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NEWBITS

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D3.1 Market Research Analysis

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1.0	27/10/2017	Ivan Zaldivar (ATOS)	Final version

Table of Contents

List of Figures

List of Tables

Abbreviations

ADAS	Advanced Driver Assistance System
AIS	Automatic Identification System
APTS	Advanced Public Transport System
ATIS	Advanced Traveller Information System
ATMS	Advanced Traffic Management System
ATPS	Advanced Transport Pricing System
B2B	Business to Business
B2C	Business to Customer

CAGR	Compound annual growth rate
C-ITS	Cooperative Intelligent Transport Systems
CoI	Community of Interest
CS	Case study
CVS	Cooperative Vehicle System
DSM	Digital Single Market
DSRC	Dedicated short-range communications
EC	European Commission
EEIS	Energy Efficient Intersection Service
ERTICO	Organization for ITS in Europe
ETA	Estimated Time of Arrival
ETSI	European Telecommunications Standards Institute
EU	European Union
FOC	Freight Operating Company
GDP	Gross Domestic Product
GIS	Global Information System
GLOSA	Green Light Optimal Speed Advisory
GPS	Global Positioning System
HMI	Human Machine Interface
IaaS	Infrastructure-as-a-Service
ICT	Information and Communication Technologies
ITS	Intelligent Transport Systems
ISA	Intelligent Speed Adaptation
I2V	Infrastructure to Vehicle
JNPT	Jawaharlal Nehru Port of Mumbai
LAMEA	Latin America, Middle East and Africa
LIDAR	Laser Imaging Detection and Ranging
MaaS	Mobility-as-a-Service
OBU	On-Board Unit
OEM	Original Equipment Manufacturer
ORION	On-Road Integrated Optimization Navigation
PPP	Public Private Partnership
RDI	Research Development and Innovation

RFID	Radio-frequency identification
RHW	Road Hazard Warning
RSU	Roadside Unit
RWW	Road Works Warning
SaaS	Software-as-a-Service
SME	Small and Medium Enterprise
SMS	Short Message Service
TEU	Twenty-foot Equivalent Unit (container volume)
TMC	Traffic Management Centre
TNO	Netherlands Organisation for Applied Scientific Research
TOC	Train Operating Company
TSP	Transit Signal Priority
UK	United Kingdom
UNEP	United Nations Environment Program
UPS	United Parcel Service
US	United States
USDOT	United States Department of Transportation
UTC	Urban Traffic Control
VNA	Value Network Analysis
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
WP	Work Package
7EAP	7th Environmental Action Program

Abstract

The (C-)ITS market is changing rapidly shaping the near future of a brand-new world. NEWBITS project aims to provide a deep understanding of this ever-changing world, analysing the current markets, trends and initiatives and developing new business models and incentives in order to accelerate the (C-) ITS deployment in Europe.

This report provides a general (C-)ITS market watch including an overview of the market, a general PESTEL analysis and identifies the current needs and trends of the (C-)ITS solutions.

In addition to this, the report provides a deep understanding of the NEWBITS case studies from a market and stakeholder's perspective, analysing the current market, market segmentation, target market and competitors along with the stakeholders' identification and assessment complemented with a mapping of their relations and dependences.

For each project case study, the resulted value chain is depicted, identifying the main activities, both primary and secondary and extracting the main conclusions of all these processes.

Executive summary

This deliverable D3.1 Market Research Analysis constitutes the first deliverable of Work Package three (WP3) aiming at providing relevant information of the (C-)ITS market in Europe with a detailed focus in the NEWBITS case studies' market and stakeholders situation along with its resulted value chain.

The report offers a general (C-)ITS market watch, including an overview of the market, a PESTEL analysis and identifies the current needs and trends of (C-)ITS solutions.

With this background, each of the NEWBITS case studies is analysed, both in terms of market analysis (current market, market segmentation, target market, specific PESTEL for the case study, SWOT analysis, competitors' assessment) and stakeholders' analysis (identification of stakeholders and their characteristics, assessment of their importance and influence, mapping of relations and dependences) and the resulted value chain is extracted.

The result of all these processes complements the information initiated in the taxonomy development in D2.3 and establishes de detail of the NEWBITS case studies:

- Case study one is a carpooling service deployed in the campus of the Universitat Autònoma de Barcelona with a B2C approach. The solution can be extended to other campuses and industrial areas within and outside the region.
- Case study two is a traffic light infrastructure integrated in the Urban Traffic Control and an Energy Efficient Intersection Service (EEIS) deployed in the Municipality of Verona. It has a B2C approach where the solution is applicable to any of the 45,000-delay hot-spots in Europe.
- Case study three is a synchromodal track-and-trace solution including a forecasting of container arrival service located in the corridor Rotterdam-Limburg. The solution compounds a B2B model for shippers, inland terminals and warehouse operators within the country and is applicable to any other deep sea – inland corridors outside the country.
- Case study four is a predictive maintenance solution deployed in the London North Western route from London to Carlisle. The solution is clearly defined for the UK market with high potential to be expanded to other rail lines and other train and freight operators in the UK.

The results of this report will be used in the extraction analysis of users' preferences in D3.3 and the Value Network Analysis in T4.2.

1 Introduction

1.1 Description of WP3 and key interrelations

WP3 “Holistic Intelligence Process” aims at outlining the landscape of the ITS and C-ITS market in order to serve as basis for the development of new business models.

To do so, WP3 has to provide a definition and assessment of the current market situation along with a consideration of how users’ preferences might shape the diverse strategies for profitable growth and a benchmark analysis on the innovation diffusion of (C-)ITS applications in Europe and the United States.

WP3 offers general (C-)ITS background and then focus in the NEWBITS case studies, providing the specific information needed in further work packages of the project. The general market information (in this deliverable D3.1) along with the benchmark analysis (D3.2) will serve as basis knowledge, then the focus is switched to the project case studies, both for specific market and stakeholders’ information (in this deliverable D3.1) and for the users’ preferences (D3.3).

The relation of WP3 with other project work packages can be seen in the following picture:

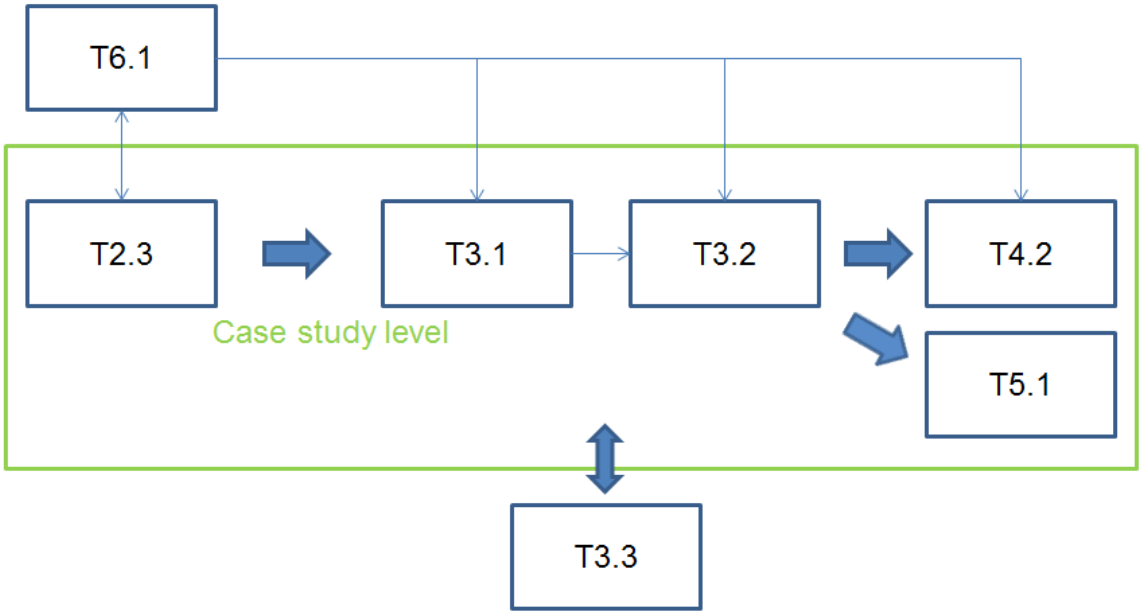

Figure 1 Diagram for key interrelations in NEWBITS

WP3 takes the outputs of WP2, mainly (but not only) from T2.3 in order to focus the results of the market and stakeholders’ analysis in the NEWBITS case studies (T3.1) and supported by the CoI’s managed by WP6. The general results of T3.1 and T3.3 along with the specific case study results of T3.1 will be firstly used in T3.2 in order to perform the conjoint analysis and obtain users’ preferences. The overall result of the WP3 will be the direct input for WP4 and WP5.

1.2 Objectives and structure of the document

T3.1 and this deliverable D3.1 aim to provide a definition of the ITS market with special focus in the NEWBITS case studies and to identify the key stakeholders taking part on each of them.

The specific objectives for this deliverable are:

- Provide a clear picture of the ITS market serving as background for the case studies specific information.
- Analyse the specific market for each case study including its definition, size, segmentation, target market and competitors.
- Analyse the key stakeholders for each case study identifying their characteristics, relevance and inter-relations.
- For each case study, extract the value chain resulted of the market and stakeholders' analysis.

The deliverable is structured as follows:

Section 1 of this document provides a description of the WP3 and its relations with other project work packages along with the objectives and structure of the document.

Section 2 of this document brings the results of a market watch providing general background for the (C-)ITS market and offering an overview from the recent past to the near future. This market overview brings a more detailed definition of the segmentation selected for the project (by type) and includes information and forecast data both from several years ago to most recent ones (from the start of the decade to current date) in order to illustrate the rapid evolution and movement of the (C-)ITS market (section 2.1).

The market segmentation (section 2.2) complements the previous section information with insights of other segmentations (geographical, mode of transport), describing the current global market.

The current market trends (section 2.3), show which are the needs driving the market and the next-generation solutions.

Finally, the market watch concludes with a PESTEL analysis (section 2.4) covering the general factors extracted from a (C-)ITS perspective.

Section 3 of this document is focused in the case studies specific market analysis and stakeholders' analysis concluding with a value chain. The details of the structure and methodology for the case studies can be found in section 3.1 of this document.

Section 4 extracts the conclusions of the overall process summarizing the work done and the main results.

The appendices of this document contain specific information about the stakeholders of the case studies (used in the stakeholders' analysis), the competitors identified by each case study and other sources used in the market and stakeholders analysis.

2 (C-)ITS Market watch

2.1 Overview of the (C-)ITS market

The term “intelligent Transportation Systems” (ITS) was coined over two decades ago to designate applications of information and communication technologies to the operational management of transportation networks.

