, the assumptions underlying them, and the actions required to achieve them on time. This was accomplished with online tools, and each stage was reported at appropriate workshops in the project. The Delphi Study also consists of a written paper, comprising a deliverable project and has been submitted as a peer-reviewed academic article to the Journal of Transport Policy.

4.1 Actions Undertaken

A Delphi Study has been conducted using SurveyMonkey with 2 rounds over 20 months to utilise expert knowledge across the EU and beyond.

Round One stage was reported at the London World Café event held in London on 26th June 2019 and online in a webinar[1] (forming a milestone for Task 2.3). Round Two was reported at the ERRAC TRA 2020 special online session webinar on the 12th June 2020[2] (forming a milestone for Task 2.3). The analysis of the whole survey was reported at the third webinar on October 30th 2020, delayed due to the summer vacation and a cyber attack on Newcastle University which led to the quarantining of data storage for a number of weeks.

A final summary was presented as a webinar as part of the ERRAC plenary on November 19th 2020. In the last six months of the project the Delphi Study was redrafted as a written paper which comprises a deliverable for Task 2.3, and was submitted to a peer-reviewed academic journal.

[1] See https://ter4rail.eu/2019/10/15/ter4rail-webinar-delphi-study-round-one/

[2] See https://ter4rail.eu/2020/05/26/errac-ter4rail-webinar-rethinking-rail-as-the-backbone-of-sustainable-european-mobility/

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5 Methodology

In order to achieve the above-mentioned goals, a methodology was developed and followed. The approach consisted of the following two steps: (a) compilation of key statements from the RAIL 2050 VISION (Mazzino *et al.*, 2017) ; followed by (b) two rounds of Delphi study, conducted online and (c) validated in a Word Café event between the first and second rounds.

5.1 Delphi Survey

The Delphi technique can be used for both quantitative and qualitative data and is an appropriate technique for collecting, aggregating and analysing the informed judgements of a group or panel of experts on previously identified issues. The method is useful to collect group judgments while avoiding negative effects related to interpersonal biases, strong personalities, defensive attitudes and unproductive disagreements. Throughout the process, panel experts are able to consider feedback from other panel members and change their opinions without the risk of embarrassment. Delphi has repeatedly been used to investigate factors influencing decision-making on a specific issue, topic or strategy area in mobility policy, practice (Islam, Dinwoodie and Roe, 2006; von der Gracht, 2012; Islam and Zunder, 2014; Kembro, Näslund and Olhager, 2017).

A Delphi study starts with in-depth desktop research to identify the issues and problems in the field and a preliminary questionnaire is developed. Generally, a broad range of topics is examined in the first round and open-ended statements are included in the questionnaire (Wellington, 2015). More than one round is carried out and, in each round, a questionnaire is used. The number of rounds can vary from two to ten (Clark and Friedman, 1982; Green, Hunter and Moore, 1990), although most use two iterations (see next section). In the later rounds, a limited range of issues is explored in a more structured way (Wellington, 2015). However, iteration is usually determined according to the achievement of consensus by the panel. Even though iteration results in a certain level of improvement or refinement, in most Delphi studies the main improvements usually occur between the first and the second rounds (Dalkey, 1969; Bardecki, 1984; Nelms and Porter, 1985). After the second round, only a few studies show much further improvement (Erffmeyer, Erffmeyer and Lane, 1986); some have found no improvement at all after the second round (Gustafson *et al.*, 1973).

The Delphi results are then validated with expert group workshops and/or webinars using facilitated discussions, break out groups and mutual brainstorming.

One of the major objectives of applying a Delphi study is to achieve consensus on some previous issues. On consensus, Stuter (1998) contends that: 'The Delphi Technique and consensus building are both founded in the same principle - the Hegelian dialectic of thesis, antithesis, and synthesis, with synthesis becoming the new thesis. The goal is a continual evolution to "oneness of mind" (consensus means solidarity of belief) – collective mind, the holistic society, the holistic earth etc.' (p.1). Thus, achieving a consensus is an important criterion in a Delphi study, although Saldanha and Gray (Saldanha and Gray, 2002) contend that the result of a Delphi study does not necessarily require the achievement of consensus. They do agree, however, that such a consensus serves a useful measure of the agreement among the panellists on a policy area. Hwang (2004) contends that 'consensus of opinion does not necessarily mean 100 per cent agreement among the participants in the panel' (p.123). A number of studies (Abdel-Fattah, 1997; Hwang, 2004; Islam, Dinwoodie and Roe, 2006; Islam and Zunder, 2014); accepted

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'consensus' as the majority of responses in their Delphi studies. Ariel (Ariel, 1989) thought that a Delphi study is an appropriate technique to steer a consensus; Islam and Zunder (2014) were of the opinion that a Delphi technique can seek solutions to a complex problem by taking opinions of a diverse group of experts. Thus the overall aim of the study is to achieve a consensus among the participants. To determine whether or not a consensus has been achieved, any arbitrary figure could be used, although some justification should be made for it (Abdel-Fattah, 1997; Abdel-Fattah, Gray and Cullinane, 1999). Abdel-Fatthah (1997), Saldanha and Gray (2002), Hwang (2004) and Islam et al. (2006) used the following formula of Average Percent of Majority Opinion (APMO), which will also be used in the present research, to find out the cut-off point for a consensus:

$$\text{APMO}=\frac{\text{Aggregate of Majority Agreements+Aggregate of Majority Disagreements}}{\text{Total Opinion Expressed}}x100$$

If neither agreement nor disagreement has a majority amongst the panel, then no score is carried to the APMO, reducing it accordingly and representing the lack of stability. Consensus, which can be either agreement or disagreement with a statement, is defined as a percentage higher than the average percentage of majority opinion. The statements that do not reach consensus are included in the next round for re-evaluation. Cottam et al. (2004) described the calculation of the APMO Cut off Rate in detail. First, the number of majority agreements and disagreements have to be calculated by expressing the participants' comments "agree", "disagree", and "unable to comment" in percentages per statement, von der Gracht et al (2012) state that the APMO Cut-off Rate leaves much freedom of analysis and interpretation for the Delphi facilitator.

The main objective of the application of the APMO formula is to achieve stable consensus among participants. 'Majority' refers to a greater than 50% agreement or disagreement with the statements in the Delphi survey. 'Aggregate of Majority Agreements' refers to the summation of the majority agreements with the statements and the 'Aggregate of Majority Disagreements' refers to the summation of the majority disagreements with the statements.

The advantages and disadvantages of the Delphi technique are noted below:

Advantages

- It elicits the views of panels of experts.
- It employs an iterative process of summarising, averaging and recycling panel members' views to encourage convergence on a consensus view.
- Panellists are given the opportunity to revise earlier answers in the light of the general opinions expressed by the panel as a whole.
- Information is collected by questionnaire and does not involve interviews or discussion.
- Members of the panel are guaranteed anonymity.

Disadvantages

- Delphi study can exaggerate the concept of expertise.
- The composition of the panel is seldom random, reflects the personal biases of the researchers and is not necessarily representative of specialist knowledge in the field.

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- Anonymity relieves panel members of accountability and hence can lead to careless responses.
- By seeking consensus, Delphi surveys promote a conservative view of the future, discourage original thinking and suppress radical views.
- It can have the effect of reinforcing existing paradigms.
- It offers little insight into the reasoning underlying the panel members' responses and gives no opportunity for their arguments to be tested in face-to-face discussion .

Following consideration of the above discussed advantages and disadvantages it was decided to adopt the Delphi technique for the current research.

5.1.1 Online platform: SurveyMonkey

There are a number of online survey tools including Survey Monkey and Bristol Online Surveys (BOS). Comparing the functionality and other suitability, SurveyMonkey was used for this survey. The design was compliant with the GDPR directive, having a clear privacy policy and statement as to the use of the data.
The full surveys are attached as Appendices A and B.

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5.2 Statement building Rounds One and Two

A Delphi survey poses statements to an anonymous panel, and asks if they agree or disagree with it. If not then dissenting statements can be made and these are taken to Round Two if no consensus has been reached in Round One for the original statement.
The construction of statements for a Delphi survey is therefore key.

5.2.1 Statement building Round One

TER4RAIL had the advantage that the ERRAC RAIL 2050 VISION (Mazzino *et al.*, 2017) document is essentially a series of statements, supported by text, that envision the future. This made the adoption of the key statements from the document the core body of statements for the process. This list was then reviewed by the TER4RAIL expert consortium, several of whom were authors of the VISION document. After 5 iterations an agreed list was settled upon and the process of writing the survey could begin.

5.2.2 Statement building Round Two

The statements on which there was no consensus in Round One (see Table 6 below) were reviewed. The dissenting comments from the panel were then used, along with the feedback from the London World Café event in June 2019, and the first webinar, to compile a new range of statements to 'tease out' the nuances of disagreement. This was often done by breaking the core statements from the ERRAC RAIL 2050 VISION (Mazzino *et al.*, 2017), into smaller unique statements, often expressed negatively to engender response.

5.2.3 Round One Statements

1. In 2050, rail transport in Europe is the backbone of an intermodal Mobility as a Service for passengers within cities and beyond, meeting the needs of customers, EU citizens and society.
2. In 2050, rail transport in Europe is the backbone of an intermodal Mobility as a Service for freight within cities and beyond, meeting the needs of customers, EU citizens and society.
3. 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.
4. The suppliers, operators and other service organisations of the European rail industry in 2050 are recognised as the world's thought leaders for railway products and services.
5. 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
6. 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 minimizing pollution and congestion
7. By 2050 new energy-efficient station designs in Europe provide easy access and seamless interchange across all transport modes, enabling railways to manage growing passenger volumes and mobility demands
8. Passengers across Europe are able in 2050 to access real time personal communication and new services for work or leisure continuously, before, throughout and after the journey.

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9. Every individual across Europe has easy tailored access to mobility services regardless of demographics, culture, language, location, or technical proficiency by 2050
10. Taking into account data privacy management, in the year 2050 relevant information is shared across the European rail stakeholders as a part of the data economy, enabling new services and applications for the benefit of the railway and its customers;
11. The rail sector of 2050 manages a growing volume of data in Europe contributing to the data economy. Collection, analysis interpretation and prediction are automated to provide consistent up-to-date information, supporting fast, well-informed decisions and business benefits.
12. The European rail sector of 2050 has a long-established collaboration with all other sectors to handle cyber security. New forms of cyber-attacks are therefore recognised at an early stage and are dealt with through joint cross-sectoral effort.
13. People feel safe and secure using European rail services in 2050 thanks to non-blocking security systems. Precautions against external threats, aggression and vandalism, supported by technologies are in place.
14. By 2050 rail has maintained its place as the safest transport mode and this is recognised and valued by European citizens. Zero casualties per year is the current status of the rail sector at urban, regional and inter-city level.
15. The European smart vehicles on rail are aware of themselves by 2050, their passengers/loads and their surroundings, know where they need to be and when and can adjust journeys automatically to meet demand.
16. 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.
17. Manned and unmanned autonomous intelligent vehicles operate safely on the same European railway network of 2050, controlled by artificial-intelligence based traffic management systems.
18. Rail Freight transport units in 2050 in Europe can communicate with one another as well as with infrastructure and operational facilities, minimising downtime.
19. The European rail system of 2050 is fully integrated with the automated multimodal logistic chain forming the backbone infrastructure, comprising new intelligent, automated cross-modal shipment transfer nodes.
20. By 2050 innovative logistics services in Europe are driven by customer demand. Shipments are moved effectively, efficiently, safely and securely through the "Physical Internet". [https://en.wikipedia.org/wiki/Physical_Internet]

5.2.4 Round Two Statements

21. By 2050 the rail freight sector will have to have addressed some fundamental issues around cost, asset utilization and customer facing connectivity.
22. By 2050 rail will not be the backbone of an intermodal Mobility as a Service for freight.
23. By 2050 the European rail sector will remain largely technically led with service and user aspects not well recognised.
24. In 2019, Europe is still a leader in the railway products and services. But by 2050, companies from Japan, South-Korea and China would probably be the new leaders.

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25. Right now, national rail services do not integrate seamlessly with rail services available in neighbouring countries. So integrating seamlessly with all other available transport modes seems a very distant prospect indeed, not by 2050.
26. Only if the rail sector is financially supported through capital investment, large amounts of which are needed now, can the European rail system in 2050 be able to detect, understand and respond to individual and collective European citizens mobility needs, delivering tailored, on demand, integrated end-to-end mobility solutions.
27. The fragmenting political structures across Europe is unlikely to facilitate mobility services tailored regardless of demographics, culture, language, location, or technical proficiency by 2050
28. A majority of native speakers in urban areas across Europe will have easy tailored access to mobility services by 2050.
29. In 2050, by obliging access to data from all providers for all modes and all asset and service providers, relevant information is shared across the European rail stakeholders as a part of the data economy.
30. In the year 2050 information that is shared across the European rail stakeholders as a part of the data economy is exploited by large businesses and threatens personal data privacy.
31. Only in urban mixed traffic environments shall the rail system of 2050 deploy 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.
32. European rail systems in 2050 will continue to be very vulnerable to terrorism.
33. People in cities feel safe and secure using European rail services in 2050 thanks to non-blocking security systems.
34. Rail is more of a mass transit solution. Tailor-made autonomous journeys will not be the solution. By 2050 as a backbone, rail in Europe will provide journeys on a regular time table so other "light" transport modes can offer autonomous trips.
35. Only some European smart vehicles on rail on low useage lines are aware of themselves by 2050 and have operational autonomy.

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6 Round One

Round One was launched 28th January 2019. The survey was closed on the 30th May 2019. 126 responses had been received, of which 57 responses or 45.24% were valid, the remainder only completed the first response or did not proceed to make any statements at all. These 57 people now formed the Delphi panel for this research.

The chronological rate of response was as shown in Figure 1 and the panel size and demographic composition (see 6.1 below) was appropriate so the round was closed.

