The SETRIS project has received funding from *the European Union's Horizon 2020 research and innovation programme* under grant agreement No 653739

SETRIS PROJECT

DELIVERABLE REPORT

Document identifier:	**SETRIS - D 1.1**
Due Date of Delivery to EC	**M 3 – 31st July 2015**
Actual Date of Delivery to EC	**02/10/2015**
Title:	**Challenges Outline**
Dissemination level:	**PU**
Work package:	**WP 1**
Lead Beneficiary:	**Newcastle University (UNEW)**
Other Beneficiaries	**ECTRI; AVL; BMT; DLR; FEHRL; POLIS; UIC; UITP; UNIFE; EUROCONTROL**
Document status:	**Draft version 4**
Document link:	Please insert the link where the document is available (if any)

SETRIS Project coordinated by:

The SETRIS project consortium consists of:

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1	Newcastle University	UNEW	UK
2	European Conference of Transport Research Institutes	ECTRI	Belgium
3	AVL List GmbH	AVL	Austria
4	BMT Group Limited	BMT	United Kingdom
5	Centro National de Competencia en Logistica Integral	CNC-LOGISTICA	Spain
6	The European Earth Friendly Logistics Association AISBL	CO-TREE	Belgium
7	Stichting Dutch Institute for Advanced Logistics	DINALOG	Netherlands
8	German Aerospace Center	DLR	Germany
9	Forum des Laboratoires Nationaux Europeens de Recherche Routiere	FEHRL	Belgium
10	Fraunhofer-Gesellschaft zur Forderung der angewandten Forschung e.v	Fraunhofer IML	Germany
11	Instytut Logistyki I Magazynowania	ILiM	Poland
12	Promotion of Operational Links with Integrated Services	POLIS	Belgium
13	Ships & Maritime Equipment Association of Europe	SEA EU	Belgium
14	Union Internationale des Chemins de fer	UIC	France
15	Union Internationale des Transports Publics	UITP	Belgium
16	The Association of the European Rail Industry	UNIFE	Belgium
17	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek	TNO	Netherlands
18	European Organisation for the Safety of Air Navigation	EUROCONTROL	Belgium

Document History:

Version	*Date*	*Modification reason*	*Modified by*
0	25/08/15	First full draft (internal)	Paulus Aditjandra (UNEW)
1	02/09/15	First full draft for comments	Paulus Aditjandra & Roberto Palacin (UNEW)
2	29/09/15	Revised draft following comments from UITP, DLR, POLIS	Paulus Aditjandra & Roberto Palacin (UNEW)
3	12/10/15	Revised conclusions following comments from POLIS and UITP	Paulus Aditjandra & Roberto Palacin (UNEW)
4	16/10/15	Updated draft following further comments from UITP	Paulus Aditjandra & Roberto Palacin (UNEW)

EXECUTIVE SUMMARY

This D1.1 document aims at identifying the level of integration required as well as metrics to measure future implementation success using an agreed set of challenges (physical, operational, economical, and political) as benchmark.

In order to describe the challenges outline, desktop research has been carried out assessing a number of high level documents that identify research and innovation challenges. One of the key documents identified is the conclusion of the European Commission consultation on the H2020 Advisory Groups and subsequent response from the transport advisory group (TAG). The TAG report is used to evaluate the strategic research and innovation agendas (SRIAs) together with the European Technology Platforms (ETPs). This appraisal has resulted in a matrix providing a first attempt to map out the alignment of the ETPs activities to the four challenges described.

The outcome shows that collaboration across ETPs has been well implemented, leading to a synergetic research and to innovation roadmaps towards addressing the EU transport research agenda. It can be concluded that the ETPs' SRIAs are generally detailed and specific and very much bound to the 'physical' dimension of research and innovation development needs. Operational, economical and political challenges/targets appear somehow less populated in the assessment matrix. This allows for the identifications of gap areas where further collaboration is desirable between ETPs with the support of SETRIS. Finally, ACARE's 4 hours mobility target is proposed as a suitable and fitting metric to measure implementation success.

TABLE OF CONTENTS:

TABLE OF TABLES:

LIST OF ACRONYMS

3D printing	Three Dimension printing
DOA	Description of Activities
ACARE	Advisory Council for Aviation Research and Innovation in Europe
ALICE	Alliance for Logistics Innovation through Collaboration in Europe
CESA	Community of European Shipyards' Associations
CSA	Coordination and Support Action
ERRAC	The European Rail Research Advisory Council
ERTRAC	European Road Transport Research Advisory Council
ETP	European Technology Platform
EC	European Commission
ECTP	European Construction Technology Platform
EGCI	European Green Car Initiative
EIRAC	European Intermodal Research Advisory Council
EPoSS	European Technology Platform on Smart Systems Integration
ETCS	European Train Control System
EU	European Union
EV	Electric Vehicle
FP	Framework Programme
FOSTER RAIL	Future of Surface Transport Research Rail
FOSTER-ROAD	Future of Surface Road Transport European Research
H2020	The European Union Framework Programme for Research and Innovation
HV	Hybrid Vehicle
IP	Innovative Programmes
IT	Information Technology
ICT	Information, Communication and Technology
Kwh	Kilo-Watt Hour
MESA	Maritime Europe Strategy Action
PESTEL	Political, Economic, Social, Technological, Environmental and Legislative
PHEV	Plugged-in Hybrid Electric Vehicle
PPP	Public Private Partnership
pkm	Passenger-Kilometre
R&D	Research and Development
R&I	Research and Innovation
SAFIER	Support Action for Implementation of ERTRAC's Road Transport Research Priorities
SETRIS	Strengthening European Transport Research and Innovation Strategies
SMARTGRIDS	European Technology Platform for the Electricity Networks of the Future
SME	Small and Medium Enterprise
SRA	Strategic Research Agenda
SRIA	Strategic Research and Innovation Agenda
SRRA	Strategic Rail Research Agenda

SRRIA	Strategic Rail Research and Innovation Agenda
TAG	Transport Advisory Group (European Commission initiative to address Horizon 2020 Framework on Transportation Research Challenges)
tkm	Tonne-Kilometre
TP	Technology Platform
TRB	Transportation Research Board
US	United States (of America)
v2i	Vehicle to Infrastructure
v2v	Vehicle to Vehicle
WG	Working Group
WINN	European Platform Driving Knowledge to Innovations in Freight Logistics
WP	Work Package
WSRA	WATERBORNE Strategic Research Agenda

1. INTRODUCTION

The purpose of 'SETRIS' is to deliver a cohesive and coordinated approach to research and innovation strategies for all transport modes in Europe. SETRIS envisages identifying synergies between the transport European Technology Platforms' (ETPs') strategic and research and innovation agendas (SRIAs) and between these and relevant national platforms. The five ETPs, in alphabetical order, are:

1) ACARE (Advisory Council for Aviation Research and Innovation in Europe);
2) ALICE (Alliance for Logistics Innovation through Collaboration in Europe);
3) ERRAC (The European Rail Research Advisory Council);
4) ERTRAC (European Road Transport Research Advisory Council);
5) WATERBORNE.

SETRIS aims to develop a framework for long-term cooperation between actors from all transport modes to facilitate the delivery of a truly integrated transport system through two specific themes: 'connecting passengers for seamless travel and sustainable mobility' and 'end to end logistics'.

The methodology used to conduct the activities reported in this document has been based on a review of existing roadmaps and the information from partners representing the five transport European Technology Platforms (ETPs). These ETPs represent all modes of transport (road, rail, waterborne and airborne) plus freight (transportation logistics for all modes). In assessing each of the ETP roadmaps, a higher level document promoted by the European Commission, the Transport Advisory Group (TAG) report (McKinnon et al. 2014), is used to benchmark the roadmaps produced by ETPs. Specifically, a set of challenges identified in the report and clustered into four distinct categories has been used (physical, political, economical and operational). Additionally, each of the research and innovation statements from all the roadmaps are categorised into four factors defining the interfaces between modes for sustainable integration from a physical, political, economical and operational dimensions.

The structure of this document is as follows: section 2 summarises the TAG report; section 3 provides an overview of the transport sector ETP roadmaps; section 4 highlights the existing cross-modal roadmaps arising from collaboration between ETPs; and section 5 provides some conclusions and recommendations for further development with SETRIS.