During the categorization of initiatives in D2.1 [1] it was decided to use the segmentation by system/type and it will be used as well in this document as one of the main segmentations of the ITS market:

- Advanced Traveller Information System (ATIS)
- Advanced Traffic Management System (ATMS)
- Advanced transportation pricing system (ATPS)
- Advanced public transportation system (APTS)
- Cooperative vehicle system (CVS).

MarketsandMarkets measured this segmentation market potential and significance stating that “*the most attractive of all the systems of ITS is Advanced Traffic Management Systems (ATMS), Advanced Public Transportation Systems (ATPS), and Electronic Pricing Systems. The rate of adoption of these systems in urban areas has been very high and will continue to be so. The major focus of the government of different countries like U.S, Japan, Korea, Germany and others is to reduce the congestion level in the urban areas, which is the major reason behind the deployment of the ATMS and ATIS systems. Developing countries like China, India, Middle East and others have significant investment plans for the development of the expressways and highways, which will boost the market for electronic pricing systems in the ITS market.*” [2].

In 2015, the GSM Association provided some history about ITS markets and past prospects in their Intelligent Transportation System report for Mobile (2015):

> *According to MarketsandMarkets (“Intelligent Transport Systems Market by System (ATMS, ATIS, ITS- Enabled Transportation, Pricing System, APTS and CVO), by Component, Application and Geography (Americas, Europe, Asia-Pacific, ROW) Analysis and Forecast to 2014 – 2020)”, the ITS market will grow at a CAGR of 11.3% from 2014 to 2020 and reach $33.75 Billion. The major market share is in the US, followed by Europe.*
>
> *A growing focus on efficient traffic management drives the global ITS market, according to a report by Global Industry Analysts, Inc. (April 2014). It will reach US$26.3 billion by 2020, driven by continued rise in vehicular traffic and the need to regulate traffic flow, enhance road safety, and escalate awareness of the socio-environmental implications of traffic congestion.*
>
> *Grand View Research, Inc forecasts the global ITS Market will reach US$38.68 Billion by 2020. Growing demand for optimising fuel consumption and reducing emissions will be the key driving forces. ITS can reduce incidents and improve safety. North America accounted for 43.8% of the global market in 2013 and will remain the*

dominant ITS market over the next six years because of favourable regulatory initiatives from transportation authorities for increasing driver safety and reducing traffic congestion. Asia Pacific will register the fastest growth of 14% from 2014 to 2020, as a result of a need to improve transportation networks and high ITS growth expected in India and China to tackle congestion and energy consumption.

HIS Automotive forecast a sales increase of self-driving cars worldwide from 230,000 in 2025 to 11.8 million by 2035 with a cumulative total of 54 million. By 2050, nearly all vehicles – private and commercial – will be self-driving cars… Self-driving cars will add $7,000 to $10,000 to a car's price in 2025, dropping to $5,000 in 2030 and $3,000 in 2035.

According to an October 2013 market report from Transparency Market Research "Connected Car Market -Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2013- 2019," the global connected car market will reach US$131.9 billion by 2019, growing 34.7% per year from 2013 to 2019.

Fleet management includes optimal routing, and monitoring of vehicle health and driving style. At least 80% of freight traffic by weight – more by value - travels by road; it is vital to national economies. The fleet management markets in Europe, Russia/CIS and China have annual growth rates of 14%, 16% and 23% respectively. Penetration will reach 20% by 2019.

"Connected car" penetration will increase globally from 11% in 2012 to 60% in 2017 (and to more than 80% in the United States and Western Europe). The global connected car market will be worth €39 billion in 2018, up from €13 billion in 2012. There will be a sevenfold increase in the number of new cars equipped with factory-fitted mobile connectivity to meet demand among regulators and consumers for safety and security features, as well as infotainment and navigation. This rapid growth will be driven in part by positive regulatory action in Europe, Russia and Brazil. [3]

More recent researches size the ITS market in US$32.54 billion in 2015 and expect it to grow to US$57.19 billion in 2022 at a CAGR of 8.7% [4] [5].

Roadways segment dominated the global ITS market in 2015 and is expected to generate revenue of US$20.01 Billion by 2022. Aviation on the other hand is expected to register a highest CAGR of 13.2% during the forecast period (2016-2022). Railways segment attained a market size of US$7.64 Billion in 2015 and is expected to grow at a CAGR of 6.2% during the forecast period. The Maritime segment would witness a growth of 12.3% CAGR from time period 2016-2022 [4].

The market size estimation has been updated recently (March 2017), stating that the global ITS market size is estimated to reach US$72.32 billion by 2022 [6].

2.2 Market segmentation

The ITS market can be segmented in several ways: by system/type, by region, by application, by technology and by mode are usually the most common segmentations. As mentioned earlier in this document, the segmentation by system was the one chosen early in

the project, since it is wide and generic enough to include all application and technologies. However, by system segmentation is not enough on its own to give an overview of the ITS market, so in this section, it will be complemented by information of the geographical segmentation and some insights of other segmentations.

Global Market Insights offer some estimation about the ITS market forecast 2015-2022:

> *ATMS market size was valued at over US$7 billion in 2014 and is likely to reach US$18.4 billion by 2022.*
>
> *APTS segment expected to grow at a CAGR of over 13% from 2015 to 2022.*
>
> *ATPS market was valued at US$4.8 billion in 2014 and is likely to be worth US$13.2 billion by 2022, growing at over 13%. High cost ratio and improved supply chain process offered by deployment of these systems has granted economic benefits in emerging countries including Brazil, India, China, South Africa and Russia. In addition, these assist users in diminishing overall travel time and fuel consumption by avoiding overcrowded routes. Chief manufacturers in emerging and established industries are installing these systems to differentiate their products from competitors.*[7]

Although no numerical values can be seen in the free version, P&S Market Research offers the overall ITS market size segmented by system in the next figure:

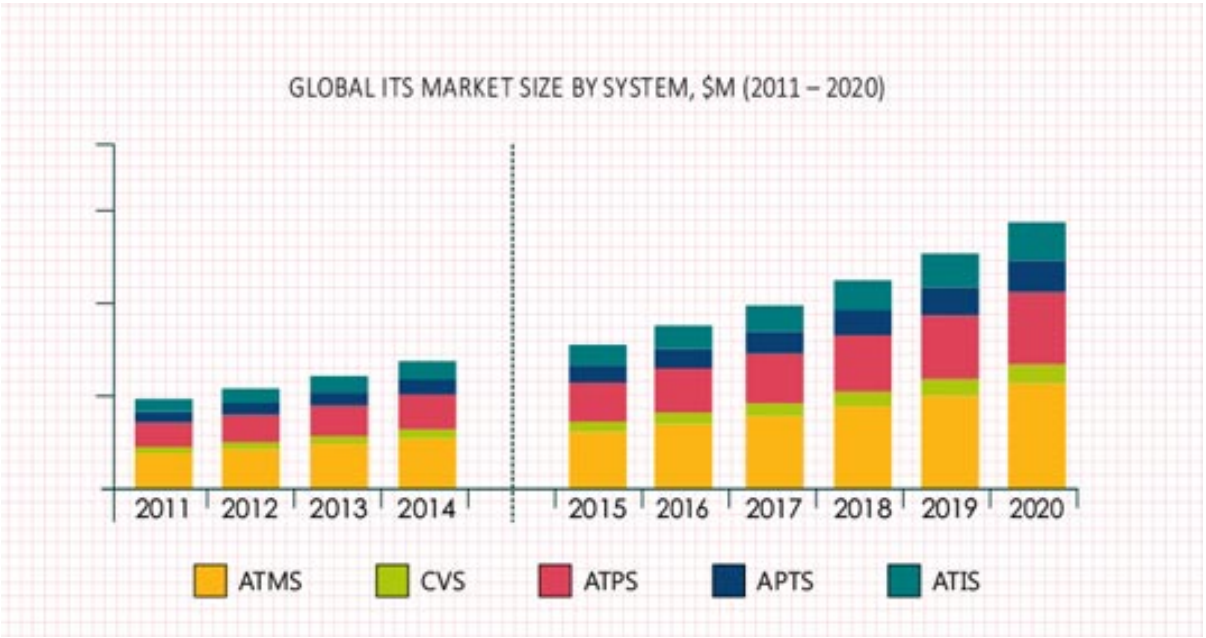

Figure 2 Global ITS market by system 2011-2020 [8]

Advanced Traffic Management System (ATMS) contributed maximum revenue to the ITS market for roadways. Growing vehicle ownership and migration from rural to urban areas are major reasons behind the increasingly deployment of ATMS. During a forecast period from 2017 to 2022, Advanced Public Transportation System (APTS) is expected to grow at the fastest rate in comparison to other systems of ITS for roadways. Increasing public-private

partnerships and growing investment on real-time information systems for bus/rail passengers are driving the demand for APTS [6].

Geographically speaking, North America ITS market share was valued over US$7 billion in 2014. Favourable regulatory initiatives paired with promotional activities are likely to spur the demand growth in the region. The European Commission has taken initiatives to make investments such as EasyWay, Galileo and eSafety, which is further expected to stimulate the regional industry growth. Germany ITS market size is forecast to grow at over 11% up to 2022. Asia Pacific intelligent transportation system market size is predicted to experience significant growth owing to rising advancements in sensor technologies. This can be credited to significant adoption in countries such as India and China. Latin America ITS market size is estimated to grow at over 13% over the next seven years [7].