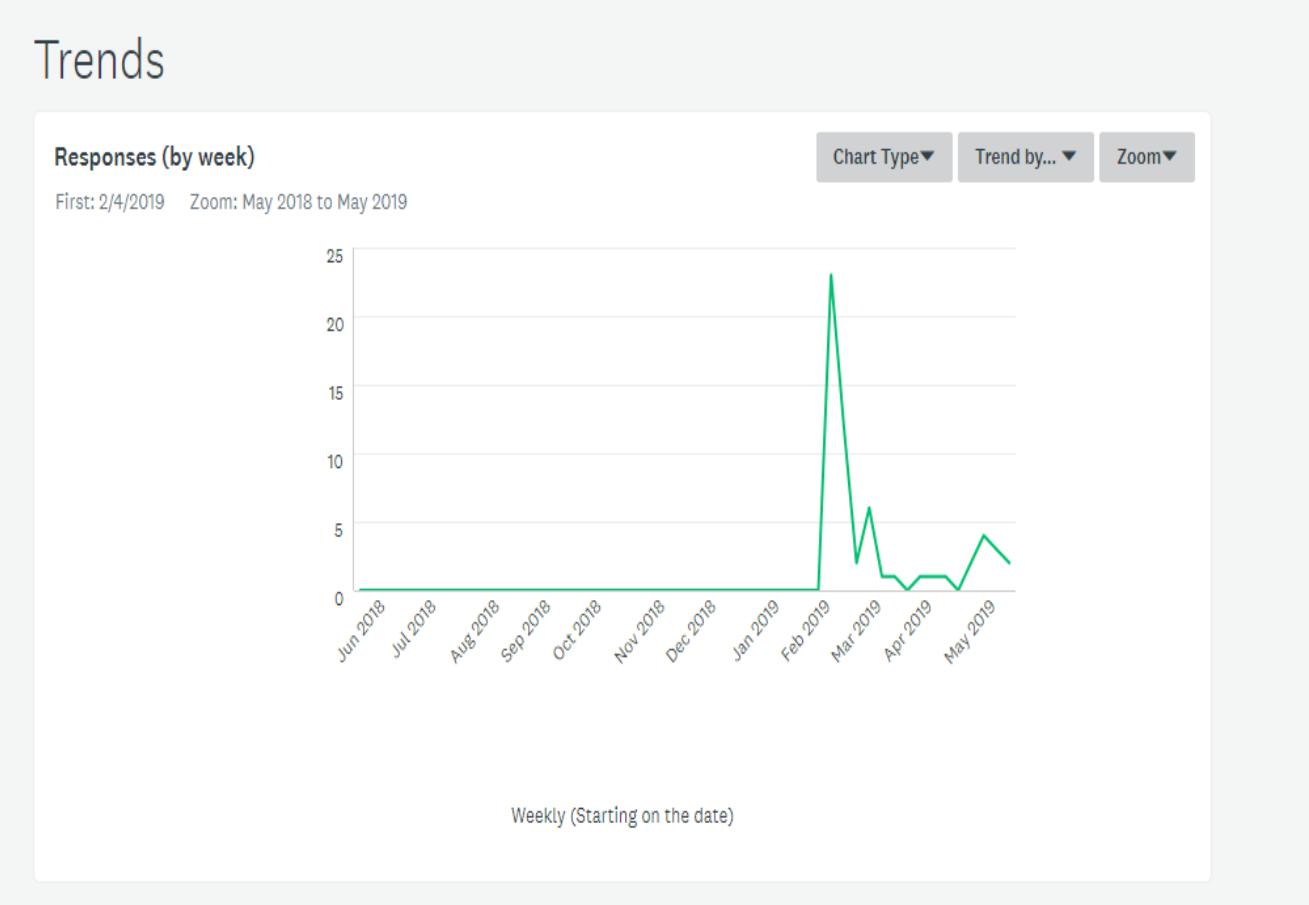

Figure 1: Round One Response Rate Trend

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6.1 Demographics of Respondents

6.1.1 Country

The countries in which the respondents work were as follows in Table 1 and Figure 2. Many of the respondents are research experts and as such their country of work may be less critical than their level of competence and knowledge.

ANSWER CHOICES	RESPONSES	
GB: United Kingdom	20.69%	12
DE: Germany	17.24%	10
FR: France	10.34%	6
AT: Austria	5.17%	3
NL: Netherlands	5.17%	3
ES: Spain	5.17%	3
CZ: Czech Republic	3.45%	2
FI: Finland	3.45%	2
HU: Hungary	3.45%	2
LT: Lithuania	3.45%	2

Table 1: Top 10 Work Countries

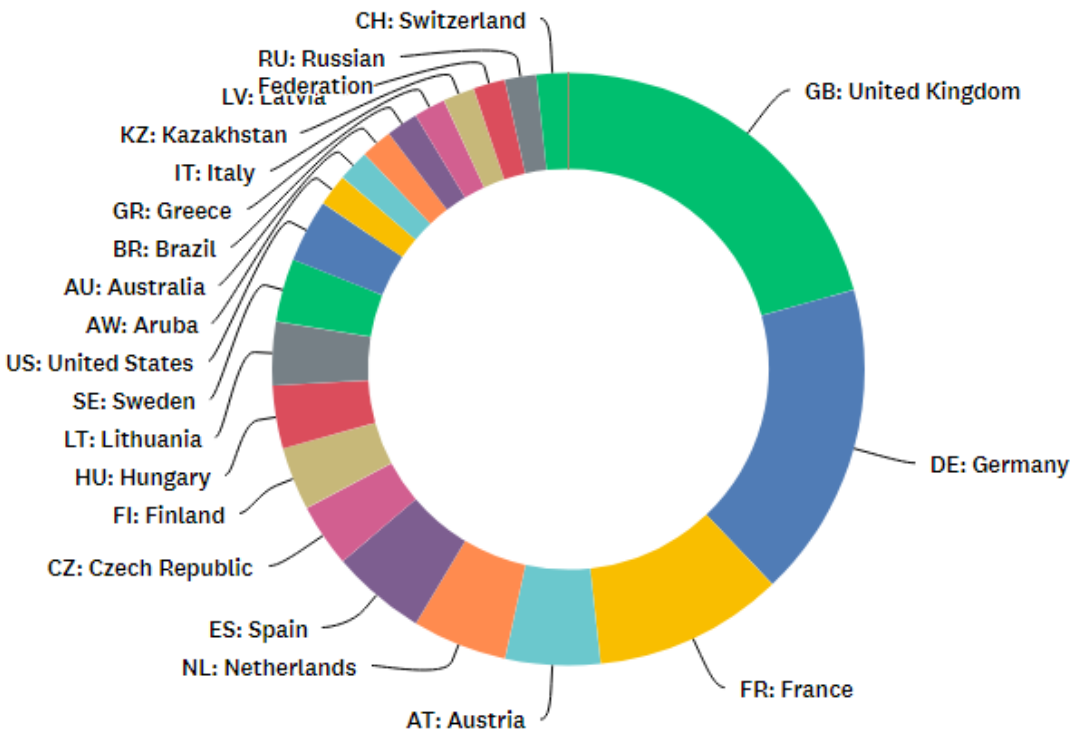

Figure 2: Work country of respondent

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6.1.2 Experience and Expertise of the Panel

The panel was experienced and used to executive decision making, with 75.86% having 10 or more years of experience in the transport sector, whilst still including those newer to the sector at 17.24% (see Figure 3). Those with senior executive roles formed 44.83% of the panel with 37.93% having middle management roles, and 17.24% with operational roles[3] (see Figure 4 below).

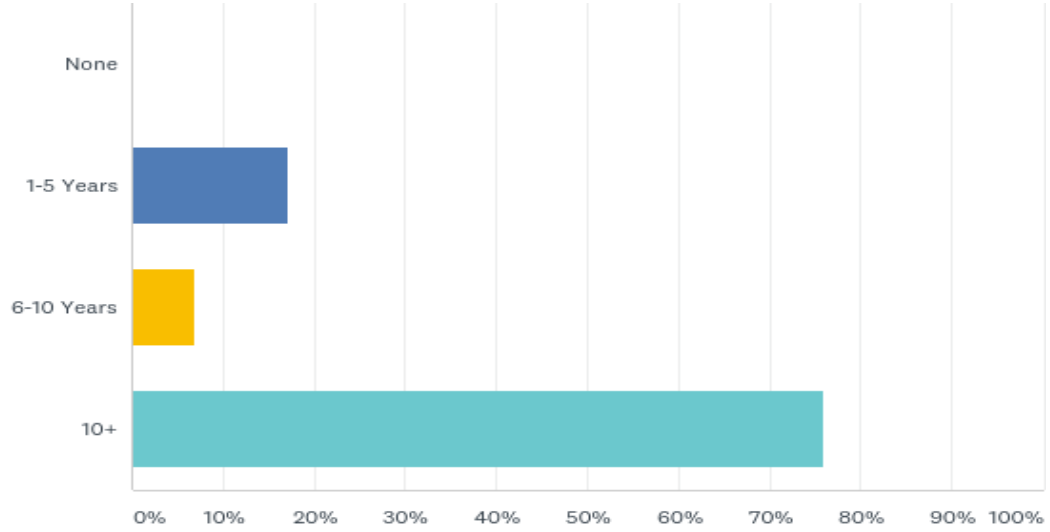

Figure 3: Q5: Years of experience in the transport sector

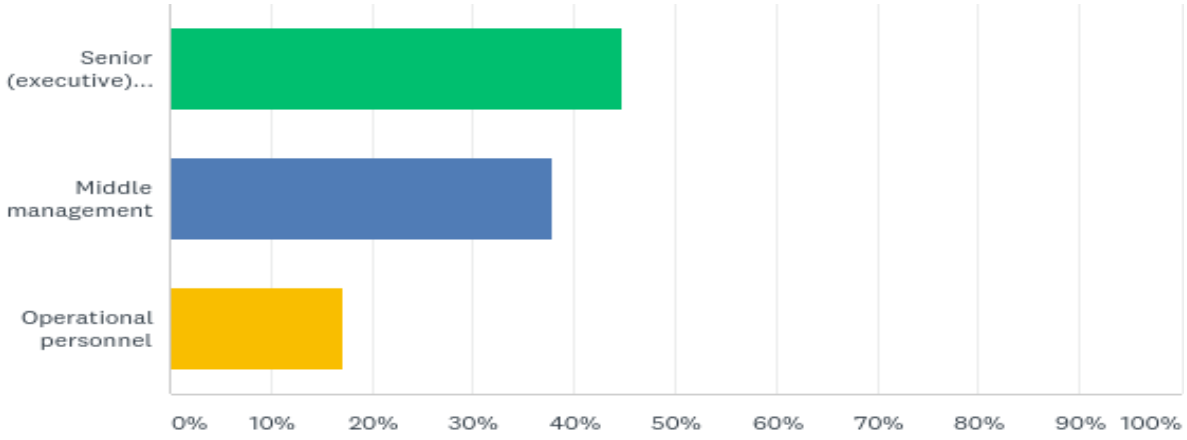

Figure 4: Q4: Which level of management are you in your organisation (or last role if you are retired or self-employed)

6.1.3 SME Representation

The panel had high SME representation, with 45.45% reporting that they worked for an organisation that had fewer than 250 employees and a turnover less than or equal to €50 million

[3] Or had had, in the possible case of retirees.

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per annum or a balance sheet of less than €43 million, the EU definition of a medium sized enterprise[4].

6.1.4 Organisational Type

The most prevalent organisational types represented in the panel were research organisations and consultancies (36.21% and 18.97% respectively) as shown in Figure 5 below. This reflects the research led nature of the work, but also that experts gravitate to such organisations and they may offer objective and independent viewpoints.

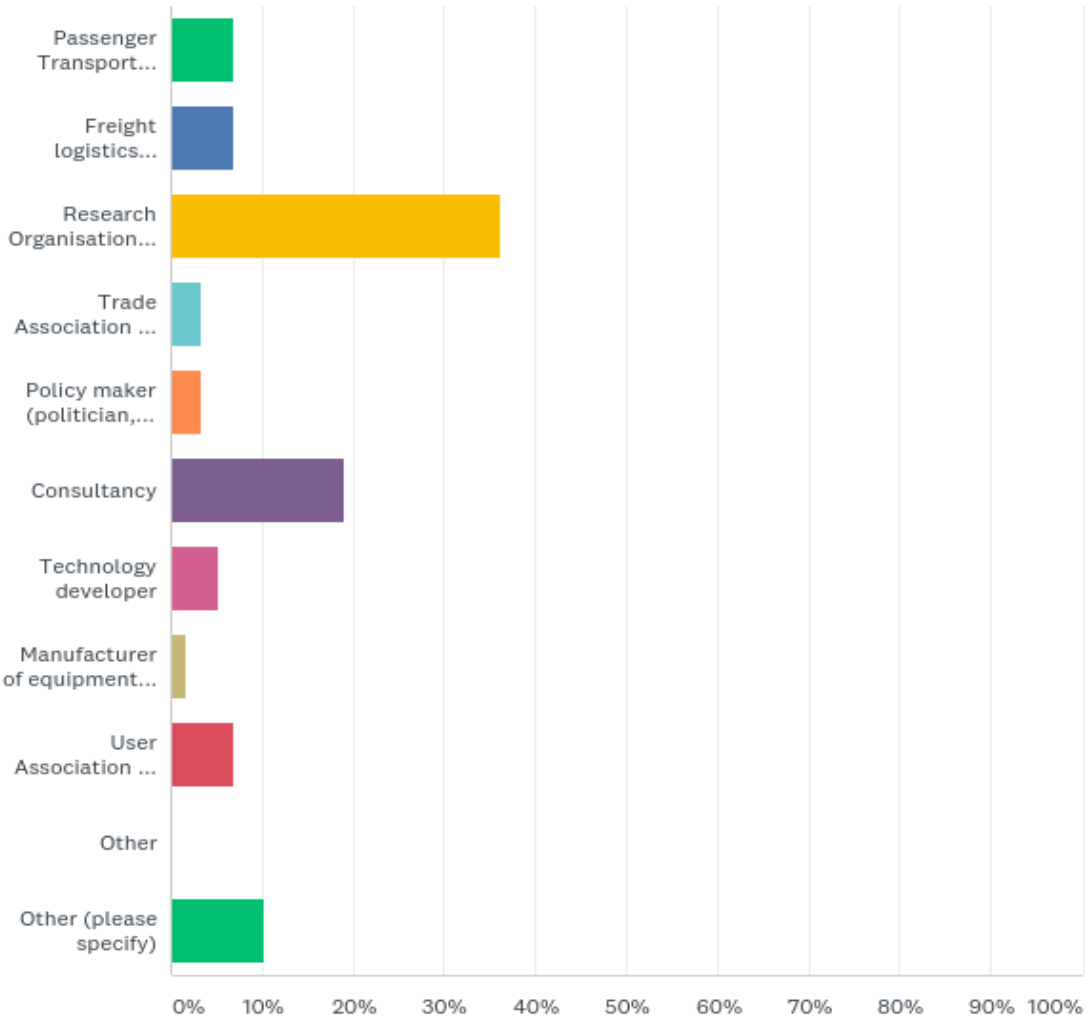

Figure 5: Q7: What sort of organisation do you work for? You may tick as many as apply.