2. THE TAG REPORT

The report (2014) produced by the Transport Advisory Group (TAG) is a response to the call from the European Commission on the consultation of H2020 Advisory Group. Membership of the TAG consists of 28 transport experts across Europe representing all modes of transport from different sectors. The report noted from the outset of the multi-dimension of transport terms and definitions that cover a number of different sectors including: service, manufacturing industry, management function, infrastructure, economic development instrument, and academic discipline. The TAG was formed following invitation from the European Commission for experts to join the H2020 Advisory Group for the Societal Challenge on 'Smart, green and integrated transport'. The first TAG meeting was held in 2013. Complete reports of the TAG meetings can be seen in this EC webpage link and also listed in the reference list: European Commission (n.d.).

The TAG was formed in response to seven questions listed in the Horizon 2020 consultation process. Below the corresponding seven answers are each summarised.

Q1: Biggest challenges in the field of transport requiring immediate action

The TAG gave the most comprehensive response to this question and for SETRIS it is the most relevant. The TAG has identified a number of new developments that can potentially drive changes in the transport research agenda, i.e. 'trend-breach' (e.g. discontinuity in longer term trends in key transport variables); new technology (cloud computing, dual carbon battery, 3D printing, etc.); new risk profile (business risk); new concepts (car sharing, crowd shipping); new policy perspectives and objectives (old White Papers); new life-styles (increasing older population, e-commerce); and new methodologies and data sources (big data).

All of the above new developments were argued to be bound to assumptions made that could be seen as a threat or an opportunity. Challenges could then emerge from those assumptions made by public policy arena, industry, civil society, the research community or some other stakeholder group. There are 11 key challenges identified by the TAG (outlined in the SETRIS WP1 DOA) within the framework of integrated transport system to supporting technology and behaviour within innovation chain path. The dimensions involved in the framework emphasised the importance of integration of transport across modes, i.e. between passenger and freight movement; between urban and inter-urban transport; and between transport and land-use.

A number of research strategies are proposed to address the challenges as well as to be framed for future H2020 transport calls. These are including: technology-driven research (development and exploitation of new technologies); methodologically innovative studies (new data collection methods); policy evaluation studies; cross-disciplinary research; geographical-diffusion studies (dissemination of good practices across EU).

The innovation chain related to transport was particularly highlighted as it links to its potential in commercial, social and environmental terms. It is duly noted that

"*Sometimes the problem lies at the start of the chain where an emphasis is placed on ideas likely to yield quick return on investment at the expense of more costly, large scale projects which, in the longer term, could potentially prove transformational*" (McKinnon et al. 2014, p.11)

Q2: Key assumptions underpinning the choices of challenges and themes

The TAG identified five assumptions in transport research. Firstly, with regards to wider political, economic, social, technological, environmental and legislative (PESTEL) trends, transport is a derived

demand, dependent on activities in other sectors. Secondly, regarding the public policy objective, transport is deemed to adhere continuously with the 2001 and 2011 Transport White Papers. Thirdly, regarding the effectiveness of research and innovation. Fourth and fifth assumptions on specific issues relating transport governance (e.g. personal freedom in choice of transport mode) and the nature of transport research (inter-disciplinary).

Q3: What output can be foreseen and what will be its impact

The TAG expected outputs are roadmaps plotting the future course in key transport parameters. Research and Innovation are deemed to generate new implementable technologies, information and business practices. Additionally, the promotion of changes in people's travel behaviour and the logistical behaviour of companies were also envisaged.

A good measure of the impact is the extent to which practitioners and policy-makers feel that research/innovation has represented a good investment of EU funds to improve efficiency, quality and sustainability of transport.

International linkages opportunities are also identified as a catalyst for European transport research much wider exposure beyond Europe.

Q4: Bottlenecks, risks and uncertainties and how might these be addressed

Three types of transport research/innovation were identified by the TAG: 1) empirical research; 2) vehicle technology; and 3) simulation modelling. Each has different types/levels of bottlenecks e.g. access to data on empirical research, gaining certification for new technologies, the size of necessary investment on vehicle technologies and the loss of realism on simulation modelling.

The effectiveness of the research program was also deemed to cause bottlenecks such as, fragmentation into too many small projects, projects assessments being too narrowly focused and not always relevant, a fundamental disconnect between research and transport decision-making processes in government and business, implementation of innovative solutions conflict with existing rules (e.g. public procurement), etc.

A number of recommended responses to the above bottlenecks include: regular dialogues between all stakeholders involved (researchers, policy-makers, and industry/practitioners) to define transport research agenda; permanent focus groups (such as the TAG); opening opportunities for crossing internship between different stakeholders; reforming the process of research and innovation project assessment to take more account of user community past feedback, etc.

The TAG also identified some risks related to transport research such as: the lower than expected impact of big data; the lower (than expected) willingness of transport infrastructure and service providers to collaborate and coordinate their activities; the temporary phenomenon (not a longer-term 'game changer') of transport asset-sharing growth; and uncertainty about future 'transport' public policy that discourage private investment.

Q5: Knowledge gaps, game changers and the role of the public sector

The TAG identified that transport knowledge gaps vary between stakeholders, e.g. many university-based researches that academics regards as important may be of little interest to policy makers and managers. Major knowledge gaps in the transport sector include:

- Key variables for forecasting, i.e. oil prices, technology adoption rates, climatic conditions;

- Links between social trends and the demand for transport infrastructure capacity (long-term);
- Data on utilisation of available carrying capacity in freight vehicles and containers;
- Rebound effects from efficiency improvements in transport sector;
- Life-cycle analysis of energy use and emissions;
- Effects of fully internalising the environmental and social costs on transport;
- Vested interests' role in shaping transport policy (local/central government);
- Widely use of autonomous vehicle and its impacts on sustainability;
- Big data beneficiaries (type of institution/governance/etc.)

The TAG also identified a number of 'game-changers' that relate to the supply side of transport including:

- Crowd sourcing of vehicle based traffic data for congestion management and navigation;
- 'Physical internet' for freight movement;
- New business models for vehicle sharing (for people and goods) in urban areas;
- Application of gain-sharing to promote logistics collaboration;
- New long-life, 'self-healing' systems for maintaining transport infrastructure;
- Proliferation of reception boxes at homes, shops and offices to tackle unattended delivery;
- Effective use of insurance pricing to promote safety measure uptake.

From the demand side, the 'game-changers' identified can be classified into two levels: one towards the citizen with 'smart mobility solutions' and the other towards city authorities through 'role of the public sector'. A number of key themes for 'smart mobility solutions' were identified:

- Vehicle sharing;
- Smart traffic/transit management;
- Interoperable mobility systems across Europe;
- Dynamic allocation of resources in the transport system;
- Smart vehicle/fleet management.

For the public sector's role, the TAG identified three key points that potentially can drive the change: 1) the role of public procurement to trial transport and logistics innovations; 2) improving transport statistics quality data via the government agency; 3) improving standardization and certification for the adoption of new transport solutions.

Q6: Exploiting the EU knowledge-base and engaging industry and SMEs

The TAG recognised that transport research collaboration, e.g. EU-US (TRB), is of value to effective leveraging of the transport knowledge-base. Furthermore, the involvement of SMEs in research

consortia, despite its difficulty due to limited resources, is deemed to promote deployment of new technologies (e.g. electro mobility impact on manufacturing and repair maintenance).

Q7: Integration, cross cutting activities, co-benefits and inter-disciplinarity

Three types of integration were recognised. The first one is the overarching sustainability aspects that span social, environmental and economics subjects. The second one is the importance of integration within the transport system between modes, across traffic types, at different spatial scales, between infrastructure and services. This is recognised by the TAG and therefore there is an excellent potential for framing research in a way that tackles several related problems simultaneously. The third integration is with other sectors: energy, ICT, materials, manufacturing, retailing, and the provision of public service.

Concluding remarks: smart, integrated and sustainable transport that focuses on the needs of personal and business users

The TAG concluded the report with key issues to be given particular attention alongside the 11 major challenges highlighted already in SETRIS WP1 description. The four key issues are:

1. Need for research to focus on the interfaces between transport technology, social acceptance and behavioural change;
2. Emphasis on integration and dismantling of the various silos[1] that have traditionally existed in transport research;
3. Exploitation of the wealth of new data likely to become available to transport researchers over the next few years;
4. Broader definition and assessment of transport externalities.

Synthesis of the TAG identified key challenges with four dimensions of physical, political, economical and operational issues

One of the approaches of SETRIS D1.1 in formulating key challenges is by synthesising those with higher level terms, i.e.