Grand View Research estimations also anticipate Asia Pacific to be the fastest growing region in the period 2016-2024:

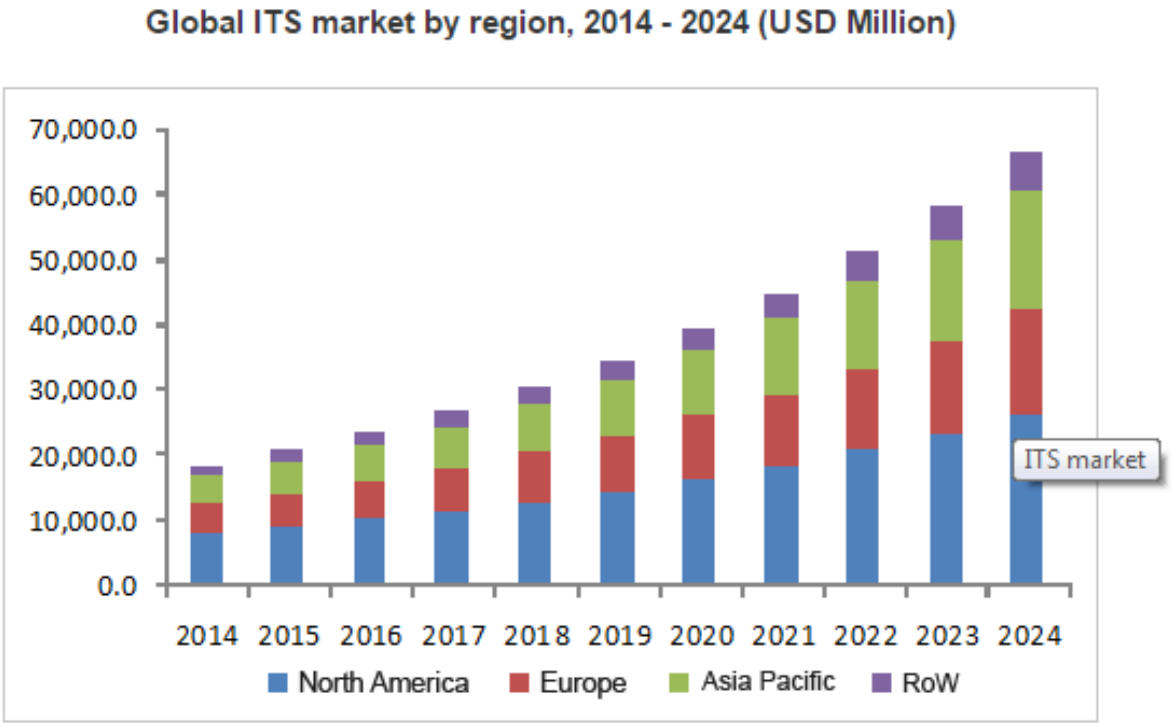

Figure 3 Global ITS market by region 2014-2024[9]

Market.biz [10] even estimate that Asia-Pacific is projected to dominate the ITS market in the forecast period of 2016 to 2022.

Some more detailed information per region (with some insights to transport mode):

North America:

The North America intelligent transportation system (ITS) market size, in terms of value, is expected to reach a market size of US$26.30 Billion by 2022, at a CAGR of 7.6% during 2016-2022. Railways, the backbone of the transportation systems in different regions, are evolving by the day and are growing increasingly complex. The adoption of railway intelligent transportation system (RITS) will be a step towards gaining competitive edge over

other modes of transportation. By implementing various intelligent techniques, the need for consumer safety can be smartly managed within this mode of transportation [11].

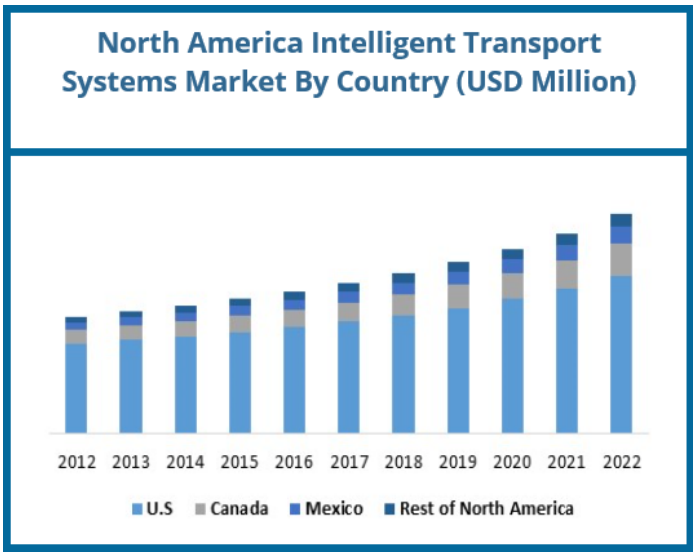

Figure 4 North America ITS systems market by country [11]

Roadways segment dominated the North America ITS market in 2015. The segment generated revenue of US$6.76 Billion in 2015. Aviation on the other hand is expected to register a highest CAGR of 12.0% during the forecast period (2016-2022) thereby achieving a market size of US$7.36 Billion by 2022. Railways is expected to grow at a CAGR of 5.1% during the forecast period. The Maritime segment would witness a growth of 11.1% CAGR from time period 2016 – 2022 thereby achieving a market value of US$4.47 Billion by 2022 [11].

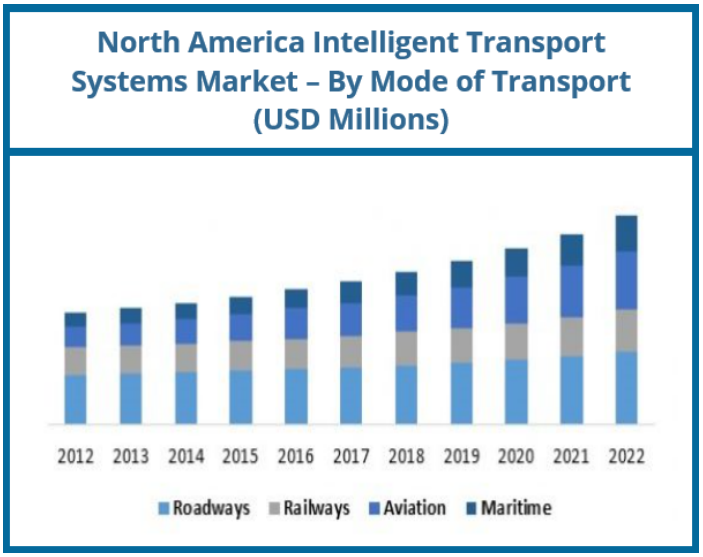

Figure 5 North America ITS systems market by mode of transport [11]

Europe:

The Europe intelligent transportation system (ITS) market size, in terms of value, is expected to reach a market size of US$16.30 Billion by 2022, at a CAGR of 8% during 2016-2022. In 2015, Germany dominated the Europe ITS Market and is expected to generate revenue of US$4.15 Billion by 2022. Italy on the other hand is expected to register a highest CAGR of 9.9% during the forecast period (2016-2022) thereby achieving a market size of US$0.97 Billion by 2022. The UK region generated a revenue of US$2.36 Billion in 2015 and is expected to grow at a CAGR of 6.6% during the forecast period. The France region would witness a growth of 8.7% CAGR from time period 2016 – 2022 [12].

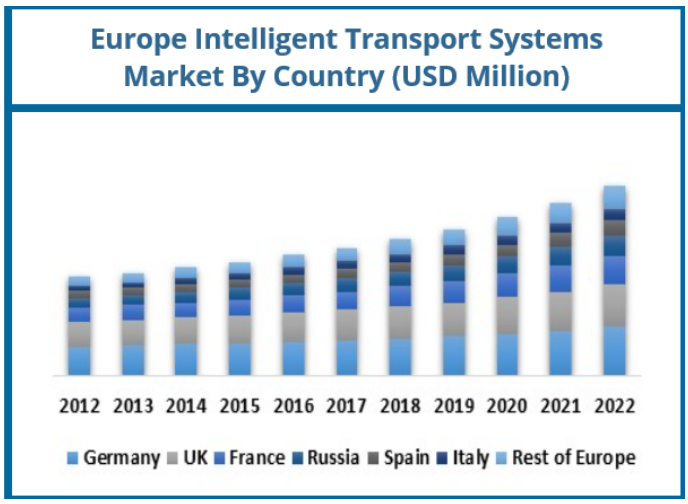

Figure 6 Europe ITS systems market by country [12]

Roadways segment dominated the Europe ITS Market by Mode of Transportation in 2015. The segment generated revenue of US$4.08 Billion in 2015, and is expected to continue its dominance further. Aviation segment on the other hand is expected to register a highest CAGR of 12.4% during the forecast period (2016-2022) thereby achieving a market size of US$4.56 Billion by 2022 [12].

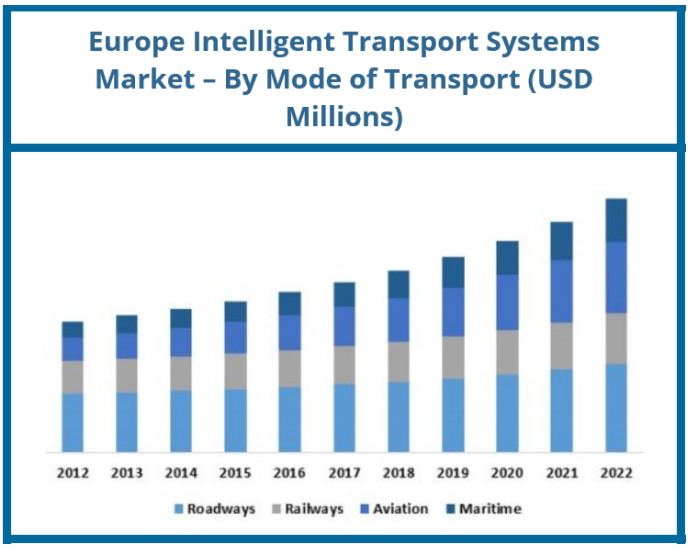

Figure 7 Europe ITS systems market by mode of transport [12]

Asia Pacific:

The Asia Pacific intelligent transportation system (ITS) market size, in terms of value, is expected to reach a market size of US$11.03 Billion by 2022, at a CAGR of 11.8% during 2016-2022. In 2015, China dominated the Asia Pacific ITS Market and is expected to generate revenue of US$2.59 Billion by 2022. The Japan region generated revenues of US$1.30 Billion in 2015 growing at a CAGR of 12.2% during the forecast period. The India region would witness a growth of 13.8% CAGR from time period 2016 – 2022 [13].

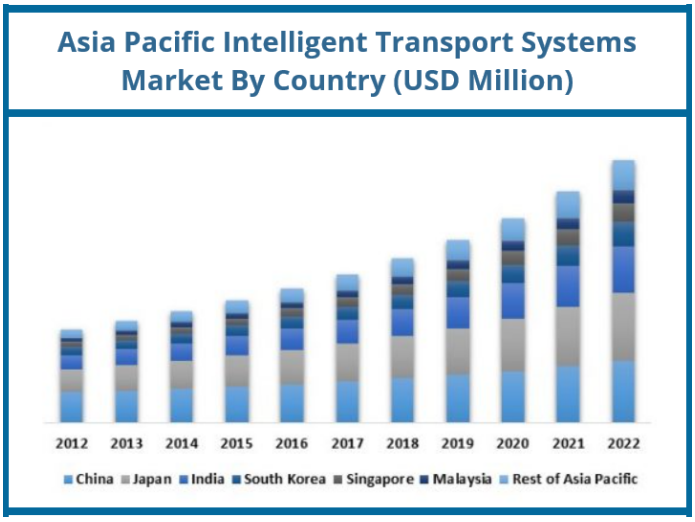

Figure 8 Asia Pacific ITS systems market by country [13]

Roadways segment dominated the Asia Pacific ITS Market by Mode of Transport in 2015 and is expected to generate revenue of US$3.86 Billion by 2022. Aviation segment on the other hand is expected to register a highest CAGR of 16.4% during the forecast period (2016-2022) [13].