6.1.5 Modal and transport activity expertise

The panel had very high expertise on rail (89.66%) but also good coverage of all other modes, with road expertise reported as 48.28%, see Table 2 below.

[4] https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en

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ANSWER CHOICES	RESPONSES	
Rail	89.66%	52
Sea	17.24%	10
Inland waterway	6.90%	4
Road	48.28%	28
Air	15.52%	9
Total Respondents: 58		

Table 2: Q9: Please tick the modes in which you have expertise in.

The panel had high expertise in the different transport activities as detailed in Table 3 below. 75.86% reported expertise in rail as a single mode[5], 31.03% as expert in road as a single mode. The panel had a high representation of those with expertise in multimodal transport (51.72%), port and/or terminals (29.32%), and expertise in freight logistics with 44.83% of the panel.

ANSWER CHOICES	RESPONSES	
Multimodal transport	51.72%	30
Single mode transport [rail]	75.86%	44
Single mode transport [road]	31.03%	18
Single mode transport [sea or water]	8.62%	5
Single mode transport [air]	10.34%	6
Port and/or terminal operations	22.41%	13
Port and/or terminal regulation	6.90%	4
Freight and logistics	44.83%	26
Total Respondents: 58		

Table 3: Q8: Please tick all the following activities you are an expert on.

[5] "single mode" refers to the use of a mode alone.. as opposed to multimodal transport, an expert may have expertise in multiple mono-modal activities as well as multimodal etc..

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7 Round Two

Round Two was launched on 21st January 2020 and sent to those who responded in the previous round. The survey was closed on the 23th March 2020. 33 responses had been received, of which 27 responses or 81.8% were valid, the remainder only completed the first response or did not proceed to make any statements at all. These people, a subset of the original panel, now formed the Delphi panel for this second stage of the research. The chronological rate of response was as shown in Figure 1 and the panel size and demographic composition (see 6.1 above) was appropriate so the round was closed.

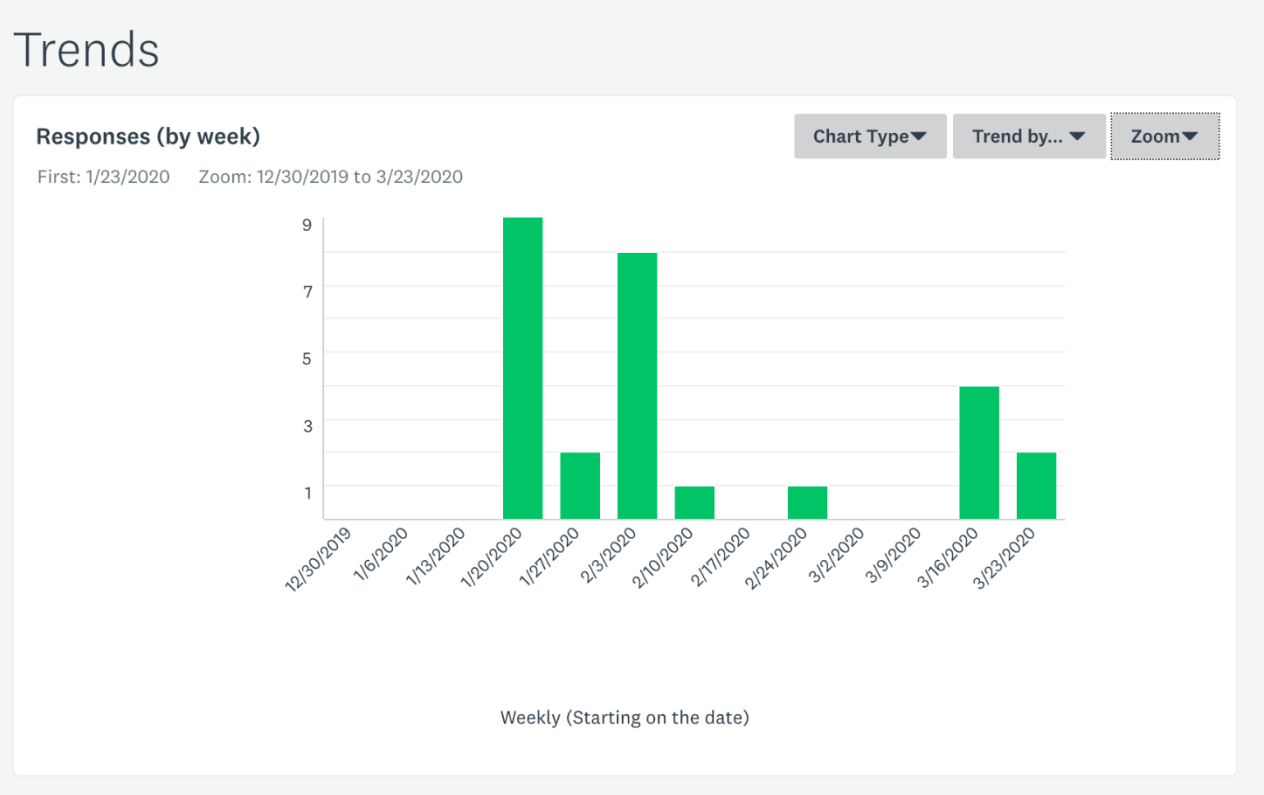

Figure 6: Round Two Response Rate Trend

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7.1 Demographics of Respondents

7.1.1 Country

The countries in which the respondents work were as follows in Table 1 and Figure 2. Many of the respondents are research experts and as such their country of work may be less critical than their level of competence and knowledge.

Country	% of respondents
GB: United Kingdom	22.22%
DE: Germany	14.81%
AT: Austria	11.11%
ES: Spain	7.41%
FI: Finland	7.41%
FR: France	7.41%
NL: Netherlands	7.41%
Not reported	7.41%
CZ: Czech Republic	3.70%
LT: Lithuania	3.70%
SE: Sweden	3.70%
US: United States	3.70%
Grand Total	100.00%

Table 4: Top 10 Work Countries

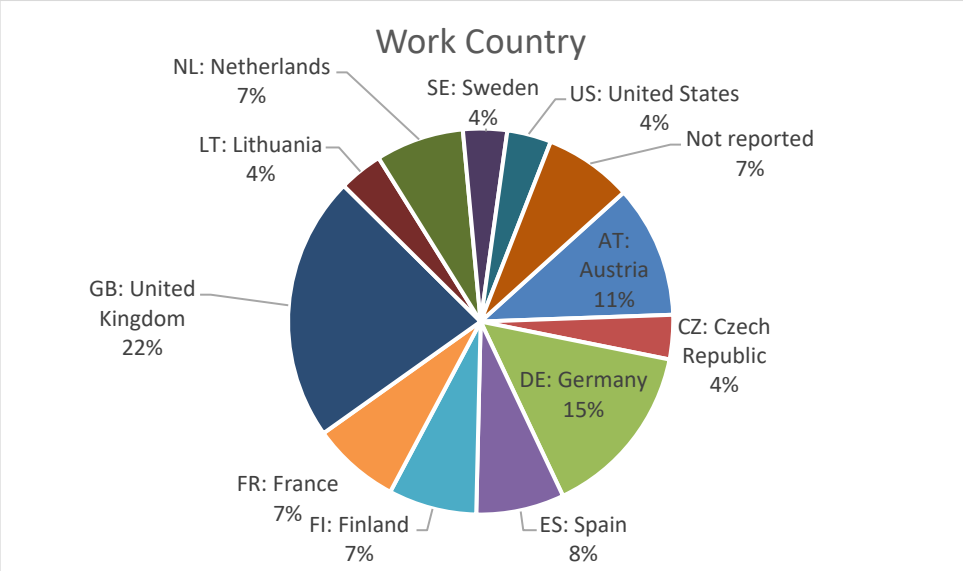

Figure 7: Work country of respondent

7.1.2 Experience and Expertise of the Panel

The panel was experienced and used to executive decision making, with 75.86% having 10 or more years of experience in the transport sector, whilst still including those newer to the sector at 17.24% (see Figure 3). Those with senior executive roles formed 44.83% of the panel with

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37.93% having middle management roles, and 17.24% with operational roles[6] (see Figure 4 below).

Figure 8: Years of experience in the transport sector

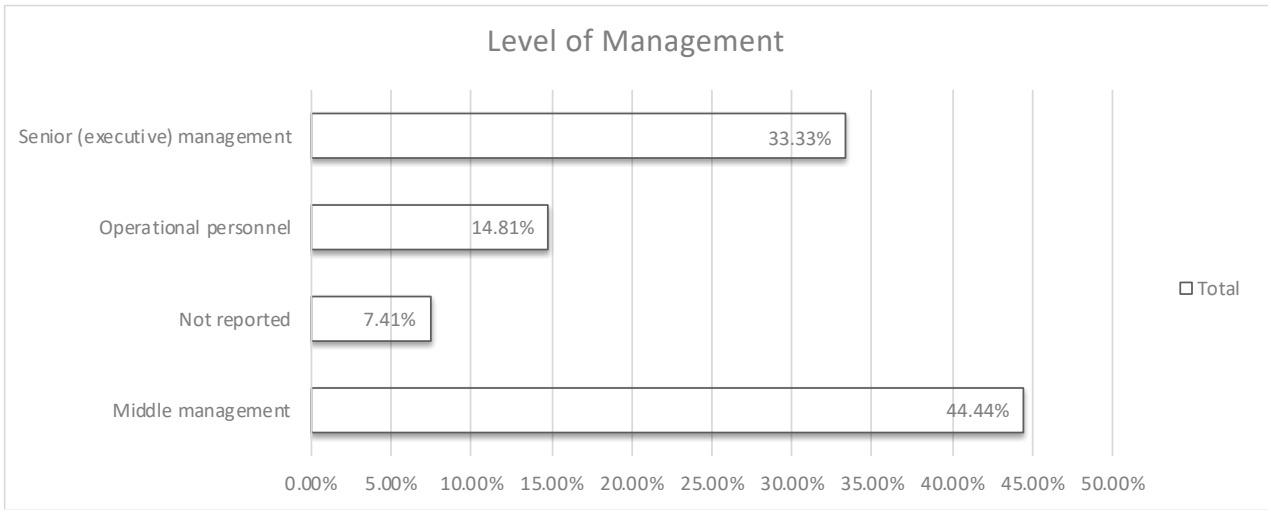

Figure 9: Which level of management are you in your organisation (or last role if you are retired or self-employed)

7.1.3 SME Representation

The panel had high SME representation, with 40.47%% reporting that they worked for an organisation that had fewer than 250 employees and a turnover less than or equal to €50 million per annum or a balance sheet of less than €43 million, the EU definition of a medium sized enterprise[7].

[6] Or had had, in the possible case of retirees.

[7] https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en

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7.1.4 Organisational Type

The most prevalent organisational types represented in the panel were research organisations and consultancies (37.04% and 25.93% respectively) as shown in Figure 5 below. This reflects the research led nature of the work, but also that experts gravitate to such organisations and they may offer objective and independent viewpoints.

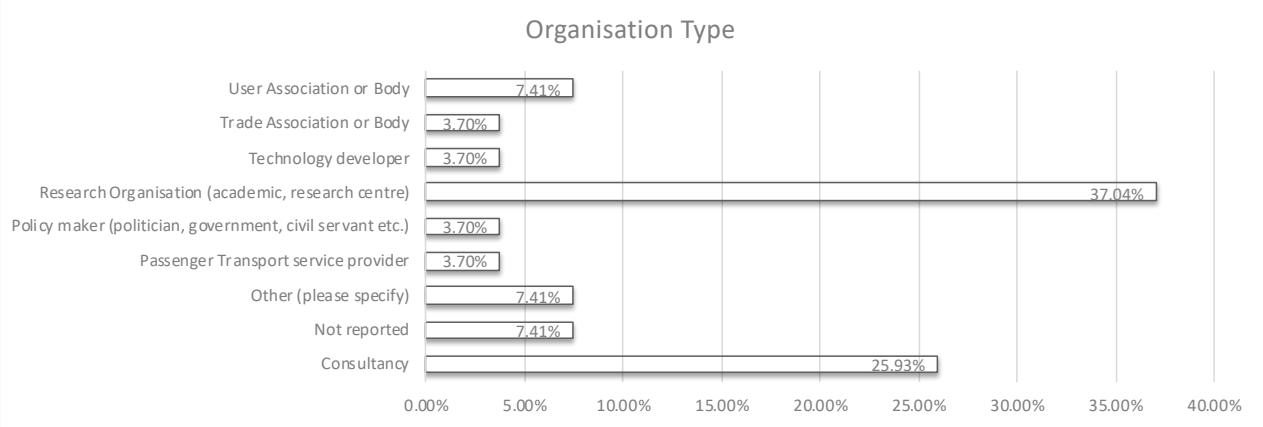

Figure 10: Q7: What sort of organisation do you work for? You may tick as many as apply.

7.2 Differences between Rounds and Panels

The subset of the panel that worked on Round Two was smaller, more influenced by UK based respondents, with a higher proportion of research organisations and consultants. However a Delphi Survey is intended to elicit experts and then work with them to develop synthesis. The panel may have been disproportionately composed of Europeans currently based in the UK, but as expert researchers and consultants to the European Rail Research Area, they were well qualified to help develop, critique and contribute to the second stage. The quality of the responses from this smaller group tends to bear this out.

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8 Round One & Two Consensus and Stability Analysis

Using the methodology detailed in Section 5.1 above the overall APMO for Round One was calculated as follows:

$$\text{APMO}=\frac{\text{Aggregate of Majority Agreements}=827+\text{Aggregate of Majority Disagreements}=0}{\text{Total Opinion Expressed}=1140}x100=72.54\%$$

Whilst there were some statements for which the panel was unstable and had not reached consensus according to the APMO of 72.54%, all had a simple majority of agreement. In a Delphi it is possible for a majority to agree or disagree with a statement, but until it has been defined as achieving stability, it is not resolved.

Using the methodology detailed in Section 5.1 above, the overall APMO for Round Two was calculated as follows:

$$\text{APMO}=\frac{\text{Aggregate of Majority Agreements}=245+\text{Aggregate of Majority Disagreements}=32}{\text{Total Opinion Expressed}=405}x100=68.40\%$$

Whilst there were some statements for which the panel was unstable and had not reached consensus according to the APMO of 69.40%, all had a simple majority of agreementor disagreement. In a Delphi it is possible for a majority to agree or disagree with a statement, but until it has been defined as achieving stability, it is not resolved.

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9 Rounds One Statement Results

Table 5 below details the statements which the panel agreed with and where a stable consensus (majority above the APMO of 72.54%) was observed. These can be viewed as settled and used for further analysis and inputted to future roadmapping for the sector.