- Physical – relating to the tangible/concrete transport infrastructures (capacity) and its associated materials/resources operating on it (e.g. vehicle fleets, ITS, transport technologies, etc.);
- Political – relating to the governance and management of transport operations at various levels from local family cluster (e.g. travel to school scheme) up to national and international level (e.g. international aviation organisation);
- Economic(al) – relating to the demand and supply of the transport (value) for businesses, utilities, operations and beyond (e.g. transport demand impact on economic growth, value for money); and
- Operational – relating to the dynamic functioning of transport (system/infrastructure) operation (e.g. congestion relieve, safety, noise mitigation, emission control, etc).

Using the above definition, the TAG key challenges can be assessed to link to each of the above dimensions as summarised in Table 1.

[1] A system, process, department, etc. that operates in isolation from others (oxford dictionary)

Table 1 The TAG key challenges assessment (source: SETRIS WP1 Consortium)

No	Challenges	physical	political	economical	operational
1	Addressing the nexus of problems affecting urban transport (including congestion, pollution, accidents and inaccessibility) and using transport as an enabler of urban renewal.	✓	✓	✓	✓
2	Achieving the required level of climate change, air pollution and noise mitigation in the transport sector.	✓	✓	✓	✓
3	Managing the impact of demographic trends and, in particular, the ageing population.	✓	✓	✓	✓
4	Effectively harnessing new transport -related ICT technology and data management opportunities.	✓	✓	✓	
5	Measuring and managing uncertainty and risk in the transport system, particularly associated with high-impact low probability events.	✓	✓	✓	✓
6	Making the transport system, and in particular infrastructure, more resilient to extreme weather.	✓	✓	✓	
7	Reducing the loss of life and adverse health effects associated with transport.		✓	✓	
8	Reducing transport's dependence on fossil fuels through improvements in energy efficiency and a switch to alternative energy sources.	✓	✓	✓	✓
9	Enhancing the competitiveness of European transport manufacturers and service providers in global markets.		✓	✓	
10	Deploying innovative technologies, materials and processes to overhaul the system of infrastructure maintenance.	✓	✓	✓	
11	Maximising resource utilization across the transport sector.		✓	✓	✓

3. TRANSPORT SECTOR ETP

This section describes the European Technology Platforms (ETP) related to passenger transport with particular reference to their research and innovation roadmaps development. The exception is ALICE, which is solely focused on freight and therefore out of the scope of WP1 (passengers). However, there is a dedicated WP to freight (WP2) where specific freight-related activities are being carried out and where an assessment of ALICE's activities has been performed.

3.1 ACARE ROADMAPS

ACARE: The Advisory Council for Aeronautics Research and Innovation in Europe (originally named Advisory Council for Aeronautics Research in Europe) was formed in response to the need of developing and maintaining a strategic research agenda towards European Aeronautics: A Vision 2020 report initiated by the European Commission on how aviation could better serve society's needs and become global leader in the field of aeronautics (www.acare4europe.com). ACARE was launched in 2001 and attracted over 40 stakeholders including representation from the Member States, the European Commission, the manufacturing industry, airlines, airports, service providers, regulators, research establishments and academia.

Since its inception, ACARE so far has developed Strategic Research (SRAs) in 2002 and 2004, an addendum to the SRA in 2008 as well as a strategic research and innovation agenda (SRIA) in 2012. Each SRA and SRIA consists of two volumes and an executive summary. Volume 1 of the documents was prepared for high-level strategic decision makers, while the volume 2 documents were for a target readership of research and innovation actors. While largely maintaining the above mentioned overall objectives, the current vision document of aviation 'Flightpath 2050 Europe's Vision for Aviation' (European Commission 2011b) extended its focus on innovation issues. Accordingly, ACARE was renamed into 'Advisory Council for Aviation Research and Innovation in Europe'.

The latest SRIA is structured along 5 goal areas described in 'Flightpath 2050'. A systematic top-down approach was applied by the 5 WGs in charge of their respective goal area to identify the research and innovation needs to achieve these goals. In total more than 300 WG members contributed to the SRIA.

The five goal areas of 'Flightpath 2050' (2012a) and the main enabler clusters to achieve them are:

1. Meeting societal and market needs:
    - Design of a customer-centric intermodal transportation system (knowing future customer profiles and expectations);
    - Travel process management (a single ticket for the entire journey);
    - Integrated air transport (seamless travel experience – aviation services).
2. Maintaining and extending industrial leadership:
    - Continued development of new technologies;
    - Efficient development and manufacturing process;
    - Continued and focussed investment in research and innovation;
    - A fair and balanced set of global regulations and standards;
    - Innovative business models, regulations and incentives;
    - Efficient certification of aviation products.

3. Protecting the environment and the energy supply:
    - Dynamic allocation of targets between stakeholders, permanent survey of research results and updated research priorities;
    - Define the air vehicles of the future;
    - Improved air operations and traffic management;
    - Improved airport environment;
    - Availability of affordable, sustainable, alternative energy sources;
    - Mastering aviation's climate impact;
    - Incentives and regulations (to promote environmentally friendly behaviour).
4. Ensuring safety and security:
    - Expectations by society for safety and security;
    - Air vehicles operations and traffic management (with particular regard to threats);
    - Design, manufacturing and certification;
    - Human factors (human machine interactions).
5. Prioritising research, testing capabilities and education:
    - Optimisation of the research and innovation lifecycle;
    - Modern infrastructure (R&D);
    - A skilled workforce: attracting talent and education;

ACARE has defined three timescales for the roadmap: 2020 (short-term), 2035 (medium) and 2050 (long). Within the Volume 2 of the ACARE roadmap, the five goal areas described above were further detailed with description of research and innovation needs that generated over 1200 research and innovation statements. Of these, goal area 1 generated the most statements (444). Goal area 2 generated 138; goal area 3: 239; goal area 4: 300; and goal area 5: 83. Each of the research and innovation needs statements can be classified into clusters of enablers (the five goal areas as described above) with each description, description of capability, sub-capability, domain of research, the statement in each phase of the roadmap (expected achievement: 2020, 2035, and 2050), and identified KPI – key performance indicator.

The category of domain of research is quite similar to the SETRIS setting for research assessment using the four dimensions of physical, political, economic(al) and operational. ACARE defined domains of research and innovation needs into:

- Knowledge (e.g. identification, investigation, definition, understanding of customers profile and properties);
- Infrastructure (e.g. develop and establish seamless intermodal security measures);
- Concepts (e.g. define and develop future collaboration models to develop technology);
- Technology (e.g. develop highly efficient lightweight air conditioning);
- Policy (e.g. facilitate, support and set up policies to ensure system resilience);
- Operational concepts (e.g. develop emissions-free taxing systems); and
- Others (applied mostly in pillar 5: education and workforce research challenges theme, in order to e.g. ensuring availability of high-qualified aviation employees).

Table 2 shows selected research and innovation statements of ACARE 2012 roadmap based on Volume 2 (2012b) of the roadmap.

Table 2 Selected list of key enablers of 2012 ACARE roadmap with assessment (Source: SETRIS WP1 consortium)

Pillar	Enabler	physical	political	economical	operational
1	Understanding customer expectation and their role in transport and mobility	✓			
	Understanding market and societal opportunity and acceptance	✓	✓		
	Assessment of mobility system concept, design and performance	✓	✓		
	From research to innovation		✓		✓
	Travel management – user oriented travel management tools	✓			
	Assessment of mobility choices include IT and risk management	✓	✓		✓
	From airports to air transport interface nodes to optimise process for passenger, baggage and freight	✓		✓	✓
	Aviation ground infrastructure environment to minimise emissions	✓			
	Information platform for operations include air traffic management	✓			✓
	System intelligence, automation, human and autonomy	✓	✓		
2	Continues and focussed investment towards competitiveness	✓	✓	✓	✓
	Regulations and standards		✓		✓
	Efficient certification		✓		
	Research and innovation lifecycle		✓		
	Technology demonstration and flight test	✓	✓		
	Efficient development and manufacturing processes	✓			
3	An achievable split of the key environmental and energy supply goals between key contributors (integration of impact of air transport to the overall system)	✓	✓		
	Policy for minimising the environmental impact and maximising sustainable energy supplies of the aviation industry		✓		✓
	Performance evaluation and monitoring system	✓			
	Design of air vehicles and technology effort definition	✓			
	Defining propulsion systems and its enabling technologies for low environmental impact and minimum fuel consumption	✓			
	Enhanced sustainability of air vehicles	✓			
	Improving air traffic management and operations	✓			✓
	Optimising airports as part of the overall multimodal transport system	✓			✓
	Mitigate aircraft and airport environmental impact: noise, emissions	✓			✓
	Managing and reducing energy sourcing and usage in the sector	✓	✓		✓
	Innovative production process ‘drop-in’ fuels and its enlargement	✓			
	Optimise aircraft fuel for better environment and economic performance including alternative fuel development knowledge, standards, and radical new solutions	✓	✓		
	Knowledge and understanding of aircraft emissions including monitoring system, aircraft-atmosphere interaction, infrastructure, processes, regulations, standards and business models	✓	✓	✓	✓