Figure 9 Asia Pacific ITS systems market by mode of transport [13]

LAMEA (Latin America, Middle East and Africa):

The LAMEA intelligent transportation system (ITS) market size, in terms of value, is expected to reach a market size of US$3.54 Billion by 2022, at a CAGR of 12.7% during 2016-2022. In 2015, LAMEA Intelligent Transport Systems Market attained a market size of US$1.56 Billion and is expected to witness a growth of 12.7% CAGR during the forecast period. In 2015, Brazil dominated the LAMEA ITS Market and is expected to generate revenue of US$0.56 Billion by 2022. The Argentina region generated revenues of US$0.19 Billion in 2015 growing at a CAGR of 13.6% during the forecast period. The UAE region would witness a growth of 11.5% CAGR from time period 2016 – 2022 [14].

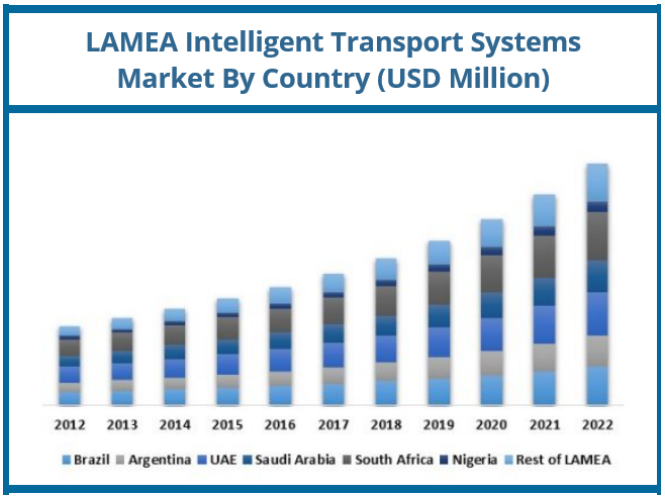

Figure 10 LAMEA ITS systems market by country [14]

Roadways segment dominated the LAMEA ITS Market by Mode of Transportation in 2015 and is expected to generate revenue of US$1.24 Billion by 2022. Aviation segment on the other hand is expected to register a highest CAGR of 17.3% during the forecast period (2016-2022) [14].

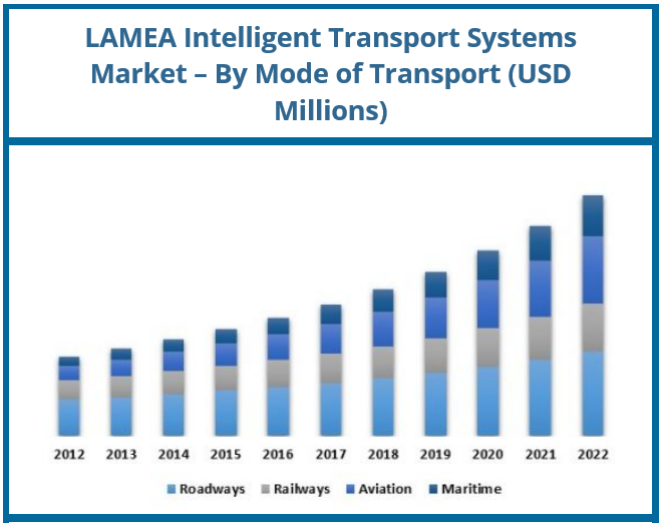

Figure 11 LAMEA ITS systems market by mode of transport [14]

2.3 Market needs and trends of (C-)ITS solutions

The previous sub-sections of this document provide a general overview of the market evolution, which regions, transport modes and systems are going to grow the most and which general direction the ITS market is taking. Navigating more into detail, this sub-section aims to provide some insight about the more prominent needs driving the ITS market, the developing trends, what is the near future and the next-generation solutions.

As a general statement, we can say that the increasing number of vehicles leading to traffic congestion has contributed to the need of intelligent transportation system for advance traffic control measures, thereby, propelling the global ITS market.

The major factor hindering the global ITS market is the slow growth of intelligent infrastructure owing to high installation cost for monitoring and controlling devices. Another key factor restricting the global ITS market is the lack of standardization and interoperability between different types of transportation and telecom technologies. However, the introduction of smart vehicles enabled with intelligent transportation system is expected to provide better driving experience, and is thus expected to contribute significantly towards the growth of the global ITS market. Another factor analysed to propel the growth of intelligent transportation systems is public private partnerships (PPP) for advanced traffic management. Also, initiatives such as vehicle to infrastructure (V2I) and vehicle to vehicle (V2V) communication are estimated to be key factors boosting the global intelligent transportation system market [15].

The growing need for public safety as collision avoidance and dynamic warning systems are introduced to reduce the frequency of accidents by making users more aware of their surroundings. Smart vehicles and smart roads is a major trend and governments of major countries are making a lot of effort to reduce collisions and accidents in different transport verticals. The introduction of smart vehicles is one such measure to avoid accidents on roads as these vehicles use advanced IT solutions that help them to control their speed and better manage traffic congestions along the route [16].

Along all these, we can safely say that some of the major trends in ITS market right now are **connected car**, **autonomous vehicle**, **big data** and **smart cities** which are in close relation with the big transversal trend constituted by the **IoT** (Internet of Things) and are affected by the socio-economic shift defining the way we consume, the on-demand economy which has derived in a **Mobility-as-a-Service**.

Connected vehicle technology focuses on wireless communication: vehicle-to-vehicle (V2V), vehicle-to-pedestrian (V2P) and vehicle-to-infrastructure (V2I), collectively referred to as V2X. Intended primarily to improve safety, V2V technology allows cars to continually communicate to the vehicles around them so each are aware of the others' speed, heading and direction. Connected vehicles also help in recognizing and alerting drivers to dangerous situations. By adding communication points in hazardous road areas and intersections, V2I technology extends crash-reduction capabilities by allowing automatic control of signal timing, speed management, and operation of transit and commercial vehicles [17].

"*The connected vehicle technologies are ready,*" said Suzanne Murtha, senior program manager for intelligent transportation initiatives at Atkins Global. "*Now it's a matter of*

governments capturing and sharing data about real-time, on-the-street traffic conditions so drivers can make better choices." [17]

Connected vehicle technology can predict road conditions by analysing driver data. Giving drivers insight into the weather they are anticipated to encounter on their upcoming journey represents the next generation of connected cars focusing on improved driver experiences. Coined "intelligent commuting", this next generation of connected car technology reigns in big data insights, translating complex data into tangible benefits drivers can implement – today [18].

By using connected car data to coordinate and connect services across multiple transportation networks (subways, trams buses, vehicle and bicycle traffic), citizens gain access to the next generation of smarter commuting powered by connected car technology [18].

Up until now **autonomous vehicles** tested on roads were concept cars. Nevada has been licensing autonomous vehicles since 2011, and in 2012 Google received the first license for an autonomous vehicle. All of those cars have been prototypes. The 2017 Mercedes-Benz E-Class will become the first "standard-production" vehicle to receive a testing license in Nevada. Other models required extra sensors or other modifications. Not the E-Class. It's ready to go. From prototype to standard production. Driverless cars are going mainstream in 2017 [19].

Autonomous cars use a combination of LIDAR (similar to sonar but with laser light), GPS, optical cameras and big-time processing power to analyse millions of possible roadway scenarios and then take the appropriate action. The ultimate goal for autonomous vehicle technology is to make the vehicle so intelligent that no driver input is needed. However, truly autonomous vehicles, wherein the driver can give up complete control to the car, remain on the distant horizon. According to Ford, it is incremental technological advancement that will one day lead to driverless cars [17].

"*By the time we get to full autonomy, the last step won't seem like such a big deal,*" he said. "*Even as we put in a lot of these features the driver still has to be vigilant and in control.*" [17]

Malcolm Dougherty, director of the California Department of Transportation, agreed. At the ITS World Congress, he said that while he believed "*the development of autonomous vehicle technology is going to accelerate … for the time being the motorist will always be responsible for the vehicle.*" [17]

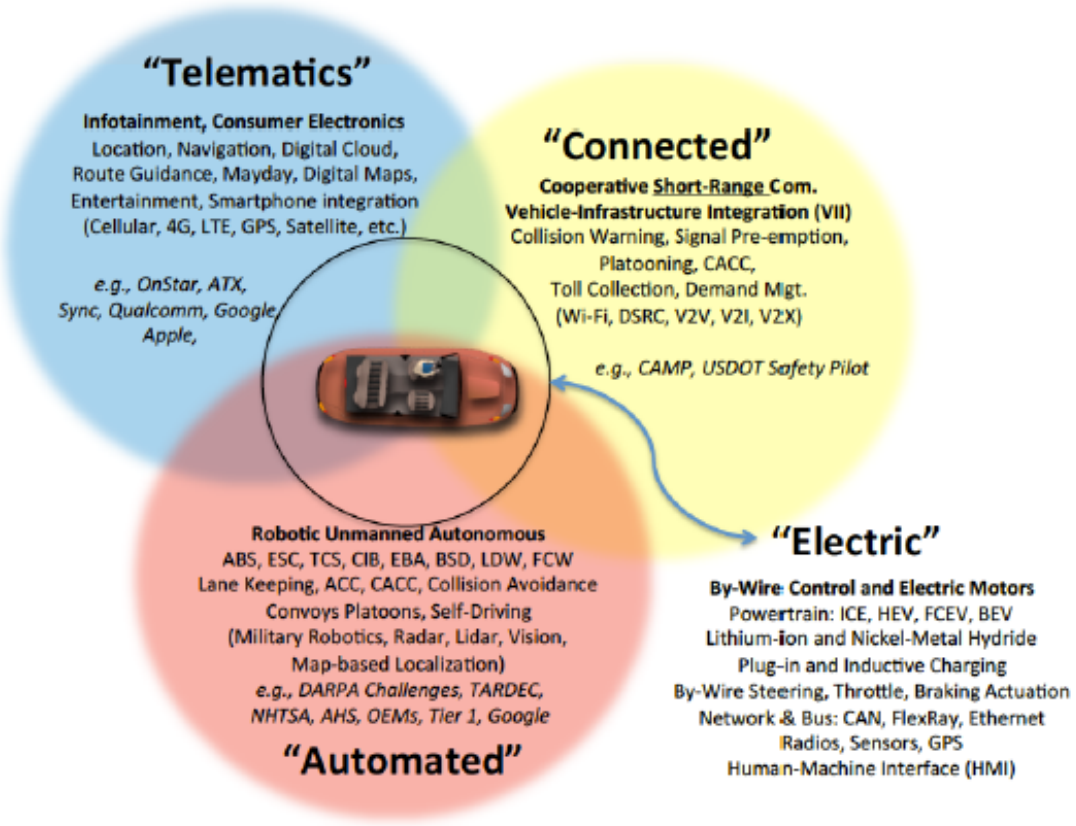

Figure 12 Four Automotive Electronics and Communications technology communities. Source: Underwood (2015)

If you buy a new car today, you're getting a preview of how driving will change as we move into the era of autonomous, connected vehicles. Features that help you park the car in a tight spot, automatically adjust cruise control speeds and sound an alert when the car drifts out of its lane are examples of technology now offered by automakers. Several states have already passed laws that allow autonomous vehicles to operate on public roads. [17]

Intelligent infrastructure generates **data** that helps civic leadership make better decisions. For local transportation managers, connected vehicles and connected infrastructure will be tools for traffic data collection and analytics [17].