Table 6 below details the statements which the panel agreed with and where a stable consensus (majority above the APMO of 72.54%) was NOT observed. These can be viewed as unsettled and used for developing further statements for Round Two to further explore where the panel may find consensus.

The panel did not achieve a stable consensus on statements 2, 4, 5, 9, 10, 12, 13, 15, and 16; these were then analysed to develop further statements for a second round as detailed in 5.2.2 above.

Round One had no statements that were disagreed with, due to the nature of the statement construction from the sector visioning documents.

The individual statements, the APMO and the qualitative comments made by the panel are detailed in Section 9.1 below

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Statement	Id no	Agree	Disagree	No comment	Agree %	Majority	Stable?	Maj. Opinion
In 2050, rail transport in Europe is the backbone of an intermodal Mobility as a Service for passengers within cities and beyond, meeting the needs of customers, EU citizens and society.	1	45	10	2	78.95%	45	stable consensus	agree
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.	3	48	7	2	84.21%	48	stable consensus	agree
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 minimizing pollution and congestion	6	42	10	5	73.68%	42	stable consensus	agree
By 2050 new energy-efficient station designs in Europe provide easy access and seamless interchange across all transport modes, enabling railways to manage growing passenger volumes and mobility demands	7	42	11	4	73.68%	42	stable consensus	agree
Passengers across Europe are able in 2050 to access real time personal communication and new services for work or leisure continuously, before, throughout and after the journey.	8	49	6	2	85.96%	49	stable consensus	agree
The rail sector of 2050 manages a growing volume of data in Europe contributing to the data economy. Collection, analysis interpretation and prediction are automated to provide consistent up-to-date information, supporting fast, well-informed decisions and business benefits.	11	48	7	2	84.21%	48	stable consensus	agree
By 2050 rail has maintained its place as the safest transport mode and this is recognised and valued by European citizens. Zero casualties per year is the current status of the rail sector at urban, regional and inter-city level.	14	48	6	3	84.21%	48	stable consensus	agree
Manned and unmanned autonomous intelligent vehicles operate safely on the same European railway network of 2050, controlled by artificial-intelligence based traffic management systems.	17	44	9	4	77.19%	44	stable consensus	agree
Rail Freight transport units in 2050 in Europe can communicate with one another as well as with infrastructure and operational facilities, minimising downtime.	18	50	2	5	87.72%	50	stable consensus	agree

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The European rail system of 2050 is fully integrated with the automated multimodal logistic chain forming the backbone infrastructure, comprising new intelligent, automated cross-modal shipment transfer nodes.	19	42	10	5	73.68%	42	stable consensus	agree
By 2050 innovative logistics services in Europe are driven by customer demand. Shipments are moved effectively, efficiently, safely and securely through the "Physical Internet". [https://en.wikipedia.org/wiki/Physical_Internet]	20	45	2	10	78.95%	45	stable consensus	agree

Table 5: TER4RAIL Delphi Survey Round One APMO Analysis STABLE Statements

Statement	Id no	Agree	Disagree	No comment	Total	Agree %	Majority	Stable?	Maj. Opinion
In 2050, rail transport in Europe is the backbone of an intermodal Mobility as a Service for freight within cities and beyond, meeting the needs of customers, EU citizens and society.	2	35	18	4	57	61.40%	35	unstable	agree
The suppliers, operators and other service organisations of the European rail industry in 2050 are recognised as the world's thought leaders for railway products and services.	4	25	22	10	57	43.86%	25	unstable	agree
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	5	38	16	3	57	66.67%	38	unstable	agree
Every individual across Europe has easy tailored access to mobility services regardless of demographics, culture, language, location, or technical proficiency by 2050	9	38	17	2	57	66.67%	38	unstable	agree
Taking into account data privacy management, in the year 2050 relevant information is shared across the European rail stakeholders as a part of the data economy, enabling new services and applications for the benefit of the railway and its customers;	10	39	12	6	57	68.42%	39	unstable	agree

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Statement	Id no	Agree	Disagree	No comment	Total	Agree %	Majority	Stable?	Maj. Opinion
The European rail sector of 2050 has a long-established collaboration with all other sectors to handle cyber security. New forms of cyber-attacks are therefore recognised at an early stage and are dealt with through joint cross-sectoral effort.	12	41	6	10	57	71.93%	41	unstable	agree
People feel safe and secure using European rail services in 2050 thanks to non-blocking security systems. Precautions against external threats, aggression and vandalism, supported by technologies are in place.	13	36	11	10	57	63.16%	36	unstable	agree
The European smart vehicles on rail are aware of themselves by 2050, their passengers/loads and their surroundings, know where they need to be and when and can adjust journeys automatically to meet demand.	15	36	15	6	57	63.16%	36	unstable	agree
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.	16	36	14	7	57	63.16%	36	unstable	agree

Table 6: TER4RAIL Delphi Survey Round One APMO Analysis UNSTABLE Statements

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9.1 Round One Statement Details

Note that an additional attribute is shown, the degree to which *the statement* is "in agreement" with Rail Vision 2050. This does not refer to the outcome of the responses, but is intended to help the reader recognise the leaning of the statement, in case of doubt. This is utilised further in analysis in Section 11 below. It is of greater use when reviewing Round Two since Round One statements are essentially extracts from the visioning.
Note that panel comments are shown verbatim, spelling errors, grammatical issues and so on, to edit them would be to interpret them and perhaps lose meaning. Their ambiguity is an artefact of the multi-cultural nature of the panel, and possibly their typing skills!

9.1.1 In 2050, rail transport in Europe is the backbone of an intermodal Mobility as a Service for passengers within cities and beyond, meeting the needs of customers, EU citizens and society.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with??
1	45	10	2	57	78.95%	Yes	Yes

Table 7: Analysis of Statement 1 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission and stable. It can be viewed as in agreement with the sector roadmaps and goals.
The minority comments nuance the possible barriers, modal competition, the interplay of politics and lobbyists, exceptions for rural lines, need for improved customer service and the problems of state owned infrastructure managers.

9.1.1.1 Comments from panel

- It should achieve this on merit and not on the discomfiture of other modes.
- The only way to transport people and for logistics in the future especially will be the rail transport because is the only way to introduce large quantities of them in the cities. And the challenge is to make them, particularly for people, more efficient, more attractive, more comfortable. To get people just consider the only way to move in the city. For logistics, it will be the only way to liberate public space in the cities. Transport vehicles are the ones that occupy the most space on the streets.
- This will only happen if the existing infrastructure is well maintained, if harmonisation follows suit, and if there are enough governments or companies to prioritise the matter. None of this seems to be the case now.
- The rail sector would have to become customer-oriented and internationally-minded for this to happen. This is far from being the case today generally.
- I would like to agree, but I doubt that with current politicians and road lobbyists this vision would be reached.
- For some segments I can agree, but especially the lower density routes I disagree (for instance rural areas).

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- Whilst I believe rail will have an important role, describing it as the backbone seems to me to be an exaggeration
- There are braking issues in rail sector versus the others
- Rail passenger transport has a key role but needs to be part of an integrated transport network, so must accept that rail may not be the optimum solution for society in all cases.
- Unless the stranglehold that the Government owned rail, infrastructure companies is broken we will be no further forward.

9.1.2 In 2050, rail transport in Europe is the backbone of an intermodal Mobility as a Service for freight within cities and beyond, meeting the needs of customers, EU citizens and society.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with??
2	35	18	4	57	61.40%	No	Yes

Table 8: Analysis of Statement 2 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable. The comments were used to develop a new statement for Round Two.
The dissenting voices talked of issues about customer service, cost and asset utilization, politics and lobbyists, lack of urban rail infrastructure, and a belief that rail is not suited to urban freight.

9.1.2.1 Comments from panel

- This should be the case. The rail sector will have to address some fundamental issues around cost, asset utilization and customer facing connectivity if is is to achieve this amongst other things
- Current political decisions are not giving enough support to railways. For economic reasons the RUs are focusing on freight corridors and transport of complete trains from A to B, neglecting smaller clients. Continuing the political hype for autonomous driving will push this sector, which could take over a great part of the freight business.
- This will only happen if the existing infrastructure is well maintained, if harmonisation follows suit, and if there are enough governments or companies to prioritise the matter. None of this seems to be the case now. Even worse, freight does not seem to be a priority in many countries.
- The rail sector would have to become freight customer-oriented and more internationally-minded than it is now for this to happen. This is far from being the case today in some countries.
- I would like to agree, but I doubt that with current politicians and road lobbyists this vision would be reached.
- Freight by rail is relevant for high volumes, high weight, high frequency and long distances (but this last criterion is not a must). So, rail freight should be the backbone of transport between big Origins/Destinations but not within the cities where tailor-made transport solutions should be proposed
- Disagree for non-bulk commodities and freight within cities.
- But the last mile problem must be solved

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- Rail has a key role but, again, as part of an integrated system as rail freight is not always the most efficient or cost-effective solution.
- No way the road lobby would give up pushing themselves further on motorways and roads.
- Within cities the rail freight has many issues. I foresee more chance in as a feeder mode for city logistics. For long distance freight I fully agree.
- Insufficient infrastructure to meet projected needs. Unable to demolish city centres to improve infrastructure.

9.1.3 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.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
3	48	7	2	57	84.21	Yes	Yes

Table 9: Analysis of Statement 3 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission and stable.
The comments explored issues about improving stations, infrastructure maintenance, integrated and multi-modal transport planning, politics and lobbyists. Doubts as to the shaping of urban form, gross numbers, and modal competition were expressed. There was a detailed comment re the potential to rethink stations and trains to achieve zero waiting times

9.1.3.1 Comments from panel

- Stations are getting more and more smart and well equipped places, attracting not only travelling passenger but "normal" clients.
- This will only happen if the existing infrastructure is well maintained - though this is perhaps the aspect that is still rather high on the agenda, it seems.
- This is more likely to happen - and is already happening in some cities - because municipalities are closely involved in urban transport issues.
- I would like to agree, but I doubt that with current politicians and road lobbyists this vision would be reached.
- Not sure about how much rail should "shape" the landscape, especially if fostering overconcentration.
- It will be highly relevent but linked closely to other modes and in particular to the rise of automonous transport.
- Agree, but note that barrier free interfaces implies in the ideal case that there is no need for waiting at stations. Transfer to connections may be important for some part of users where others need to arrive close to the activities mentioned. A radical rethinking of the station functions, maybe in combinations with a more modular configuration of "trains" into units that can virtually connect and therefor also at the station can roll to different end-points. The service platform system can provide dedicated services and information to the passengers. A station then could become an area rather than a location.

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- Whilst I believe rail will have an important role, describing it as the backbone seems to me to be an exaggeration
- But if urban rail is green and not overwhemed by new road modes
- This is an area where rail should be an effective contributor.
- Stations will be stations and people will carry the smart mobility with them. They might use stations as hubs but more likely they will just be interchanges
- Partially but in gross numbers, no
- Part of an integrated multi-modal approach.

9.1.4 The suppliers, operators and other service organisations of the European rail industry in 2050 are recognised as the world's thought leaders for railway products and services.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
4	25	22	10	57	43.86%	No	Yes

Table 10: Analysis of Statement 4 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable.
The comments were used to develop a new statement for Round Two. The comments were largely dissenting and queried if the European rail industry in 2050 would have thought leadership. The dissenters appeared to perceive that Asia was either already in the lead or at a tipping point. Noteable one opened the question as to whether this was an appropriate vision and that transport as a system was more important than industry sector concerns. The concept that companies transcend national or regional categories was raised with the discussion of EuroSino companies.

9.1.4.1 Comments from panel

- This is good as a vision. However, the rail activities in China, Japan and Asia generally represent a formidable fast growing competition
- We wished.
- Europé have to compete with Asia and should be focusing on innovation within some technical areas
- Suppliers: yes. Operators and other service organisations: have a lot of catching up to do.
- Japan is the leading rail industry country.
- It's all about transport, and rail industry should not be the sole voice, at the risk of emphasizing transport growth or sector growth rather than overall socio-economic benefits.
- Asian industry will have the leadership
- In 2019, Europe is still a leader in the railway products and services. But by 2050, companies from Japan, South-Korea and China would probably be the new leaders.
- The statement implies that the European industry will be ahead of those of China, Japan and North America, which seems to me to be open to doubt

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- China will be ahead if Europe does not react immediately
- We should aim for this but need to address the issues around the high cost and poor efficiency of rail operators and suppliers at a time when competitor transport systems are investing heavily in new technologies.
- I think Asia (esp. China, Korea) will develop faster as we foresee now.
- They are essentially technology drivers and not close enough to emergent market/commercial trends
- The Siemens-Alstom "rail business merger" looks unlikely to be agreed. Most unfortunate for the European rail supply chain.
- some are, some are not.
- How do you define a EuroSino company?
- Also the Chinese

9.1.5 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

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
5	38	16	3	57	43.86%	No	Yes

Table 11: Analysis of Statement 5 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable. The comments were used to develop a new statement for Round Two.
The comments discussed the minority role rail has played in Mobility as a Service (MaaS) so far, and the challenges in achieving harmonisation within rail and then between modes.

9.1.5.1 Comments from panel

- While there are lots of endeavours in the area of mobility as a service, rail plays a rather small role in them.
- There is a field of improvement in going from technical skills to market oriented behaviour
- Right now, national rail services do not even integrate seamlessly with rail services available in neighbouring countries. So integrating seamlessly with all other available transport modes seems a very distant prospect indeed, not before 2050.
- Only if the rail sector is financially supported through capital investment, large amounts of which are needed now.
- Some european stakeholders are already assessing these topics. But in 2050, will the European Rail System be homogeneous? I have some doubts.
- Depends a lot on leadership and political support. Further it is essential to harmonise safety regulation for all modes (level-playing field). Self-driving cars/trucks and trains/trams/metro

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should use the same communication and safety systems. Eventually this will even provide the option to blend the modes into one system and network (note that I expect that some rail infra for less dense routes will have available capacity for this "plan B").

- This again is a big challenge. I hope it succeeds
- A good aspiration but this must also be affordable.
- This is aspirational and does not seem to synchronise with nthe competences of the current rail sector and its political masters
- Essential the Channel Tunnel, Great Belt crossing (Germany-Denmark), Rail Baltica & other rail infrastructure improvements are delivered & fully exploited.
- We still cannot get all modes operating together and it is unlikely this will change as competitive pressure will remain.