	Regulatory framework to promote innovation and mitigate environmental impacts		✓		
	Fiscal instruments to accelerate introduction of technology and improved performance		✓		
4	System-wide safety and security management systems	✓	✓		
	Intelligence innovative methods to meet societal expectation	✓	✓		
	Safety and security radar for air vehicle operation and traffic management systems and procedures including system behaviour monitoring and self-healing	✓			
	Diagnostic analysis: tools, standardisation, certification, and resilience for design and manufacturing	✓	✓		
	Human-centred automation	✓	✓		
	New crew and team concepts and passenger management (addressing resilience)	✓			
5	Research of the research and innovation lifecycle	✓	✓		
	Bridging gap between basic research including technology watch mechanisms, funding instruments and knowledge transfer	✓	✓		✓
	Targeted research; technology evaluator and impact assessment tools and methodologies	✓	✓		✓
	Multidisciplinary research for FP2050 (definition, standards, setup of multidisciplinary technology clusters, and demand and accessibility of transport studies)	✓	✓		✓
	Common standards, business models, strategic roadmap and legal framework for infrastructure	✓	✓	✓	✓
	Access to network of research studies, virtual test and certification	✓			
	Passenger/payload centred fast simulator to enable research on and validation of innovative aviation concepts (addresses 90% of travellers need max 4h door to door)	✓	✓		
	Support for multidisciplinary clusters	✓			
	Primary, secondary, vocational and professional development education	✓			
	Aviation sector current needs analysis	✓			
	Other education and workforce related activities to ensure the workers with the appropriate skills are available in the right place and time	✓	✓	✓	✓
	Partnership between research, universities and industry on education	✓	✓		

3.2 ERRAC ROADMAPS

ERRAC: The European Rail Research Advisory Council was established in 2001 to create a single European body with the competence and capability to help revitalising the European rail sector, by fostering increased innovation and guiding research efforts at European level (www.errac.org). ERRAC is formed by all major rail research stakeholders including manufacturers, operators, infrastructure managers, the European Commission, EU Member States, academics and users groups. ERRAC covers all forms of rail transport: from conventional, high speed and freight applications to urban and regional services.

ERRAC structure for the development of a framework of quality roadmaps was structured around each of the key work packages identified by the ERRAC ETP, through a series of working groups:

- Greening Surface Transport;

- Encouraging modal shift[2] (long distance) and decongesting transport corridors;
- Ensuring sustainable urban transport (including modal shift, light rail vehicles and metros);
- Improving safety and security;
- Strengthening competitiveness;
- Evaluation working group.

The ERRAC Strategic Rail Research Agenda (SRRA) was built up on 6 pillars:

- Energy and environment;
- Personal security;
- Test, homologation and safety;
- Competitiveness and enabling technologies;
- Strategy and economics;
- Infrastructure.

A number of reports carried out by the ERRAC stakeholders were published based on the above pillars. The first strategic rail research agenda recommended investments in infrastructure, technological advancements, improved network integration and interoperability in addressing capacity constraints. Additionally, development of technologies addressing railway interoperability, intelligent mobility, safety and security, environment, materials and production methods were all on the research and innovation agenda.

Following the inception strategic research agenda published in 2002, two recent updated roadmap documents were established: Strategic Rail Research Agenda 2020 (2007) and Strategic Rail Research and Innovation Agenda (2014). Alongside these two key documents, a number of publications, mainly derived from the FP7 ERRAC ROADMAP project deliverables, were also publicly accessible from the ERRAC website portal and represent the backbone of the latest 2014 SRRIA deliverable including:

- Towards 2030 – Energy roadmap for the European Railway Sector (ERRAC 2011a);
- Towards 2030 – Noise and vibrations roadmap for the European railway Sector (ERRAC 2011b);
- Encouraging long-distance modal shift and decongesting transport corridors: the passenger roadmap (ERRAC 2012a);
- Encouraging long-distance modal shift and decongesting transport corridors: the freight roadmap (ERRAC 2012b);
- Urban, suburban and regional rail research roadmap (ERRAC 2012c);
- Joint ERTRAC-ERRAC urban mobility research roadmap (ERTRAC + ERRAC 2013);

[2] This term is mostly applied to the surface transportation where road transport is deemed to contribute significantly to various transport problems (e.g. road congestion, environmental pollution), and imbalance between modes were highlighted as the root cause of the problem in the Transport White Papers (European Commission 2001)

- Improving safety and security roadmap (ERRAC 2012d);
- Strengthening competitiveness roadmap (ERRAC 2012e);
- Rail route 2050: The Sustainable Backbone of the Single European Transport Area (ERRAC 2013).

Strategic Rail Research Agenda 2020 (2007)

The long-term framework for the updated ERRAC Strategic Rail Research Agenda (SRRA) since its inception in 2002 was the identification of the seven research priorities to address the future of rail in 2020 that have been envisaged to play an increasing role in the European transport system. The future of European rail is deemed to provide seamless and integrated high speed passenger services and door-to-door freight services as well as efficient metropolitan urban mass transport. Particular attention was given to the realisation of *Railway Business Scenarios* to doubling the share of freight and passenger markets and tripling the freight and passenger market volume compared with 2000. ERRAC (2007) projected transport demand in 2020 with 43% more passenger-km, and 70% more freight tonne-km, more than in the year 2000; for modal split, rail share was expected to increase to 14% share for freight (11.5% in 2000 and 10.8% in 2007, European Commission 2010, p.108) and 11% share for passengers (7.6% in 2000 and 7.3% in 2007, European Commission 2010, p.118).

A number of rail markets were identified to be addressed differently due to different types of customers, such as passengers on long distance, inter-regional/suburban, rural and urban, and freight. The importance of value for money on European railway revitalisation was emphasised, with one example of significant expenditure for a railway has been on safety that cost approximately half of the operating cost of a train service through infrastructure maintenance. So, reducing infrastructure maintenance cost would potentially release substantial capital for further investment for other aspects of railways such as passenger services and modal shift.

Table 3 demonstrates the seven key research areas identified by ERRAC with additional R&D statements from SETRIS consortium WP1 to update and clarify the broad research statement used in the official ERRAC 2007 SRRA.

Table 3 ERRAC 2007 SRRA R&D statements with updated R&D statements from SETRIS consortium and assessment (source: SETRIS WP1 consortium)

	Research cluster	R&D statements	Physical	Political	Economical	Operational
1	Intelligent mobility	Customer focus to achieve seamless cross border transport and across transport modes	✓	✓	✓	✓
		Compatible ticketing system across borders and urban transit	✓	✓	✓	✓
		High-performance telematics systems to better manage passenger and freight traffic (better interface protocols offering greater cross border utilisation)	✓	✓	✓	✓
		Secure transmission of passenger information, considering civil liberties and security needs	✓	✓		✓
		New traffic management systems and techniques to	✓		✓	✓