Better traffic flow is achievable in part with better systems for collecting and analysing real-time traffic data. In this arena, transportation managers can learn from the technologies and practices deployed by private companies, especially those with large fleets [17].

For instance, some keen-eyed observers know that the familiar brown UPS trucks rarely make a left turn. The reason is that for decades UPS has worked to optimize routes. The UPS On-Road Integrated Optimization Navigation (ORION) software, which provides analytics for routing the company's delivery trucks, is the latest in route optimization. The system combines daily data on package delivery commitments and historical route tracking to identify the optimal path (out of hundreds of thousands of possibilities) for each UPS driver to follow that day. UPS expects the ORION system to significantly reduce fuel consumption and miles driven in its trucks. Public transportation departments will benefit from using similar analytics tools said Tom Madrecki, strategic communications manager at UPS [17].

"*It's really about diving into the data and, based on where people need to go, determining how to make the transportation system the best it can be, then investing in the needed technology to realize those improvements*," Madrecki said. [17]

You can design trips and routes more dynamically and reliably with real-time information. Passenger information and ticket pricing will become more dynamic as predictive analysis and data from different transport forms becomes available in real-time. Congestion and traffic bottlenecks can be reduced. The value of real-time data increases in a variety of unforeseen situations [20].

The demand for digital services grows dramatically in the short term. Communications and information becomes increasingly mobile, which gradually leads to more personalised services [20].

Systems will first learn to understand each other and then actually use each other's information. Eventually, different systems will be replaced by a centralised system that enables both a comprehensive operator model as well as a variety of applications that efficiently utilise big data. Technological progress integrates our devices directly into our surroundings [20].

In next-generation solutions, systems will be compatible and connected. Very shortly, we will aggregate real-time data from different forms of transport. These data sets will help make real-time decisions and monitor traffic flow. The same big data services will also provide information for passengers, ensuring seamless public transport transfers. Data from vehicular systems is sharable with stakeholder systems, e.g. the Transport Agency, which can use such data to analyse traffic flow [20].

In the 2020s, the focus on devices will decrease. As more functionalities are transferred to the back end, vehicular devices and systems are simplified, or vanish altogether. Today, separate intelligent transport devices are already no longer needed, as the necessary information and location technology is installed into vehicles on the factory floor. The Internet of vehicles has already been born. [20]

More **smart cities** testbeds and municipal innovation zones are expected in the next few years.

A new wave of technology will enter the market in late 2017 that significantly lowers the cost of deploying traffic sensors. It's already happening in Chicago. They've just launched Array of Things[1], a ground-breaking urban sensing project. The plan is to install 500 nodes on city streets that can measure air quality, climate, traffic and other urban features. This technology will collect data that will help the municipality understand environmental, traffic or pedestrian trends so it can make better and safer municipal planning decisions [19].

Many cities will tackle ITS security. As public works infrastructure begins to rely on sensor integration and data gathering as part of its operations, data security will emerge as a key concern for cities. This issue will move from a theoretical "what if" in 2016, to a practical "must have" for cities in the year ahead [19].

[1] https://news.uchicago.edu/article/2016/08/29/chicago-becomes-first-city-launch-array-things

A thorough data security policy which covers how data is transmitted to and from infrastructure, where data is stored, and who has access to use it will become a critical management questions for traffic agencies. Many cities will rely on guidance from sources like Smart City IoT best-practices[2] [19].

In the same way that many technology companies have moved to hosted "software-as-a-service" (SaaS) platforms to run their businesses, cities will start embracing "infrastructure-as-a-service" (IaaS) to help run traffic operations. For many cities, this will be driven by the desire to move away from the mind-set of needing to own, host, and operate all ITS technology, which can place excessive burden on IT and transportation departments, especially for smaller traffic agencies [19].

Leveraging IaaS introduces agencies to fully managed and hosted services for everything from traffic signal communications to video storage and data analysis. IaaS has the potential to not only save traffic agencies money, but also empowers their traffic engineers to focus on using data to fix traffic challenges instead of coping with IT challenges of simply acquiring the data. [19]

This bit of information extracted from an article in the U.S can reinforce the ideas seen until now:

> *According to the U.S. Department of Transportation's Federal Highway Administration, Americans drove more than 3.1 trillion miles in 2015, setting a new record. If that number doesn't impress you, the DOT also reports an expected increase of more than 70 million people in 11 "mega-regions" by 2045. 70 million. That's a lot of people on the road in densely populated areas where mobility is already considered a top concern.*
>
> *With Americans spending so much time in their cars, and cities facing inadequate funding for long term infrastructure needs, local agencies have become reliant upon innovative and cost-effective alternatives such as Intelligent Transportation Systems, or ITS. Benefits of ITS include traffic monitoring, improved traveller information and the ability to quickly detect and respond to traffic incidents. Widely deployed across the world over the last 30 years, ITS is everywhere.*
>
> *Those electronic road signs that alert drivers to traffic delays, accidents and roadway construction? That's ITS. The radar speed signs that tell us how fast we're driving, or if we're speeding? That's ITS, too. The closed-circuit television cameras that capture everything from license plates at toll booths to car crashes on film? That's all part of the ITS family as well.*
>
> *There's more. ITS technology continues to expand its reach by adding benefits inside of our vehicles. We already have backup cameras and blue tooth capability. Now the Obama administration has announced it will earmark $4 billion for research into self-driving cars. And the DOT has made research into connected vehicles and automation two of their priorities over the next few years. [21]*

[2] https://news.uchicago.edu/article/2016/08/29/chicago-becomes-first-city-launch-array-things

Another good real example of this could be the Siemens case study in Singapore:

> *Recently, Siemen's recognized Singapore as an "Intelligent City Infrastructure" winner because of their successful implementation of ITS technology.*
>
> *According to a Siemen's case study[3], which recognized Singapore's leadership in ITS technology, "the growing population and lack of available physical space have made traffic management increasingly challenging in Singapore. By 2020, travel demand is expected to rise from 8.9 million journeys per day to about 14.3 million, signifying the marked increase in the city-state's population. Concurrently, Singapore faces major constraints in space, with 12% of land already occupied by the 3,300 km-road network and another 15% devoted to housing. Expanding the road network to address transport demand has not been seen as a sustainable option. Instead, the Singapore government has utilized policy and technology to manage transport demand and supply, maximizing the current sustainable systems while minimizing more environmentally impactful modes of transit."*
>
> *To address this challenge, Singapore successfully implemented an advanced range of ITS technologies to improve the lives of citizens using big data insights and advanced transportation technology.*
>
> *According to Siemen's case study, "Singapore has implemented a sophisticated Intelligent Transport System (ITS), which uses data collection and ITS solutions to keep road traffic running safely and smoothly. The ITS acts in concert with a number of other transport initiatives: free public transportation in pre-morning peak hours, a vehicle quota system, a congestion charge, and an extensive public transport system."* [18]

The **IoT** global market is affecting the ITS market and as a result, the market for IoT in intelligent transport systems is slated to make gigantic progress in the years to come. A report by Transparency Market Research predicts the market to rise at a 19.8% CAGR during the period between 2017 and 2025. At this pace, the market will likely attain a value of US$249.84 billion by 2025-end from US$41.57 billion in 2015 [22].

Along with smart cities and V2V solutions, IoT applies to the transport market in predictive and preventive maintenance (IoT sensors allow administrators to monitor the health of a fleet, extending vehicles life and improving their reliability) and providing safety compliance (IoT devices can ensure drivers are following the regulations and industry guidelines, organization can track the speed of vehicles and for how long they remind idle).

IoT comes with blockchain, and the push to commercialise applications leveraging both technologies grows. The latest industry to embrace this confluence is the transport and logistics industry. In late August 2017, the Blockchain in Trucking Alliance[4] (BITA) launched with 150 or so member organizations including transportation, management companies,

[3] https://www.siemens.com/press/pool/de/events/2014/infrastructure-cities/2014-06-CCLA/singapore-climate-close-up.pdf
[4] BITA https://bita.studio/

brokers, carriers, shippers and technology vendors. BITA's started goal is to create standards and educate industry stakeholders about the promise of blockchain [23].

All these technological advancements are allowing the swift in the mobility from ownership to service access, this is, the **Mobility-as-a-Service** (Maas). MaaS was already defined in D2.1 [1] and can be summarised as a move away from a world dominated by a need to own a primary mode of transport (such a car) towards a model where traveling happens through a combination of public/private and shared transport model [24].

MaaS is able to provide personalised travel information and recommendations. Often, existing mobility planning services provide sub-optimal mobility guidance since efficient non-obvious routes and mode combinations are intuitively known and regularly used by commuters but are not identified by these services. MaaS, IoT and big data are able to having insight into the daily commutes and analysing each user's unique set of decisions factors used when considering a trip, and could offer advice when the preferred route is unavailable and offer useful alternatives to get to the destination [24].