9.1.6 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 minimizing pollution and congestion

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
6	42	10	5	57	66.67%	No	Yes

Table 12: Analysis of Statement 6 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable. The comments were used to help develop new statements for Round Two.
An interesting question raised and perhaps even more pertinent during the times of pandemic was “what's the threshold size for a "smart city"? Is it sensible to push for more concentration just to make rail relevant?”

9.1.6.1 Comments from panel

- Current mobility as a service endeavours tend to focus much more on car sharing options than rail.
- I would like to agree, but I doubt that with current politicians and road lobbyists this vision would be reached.
- The problem of "capillary connections" is not resolved with rail alone, and the current trends (whether good or bad is an open question) are to further close small lines and stations. In other words: what's the threshold size for a "smart city"? Is it sensible to push for more concentration just to make rail relevant?
- I agree, but technology will enable road to deliver some of these services so rail needs to focus on areas where it can offer real benefit.
- Essential robust land use & transport planning go hand-in-hand. New town & garden village developments to be rail-served

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9.1.7 By 2050 new energy-efficient station designs in Europe provide easy access and seamless interchange across all transport modes, enabling railways to manage growing passenger volumes and mobility demands

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
7	42	11	4	57	73.68%	Yes	Yes

Table 13: Analysis of Statement 7 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission and stable.
The comments queried why energy-efficiency and seamless interchange were linked, perhaps showing that the Rail Vision 2050 statements have a tendency to be bundles and not a discrete checklist. Perhaps prophetic one commenter queried the continued growth of mobility, certainly extant in mobility circles for the last 20+ years but only became mainstream during COVID.

9.1.7.1 Comments from panel

- We wished.
- Infrastructure is expensive and long-lived, so 2050 is too short-sighted to be able to speak of a significant improvement on stations.
- When shall we stop thinking "growth by all means"? Why should mobility demand (per capita) grow, where for instance companies start to understand the benefits of telecommuting?
- What is the link between the energy efficiency of the stations and the intermodality? I think the stations will be more energy efficient. There is still a huge amount of work to promote intermodality.
- This will all need competent and visionary management
- Light rail & Tram-Train vital to deliver this, in conjunction with heavy rail.
- All surface modes, perhaps. Not clear what energy-efficient means.
- Only in locations where funding has allowed this

9.1.8 Passengers across Europe are able in 2050 to access real time personal communication and new services for work or leisure continuously, before, throughout and after the journey.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
8	49	6	2	57	85.96%	Yes	Yes

Table 14: Analysis of Statement 8 TER4RAIL Delphi Survey Round One

- This will happen in an earlier stage
- Yes but let the market take care of the development of services such as APPs etc
- Disagree. Where the lines are succesfull for commuting, trains should be full including many standing people. Further for longer distance services people can already now work or leisure

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continuously during their journey, and after roll out of 5G by 2020 this wil already improve. So I would recommend to just focus on getting train services more reliable.

- This technology will also reduce the need for business travel so rail needs to focus on commuting and leisure.
- The ability to detach from some of these whilst in transit should not be dismissed
- Possibly if there is sufficient call for it from the citizens

9.1.9 Every individual across Europe has easy tailored access to mobility services regardless of demographics, culture, language, location, or technical proficiency by 2050

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
9	38	17	2	57	66.67%	No	Yes

Table 15: Analysis of Statement 9 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable. The comments were used as input to development of new statements for Round Two.
The comments seemed to doubt that universal access regardless of demographics, language or location would be universal.

9.1.9.1 Comments from panel

- Please determ 'easy' compare to the target group that has access to the system. There will always be disadvantaged areas that are not incl in the business case or service
- Mobility as a service options would need to improve a lot not just in the development of apps but their back link to payment systems beyond country boundaries, and in language support beyond the dominant language(s) of any given country. Apps are becoming more user-friendly but there is also a trend towards non-smart phones for the elderly, for example.
- Technical proficiency might be a problem: this will depend on how well educational systems adapt to the digital revolution and make sure that all schoolchildren acquire digital skills
- Much work is ahead though to achieve this objective, specially for dissemination, digitalisation, common onthology and vocabularies, and automation subjects
- Agree, but only when the appropriate measures are taken now.
- Ensuring access for everyone regardless of location, income and technical proficiency is again a challenge
- Every individual - too strong expression
- The fragmenting political structure across Europe is unlikely to facilitate this.
- I am not sure about the rural areas without proper connections to rail.
- 30 years just are less than enough for developing everywhet
- Aspirational
- So many languages to produce information in, likely a reduced amount of data will be available to non-indigenous travellers

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- Inequality will continue to exist

9.1.10 Taking into account data privacy management, in the year 2050 relevant information is shared across the European rail stakeholders as a part of the data economy, enabling new services and applications for the benefit of the railway and its customers

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
10	39	12	6	57	68.42%	No	Yes

Table 16: Analysis of Statement 10 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable. The comments were used as input to development of new statements for Round Two.
Comments doubted the use the data would be put to, whether competitors would share the data and whether data should be collected at all.

9.1.10.1 Comments from panel

- I believe that in times of accelerating digitisation this aspect is on one hand a big challenge for the stakeholders, but on the other hand sharing absolutely necessary to provide the adequate customer solutions.
- We wished. This has been on the agenda for so long, why would it now miraculously happen?
- By 2050, more information will be shared. Is this information relevant? that is another question. The stakeholders will probably use this information for business purposes. If it benefits to the whole community, then it is good. But not sure it is the first goal.
- agree, but providing acces to data should be obliged for all providers to get this running. For all modes and all asset and service providers, by the way.
- How is this to be achieved, given that rail stakeholders are often competitors?
- Hopefully not ... i am deeply again of this "lets collect and share every information about people" thing
- Not clear what is the novelty exactly.
- Political difference will prevent this

9.1.11 The rail sector of 2050 manages a growing volume of data in Europe contributing to the data economy. Collection, analysis interpretation and prediction are automated to provide consistent up-to-date information, supporting fast, well-informed decisions and business benefits.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
11	48	7	2	57	84.21%	Yes	Yes

Table 17: Analysis of Statement 11 TER4RAIL Delphi Survey Round One

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This agree result is in support of the Rail Vision 2050 mission and stable.

9.1.11.1 Comments from panel

- Whose business, please? The "data economy" benefits to end users and societies are more controversial, and need to be better understood. Facebook is big business, tobacco is also big business. Nobody would say today that the tobacco business is good for society, let alone for individuals.
- This depends somewhat on who will own the data (IM, RU, other companies that are not yet on the market) and how willing they will be to share it or under what conditions.
- A lot of data is already collected. More will be collected by 2050. Analysis, interpretation and prediction models are the key issues. Maybe 2050 will show huge evolutions in these fields.
- Without doing so rail shall be offset of the landscape

9.1.12 The European rail sector of 2050 has a long-established collaboration with all other sectors to handle cyber security. New forms of cyber-attacks are therefore recognised at an early stage and are dealt with through joint cross-sectoral effort.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
12	41	6	10	57	71.93%	No	Yes

Table 18: Analysis of Statement 12 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission and stable

9.1.12.1 Comments from panel

- the interest (Economy, politics, policy) will be too far apart
- This will be essential as transport becomes increasingly automated
- I don't think the cybersecurity will be a problem. In my view all data should be shared among all.
- This will hopefully be the case but some harsh lessons will most likely be learned between now and then.
- I might got too old for this cyber stuff...
- Need to maintain vigilance and emergent threats.
- Too many different legacy systems both within states and between them.
- Multiple stand-alone systems will prevent this

9.1.13 People feel safe and secure using European rail services in 2050 thanks to non-blocking security systems. Precautions against external threats, aggression and vandalism, supported by technologies are in place.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?

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13	36	11	10	57	63.16%	No

Table 19: Analysis of Statement 13 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable. The comments were used as input to development of new statements for Round Two.

9.1.13.1 Comments from panel

- 1) clarify "non blocking"; 2) safety and security come at a price, and the question is what price the users and non-users (e.g. taxpayers) are willing to pay. We know (from experience) that willingness to pay varies with time, transport mode, and location. While the trend was upwards in an increasingly risk-averse society, forecasting is difficult.
- Security systems are only creating problems and are expensive. Passenger are already safe enough.
- Rail system is and will probably continue being very vulnerable to terrorism
- This would be good and welcome, but we know that the most intelligent brains often are used also by the attackers.
- For smaller cities and villages this statement is false.
- This should be a key given/selling point.
- People will not feel more safe thanks to non-blocking security systems.
- Depending on the threat

9.1.14 By 2050 rail has maintained its place as the safest transport mode and this is recognised and valued by European citizens. Zero casualties per year is the current status of the rail sector at urban, regional and inter-city level.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?
14	48	6	3	57	84.21%	Yes

Table 20: Analysis of Statement 14 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission and stable.

9.1.14.1 Comments from panel

- Zero is not a number, just a goal
- "maintained" is dubious, if compared to e.g. air transport, and depends on how safety is measured. Zero per year could be achieved by some networks in particularly good "vintages" (Shinkansen is very proud of it), but is not formally correct a commitment (Poisson law comes to mind)
- It is unlilkely to reach zero casualties, but the number can be reduced.
- Zero casualties is not the current status. But rail is the safest land transportation mode and must remain as such.

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- This is not true. There are quite some casualties at crossings and by suicides. The number of casualties at crossing will go down since the number of level crossings should go down when the headway between trains becomes small.
- It will continue being the safest mode, but the zero casualties status is imposible to achive in real life.
- Hopefully this is true.
- I wish this will happen once...
- Highly unlikely that zero casualties will ever be experienced, once you add human beings to interactions accidents will happen.
- Zero will be very expensive, but close to it is realistic.

9.1.15 The European smart vehicles on rail are aware of themselves by 2050, their passengers/loads and their surroundings, know where they need to be and when and can adjust journeys automatically to meet demand.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?
15	36	15	6	57	63.16%	No

Table 21: Analysis of Statement 15 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable. The comments were used as input to development of new statements for Round Two.
A message from the comments could be seen as a view that rail is more of a mass transit backbone, and not the universal autonomous vehicle system of the statement.

9.1.15.1 Comments from panel

- Agree, but I don't see the development of the necessary equipment currently
- Last part is dubious; there are trade-offs between capacity and adaptation to demand (esp. time). Mass transport is still (technically and economically) desirable for rail.
- Agreed, these will probably also be a massive support to more rural locations ensuring that rail services there have a critical mass in order to remain in operation.
- Rail is more a mass transit solution. Tailor-made journeys may not be the solution. As a backbone, rail may provide journeys on a regular time table so that passengers, and other "light" transport modes can lean on.
- I am not clear how a mixed traffic rail system could work entirely with vehicles adjust journeys to demand.
- Much of this I agree with, but I believe that there will still be many/mostly fixed timetable 'heavy rail' services as it is hard to adjust what the vehicles do 'real time' when they have a range of passengers with different destinations and expectations about arrival times.
- I disagree because rail have restraint in access and capacity
- Frteight & passenger.
- Not sure this will meet commercial needs.

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- Bit completely. Different rates of funding and enthusiasm will apply

9.1.16 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.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
16	36	14	7	57	63.16%	No	Yes

Table 22: Analysis of Statement 16 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission but not stable. The comments were used as input to development of new statements for Round Two.
The comments here did not provide much insight so input from the authors and the webinar panels was used for the new statement.

9.1.16.1 Comments from panel

- only on the unexpected predictable situations, how can we prepare for the unexpected events
- Agree, but I don't see the development of the necessary equipment currently
- Technically this may be possible, the question of ethics in such decisions needs to be sorted out, though.
- Again, this is not road transport; as vehicles (assuming they are small: a carbody for instance) should often travel as a single convoy, they become a bit dumber, for the benefit of overall efficiency.
- Perhaps not by 2050 but this will most likely happen.
- Idem to the last
- Again this seems to me to be over ambitious
- Essential
- Not sure that this is actually achievable.

9.1.17 Manned and unmanned autonomous intelligent vehicles operate safely on the same European railway network of 2050, controlled by artificial-intelligence based traffic management systems.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
17	44	9	4	57	77.19%	Yes	Yes

Table 23: Analysis of Statement 17 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission and stable.

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9.1.17.1 Comments from panel

- Agree, but I don't see the development of the necessary equipment currently
- This is most probable for rail transportation as opposed to other transportation modes.
- Partly in some main corridors
- The interesting side is, "where do we still require human intelligence, why, and how to get it". Needs would be either for crafting AI systems, or for supervising some management aspects (esp. off routine)
- Not sure it will come soo fast...
- Not convinced. On-board personnel required for train ops in open systems

9.1.18 Rail Freight transport units in 2050 in Europe can communicate with one another as well as with infrastructure and operational facilities, minimising downtime.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
18	50	2	5	57	87.72%	Yes	Yes

Table 24: Analysis of Statement 18 TER4RAIL Delphi Survey Round On19

This agree result is in support of the Rail Vision 2050 mission and stable.

9.1.18.1 Comments from panel

- Agree, but I don't see the development of the necessary equipment currently
- They always could in principle but don't.
- Intelligent assets in freight must be runned as valuable assets and turnover increase. Automation leads this development
- I wish they could communicate with the loader and client too... Do not forget that not everything is software. Auto couplers are used by all really successful freight operators (US, Russia). Auto-coupler introduction failed twice in Europe. European freight is still XIXth century!!! 2050 is a far cry.
- Agree, but huge investments and advancements are needed before this can be rolled out.
- This is an ideal world. But there are so many layers. Not by 2050.
- Maybe
- Vital!

9.1.19 The European rail system of 2050 is fully integrated with the automated multimodal logistic chain forming the backbone infrastructure, comprising new intelligent, automated cross-modal shipment transfer nodes.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
19	42	10	5	57	73.68%	Yes	Yes

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Table 25: Analysis of Statement 19 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission and stable.

9.1.19.1 Comments from panel

- Agree, but I don't see the development of the necessary equipment currently. Here I also miss the will of the concerned stakeholders to collaborate.
- The timeline seems to short to achieve this, though it is feasible
- This will probably be implemented in the areas in which the use of rail is enforced (e.g. in the Alps) but not where it is not.
- Sounds good, but then I wonder why such past initiatives were doomed, to make sure that we won't repeat the same failures. (There were full scale experiments in France around 1990... shelved)
- Europe is a mixed network (passengers and freight). Rail freight is 17.4% of the total European freight market in 2016 (source Eurostat 2018) while road is 76.4%. With significant differences between countries (1% in Ireland and 65% in Lithuania). So rail freight will probably be more integrated into the global supply chain but for the moment road is the backbone.
- agree, in case the innovations above are realised.
- Again there are major organisational challenges to bring this about
- Should be and hopefully will be.
- Not sure but can happen in some country. Definately bot in all of them.
- Not unless state control is removed from the infrastructure companies, despite the rail directives.
- same prediction as 25? Too many buzzwords.
- Partially integrated

9.1.20 By 2050 innovative logistics services in Europe are driven by customer demand. Shipments are moved effectively, efficiently, safely and securely through the "Physical Internet". [https://en.wikipedia.org/wiki/Physical_Internet]

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
20	45	2	10	57	78.95%	Yes	Yes

Table 26: Analysis of Statement 20 TER4RAIL Delphi Survey Round One

This agree result is in support of the Rail Vision 2050 mission and stable.