		enable efficient use of infrastructure				
		Information exchange (real time data) harmonisation for cross borders, especially for operations management and logistical planning		✓	✓	✓
		Innovative communications technologies based on Galileo services and mobile broadband to achieve affordable cost services		✓	✓	✓
2	Energy & environment	New design for energy efficiency, including route planning and optimised timetable, to reduce the dependence on fossil fuels	✓	✓	✓	✓
		Improved energy utilization on vehicles and track (lighter vehicle and reducing overall track forces)	✓		✓	✓
		Control of exhaust emissions, especially considering the generation and propagation of diesel particulates	✓	✓	✓	✓
		New standardisation for materials on noise and vibration	✓	✓		✓
		Design for the environment (closed cycle waste management systems, recycling and others)	✓	✓	✓	
3	Personal security	Safety and security standards via better integration of personal security concerns with the design of infrastructure, stations and rolling stock	✓	✓		✓
		Assessment of the impact of personal security				✓
		Providing better personal security	✓			✓
		Threat analysis, risk assessment and prevention, effective emergency and crisis management		✓		✓
		Reduction of the impact of human errors on the railway system via development of initiatives for public transport security legislation, standardisation, certification and staff training		✓		
		Development of safety systems and protocols to help for the selection and development of intelligent decisions and take preventive actions under dangerous conditions		✓		✓
		Revenue protection and ensuring only ticket holders only access the system	✓			✓
4	Test, homologation and security	Reduce the risk of fatality (passengers, employees and passers-by)	✓	✓	✓	✓
		Reduce the impact on operational performance of degraded mode operation	✓		✓	✓
		Reduce the cost of safety acceptance for railway materials by eliminating the need for national requirements		✓	✓	
5	Competitiveness	Improving product attractiveness for customers,	✓	✓	✓	✓

	and enabling technologies	removal of barriers to interoperability and intermodality and improved vehicle and sub-system certification methods (rolling stocks and subsystems)				
		Accelerating the network integration (investment models, sub-system certification and operational models)		✓	✓	✓
		Reducing life cycle costs through modern technology (i.e. rolling stock, maintenance procedures, ticketing systems, infrastructure, capacity optimisation, innovative maintenance technologies and investment in intelligent mobility and interface harmonisation)	✓		✓	✓
6	Strategic and economics	Long term projections of rail		✓	✓	✓
		Managing increasing demand for rail	✓	✓	✓	
		Economic development impact of rail (local, regional and national)		✓	✓	
		Interoperability implementation: best practices and standards	✓	✓	✓	✓
		Optimisation of full life operating and infrastructure costs	✓		✓	✓
7	Infrastructure	Cost efficient maintenance system	✓		✓	✓
		Identifying ways of building new capacity on the existing network at less cost	✓		✓	✓
		New train control technologies, e.g. ETCS level 3 to increase the capacity			✓	✓
		Development of specifications and hardware for a new generation of interlocking systems	✓	✓	✓	
		Improve traffic operation and timetabling			✓	✓
		Development of rolling stock and infrastructure standards			✓	
		Development of track train and track designs	✓			✓
		Interchanges: improve station design to attract passengers and improve personal security and access		✓		✓
		Maintenance-free interoperable system: optimise operations at freight traffic nodes	✓	✓	✓	✓

Note: Shaded boxes are additional R&D statements from SETRIS WP1 consortium

Strategic Rail Research and Innovation Agenda (2014)

This latest ERRAC roadmap has been in place to foster the launch of EC H2020 research and innovation framework programme for rail sector (launched in December 2013). The roadmap also takes account of the first Public Private Partnership (PPP) initiative in rail research in the form of SHIFT^{2}RAIL programme to respond to the current mobility challenges outlined by the last EC

Transport White Paper (2011a). The new roadmap is using similar key research priorities but with simpler focused headings and reordering the priority with a few extended key research priorities (also called 'challenges'). Instead of seven, the recent ERRAC SRRIA (2014) formulated just three key pillars (attractiveness of rail and public transport; a whole system approach; and assets) encompassing 9 sub-themes. A '**C U S T O M E R S**' concept was introduced to summarise the challenges of research area themes in a concise manner:

- **C**apacity,
- **U**ser,
- **S**afe and Secure,
- **T**echnological breakthrough and competitiveness of the rail sector,
- **O**ptimised design and operations/connectivity/interoperability,
- **M**aximised value for money leading to modal shift,
- **E**fficient and environmentally sustainable,
- **R**eliable and resilient, and
- **S**kills.

Unlike the previous roadmaps that started the technology innovation as key pillars to revitalise the rail sector, the last ERRAC three key pillars' roadmap started with business perspective first as outlined in Table 4 with assessment of its link to the SETRIS challenges dimensions.

Table 4 ERRAC 2014 SRRIA with assessment (source: SETRIS WP1 consortium)

No	Cluster	Sub-topic	Physical	Political	Economical	Operational
1	Attractiveness of rail and public transport	Customer experience	✓		✓	✓
2		Strategy and economics	✓	✓	✓	✓
3	A whole system approach	Capacity, performance and competitiveness			✓	✓
4		Energy and environment	✓		✓	✓
5		Safety (including certification) and security	✓	✓	✓	✓
6	Assets	Control, command, communication and signalling	✓		✓	✓
7		Infrastructure	✓		✓	✓
8		Rolling stock	✓		✓	✓
9		IT and other enabling technologies	✓	✓	✓	
10		Training and education	✓	✓	✓	

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Alongside the latest roadmap development, it is notable that ERRAC has engaged in a number of joint working groups with other ETPs:

- on urban mobility with ERTRAC that delivered the 'Urban Mobility Roadmap' (2013);
- on 'Urban Logistics' with all ETPs to develop a joint roadmap on urban freight;
- on infrastructure with ERTRAC, ACARE, WATERBORNE and ECTP (European Construction Technology Platform) that delivered 'Roadmap for Cross-Modal Transport Infrastructure Innovation' (2013).

The ERRAC Roadmaps Working Group (WG) is no longer active but followed by the formation of FOSTER-RAIL Coordination Support Action (CSA) that aims to carry on ERRAC and its Working Groups endeavour. FOSTER-RAIL comprised of seven Work Packages including one work package dedicated for cooperation, communication and coordination with other ETPs and national technology platforms. One of the latest development in the rail sector towards H2020 is the establishment of SHIFT2RAIL Joint Undertaking which is a Public Private Partnership (PPP) programme for rail research (CESA 2015). SHIFT^{2}RAIL Joint Undertaking is structured into 5 Innovative Programmes (IP): new generation rail vehicles (cost-efficient and reliable trains, including high capacity trains and high speed trains); advanced traffic management and control systems; cost efficient and reliable high capacity infrastructure; seamless travel across Europe (IT solutions for attractive railway services); and, technologies for sustainable and attractive European freight transport.

3.3 ERTRAC ROADMAPS

ERTRAC (www.ertrac.org) is the European Road Transport Research Advisory Council. It is the European technology platform, which brings together road transport stakeholders to develop a common vision for road transport research in Europe. ERTRAC was established in 2003 (European Commission n.d.) to support the European Commission in formulating strategic research agenda. ERTRAC represents at least 10 types of key road stakeholders: automotive suppliers; intelligent transport systems; road infrastructures; EU and national bodies; users/consumables; cities and regions; service providers; vehicle manufacturers; energy/fuel supply; and research providers.

ERTRAC currently has 5 working groups (WGs) addressing research roadmaps (13 altogether in total). Each WGs developed strategic roadmaps with particular agenda/topic:

- Urban mobility WG (1): four roadmaps on urban mobility system integration (ERTRAC 2011i), road user behaviour (ERTRAC 2011f), European bus system (ERTRAC 2011j), and land use and transport interaction (ERTRAC 2013b);
- Long distance freight transport WG (2): two roadmaps on heavy duty truck (ERTRAC 2012a)and sustainable freight system – green, safe and efficient corridors (ERTRAC 2011h);
- Energy and Environment WG (3): five roadmaps on energy carriers for powertrain (ERTRAC 2014), electrification of road transport (ERTRAC + EPoSS + SMARTGRID 2012), hybridization of road transport (ERTRAC 2011e), future light duty powertrain technologies and fuels (ERTRAC 2011d), and infrastructure for green vehicles (ERTRAC 2012b);
- Road transport safety and security WG (4): a roadmap on safe road transport (ERTRAC 2011g);

- Global competitiveness WG (5): a roadmap on technology and production concept for electric vehicles (ERTRAC 2011c).

Alongside the above WG roadmaps, ERTRAC has developed a number of strategic research agenda (SRA) and its associated documents to tackle the societal challenges of road transport as recently identified including:

- ERTRAC Strategic Research Agenda 2010 'Towards a 50% more efficient road transport system by 2030' (ERTRAC 2010a; ERTRAC 2010b);
- ERTRAC Research and Innovations Roadmaps (ERTRAC 2011a) – which is basically compilation of all the above WG roadmaps dated 2011;
- Climate change resilient transport (ERTRAC 2011b);
- ERTRAC Multi-Annual Implementation Plan for Horizon 2020 (ERTRAC 2013a);
- Urban Mobility Roadmap (ERTRAC + ERRAC 2013);
- Urban freight research (ERTRAC + ALICE 2015).