The following figure shows the main actors in the MaaS market:

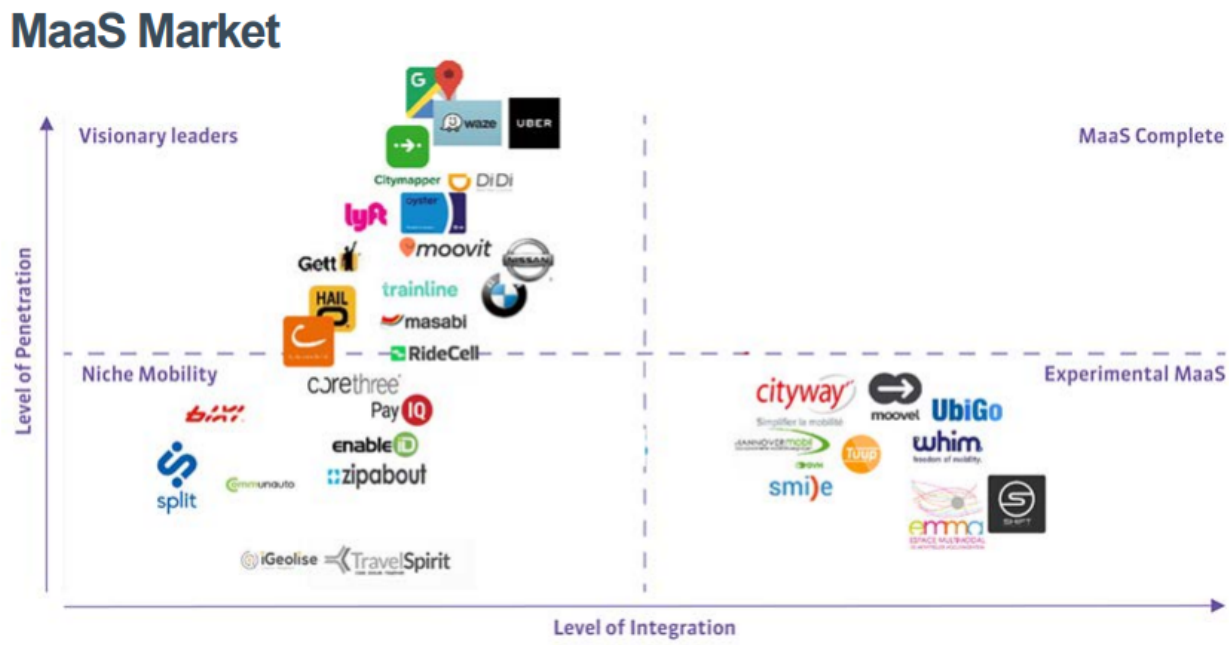

Figure 13 Main actors in the MaaS market. Source [25]

2.4 General (C-)ITS PESTEL analysis

PEST is an acronym for Political, Economic, Social and Technological factors. The PEST Analysis is a business measurement tool used to assess the market by determining how these external factors affect the performance and success of a business situation.

Since the scope of the NEWBITS Case Studies is located within Europe, this section analyses these factors of the general (C-)ITS business but focusing in the European environment. Technological factors, being somehow similar worldwide, include some insight of the United States in order to check the alignment with European strategic plans. The other

major actor (Asia-Pacific) has been also taken into consideration although not reported since their technological strategies are aligned with Europe and US.

The PEST analysis has been extended to PESTEL, considering as well the Environmental and Legal factors in the (C-)ITS market. The following picture summarises the key findings of the analysis, which are explained in detail afterwards.

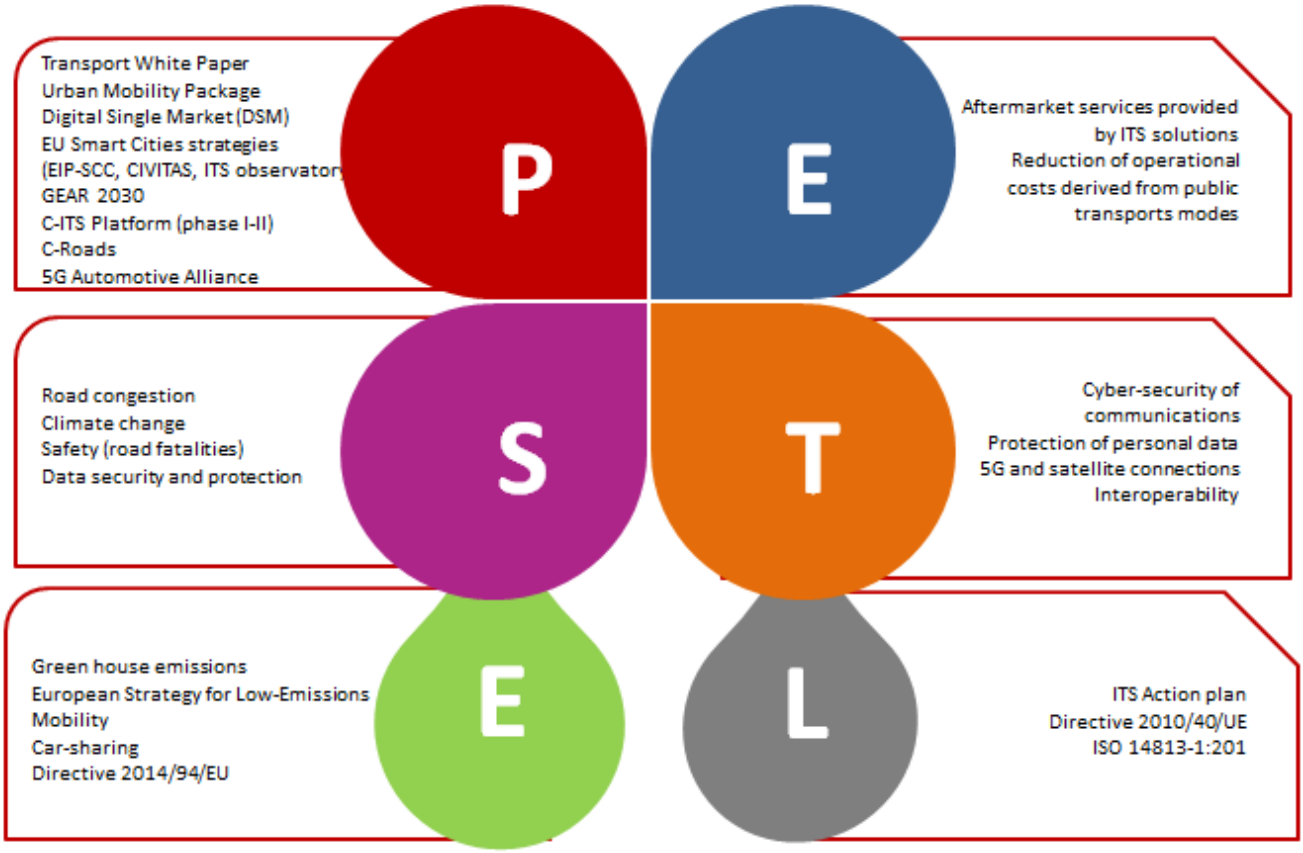

Figure 14 General ITS PESTEL

Political factors

The European Commission launched the **Transport White Paper** in 2011 [26], adopting a roadmap of initiatives for the next decade to build a competitive transport system increasing mobility, remove major barriers in key areas and cut carbon emissions in transport by 60%.

After this white paper, the European Commission created the **Urban Mobility Package** in 2013 [27], to reinforce the support to European cities for tackling urban mobility challenges, explaining how the Commission will strengthen its actions towards sustainable urban mobility and encouraging Member States to take more decisive and better coordinated action.

From 2014 onwards, **Horizon 2020** [28] reflects the policy priorities of the European strategy in transport research, contributing to find solutions to the increasing mobility of people, with

low-carbon technologies, clean vehicles, smart mobility systems and integrated services for passengers and freight.

Horizon 2020 considers Intelligent Transport Systems as key to achieve the vision of seamless transport both in passenger and in goods transport markets. ITS is also one of the essential elements for making Mobility as a Service (MaaS) a reality, by connecting all the elements of the multimodal transport system – travellers, goods, vehicles, information and communication technologies and infrastructures, and the regulatory framework – and thereby forming a major building block of a digitally integrated transport system.

In parallel, **EU Smart cities initiatives** have been released in order to harmonise and define common objectives for European cities in the scope of urbanisation, transport and energy topics. Some examples of these initiatives are: EIP-SCC, CIVITAS, ITS Urban Observatory, ITS National Networks (promoted by ERTICO), etc.

In the coming years, we are going to face a strong digitalization of transport in general and ITS in particular. The European Commission has adopted a new strategy to create a fully integrated Digital Single Market (DSM) [29], in order to gradually bring down the remaining obstacles and move from 28 national markets to a single one. In this regard, the European Commission aims to make more use of ITS solutions to achieve a more efficient management of the transport network for passengers and business. ITS will be used to improve journeys and operations on specific and combined modes of transport. The European Commission also works to set the ground for the next generation of ITS solutions, through the deployment of Cooperative-ITS, paving the way for automation in the transport sector. C-ITS are systems that allow effective data exchange through wireless technologies so that vehicles can connect with each other, with the road infrastructure and with other road users [30].

On top of that, to ensure a co-ordinated approach and to address the challenges faced by the European automotive industry in the next 15 years, the Commission has launched a new High Level Group for the automotive industry: GEAR 2030. In this sense, the key objectives for this strategy are the following ones:

- The adaptation of the value chain to new global challenges.
- The automated and connected vehicles.
- Trade, international harmonisation and global competitiveness.

The High-Level Group gathered relevant Commissioners, Member States and stakeholders representing various industries: automotive, telecoms, IT, insurance. It's expected that this group will assist the Commission in developing a long-term EU strategy for highly automated and connected vehicles by the end of 2017.

The main relation of ITS and C-ITS areas within GEAR 2030, it's the fact that the development the **C-ITS platform** will enhance the current position of EU within the connected and automated cars by providing a holistic overview of multiple technical, business and societal aspects which are not currently addressed by the existing frameworks. In the second phase, the focus of the European Commission with all relevant stakeholders in the **C-ITS Platform (phase II)** domain has been work together to steer the development of a common security and certificate policy and other accompanying documents needed for the deployment and operation of C-ITS in Europe. The outcomes of the work are allocated in the

document "*Certificate Policy for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS)*"[5] released on June 2017.

The following figure represents the most representative EU macro-strategies in relation with the implementation of ITS, C-ITS, autonomous and connected vehicles in a common timeline.