9.1.20.1 Comments from panel

- Difficult to achieve due to the level of automation connection and IA required
- Agree, but maybe just a hub-oriented system and not exactly PI.
- Need for physical carriage of passengers & goods still essential.

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10 Round Two Statement Results

Table 27 below details the statements which the panel agreed with and where a stable consensus (majority above the APMO of 72.54%) was observed in Round Two. These can be viewed as settled and used for further analysis and inputted to future roadmapping for the sector.

Table 28 details the statements which the panel agreed with and where a stable consensus (majority above the APMO of 72.54%) was NOT observed. These can be viewed as unsettled and used for developing further statements for Round Two to further explore where the panel may find consensus.

The panel did not achieve a stable consensus on statements 22, 23, 25, 27,30, 31, 32, and 33; these are then to be reported for use in further roadmapping and research.

Round Two had statements that were disagreed with, due to the nature of the statement construction to elicit insight, sometimes a disagreement may have been in alignmnment with Rail Vision 2050.

The individual statements, the APMO and the qualitative comments made by the panel are detailed in 10.1 below

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Statement	Id no	Agree	Disagree	No comment	Agree %	Disagree %	Majority	Stable?	Maj. Opinion
By 2050 the rail freight sector will have to have addressed some fundamental issues around cost, asset utilization and customer facing connectivity.	21	26	1	0	96.30%	3.70%	26	stable consensus	agree
In 2019, Europe is still a leader in the railway products and services. But by 2050, companies from Japan, South-Korea and China would probably be the new leaders.	24	20	4	3	74.07%	14.81%	20	stable consensus	agree
Only if the rail sector is financially supported through capital investment, large amounts of which are needed now, can the European rail system in 2050 be able to detect, understand and respond to individual and collective European citizens mobility needs, delivering tailored, on demand, integrated end-to-end mobility solutions.	26	21	5	1	77.78%	18.52%	21	stable consensus	agree
A majority of native speakers in urban areas across Europe will have easy tailored access to mobility services by 2050.	28	22	2	3	81.48%	7.41%	22	stable consensus	agree
In 2050, by obliging access to data from all providers for all modes and all asset and service providers, relevant information is shared across the European rail stakeholders as a part of the data economy.	29	24	1	2	88.89%	3.70%	24	stable consensus	agree
People in cities feel safe and secure using European rail services in 2050 thanks to non-blocking security systems.	33	19	4	4	70.37%	14.81%	19	stable consensus	agree
Rail is more of a mass transit solution. Tailor-made autonomous journeys will not be the solution. By 2050 as a backbone, rail in Europe will provide journeys on a regular time table so other "light" transport modes can offer autonomous trips.	34	25	2	0	92.59%	7.41%	25	stable consensus	agree

Table 27: TER4RAIL Delphi Survey Round Two APMO Analysis STABLEand AGREE Statements

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Statement	id no	agree	disagree	no comment	agree %	disagree %	majority	stable?	maj. opinion
By 2050 rail will not be the backbone of an intermodal Mobility as a Service for freight.	22	9	15	3	33.33%	55.56%	15	unstable	disagree
By 2050 the European rail sector will remain largely technically led with service and user aspects not well recognised.	23	8	17	2	29.63%	62.96%	17	unstable	disagree
Right now, national rail services do not integrate seamlessly with rail services available in neighbouring countries. So integrating seamlessly with all other available transport modes seems a very distant prospect indeed, not by 2050.	25	14	11	2	51.85%	40.74%	14	unstable	agree
The fragmenting political structures across Europe is unlikely to facilitate mobility services tailored regardless of demographics, culture, language, location, or technical proficiency by 2050	27	15	11	1	55.56%	40.74%	15	unstable	agree
In the year 2050 information that is shared across the European rail stakeholders as a part of the data economy is exploited by large businesses and threatens personal data privacy.	30	14	11	2	51.85%	40.74%	14	unstable	agree
Only in urban mixed traffic environments shall the rail system of 2050 deploy 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.	31	15	10	2	55.56%	37.04%	15	unstable	agree
European rail systems in 2050 will continue to be very vulnerable to terrorism.	32	17	8	2	62.96%	29.63%	17	unstable	agree
Only some European smart vehicles on rail on low useage lines are aware of themselves by 2050 and have operational autonomy.	35	13	10	4	48.15%	37.04%	13	unstable	agree

Table 28: TER4RAIL Delphi Survey Round Two APMO Analysis UNSTABLE Statements

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10.1 Round Two Statement Details

Note that an additional attribute is shown, the degree to which *the statement* is in agreement with Rail Vision 2050. This does not refer to the outcome of the responses, but is intended to help the reader recognise the leaning of the statement, in case of doubt. This is utlised further in analysis in Section 11 below. It is of greater use when reviewing Round Two statements since many are phrased negatively and were drafted from Round One comments.
Note that panel comments are shown verbatim, spelling errors, grammatical issues and so on, to edit them would be to interpret them and perhaps lose meaning. Their ambiguity is an artefact of the multi-cultural nature of the panel, and possibly their typing skills!

10.1.1 By 2050 the rail freight sector will have to have addressed some fundamental issues around cost, asset utilization and customer facing connectivity.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
21	26	1	0	27	96.30%	Yes	Yes

Table 29: Analysis of Statement 21 TER4RAIL Delphi Survey Round Two

This agree result is in support of the Rail Vision 2050 mission and stable.

10.1.1.1 Comments from panel

- Even before 2050.
- This is vital to any overall re-positioning of the sector
- Rail freight for non-bulk products remains inefficient.
- Increased electrification very important
- These have been issues for many years, I am not sure they will resolved by 2050

10.1.2 By 2050 rail will not be the backbone of an intermodal Mobility as a Service for freight.

Statement	Agree	Disagree	No comment	Total	Disagree %	Stable?	Agreement with?
22	9	15	3	27	55.56%	No	No

Table 30: Analysis of Statement 22 TER4RAIL Delphi Survey Round Two

Whilst a disagree result this response is in support of the Rail Vision 2050 mission but not stable. This disagreement and the comments should be taken into the next phase of roadmapping by the sector.

10.1.2.1 Comments from panel

- 30% more freight by 2030 and 50% by 2050 are the shared perspectives in Europe. You can not absorb this growth without rail. Rail MUST be the backbone. Safer, less external costs, more reliable.
- Rail Freight is already today only a "niche market".

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- An modified and rejuvenated rail sector will have been developed (more of the same will not work) and it will have positioned itself as an energy efficient emissions free mode by exploiting its inherent endowments.
- There is a window of opportunity now that sustainable transport has risen to the top of the agenda. Rail freight should seize the moment and emphasise its environment-friendliness at every opportunity.
- Private sector road hauliers are unlikely to embrace rail as long as it remains inefficient.
- disagree as the current trend to sustainability and the will of the industry to get greener is a big chance to increase intermodal freight transport with rail as core mode
- Agree, disagree if the sector isn't rapids its competitive position and integration of the multimodal transport roadmaps.
- Essential rail is seen as an inter-modal first choice
- The lack of freight paths will stifle freight transport by rail, especially as passengers give greater profit per unit than freight and so passenger traffic will always take priority.
- Please note that a backbone is only a relatively small part of the body and can not move in all directions like arms and legs. So rail as backbone of MaaS could mean that clear choices are made where rail should fit in the system (where large flows are) and other services make it possible to move flexibly in all directions.And this links to question 4.
- With climate change mitigation considered, rail will still play a significant role
- By 2050, rail and water ways will be the backbones of an intermodal Mobility as a Service for freight.
- We still have 30 years to achieve this goal.
- Rail would be the most important way to deliver goods on the cities. European logístics, countries, cities, regions by rail.
- Rail may make progress in long distance and bulk freight but will neve become the backbone of freight mobility as a whole
- A new mode of transport can be developed. But generally, rail is the only possibility as the backbone mode.
- It should be. This is the best way to provide sustainable freight transport.
- I wish freight will be the backbone of intermodal mobility but it has to overcome a lot of obstacles like cost and priority to passenger and it will be very difficult. Increasing freight share is however a must to fight climate change.

10.1.3 By 2050 the European rail sector will remain largely technically led with service and user aspects not well recognised.

Statement	Agree	Disagree	No comment	Total	Disagree %	Stable?	Agreement with?
23	8	17	2	27	62.96%	No	No

Table 31: Analysis of Statement 23 TER4RAIL Delphi Survey Round Two

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Whilst a disagree result this response is in support of the Rail Vision 2050 mission but not stable. This disagreement and the comments should be taken into the next phase of roadmapping by the sector.

10.1.3.1 Comments from panel

- Once again it is an industrial transport mode which should be designed to offer regular, timed, mass transit (passengers and freight. Flexibility will come from high number of trains, saturation of means and ressources.
- To maintain and increase the railway role a modification towards user aspects is necessary very soon.
- The sector will have had to recognize that the limitations of its product and service offer were not relevant to the needs of commerce, industry and wider society.Fundamental changes i9n its technical, operational, commercial and management models will have been introduced and succeeded
- Service and user aspects definitely need to be recognised.
- we should work on it to prevent this to happen!
- There is a growing move towards a service-led railway and this will continue if it is run for its customers and not solely for the benefit of its staff or the politicians.
- the needs of the clients are more and more in the focus of railways and the efforts to adapt the rail services to these needs will therefore show their results far before 2050
- Customer service vital
- This will depend on actions taken from now on. The historical speed of progress is not very promising though.
- There is a shift towards customer/user needs across all transport modes
- We still have 30 years to achieve this goal
- If service and user aspects not yet well understood the industry will become increasingly irrelevant.
- On balance I fear this will be the case
- The service and users aspects are of primary interest, and there is no reason for not well-recognised service and user aspects.
- This statement makes an assumption that it is largely technically led now, which I disagree with.
- This all should take user aspects into account.
- Digitalisation will play a major role and rail sector has to adapt the service to the user

10.1.4 In 2019, Europe is still a leader in the railway products and services. But by 2050, companies from Japan, South-Korea and China would probably be the new leaders.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
24	20	4	3	27	74.07%	Yes	No

Table 32: Analysis of Statement 24 TER4RAIL Delphi Survey Round Two

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Whilst an agree result this response is not in support of the Rail Vision 2050 mission and stable. This dissension and the comments should be taken into the next phase of roadmapping by the sector.

10.1.4.1 Comments from panel

- Europe is a major player. But Asian countries are ALREADY top players. The quality level is so high in South Korea and Japan. And China is such a big market, and the whole system is financed by the State. They do not play with the same rules.
- If we do not respond, yes we will loose the position. Therefore we should act now.
- Europe seems unlikely to be able to compete with Far East suppliers.
- the current rapid development of the network in china, especially the high speed network, shows to huge potential
- European companies such as Siemens & Alstom must step up to the plate!
- Change is needed, position of current national RU's and IM's should be discussed and changed in order to vercome these issues
- This should be a straightforward solution if there was reduced political interference and less state-backing of a trade union position.
- Frictionless rail travel (passenger & freight) essential across borders
- There seems to be a reluctance to integrate services and so lose commercial superiority. However where full code sharing is utilised then integration works better.
- I do not see the connection between international connectivity and connectivity with for instance urban modal options, which is suggested in the second sentence. But in general, in cases where there is a real desire to make changes and a possibility to have a strong top-down governance with the mandate to direct the developments of rail then seamless integration is possible on short to medium term. However current paradigms target a bottom-up approach where decissions are left to the market. So under current paradigms I agree with the statement. But in general there are definitely possibilities to speed up.
- We still have 30 years to achieve this goal
- Hardly to predict.

10.1.5 Right now, national rail services do not integrate seamlessly with rail services available in neighbouring countries. So integrating seamlessly with all other available transport modes seems a very distant prospect indeed, not by 2050.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
25	14	11	2	27	51.85%	No	No

Table 33: Analysis of Statement 25 TER4RAIL Delphi Survey Round Two

Whilst an agree result this response is not in support of the Rail Vision 2050 mission and stable. This dissension and the comments should be taken into the next phase of roadmapping by the sector.

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10.1.5.1 Comments from panel

- Technologically it has been shown, that integration - between different former state railways and other as well as with other modes is possible. If the will of politics and management is there, it can be done until 2030!
- This must be a mandatory requirement to compete with road freight which does not accept this position.
- Much of the solution lies with the service providers, who need to revise their business model and not expect to be cross-subsidised by the state or by passenger operations.
- There should be no need to financial support of the systems are run commercially as they are in the UK, despite the current operational problems we are currently experiencing.
- Note that not only the current rail stakeholders should be meant here. The new rail sector may be organised completely different and some roles may be automated by ICT services comming from new players.
- This is not only a case for large amounts of capital investments, this is a case for new collaboration "shared services" to overcome the current limits to deliver integrated end-to-end solutions.
- I would expect substantial progress in the next 30 years.
- How is this integration to be achieved? By government controlling all modes of transport? By operators cooperating voluntarily?
- The improvement of integration is significant in the last two decades. We can expect even accelerated process.
- Let's hope all transport modes can cooperate in the year to come to offer integrated intermodal solutions to answer passenger needs.

10.1.6 Only if the rail sector is financially supported through capital investment, large amounts of which are needed now, can the European rail system in 2050 be able to detect, understand and respond to individual and collective European citizens mobility needs, delivering tailored, on demand, integrated end-to-end mobility solutions.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
26	21	5	1	27	77.78%	Yes	Yes

Table 34: Analysis of Statement 26 TER4RAIL Delphi Survey Round Two

This is an agree result and this response is largely in support of the Rail Vision 2050 mission & stable. However it adds a new rider i.e. “[o]nly if the rail sector is financially supported through capital investment, large amounts of which are needed now..”

10.1.6.1 Comments from panel

- Rail system is mass transit for passengers and high volumes/tonnages for freight. rail transport mode is an industrial transport mode. It dos not answer individual needs. It should not be tailored

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on demand. It must become the backbone of the transport system and then the other modes who are more flexible and adaptable can be added to offer an end-to-end mobility solution.