All of those reports counted as many as over 30 published documents spanning between ERTRAC inception in 2003 and present time and the numbers keep growing due to ongoing working groups' activities that responded to the need of the sector for research and innovation roadmaps. A significant number of publications (about 20 published documents) were completed after 2010 and have been selectively reviewed to be included in this document. The selection is based on the importance to link with other ETP as what the SETRIS project objected to accomplish. It is notable that the recent roadmaps are multi-modal and multi-sectoral and form the basis of SETRIS development that aim to establish an integrated multimodal transport technology platform.

ERTRAC Strategic Research Agenda 2010

ERTRAC roadmaps envisage a road transport system that is 50% more efficient than 2010, by 2030. The approach taken by the SRA recognises the societal demand for decarbonisation, reliability and safety of the road transport system from a user's perspective. For each of these social needs, clear indicators have been selected, each with specific guiding objectives towards 2030 as can be seen in Table 5.

Table 5 ERTRAC guiding objectives 2030 (ERTRAC 2010a; ERTRAC 2013a)

	Indicator	Guiding objective
Decarbonisation	Urban passenger energy efficiency	+ 80% (pkm/Kwh)
	Long distance freight energy efficiency	+ 40% (tkm/kWh)
	Renewables in the energy pool	Biofuels: 25%
		Electricity: 5%
Reliability	Transport schedule	+ 50%
	Urban accessibility	Preserve and improve
Safety	Fatalities and severe injuries	- 60%
	Cargo lost to theft and damage	- 70%

Note: + means 'increase'; - means 'decrease'

In addressing the above key objectives, ERTRAC adopts a comprehensive 'system approach' where three key elements in the road transport system were defined: urban mobility; transport interfaces; and long-distance freight transport. In each of the key elements, four levels of research domains were used to identify research and innovation needs. The four ERTRAC research domains are: vehicles; infrastructure; logistical and mobility services; and energy and resources.

Alongside the three societal demands as described above, ERTRAC also recognizes the need for research and development towards global competitiveness. For this vision, three economic indicators were identified as catalyst towards 2030 European Road Transport: economic success; environmental awareness; and social responsibility.

Table 6 and Table 7 demonstrated the list of Research and Innovation priorities from the ERTRAC strategic research agenda (ERTRAC 2010a) and its assessment towards SETRIS four dimensions. This SRA is ERTRAC formal Research and Development (R&D) report publicly available for all parties interested with ERTRAC research and innovation development.

European Green Cars Initiative

Alongside the many roadmaps that ERTRAC has developed as described above, ERTRAC has also coordinated with other ETPs (EPoSS, SMARTGRIDS and EIRAC) to launch a Public Private Partnership (PPP) to identify research and innovation policy in response to the 'European Economic Recovery Plan' call from the European Commission in November 2008 (EGCI Ad-hoc Industrial Advisory Group 2011). The European Green Cars Initiative is one of the three PPP introduced, the other two are 'Energy Efficiency Buildings' and 'Factories of the Future'. The automotive sector was selected alongside the building and manufacturing sectors due to severe impact of the crisis on their activities, combined with the high potential for green growth (EGCI Ad-hoc Industrial Advisory Group 2011).

Since its inception, the European Green Cars PPP initiative has selected numerous proposals (with a total indicative of EC budget of EUR 108 million) to address three areas of research priorities: electrification of road transport; long-distance trucks; and logistics and co-modality. Table 8 demonstrates summary of the SRIA of European Green Cars Initiative with assessment towards SETRIS dimensions. This SRIA can be seen as an attempt from ERTRAC to address research priorities that overlap with other ETPs, e.g. logistics and co-modality with ALICE. Those research priorities were given further detail within cross ETP collaboration as can be seen in ALICE WG1 (on supply chain management), WG2 (on green hubs and green corridors), and WG5 (on city logistics) respectively.

Table 6 ERTRAC 2010 R&I Priorities and assessment (source: SETRIS WP1 consortium)

R&D Pillar	R&D statements	Decarbonisation	reliability	safety	Physical	Political	Economical	Operational
Vehicles	Integrated drivelines	✓			✓			
	Energy management	✓			✓			✓
	v2v and v2i communications and cooperative systems	✓	✓	✓	✓			✓
	Electric vehicles	✓			✓			
	Reduced resistance to motion	✓			✓			
	Advanced driver support systems	✓		✓	✓			
	Matching vehicles to tasks	✓	✓		✓			
	Automated systems	✓	✓	✓	✓			
	Safety of 'low carbon' vehicles			✓	✓			
	Tyre-road surface interaction and friction-force estimation			✓	✓			
	Safety and vulnerable road users			✓	✓			
	Management of driver behaviour			✓	✓			✓
	Accidentology			✓	✓			
	Safeguarding systems against theft and damage			✓	✓			
Infrastructure	Advanced road surface and bridge material	✓	✓		✓			
	Efficient infrastructure maintenance and reconstruction	✓	✓		✓			✓
	Dynamic demand management	✓	✓		✓			✓
	Integrated mobility planning	✓	✓		✓			
	Multi-modal infrastructure and interfaces	✓	✓		✓			
	Integrated management of network infrastructure	✓	✓		✓			

	Dedicated infrastructure	✓	✓		✓			
	Assessment of (urban) accessibility		✓		✓			
	Self-explaining and forgiving infrastructure			✓	✓			
	Secure road transport facilities			✓	✓			
Logistical and mobility services	Integrated information services	✓	✓		✓	✓	✓	✓
	Understanding users mobility behaviour	✓	✓		✓			
	Integrated and optimized logistics services	✓	✓		✓			
	Services at transport interfaces	✓	✓		✓			
	Sustainable mobility services	✓	✓		✓			
Energy and resources	Energy storage and battery systems	✓	✓		✓	✓	✓	✓
	Biofuels production	✓			✓	✓		
	Advanced fuels production	✓			✓			
	Closed loop recycling	✓			✓			
	Grid-integration and reliability	✓	✓		✓			
	High performance from abundant materials	✓			✓			
	Impact assessment and modelling		✓		✓			
	Fuel distribution and refuelling		✓		✓			

Table 7 ERTRAC 2010 R&I priorities for global competitiveness and assessment (source: SETRIS WP1 consortium)

R&D Pillar	R&D statements	Economic success	Environmental awareness	Social responsibility	Physical	Political	Economical	Operational
Production processes	Mutual interdependence between 'highly reactive and complex automotive sector' and less flexible industries	✓			✓			✓
	Step-change increase in product variants without compromising quality; brand + suppliers = car 2.0	✓			✓			
	Risk mitigation in decentralized or localised automotive production networks	✓			✓	✓	✓	✓
	Increase of multi-disciplinarity in EV product creation	✓			✓	✓		✓
	Optimization of the global automotive production footprint	✓			✓	✓		
	Global responsiveness through decentralised/downsized sites; decentralised global production grids	✓				✓		✓
	Production flexibility in assembly of traditional cars, HVs/PHEVs and EVs on the same assembly line	✓				✓		✓
	Renewables energies and environmentally neutral materials in global automotive production and logistics		✓			✓		
Logistic processes	New production networks for enabling electrification of the vehicle	✓				✓	✓	
	Shortening lead-time through a radically new 'localisation' approach	✓			✓	✓	✓	✓
	ICT, methods, tools and standards for sustainable global production	✓						✓
	Optimised transport flow, i.e. what is where at which point in time'		✓					✓
Business processes	Real-time reactivity on changes in the global business scenarios	✓				✓		✓
	Technical standards for EVs and their impact on global market penetration	✓			✓	✓	✓	✓
	Network simulation studies		✓		✓			✓
	Assessment of the Eco2 balance optimum and implementation		✓		✓			✓
	Global sourcing and commodity management for automotive components		✓			✓		✓
	Collaborative distributed engineering			✓		✓	✓	✓
	'COMPEDIA': the Wiki for global competence rating of research establishments and academia in automotive matters			✓	✓			

Labour standards and their implications on the automotive industry for global competitiveness	✓	✓

Table 8 European Green Cars Initiative roadmap and assessment (source: SETRIS WP1 consortium)