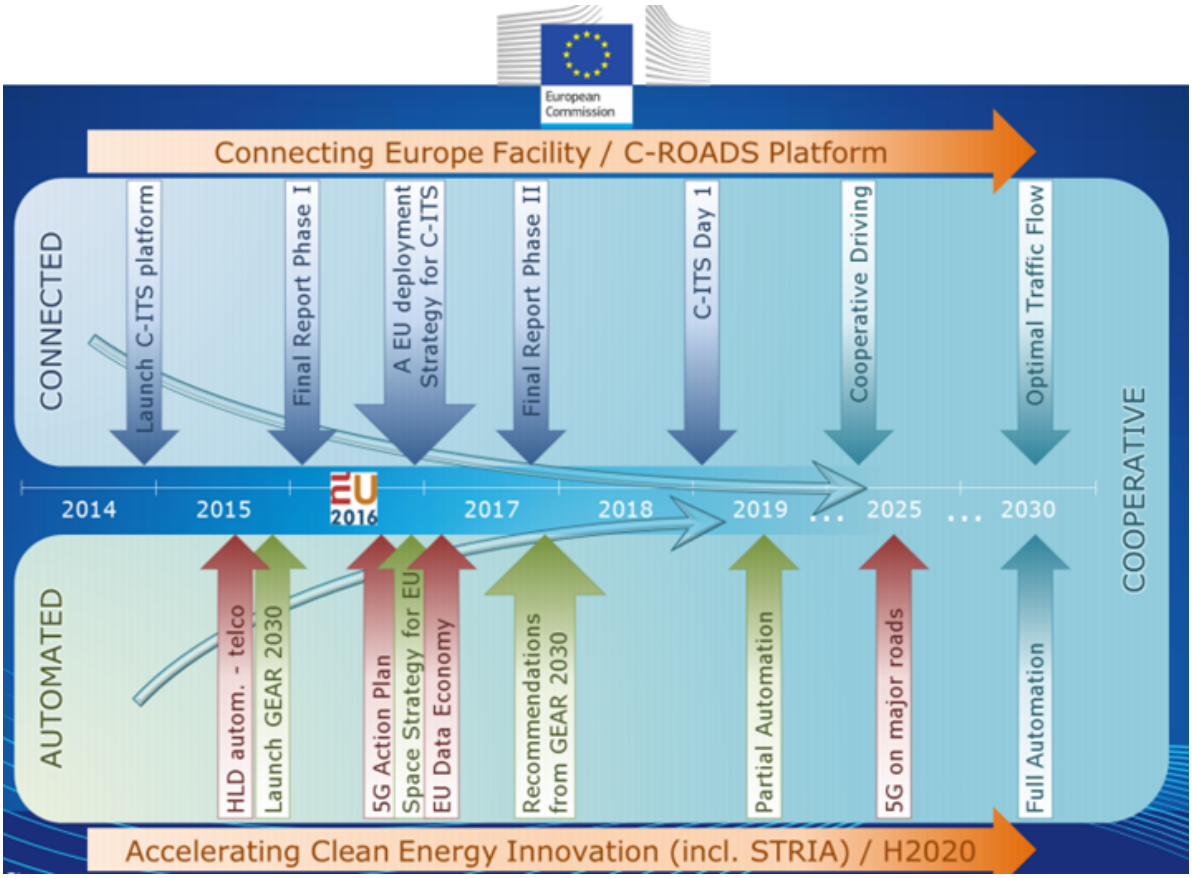

Figure 15 EU Strategies timeline in relation to ITS and C-ITS[6]

Economic factors

From the European Commission perspective, there are several economic factors, such as:

In 2015, the Council of the European Union published the broad guidelines for the economic policies of the Member States and the European Union stating:

"Delivering a strong energy Union should ensure affordable, secure and sustainable energy for businesses and households. A cost-effective implementation of the 2030 climate and energy framework and transition to a competitive, resource efficient low carbon economy should be pursued, including through both demand and supply side reforms, while promoting green jobs, green technologies and innovative solutions. In that regard, the energy and

[5] https://ec.europa.eu/transport/sites/transport/files/c-its_certificate_policy_release_1.pdf
[6] 14 February 2017 Amsterdam Gerhard Menzel, European Commission - DG MOVE

transport sectors continue to require particular attention, including with respect to interconnections and infrastructure." [31]

Transport sector is still lagging behind so the European Commission targeted transport in Horizon 2020 stating:

"Efficient transport is a fundamental condition for sustainable prosperity in Europe. Transport provides citizens with essential means of mobility and contributes to employment, growth and global exports. The European transport industry represents 6.3% of the Union's GDP and employs nearly 13 million people.

However, our transport systems and habits are too dependent on oil, which will become scarcer and is a serious polluter of our planet. Transport accounts for about 63% of oil consumption and 29% of all CO2 emissions.

Unless the present trends are corrected, the economic costs of traffic congestion will increase by about 50% by 2050, the accessibility gap between central and peripheral areas will widen and the social costs of accidents and pollution will continue to rise." [32]

Intelligent Transport Systems is playing a crucial role to achieve the main European objectives for transport safety and sustainability. ITS in road transport and linked with other modes increases safety and capacity through higher interoperability and better use of the existing infrastructure, with subsequent financial and environmental benefits. Europe's Horizon 2020 will invest €6.3 billion to address the societal challenge "Smart, Green and Integrated Transport" and ITS is the backbone of the "Mobility for Growth" priority, as it fosters innovation in transport to yield improved mobility solutions [33].

From the private industry perspective, one of the main economic factors is the on-demand economy, and how the Mobility-as-a-Service transport paradigm is responding to this shift from ownership to service access. The on-demand economy currently attracts more than 22.4 million consumers annually being transportation its second biggest category. Thanks to start-ups like Lyft and Uber, it claims more than 7.3 million monthly consumers and US$5.6 billion in annual expending [24].

This is also affecting the automotive sector where industry OEMs (Original Equipment Manufacturers) are focusing in generating service models such as car-sharing and new mobility concepts that change the ownership of vehicles. This change in end-users' markets towards car ownership has a big impact in innovation management and business strategy in these companies.

For example, if we consider car-sharing, Europe being the biggest market and China holding the greatest growth potential, we can see the evolution of these services in the following figure:

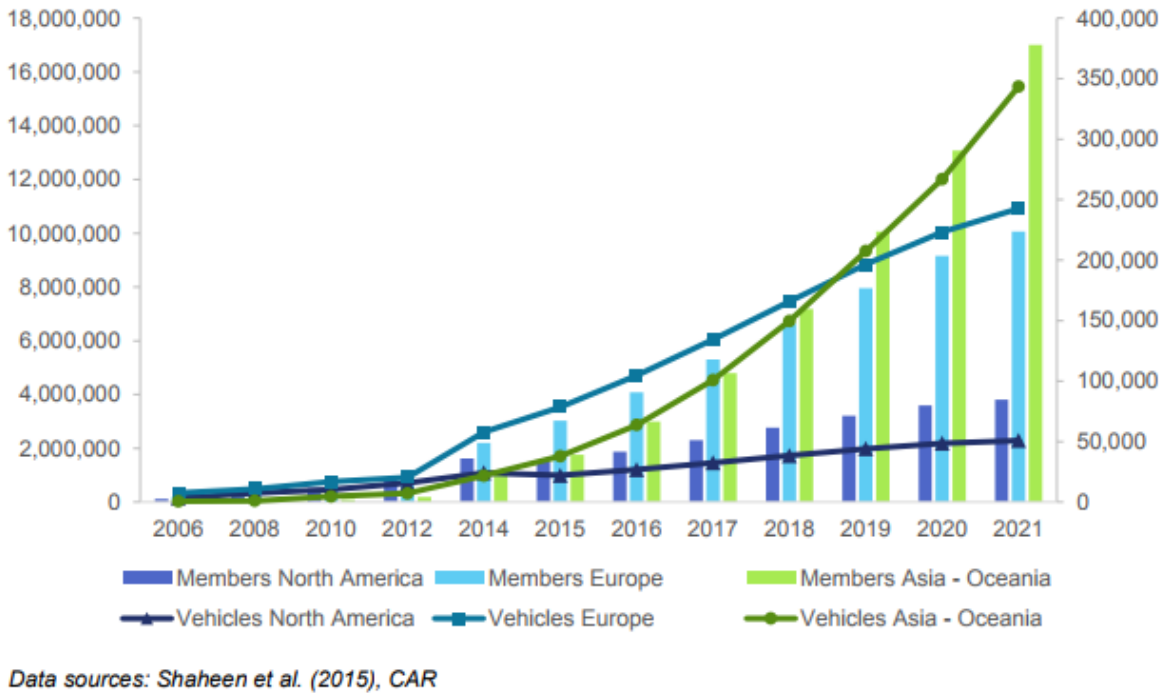

Figure 16 Car-sharing 2006-2014 historic growth and 2015-2021 projections in three regional markets [34]

These new mobility services are pushing vehicle manufacturers to rethink about their existing business models and explore new ones, showing their customers they understand the shift toward on-demand shared mobility and they have new products and services to offer. Last years, automakers have started investing in, partnering with, or acquiring new mobility companies:

Figure 17 Automakers and new mobility companies. Examples of partnerships and investments [34]

Another big factor to consider is the autonomous Mobility-as-a-Service market, where autonomous cars can become the greatest economic transformation since the railroad. Manufacturers like Ford or General Motors have made quick moves to gravitate towards an autonomous strategy. Tesla is the only automaker currently selling consumers vehicles with the hardware necessary to collect autonomous data. Google may have the best performing autonomous car from a technological perspective and is taking steps toward commercialisation with its recently formed entity Waymo [35].

Merger and acquisition activity in the auto industry raised to US$74.4 billion in 2015 and 2016, three times the annual average over the last ten years. The driving force behind this is the pressure to keep up with the shift toward autonomous driving that started not so long ago. Suppliers need the know-how to help cars see their environment much as a human pilot would, which means sensors, cameras and radar, plus the computing power to comprehend the waves of data and share some of it, like traffic conditions, from vehicle to vehicle. In 2014, ZF Friedrichshafen AG[7] bought TRW[8] for US$13.5 billion, took a 40 percent stake in radar supplier Ibeo Automotive Systems GmbH[9] and bid 4.41 billion kronor (US$515 million) to win brake maker Haldex AB[10] away from competitor SAF-Holland SA[11]. Ningbo Joyson Electronic Corp[12], a Chinese supplier to several of the world's largest automakers, agreed in February 2016 to buy U.S. bag maker Key Safety Systems[13] for US$920 million. BMW AG is working with chipmaker Intel Corp. and camera software company Mobileye NV[14] (which sensors are used also by GM and Volkswagen) to bring a car to the road by 2021 that can cruise highways autonomously. Volvo Car is promising the same. Samsung has been talking for a year about acquiring Mageti Marelli[15] from Fiat Chrysler Automobiles. Chip-maker Nvidia[16] is outpacing Intel producing extremely powerful processing units used by Audi and Tesla [36] [37].

Social Factors

Transport in Europe is fundamental to the economy and society. Mobility is vital for growth and job creation and the transport industry directly employs around 10 million people and accounts for about 5% of gross domestic product (GDP). Effective transport systems are key to European companies' ability to compete in the world economy. Logistics, such as transport and storage, account for 10–15% of the cost of a finished product for European companies. The quality of transport services has a major impact on people's quality of life. On average 13.2% of every household's budget is spent on transport goods and services [38].