- The industry needs to address its cost base, sweat its assets a good deal harder and not rely on external (government) funding as its salvation. This implies fundamental and radical changes to existing models
- Business needs are often able to override political fragmentation. If railways behave like businesses, rather than arms of the State, they can achieve what the air transport sector achieved a long time ago.
- we should work and overcome the above mentioned fragmentation
- Each state will protect its short term national interests rather than looking for long term societal benefits.
- With fragmentation you get differing rules and regulations which stifles integration. What is needed is an open source system where companies can share data as and when they are content.
- Multi-level governance is not the key barrier for integrated end-to-end mobility solutions. But we need multi-stakeholder facilitation excellence to work within this complexity.
- Even with heavy investment, I do not understand how rail can deliver tailored on demand on demand end to end solutions. This requires a multi modal multi operator approach
- The rail sector requires financial support. But this support needn't be in the form of capital investment or direct subsidy, but also tax policy etc. the direct connection between capital investment and understanding needs is not clear.

10.1.7 The fragmenting political structures across Europe is unlikely to facilitate mobility services tailored regardless of demographics, culture, language, location, or technical proficiency by 2050

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
27	15	11	1	27	55.56%	No	No

Table 35: Analysis of Statement 27 TER4RAIL Delphi Survey Round Two

Whilst an agree result this response is not in support of the Rail Vision 2050 mission but is unstable.
This dissension and the comments should be taken into the next phase of roadmapping by the sector.

10.1.7.1 Comments from panel

- Commercial and operational models will need to recognize these constraints and work around them to minimize their impact..
- I am not convinced that commercial entities will expose all of their data to competitors if previous experience is anything to go by.
- And also non native speakers.... Tools become available that can translate any written or spoken text instantly from and to all languages.
- I would imagine there would be some progress in the next 30 years.

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- But hopefully progress may be made despite the unfavourable political climate
- The political structures are fragmented, but the same aim.
- It's possibly that this statement is true but it seems more likely to me that congestion and environmental issues will lead to funding to develop more tailored journey opportunities as part of a package of expenditure to provide more public transport capacity

10.1.8 A majority of native speakers in urban areas across Europe will have easy tailored access to mobility services by 2050.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
28	22	2	3	27	81.48%	Yes	Yes

Table 36: Analysis of Statement 28 TER4RAIL Delphi Survey Round Two

Whilst an agree result in support of the Rail Vision 2050 mission and stable, it reduces the scope to “a majority of native speakers in urban areas”.

10.1.8.1 Comments from panel

- The larger the city the better it is today and will be in the future. In small cities it will remain difficult.
- Yes, but we need adequate controls to minimise abuse.
- Assuming a paradigm shift in policy making for most EU countries.
- I am not sure what the word 'tailored' means, but assuming it is the access the is tailored, not the services, this should be possible
- Let's hope so!

10.1.9 In 2050, by obliging access to data from all providers for all modes and all asset and service providers, relevant information is shared across the European rail stakeholders as a part of the data economy.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
29	24	1	2	27	88.89%	Yes	Yes

Table 37: Analysis of Statement 29 TER4RAIL Delphi Survey Round Two

This agree result is in support of the Rail Vision 2050 mission and is stable.

10.1.9.1 Comments from panel

- Some data is commercial data and some stakeholders will not share it. Especially if competition is increasing by 2050.
- I think this statement covers a wide range and whether it is "the minimum of data" or "all data" is unclear today, but will make a huge difference.
- This would put Europe in the same position as the US was in the late 1970s.

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- it should not threaten personal data privacy. So the data ecenomy is shaped in such a way, it doesn't. we need to work on this!
- Probably, yes, but control measures need to develop as the same rate as technology, not lag several years behind.
- This can be restricted by anonomising sensitive personal data.
- Much work is being done to prevent this. For instance at DG Connect.
- I'm uncomfortable with the word 'oblige' here - I think that the benefits of sharing will become self-evident

10.1.10 In the year 2050 information that is shared across the European rail stakeholders as a part of the data economy is exploited by large businesses and threatens personal data privacy.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
30	14	11	2	27	51.85%	No	No

Table 38: Analysis of Statement 30 TER4RAIL Delphi Survey Round Two

Whilst an agree result this response is not in support of the Rail Vision 2050 mission, questioning the impact of the data economy on personal data privacy. It is not, however, stable. This dissension and the comments should be taken into the next phase of roadmapping by the sector.

10.1.10.1 Comments from panel

- Some data is commercial data and some stakeholders will not share it. Especially if competition is increasing by 2050 in the rail sector
- Will be the case much earlier.
- Free sharing of information is fundamental for railway progress
- Controls on data access will protect the stakeholders with penal provisions for any breaches identified.
- This seems to be blue sky thinking. We have not developed the fully smart road vehicle yet ad this is holding back the rail sector
- yes for urban. Also some interregional railway lines I expect. Prbably not all.
- It will not happen if a strict control of sensitive personal information is kept
- This challenge will have to be addressed far beyond the railroad industry.
- Cibersecurity is one of the most important problems to resolve.
- Adequate rules can be devised and enforced to protect privacy
- Cybersecurity and data privacy and their protection are the significant topics of all stakeholders.
- Whilst it will be exploited, I don't see it as a threat to personal data privacy.

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10.1.11 Only in urban mixed traffic environments shall the rail system of 2050 deploy 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.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
31	15	10	2	27	55.56%	Unstable	No

Table 39: Analysis of Statement 31 TER4RAIL Delphi Survey Round Two

Whilst an agree result this response is not in support of the Rail Vision 2050 mission in that it delimits the scope to 'urban mixed traffic environments", but not stable.
This dissension and the comments should be taken into the next phase of roadmapping by the sector.

10.1.11.1 Comments from panel

- Not only in urban environments.
- Mixed traffic environments with full scale mainline rail vehicles are really rare in Europe! It is more an issue for light rail and even more for trams.
- Mixed traffic for rail system is not realistic.
- This is one of a series of options that could enhance rail's capabilities. Any controlling and monitoring systems will need to be very flexible and responsive to compound multiple events (eg disruption events).
- Any open access system is vulnerable, although the risk of violent behaviour will probably remain as the greater true rather than perceived risk.
- more traffic and denser networks to increase capacity make rail more vulnerable. on the other hand, new technologies like drone survey or FOS will be developed to prevent from terrorism
- Any location where many people are concentrated. So this would be favouring a system with small multi-modal pods performing door-to-door services.
- By then measures should be put in place to minimise such attacks
- There are still 30 years left to achieve this goal
- Hopefully application can be more widespread
- The rail system shall have the above-mentioned characteristics generally.

10.1.12 European rail systems in 2050 will continue to be very vulnerable to terrorism.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
32	17	8	2	27	62.96%	No	No

Table 40: Analysis of Statement 32 TER4RAIL Delphi Survey Round Two

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This agree result is not in support of the Rail Vision 2050 mission but is not stable. It is a split of two unstable statements from the first round, and elicits two different but complementary views, that terrorism will continue (this statement), but that people feel secure due to non-blocking systems (next statement).

10.1.12.1 Comments from panel

- Which is in fact a system aspect and not so much a question of full automation
- Agree, if regulation remains current.
- I believe that security will increase in the coming years due to the ongoing terrorist threats.
- I do not understand what is meant with 'non-blocking'.
- The openness of the rail system lends it to be vulnerable to security related attacks.
- I´m sure european security strategies will be implement by the UE.
- Security is a topical issue, but unfortunately, terrorism is inventive.
- Real efforts have to be done in safety measures in stations + digitized surveillance on tracks

10.1.13 People in cities feel safe and secure using European rail services in 2050 thanks to non-blocking security systems.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
33	19	4	4	27	70.37%	Yes	Yes

Table 41: Analysis of Statement 33 TER4RAIL Delphi Survey Round Two

This agree result this response is in support of the Rail Vision 2050 mission and is stable. It is a split of two unstable statements from the first round, and elicits two different but complementary views, that people feel secure due to non-blocking systems (this statement), but that systems will will continue to be very vulnerable to terrorism (previous statement).

10.1.13.1 Comments from panel

- Do they ever feel safe and secure?
- Security systems are anyway blocking. They should be avoided to make rail services attractive.
- High-frequency mass transit is more sustainable than individual journeys on a whim. We need to learn to minimise and bundle our journeys.
- I agree, provided that the political will is there to deliver this.
- This is indeed the easy solution. But more is possible.
- Rail services are very vulnerable to terrorism

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10.1.14 Rail is more of a mass transit solution. Tailor-made autonomous journeys will not be the solution. By 2050 as a backbone, rail in Europe will provide journeys on a regular time table so other "light" transport modes can offer autonomous trips.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
34	25	2	0	27	92.59%	Yes	No

Table 42: Analysis of Statement 34 TER4RAIL Delphi Survey Round Two

This agree result is viewed by the authors as supporting the Rail Vision 2050 mission that rail provides the backbone for mobility. It is a nuanced version of statement 2 and is stable.

10.1.14.1 Comments from panel

- Completely right. See previous answers
- Especially in the Peripherie of large cities on demand rail transit with small vehicles (like a small road bus) can be very attractive and much earlier available as a reliable service than on streets.
- This is a limiting perspective. What is required is the ability to plan and re-plan itineraries across modes easily including all public and private options
- If self-aware vehicles are operational then this is not only on low usage lines and also not only part of the vehicles of operation.

10.1.15 Only some European smart vehicles on rail on low useage lines are aware of themselves by 2050 and have operational autonomy.

Statement	Agree	Disagree	No comment	Total	Agree %	Stable?	Agreement with?
35	13	10	4	27	48.15%	No	No

Table 43: Analysis of Statement 35 TER4RAIL Delphi Survey Round Two

Whilst an agree result this response is not in support of the Rail Vision 2050 mission but is not stable.

- It depends if you count individual vehicles or series. I do not expect many classes but a high number of small vehicles from a few series.
- Autonomous railway vehicles can be developed more effectively and more largely than road vehicles, therefore I envisage a large usage also in high usage systems.
- The use of autonomous trains in open networks is unikely for safety and intervention reasons
- We still have 30 years to achieve this goal
- More widespread application should be possible although obviously operational autonomy is constrained by high capacity utilisation
- General trend.
- Autonomous vehicles will be a fact for rail in a near future

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11 Reflections on the Survey

Although some Delphi studies continue to a third round (Kembro, Näslund and Olhager, 2017), the consensus seems that when diminishing consensus and decline in panel size and consistency suggests it, it is wiser to report the results so that a futher plan of research, maybe with a different methodological paradigm be deployed (Islam, Dinwoodie and Roe, 2006; von der Gracht, 2012). There has been some development of techniques to measure the stability of answers at a group (Dajani, Sincoff and Talley, 1979) and individual level (Chaffin and Talley, 1980); this seems better suited to studies with more than two rounds. We chose to clearly define the process in advance and then use consensus tests to check for the degree to which we had agreed statements.

This was a multi national panel, with many members working in a non-native language (English). This generated some ambiguity. For example, one respondent often commented "We wished" with regard to a future vision statement. Was this, as it seems on face value, a comment based in a hypothetical 2050, looking back to 2019/20 and stating regret that the vision had not come to pass, or a confusion over tense, and was meant as "We wish", so a tentative hope for the future? Whilst this could be explored in the workshop and webinar, it would break the anonymity of the Delphi methodology to do what one would wish and ask what the respondent meant. Even within AGREE response, there can be found multiple caveats, nuances and even disagreements.

There were very few comments supporting the Rail Vision 2050, as opposed to those that disagreed. Respondents, and at this level we do not know their demographics, who agreed with the Rail Vision 2050 did not make comments, they simply ticked Agree. Those that tended to disagree did make comments.Disagreement was encouraged, did this lead to lower supporting comments or did those that agree regard the statements as self evident? Future studies may wish to encourage all comment rather than focusing on dissent. A series of questions at the end of the survey form asking such procedural or methodological questions could be helpful in future studies. This kind of anonymity is key to Delphi and was explored in this work by the use of webinars. In the webinars the same pattern was observed, multiple questions and comments from dissenting or sceptical voices, none expressed unreservedly supporting the vision statements.
We do have some data we can query to explore some questions on the study, the profile of the panel and the individual voting record, which can be legitimately collected in anonymised groups to compare.

11.1.1Statistical Analysis of Results.

It was hypothesised that different groups may have had a tendency, for reasons unknown, to tend to favour the statements from the visioning. To test that the data was recoded and imported into SPSS for analysis.

A Kruskal-Wallis test showed that there was no significant difference in the responses for agreement or dissension from the Rail 2050 Vision by Organisation Type There was no significant difference in the responses for agreement or dissension from the Rail 2050 Vision by Level of

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Management. There was no significant difference in the responses for agreement or dissension from the Rail 2050 Vision by rail experts and non rail experts.

There was significant difference between the level of dissension when analysed by Years of Experience, see Table 44 below. This difference was between those with 1-5 years of experience and those with 10+ years of experience, with those with longer experience showing more dissent, as illustrated below in Figure 11.