R&D Pillar focus	R&D statement	Physical	Political	Economical	Operational
Electrification of road transport	Energy storage systems	✓			
	Drive train technologies	✓			
	Vehicle system integration	✓			✓
	Grid integration	✓			
	Safety systems	✓			
	Transport system integration	✓			
Long distance trucks	The safe and intelligent truck	✓	✓	✓	✓
	Matching vehicle to operation	✓			
	Design dimensions for optimized load capacity	✓			
	Aerodynamics	✓			
	Low rolling resistance	✓			
	Energy management and efficient auxiliaries	✓			✓
	Advanced materials and design	✓			
	Future powertrain concepts and system integration	✓			
	Advanced combustion and after-treatment	✓			
	Waste heat recovery	✓			
	Advanced control	✓			
	Friction	✓			
	Hybrid powertrain	✓			
	Innovative high efficiency energy conversion	✓			
	Driver efficiency	✓			
Logistics and co-modality	City logistics	✓	✓	✓	✓
	Green hubs and green corridors	✓	✓	✓	✓
	Supply chain management	✓		✓	✓

3.4 WATERBORNE ROADMAPS

WATERBORNE European Technology Platform is a forum where all stakeholders from the waterborne sector (sea and inland) define and share a common vision and a strategic research agenda, driving the necessary innovation efforts forward (www.waterborne-tp.org). WATERBORNE Technology Platform (TP) initiative came from the Maritime Industries and its Research and development committee in 2005 to regularly update R&D requirements for European competitiveness, innovation and meeting the regulations, such as safety and environment. The stakeholders include EU associations covering deep and short sea shipping, inland waterways, yards, equipment manufacturers, marine leisure industry, and research and university institutions.

In 2011 the WATERBORNE declaration was published to inform the H2020 development programme (CESA 2015). Since then, the strategic research agenda and implementation plan for WATERBORNE technology platform revised and documented in to two key documents: VISION 2025 (2011b) and the Strategic Research Agenda (2011a). *Ad Hoc* Working Group is noticeable within the WATERBORNE structure with the theme 'vessel for the future' that defined 7 technologies' development needs (technology arenas) for the sector: energy management; hull/water interaction; ICT and E-maritime; materials, design and production; propulsion systems and fuels; new vessels and systems concepts; and vessel modelling infrastructure (CESA 2015). The structure of the roadmap or 'route map' as widely used in the sector of WATERBORNE SRIA in the 2025 VISION document (2011b) and MESA project deliverable (2015) defined three main areas for R&D:

1. Sustainable waterborne transport
2. Support for the harvesting of offshore resources
3. Minimising impact on the oceans

The Vision 2025 document (2011b) is an update of a VISION 2020 paper published in 2005 followed by a Strategic Research Agenda in 2006 and Implementation Plan in 2007 (CESA 2015). The objective of the VISION 2025 is to help achieve smart, sustainable and inclusive growth towards societal and economic challenges. Table 9 demonstrates the assessment for each of the route map of current R&D statements.

Table 9 WATERBORNE current SRIA Route map with assessment (source: SETRIS WP1 consortium)

R&D Pillar	Route map statement	Physical	Political	Economical	Operational
1	Assuring security of supply		✓		✓
	Increasing the energy efficiency of ships and vessels	✓			✓
	Building safer ships and vessels	✓			
	Increasing competitiveness	✓	✓	✓	✓
	Recruiting and retaining skilled workforce	✓			
	Developing advanced waterborne infrastructure including e-maritime solutions	✓			
2	Renewable energies: wind, wave and tidal energy	✓	✓		
	Fossil fuels and raw materials	✓	✓		
	Fisheries and aquaculture	✓			
3	Developing a better understanding the oceans	✓			
	Improving products and services for marine monitoring	✓			
	Increasing direct collaboration with the marine sciences	✓	✓		

Within the recent WATERBORNE Strategic Research Agenda (WSRA) (2011a), VISION 2020 is still notably used as date threshold that consequently represent similarity of issues need addressing now and then as of ten or 15 years ago. The WSRA addressed the innovation challenges under the three key priorities for research (R&D Pillars) on medium and long term development and innovation:

1. Safe, sustainable and efficient waterborne operations;
2. A competitive European maritime industry;
3. Manage and facilitate growth and changing trade patterns.

Table 10 WATERBORNE 2011 SRIA and assessment (source: SETRIS WP1 consortium)

R&D Pillar	Research clusters	R&D statements	Physical	Political	Economical	Operational
1	Frameworks for cost efficient safety	Implementing risk based regulation/approval	✓	✓	✓	✓
		Implementing risk based design			✓	✓
	The 'zero accidents' target	Improving vessel usability and maintainability	✓			
		New systems and procedures for safe waterborne operations	✓			✓
		Enhanced vessel operations under severe conditions	✓			✓
	The 'crashworthy' vessel	Collision and grounding scenario research	✓			
		Failure mechanisms research and modelling	✓			
	'Low emission' vessels and waterborne activities	Minimising airborne emissions	✓	✓		✓
		Cost effective waste management and ballast water treatment	✓		✓	✓
		Minimising wash, noise and vibration	✓			✓
		'Life cycle minimum emissions' and environmental protection	✓			
	Enhanced waterborne security	Monitoring and data logging	✓			✓
		Simulation support and identification of vulnerability issues	✓			
		Development of efficient and economically viable security strategies equipment and specialised vessels	✓			
2	Innovative vessels and floating structures	Life cycle philosophy	✓			✓
		New vessels for changing and new markets	✓			
		Design innovation and system optimisation	✓			✓
	Innovative marine equipment and system	The energy efficient ship (power generation, propulsion efficiency and electric propulsion)	✓			
		Intelligent automation and navigation systems and information management	✓			
		Ship/shore interface design and logistic chain	✓			

		integration (cargo handling systems)				
	Tools for accelerated innovation	Tools for design and analysis	✓			
		Simulation software for process acceleration and minimising risk	✓			
		Product model and inter-system data communication	✓			
	Next generation production process	Innovative process management systems	✓			
		Integration of design and production planning	✓			
		Modules, the building blocks of future vessels	✓			
		New materials and production methods	✓			
	Effective waterborne operations	Supporting tools for life cycle cost planning and minimisation	✓			
		Minimisation of energy consumption	✓			✓
		Intelligent maintenance planning and optimisation	✓			✓
		Automation and platform management	✓			✓
	Technologies for new and extended marine operations	Procedure and support tools	✓			✓
		Enhanced sub-sea capability	✓			
3	Accelerated development of new port and infrastructure facilities	Planning tools for optimal logistic chains and hinterland connections	✓	✓	✓	✓
	Interoperability between modes	Transfer nodes	✓			
		IT systems	✓			
		System of transfer	✓			
		Intermodality of transport	✓			
		High quality and efficient intermodal services	✓			✓
	More effective ports and infrastructure	Equipment and systems for faster cargo handling	✓			
		Automatic operations	✓			
		New generation inland navigation	✓			
	Intelligent transportation technologies and integrated ICT solutions	Optimum vessel utilisation	✓			
		Container imbalances and management of empty containers	✓			
		Simulation of logistic chain	✓			
		Ports network and data exchange	✓			
	Understand environmental impact of infrastructure building and dredging	Analysis of regulatory functions, inconsistencies and public decision making processes	✓			✓
		Marina and leisure facility development	✓			
	Traffic management strategies	Decision support systems and ICT	✓			

Alongside the comprehensive list of WSRA as described above, WATERBORNE identified a number of enablers as part of the implementation strategy. Those enablers include human resources, education

and training; intellectual property defence; technology transfer to small shipyards; and political framework on joint initiatives and level playing field.

4. EXISITING CROSS ETP ROADMAPS DEVELOPMENT

4.1. ERRAC + ERTRAC URBAN MOBILITY ROADMAP

The root of the collaboration is the EC FP7 funded project of ERRAC ROADMAP and SAFIER (that represent ERTRAC) that recognised the importance of both sectors in addressing the research and innovation gaps towards the urban mobility theme (ERTRAC + ERRAC 2013). This collaboration was noted as delivering the biggest output among ETPs supported by the FOSTER projects that trigger the further development of other ETPs collaboration (CESA 2015).

The Urban Mobility Roadmap defined four areas for research and innovation (R&I):

- Integrating the urban mobility system via:
- Developing services and infrastructure for the long term efficiency of the urban system via:
- Supporting knowledge and innovation via:
- Understanding better the user behaviour in the urban environment.

Table 11 shows the assessment for each of the R&I statements. It can generally be observed that the combination of the four dimensions are present in all the R&I statements.