Nonparametric Tests

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Agreement is the same across categories of Yearsofexperience.	Independent-Samples Kruskal-Wallis Test	.523	Retain the null hypothesis.
2	The distribution of Dissension is the same across categories of Yearsofexperience.	Independent-Samples Kruskal-Wallis Test	.046	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 44: Variation of Agreement and Dissent by Years of Experience

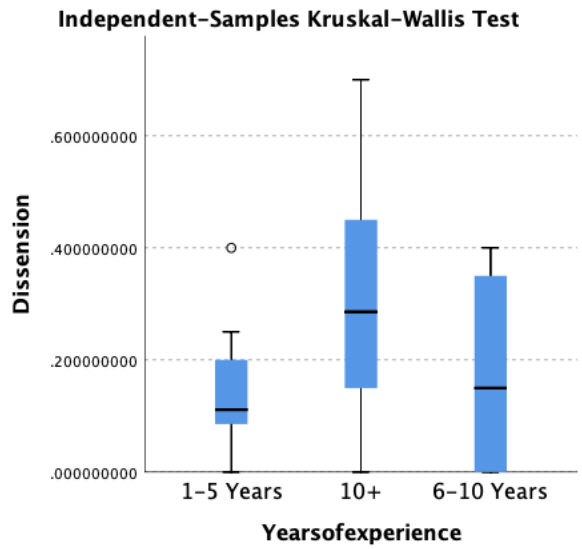

Figure 11: Box and Whisker Chart, Rail 2050 Vision Dissension by Years of Experience

There was significant difference in agreement and dissension between SMEs and Non SMEs, with SMEs agreeing less and dissenting more as shown in Table 45, Figure 12 & Figure 13 below

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Nonparametric Tests

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Agreement is the same across categories of SME.	Independent-Samples Kruskal-Wallis Test	.040	Reject the null hypothesis.
2	The distribution of Dissension is the same across categories of SME.	Independent-Samples Kruskal-Wallis Test	.028	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 45: Variation of Agreement and Dissent by SME status

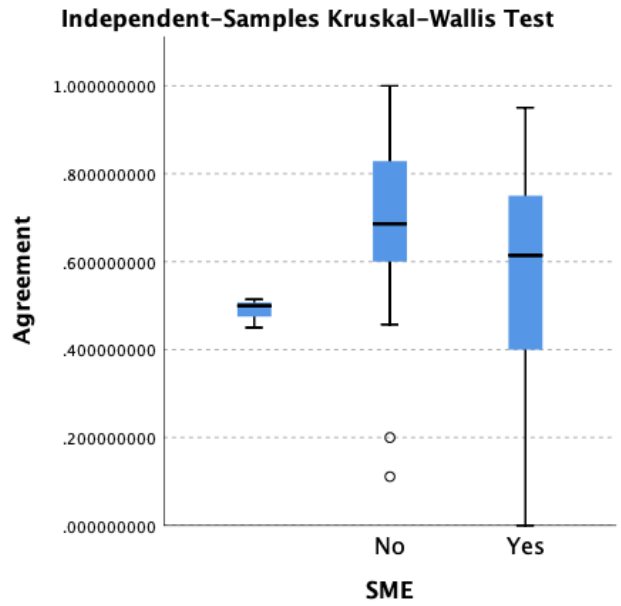

Figure 12: Box and whisker chart showing Variation of Agreement and by SME status

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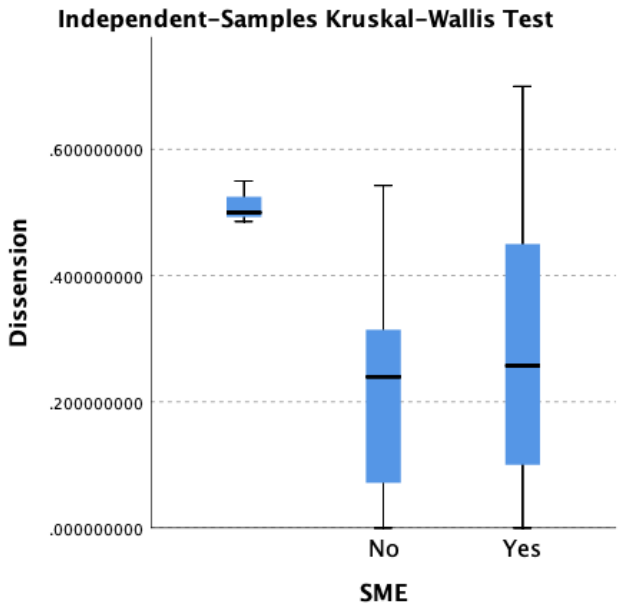

Figure 13: Box and whisker chart showing Variation of Agreement by SME status

From the statistical analysis we can suggest that the older and more senior a panel member or if they work for an SME, the *more* likely they were to express dissenting views about the Rail 2050 Vision, and this variation is summarised in Table 46 below.

Level of Management*	Mean percentage of Agreement	Mean percentage of Dissension
Middle management	65%	21%
Operational personnel	67%	29%
Senior (executive) management	59%	33%
Whole Population	63%	28%
** doesn't total 100% since no comment not included*		

SME?	Mean percentage of Agreement	Mean percentage of Dissension
No	69%	23%
Yes	57%	30%
(blank)	49%	51%
Whole Population	63%	28%
** doesn't total 100% since no comment not included*		

Years of Experience	Mean percentage of Agreement	Mean percentage of Dissension
1-5 Years	69%	15%
6-10 Years	71%	18%

10+	61%	31%
Whole Population	63%	28%

** doesn't total 100% since no comment not included*

Table 46: Summary of significant differences between panel and orientation to Rail 2050 Vision

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12 Insights and Conclusions

12.1.1 Summary of agreed statements

In order of % agreement the statements that the Delphi Study had stable consensus on were, by round[8]:

12.1.1.1 Round One stable statements ranked by agreement

- Rail Freight transport units in 2050 in Europe can communicate with one another as well as with infrastructure and operational facilities, minimising downtime.
- Passengers across Europe are able in 2050 to access real time personal communication and new services for work or leisure continuously, before, throughout and after the journey.
- 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.
- The rail sector of 2050 manages a growing volume of data in Europe contributing to the data economy. Collection, analysis interpretation and prediction are automated to provide consistent up-to-date information, supporting fast, well-informed decisions and business benefits.
- By 2050 rail has maintained its place as the safest transport mode and this is recognised and valued by European citizens. Zero casualties per year is the current status of the rail sector at urban, regional and inter-city level.
- In 2050, rail transport in Europe is the backbone of an intermodal Mobility as a Service for passengers within cities and beyond, meeting the needs of customers, EU citizens and society.
- By 2050 innovative logistics services in Europe are driven by customer demand. Shipments are moved effectively, efficiently, safely and securely through the "Physical Internet". [https://en.wikipedia.org/wiki/Physical_Internet]
- Manned and unmanned autonomous intelligent vehicles operate safely on the same European railway network of 2050, controlled by artificial-intelligence based traffic management systems.
- 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 minimizing pollution and congestion
- By 2050 new energy-efficient station designs in Europe provide easy access and seamless interchange across all transport modes, enabling railways to manage growing passenger volumes and mobility demands
- The European rail system of 2050 is fully integrated with the automated multimodal logistic chain forming the backbone infrastructure, comprising new intelligent, automated cross-modal shipment transfer nodes.

[8] Since the panel sizes were different between rounds it is not appropriate to mix the ranking between rounds.

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12.1.1.2 Round Two stable statements ranked by agreement

- By 2050 the rail freight sector will have to have addressed some fundamental issues around cost, asset utilization and customer facing connectivity.
- Rail is more of a mass transit solution. Tailor-made autonomous journeys will not be the solution. By 2050 as a backbone, rail in Europe will provide journeys on a regular time table so other "light" transport modes can offer autonomous trips.
- In 2050, by obliging access to data from all providers for all modes and all asset and service providers, relevant information is shared across the European rail stakeholders as a part of the data economy.
- A majority of native speakers in urban areas across Europe will have easy tailored access to mobility services by 2050.
- Only if the rail sector is financially supported through capital investment, large amounts of which are needed now, can the European rail system in 2050 be able to detect, understand and respond to individual and collective European citizens mobility needs, delivering tailored, on demand, integrated end-to-end mobility solutions.
- In 2019, Europe is still a leader in the railway products and services. But by 2050, companies from Japan, South-Korea and China would probably be the new leaders.
- People in cities feel safe and secure using European rail services in 2050 thanks to non-blocking security systems.

These statements offer clear insights into the consensus view of the expert panel that can be used to critique, support or amend the future roadmaps, especially the next Strategic Rail Research Agenda (SRIA) currently under development as of November 2020.

12.1.2 Relation to Roadmap Gap Analysis

The Delphi study results are interrelated to and triangulate with the roadmap analysis in D2.2 that focused on the identification of gaps that must be addressed to reach the vision of rail as the backbone of European mobility. To be able to do so, D2.2 employed the keywords extracted from the roadmaps analysis to filter the data resulting from the four data collection phases, including the Dephi study and the World Café Method.
As such, the process of gap identification works as a funnel that filters the keywords resulting from the Dephi study and the World Café Method through a word cloud composed of the keywords resulting from the roadmap analysis. In this context, D2.1 allows the identification of misalignments between the statements identified in both the Dephi study and the World Café Method and the roadmap analysis conducted in D2.2 (Kommers *et al.*, 2020).

As D2.2 shows, the overlap between the roadmaps vision and the collected data from the transport experts during the Delphi and World Café is significant within certain domains. The following table indicates the percentage of this overlap.

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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%**

Table 47: Percentage of the overlap between roadmaps and the collected data

D2.2 identified several gaps clustered into four areas:

- railway users,
- policymakers,
- multi-modal approach,
- on-demand mobility.

The relevance of the unstable statements showing areas of continued concern and dissent from the panel identified in D2.1 map well to these four areas: ten unstable statements out of 17 refer to these four areas:

- The statements 9, 23 and 30 might be included within area 1) railway users.
- Statement 27 might be included within area 2) policymakers
- The statements 2 and 22 might be included within area 3) multi-modal approach
- The statements 5, 10, 15 and 25 might be included within area 4) on-demand mobility.

These ten statements provide a level of corroboration of the validity of the areas around which the gaps identified in D2.2 are clustered. Note that this identifies gaps in roadmaps that would benefit from further attention, since they are unstable it suggests indefinite views and lack of consensus.

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12.1.2.1 Dissent, Doubt and Uncertainty

One of the major objectives of applying a Delphi study is to achieve consensus on some previous issues. On consensus it has been said that 'The Delphi Technique and consensus building are both founded in the same principle - the Hegelian dialectic of thesis, antithesis, and synthesis, with synthesis becoming the new thesis' (Stuter, 1998). However many feel that the search for consensus is just one part of the process and that it can often be the dissenting voices and the non –consensus statements that can yield value.

The statements that remained unstable and unresolved at the end of Round Two, and therefore in need of further research and examination for the future of the sector were:

- By 2050 the European rail sector will remain largely technically led with service and user aspects not well recognised.
- By 2050 rail will not be the backbone of an intermodal Mobility as a Service for freight.
- Only some European smart vehicles on rail on low useage lines are aware of themselves by 2050 and have operational autonomy.
- Right now, national rail services do not integrate seamlessly with rail services available in neighbouring countries. So integrating seamlessly with all other available transport modes seems a very distant prospect indeed, not by 2050.
- In the year 2050 information that is shared across the European rail stakeholders as a part of the data economy is exploited by large businesses and threatens personal data privacy.
- The fragmenting political structures across Europe is unlikely to facilitate mobility services tailored regardless of demographics, culture, language, location, or technical proficiency by 2050
- Only in urban mixed traffic environments shall the rail system of 2050 deploy 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.
- European rail systems in 2050 will continue to be very vulnerable to terrorism.

12.1.2.2 Common Themes

We concentrated on the comments of the panels, both on the stable and unstable results and found common denominators in the varieties of the replies. Some of them were contrasting, so that on the same statement comments both partially reinforced or were totally in disagreement. This in itself indicates that actions need to be taken but the panel did not have a clear idea on how the shortcomings would be solved if any. We have identified 12 of these common denominators which repeat themselves although using different expressions.

12.1.2.3 Panel comment common themes

- Market orientation;
- Cost, competition and efficiency;
- Leadership, political issues, lobbying, government interventione for good or ill;

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- Lack of seamlessness for many reasons;
- Inadequate speed of reaction/investments compared to Asian competitors;
- Lacking technical/technological innovations and skills;
- Language barriers;
- Different regulations barriers in EU rail space;
- Info, data availability sharing and management;
- Safety and security issues;
- Accessibility and capacity;
- A limiting of scope from universal visions to
    - Urban,
    - Native,
    - Backbone.

Similar factors can be seen in D3.3 in the SWOT analysis, and it reinforces the process and conclusions of TER4RAIL as a whole.

12.1.3 Conclusions

We have used both the areas of consensus and also of dissent to inform a narrative to inform the future roadmapping of the EU rail sector and in particular the strategic rail agenda, the STRIA.

There are issues with rail freight, in order for increasing use of rail freight and for it to become the backbone for freight it is imperative that it addresses some fundamental issues; namely cost competitive, asset utilization and customer facing connectivity. These service user aspects are the important challenges that need to be addressed in order for rail freight to raise expectations and to enable the shift of freight from road to rail. An important aspect that has been highlighted, it is expected that rail freight transport units will be able to communicate with each other as well as with the infrastructure and operational. This expectation will not become a reality without significant investment and development of the appropriate communication standards towards the intelligent freight train which will communicate over the next generation communication system.

A very challenging target that will need significant support is to move from competitive rail freight to rail taking the lead and becoming the backbone of an intermodal Mobility as a Service for freight. The freight business has not yet been consolidated but there are opportunities with sea transports that lead to success for rail. Intermodal transport with a rail backbone is the segment with a great potential. To achieve this potential there must be investment in terms of capital but also essential research. One way of improving intermodal mobility to improve rail provisions in terminals and close to ports.

With respect to passengers there is a clarity that rail and public transport are the solution to provide mobility for passengers. This belief builds on rail's existing credentials and credibility as the most environmentally friendly form of mass land transport with an excellent safety record. In 2050 rail will still the safest mode with zero casualties and this is recognised and valued by

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European citizens. This opportunity is enhanced by the fact that passengers across Europe are to access real time personal communication continuously, before, throughout and after the journey. This situation will only improve as passengers demand connectivity and entertainment through their mobile devices.

One issue that will hold back seamless services is that national rail services do not integrate seamlessly with rail services available in neighbouring countries. This situation must be addressed by research into standards and data sharing. Without serious consideration of this aspect integrating seamlessly with all other available transport modes would seem unrealistic.

The flagship for passenger services is rail at the backbone of urban mobility with rail considered the mass transit solution, with large numbers comes the responsibility for protection and improvement of service but also the revenue to provide intelligent stations at the heart of smart cities, being life-centric places to work, meet and communicate. This improvement is considered as a given and it is believed that the expected innovation in mass transit will lead to rail being fully intelligent, operating autonomous vehicles operating in cities with the offer further from the city centre being less focused on mass transit with the innovation such as pods being researched and developed for the final stages of the journey. These pods or fully-smart vehicles 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.

Especially in cities there will be new energy-efficient station designs in Europe providing easy access and seamless interchange across all transport modes, enabling railways to manage growing passenger volumes and mobility demands funded by the secondary spend in stations.

There is one basic assumption that has to become a reality for the strategic development of the rail system. Free access to data from all providers for all modes and all asset and service providers, relevant information must be shared across the European rail stakeholders as a part of the data economy. An additional challenge is to have a harmonised system architecture and data organisation able to support the challenges listed above in an open, interoperable way whilst preserving the requirements of some of the parties' privacy in terms of data confidentiality. A commitment needs to be made to managing the growing volume of data in Europe contributing to the data economy. Tools will need to be jointly developed for the collection, analysis interpretation and prediction of passenger flows. Passenger information needs to be automated to provide consistent up-to-date information, supporting fast, well-informed travel choices and aiding decisions. This will all benefit rail as a business.

Europe has a number of languages and native speakers in urban areas across Europe will have easy tailored access to mobility services. The same is not true for non-native speakers and therefore research should be conducted into the use of smart systems to assist non-native speakers.

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14 Appendices: The Surveys