Table 11 Urban Mobility SRIA and assessment (source: SETRIS WP1 consortium)

No	R&I areas	R&I statements	Physical	Political	Economical	Operational
1	integrating the urban mobility system	the integration of urban traffic and travel information	✓		✓	✓
		the integration of ticketing and charging services for all mobility related changers in urban areas			✓	✓
		interchanges for passenger travel and transport	✓			✓
		new city logistics concepts and interfaces for a more efficient freight delivery		✓	✓	✓
		integrating urban mobility management	✓	✓	✓	✓
2	developing services and infrastructure for the long term efficiency of the urban system	New mobility service	✓		✓	✓
		infrastructure	✓		✓	
3	supporting knowledge and innovation	improving knowledge with data collection and analysis	✓		✓	✓
		strengthening the cooperation between stakeholders		✓	✓	✓

4	understanding better the user behaviour in the urban environment	✓		✓	✓

It is notable that urban freight is also part of the urban mobility activity and a roadmap addressing this has been developed recently through ALICE + ERTRAC collaboration that was described earlier in section 3.2 under Working Group 5 on urban freight.

4.2. CROSS-MODAL TRANSPORT INFRASTRUCTURE INNOVATION

One of the first effort of cross multi ETPs for transport sector collaboration roadmap was the development of the Task Force between, ERTRAC, ERRAC, WATERBORNE and ACARE (on the transport sector) and ECTP (on the construction building sector) (Joint ETP Task Force 2013). The focus of the roadmap is thus considering transport infrastructure and the transport services and operations elements. This development activity is also partially supported with FOSTER ROAD and FOSTER RAIL projects (CESA 2015).

The task force dwell on a vision 2050 and guiding goal for 2030 towards an integrated transport infrastructure enabling a single European transport area via:

- Optimal availability and capacity of transport infrastructure;
- Optimal inter-connectivity between the modes;
- Optimal cross-modal investment decisions;
- Enhanced safety and security;
- Reduced impact on environment, spatial quality and society;
- Fully shared data/information base across the modes;
- Interoperable interface, open to the infrastructure user;
- Affordable in terms of total cost of ownership

The task force envisaged that by 2030 research and innovation should enable an improvement of 50% in infrastructure performance, risk and cost versus a 2010 baseline as well as enable seamless door-to-door services for passenger and freight.

The task force identified three research and innovation domain:

- Construction and maintenance:
- Supporting systems and services:
- Governance, management and finance:

Table 12 shows the assessment for each of the R&I statements of the cross modal transport infrastructure roadmap. Since the cross ETP roadmap is addressing infrastructure, each R&I statement is certainly related to 'physical' dimension. But similar to other cross ETP roadmaps, the multi-dimensional aspects included in the R&I statements are obvious.

Table 12 Cross modal transport infrastructure R&I and assessment (source: SETRIS WP1 consortium)

No	R&I domain	R&I statement	Physical	Political	Economical	Operational
1	Construction and maintenance	Non-intrusive construction, maintenance, enhancement and renewal	✓		✓	

		Towards zero carbon footprint	✓	✓	✓	✓
		Multi-modal transport nodes and corridors (strong link on all ETPs)	✓		✓	✓
2	Supporting systems and services	Integrated transport infrastructure data/information systems (strong link on all ETPs)	✓		✓	✓
		User information management	✓		✓	✓
		Safe and secure transport infrastructures and operations	✓		✓	✓
3	Governance, management and finance	Resilient transport infrastructure operations across Europe (strong link on all ETPs)	✓	✓	✓	
		Decision making in European transport infrastructure investment	✓	✓	✓	

5. CONCLUSIONS

Efforts from the sector ETPs to roadmap transport and innovation research have been evidently encouraging. In reviewing those roadmaps, it becomes clear that ETPs have been collaborating within the European Commission research framework and consequently addressing the EC's transport research objectives and agenda. One of the key drivers for research and innovation in Europe is the need to respond to the environmental agenda that consequently leads to numerous technology-driven research and innovation initiatives towards the state-of-the-art of transport sector as carried out by the road, rail and waterborne sector for the surface transport (European Commission 2012) as well as by the aviation sector (Janić 2011; Evans 2016). Each of the modes has boosted its activities with EC Coordination and Support Action funding to develop the sectors' roadmaps e.g. FP6 ERTRAC, FP7 SAFIER and FP7 FOSTER-ROAD for road; FP7 ERRAC ROADMAP and FP7 FOSTER RAIL for rail, and FP7 MESA for waterborne. In parallel to the activities of the three surface transport ETPs, ACARE's vision has been used to deliver research and innovation projects for air and ALICE for logistics via FP7 WINN.

In the recent report delivered via WATERBORNE FP7 MESA (2015), collaboration across surface transport ETPs have been well documented (between WATERBRONE, ERRAC, ERTRACT, and ALICE) and the following extension of working with ACARE is anticipated to be one of the SETRIS tasks to deliver detail research and innovation action plan involving the entire transport ETPs. The deliverable also documented the recent development of ETPs collaboration that resulted into four research and innovation areas. Table 13 shows the summary of the cross ETPs research and innovation (R&I) areas development with particular reference to transport sector ETP collaboration.

Table 13 cross ETP R&I development (source: this study)

No	R&I area of cross ETP	Transport sector ETP involved					Non-transport ETP
		ACARE	ALICE	ERRAC	ERTRAC	WATERBORNE	
1	Urban mobility			✓	✓		
2	Urban freight		✓		✓		
3	Long distance freight		✓	✓	✓		
4	Transport infrastructure	✓	✓	✓	✓	✓	construction

When assessing each of the research and innovation statements, it becomes evident that the dimensions of which SETRIS aim to contextualise (i.e. physical, political, economic(al) and operation) are not always easy and straightforward to implement. The reason for this is each research statement has various rationale foundations many of which depend on the circumstances as to what perspective of the research and innovation can be useful to inform the different transport sectors. It is clear that research and innovation within the individual modal transport sector is characterised heavily by the need of 'physical' dimension development. The 'physical' dimension here is including all kind of development from 'knowledge', 'technological devices', and 'human resources development'. ERTRAC, ERRAC, ACARE and WATERBORNE roadmaps are invariably bound to 'physical' based research and innovation development. The notion of other challenge dimensions (i.e. political, economical and operational) in the key transport sector ETPs is relatively complementary to the physical dimension but without implying any level of prioritisation. Although this is not entirely affirmative as some of the ETPs' key stakeholders aware of, for example, the inherent economical challenge of SRIA. Notwithstanding the obvious challenge(s), it can be said that the other dimensions' challenges are not so well structured/outlined. One of the reasons for this is

perhaps due to the roadmaps being developed by a large number of specific research and innovation from industry. The cross ETP roadmaps were much more multi-dimensional and demonstrated the next generation of research and innovation roadmaps. The following table provides an overview of the current level of integration between modes/ETPs and the targeted further collaboration required to fill the gaps described in this document.

	Passenger			
	Urban mobility		Long distance travel	
Modal cooperation	Current cooperation level	Required for future SRIAs?	Current status	Required for future SRIAs?
Road-Rail	strong	yes	medium	yes
Road-Air	medium	yes	medium	yes
Road-Waterways	Non-existing	to be explored	Non-existing	yes
Rail-Air	medium	yes	medium	yes
Rail-Waterways	Non-existing	to be explored	Non-existing	to be explored
Air-Waterways	Non-existing	to be explored	Non-existing	to be explored

These findings can be interpreted as the need for SETRIS to recommend interventions addressing gaps in the joint strategies dedicated to foster physical dimension (e.g. the ETPs priorities) through political, economical and operational aspects. This is especially true for all ETPs except ACARE where category of research and innovation statements roadmaps have already been in use in a similar manner. ACARE defines a number of categories to support their particular physical research and innovation development needs: knowledge, infrastructure, concepts, technology, policy, operational concepts, and others (see section 3.4 for further detail).

The TAG report on the other hand has almost been able to include all dimensions on each of the research priority due to the broad and wide spectrum of the research questions. In other words, it is helping identifying the gaps in the roadmaps and/or implementation plans (were available).

The combined visions of the transport White Paper and the Single European Transport Area (SETA) are a clear, fitting framework for SETRIS. In order to measure the success of implementing joint research agendas in the context of this WP, it is proposed to adopt as a metric ACARE's goal of facilitating 90% of travellers within Europe to be able to complete their long-distance journey door-to-door within 4 hours.

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