[7] https://en.wikipedia.org/wiki/ZF_Friedrichshafen
[8] https://en.wikipedia.org/wiki/TRW_Automotive
[9] https://www.ibeo-as.com/
[10] https://en.wikipedia.org/wiki/Haldex_(company)
[11] https://safholland.com/
[12] http://en.joyson.cn/
[13] http://www.keysafetyinc.com/
[14] https://www.mobileye.com/
[15] https://en.wikipedia.org/wiki/Magneti_Marelli
[16] https://en.wikipedia.org/wiki/Nvidia

Road congestion is one of the big problems for the society, mainly derived from the urbanization. In 2007, and for the first time in the history, more than half of the world population lived in cities and, by 2050, the percentage is expected to increase to 70%, according to the UN Environment Program (UNEP).

Official estimates show that “road congestion costs, including commuting and leisure traffic as well as business and freight traffic, amounts to an average 1 percent of GDP in the European Union, with Britain and France at 1.5 percent.” Over the past decades, transport has increased in line with economic growth but there is an obvious need to cope with growing demand: where real GDP grew by 2.4 % per year in the period 1995-2006, freight transport growth in EU-27 has been 2.8 % per year and passenger transport growth 1.7 %. Freight transport demand has increased more strongly for modes offering greater flexibility, in particular road transport (1995-2006: road freight +3.5 %, passenger +1.6 %). The increase of traffic demand has led to bottlenecks in corridors crossing densely populated areas and sensitive areas such as the Alps and the Pyrenees. More infrastructure is not a solution, especially not in the short term given the long planning and construction times for new infrastructure and the need to minimise capacity reductions caused by maintenance and local upgrades [39].

Another social key factor is the **climate change**, where transport in general and road transport in particular has a significant impact. All sectors but transport have lowered emissions since 1990 but in 2012, transport emissions were 14% above 1990 levels and accounted for about 19% of the total EU, making it the second largest source after the energy industries.

Emissions from the transport sector showed a continuous growth between 1990 and 2007; followed by a slight dip (-6 %) between 2007 and 2011. This downward trend is, however, considered to be mainly due to the economic recession [40].

Even when the European roads remain the safest of the world, **safety** is also an important social factor. In 2016, the EU counted 50 road fatalities per one million inhabitants, against 174 million deaths per million globally.

Last year marked a turning point in reducing road fatalities: after two years of stagnation, the number of those who lost their lives on the roads was reduced by 2%. 25.500 people were killed in 2016, 600 fewer than in 2015 and 6.000 fewer than in 2010. This represents a 19% reduction over the last six years [41].

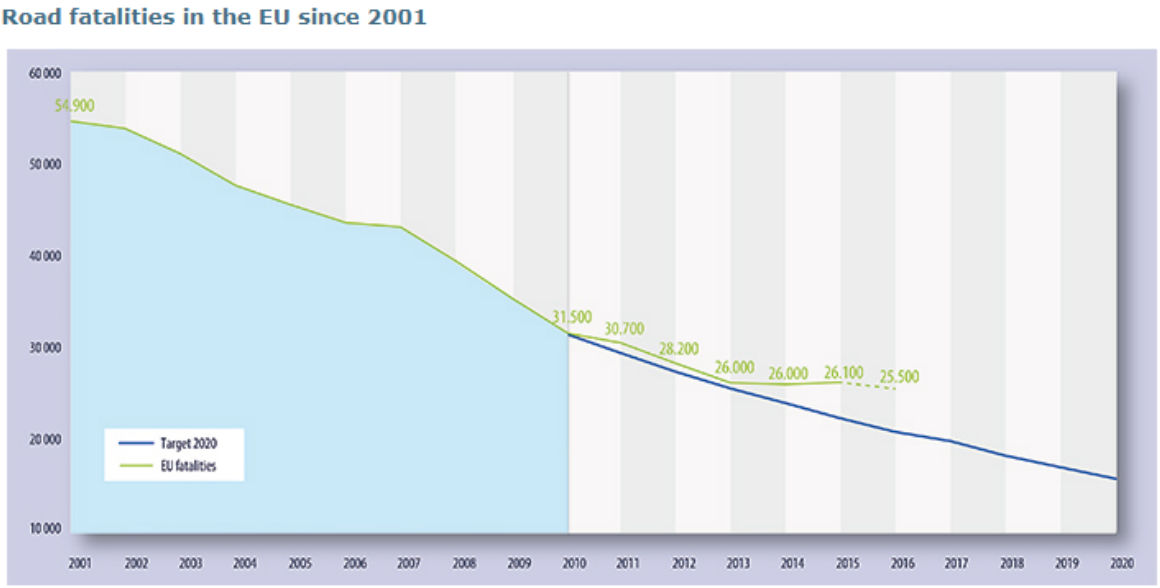

Figure 18 Road fatalities in the EU since 2011 [41]

For every person killed in traffic crashes, many more suffer serious injuries with life-changing consequences. Serious injuries are not only more common but are also often costlier to society because of the long-term rehabilitation and healthcare needed. Vulnerable road users, such us pedestrians, cyclists, motorcyclists or elderly road users, are especially affected [41].

Technological factors

Wold-wide technological innovation is contributing to a growing demand of new mobility services. Digital technologies are one of the strongest drivers of this growing demand, allowing to exchange data between different actors in the transport system and therefore matching supply and demand in real-time.

The US ITS Strategic Plan 2015-2019 presents the new sets of priorities, strategic themes and program categories under which ITS research, development and adoption activities will take place. It defines two primary strategic priorities – realizing connected vehicle implementation and advanced automation, in line with the overall USDOT strategic priorities that focus on increasing safety, enhancing mobility, limiting environmental impacts, and promoting innovation and information sharing [42].

In the same line, the European Union has already made substantial funding (co-funding over 130 million EUR) available for cooperative, connected and automated vehicles. For more than 15 years, research and deployment projects have proved the feasibility of C-ITS services. More recently, under the European horizon 2020, research into Intelligent Transport Systems has sifted focus to the integration of transport modes and the links with automation. In the context of the Strategic Transport Research and Innovation Agenda, the Commission is developing a roadmap on connected and automated transport to steer and coordinate future R&I activities in Europe [43].

On the policy for highly automated and connected vehicles, a great effort is done involving authorities' bodies, non-governmental organizations, industry stakeholders and Commissioners to look at the future of the automotive sector. The outcomes are expected to help the automotive sector take advantage of digital developments such as the Internet of Things, Big Data, the telecoms policy and digitalisation of industry, and have already resulted in a commitment from both industries to form new alliances and start experimenting with 5G technologies [43].

In terms of technology, the European Commission has identified issues to be tacked at EU level [43]:

- Security of communications. As the transport system becomes more and more digitised, it may also become more vulnerable to hacking and cyber-attacks. The cyber-security of communications is therefore critical, and requires action at European level. A common security and certificate policy 17 for the C-ITS deployment in Europe needs to be developed.
- Privacy and data protection safeguards. Protection of personal data and privacy is a determining factor for the successful deployment of cooperative, connected and automated vehicles. Users must have the assurance that personal data are not a commodity, and know they can effectively control how and for what purposes their data are being used.
- Communication technologies and frequencies. A hybrid communication approach is needed, i.e. by combining complementary communication technologies the communication messages should be unaware of, and thus flexible about the communication technology used, easing the inclusion of future technologies (e.g. 5G and satellite communication). Currently, the most promising hybrid communication mix is a combination of ETSI ITS-G5 and existing cellular networks.
- Interoperability at all levels. An integrated transport system relies on the interoperability of its components. That means that systems need to be able to interact with each other, across borders and transport modes, at all levels: infrastructure, data, services, applications and networks.

Automated and connected vehicles can reduce the energy consumption and emissions; the Digitising European Industry Strategy identifies cooperative, connected and automated vehicles as a priority topic for boosting the competitiveness of the European industry. Communication between vehicles and with the infrastructure will increase the safety of automated vehicles. Cooperation, connectivity and automation are technologies reinforcing each other and will merge in the near future.

Environmental factors

Transport represents almost a quarter of Europe's greenhouse gas emission and it is the main cause of air pollution in cities. In this regard, road Transport is still responsible for over

[17] The common security and certificate policy documents will, for instance, define the European C-ITS Trust model based on Public Key Infrastructure.

70% of transport greenhouse gas emissions and much of the air pollution. Low-emission mobility is an essential component of the broader shift to the low-carbon, circular economy needed for Europe to stay competitive and be able to cater to the mobility needs of people and goods [44].

Over the 1990-2011 period, emissions from road transport and civil aviation grew by 21% and 17% respectively; while emissions from domestic maritime transport presented a 1% growth. In contrast, emissions from railway transportation fell by 46%. A breakdown by sector shows that road transport has dominated emissions from this sector throughout this period (94% in 2011) [40].

The amount of CO2 emitted per passenger and kilometre for different modes of transport is highly dependent on the type of vehicle, as well as on the load factor. Typical CO2 emissions of air transport are in the range of 30 to 110g per passenger/km, which are comparable to passengers travelling by car or light truck. CO2 emissions per passenger/km from bus or coach transport are significantly lower; usually less than 20g per passenger/km. As concerns rail travel, CO2 emissions depend on several factors, such as the source of primary energy and the load factor, while emissions vary from numbers lower than 5g to a maximum of 50g per passenger/km [40].

The digital mobility solutions and specifically the deployment of Intelligent Transport systems for all transport modes are part of the European Strategy for Low-Emissions Mobility [44] and has become an integral part of the development of the multimodal Trans-European Transport Network.

Legal Factors

On 2008, the European Commission adopted an **Action Plan for the Deployment of Intelligent Transport Systems in Europe (COM (2008) 886)**, which outlines six priority areas and the related measures for speeding up the deployment and interoperability of ITS in road transport across the European Union.

This Action Plan was the basis for the **Directive 2010/40/EU** (the ITS directive) which provides the legal framework for the coordinated and coherent deployment and use of Intelligent Transport Systems (ITS) within the Union, in particular across the borders between the Member States, and sets out the general conditions necessary for that purpose. This is the first EU-wide legislative basis for the coordinated deployment of ITS for the road and for interfaces with other modes of transport.

Article 2 of the Directive defines four priority areas for the development and use of specification and standards:

- Optimal use of road, traffic and travel data.
- Continuity of traffic and freight management ITS services.
- ITS road safety and security applications.
- Linking the vehicle with the transport infrastructure.

Within the priority areas, it defines six priority actions for the development and use of the specifications and standards:

- The provision of EU-wide multimodal travel information services.
- The Provision of EU-wide real-time traffic information services.
- Data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users.
- The harmonised provision for an interoperable EU-wide eCall.
- The provision of information services for safe and secure parking places for trucks and commercial vehicles.
- The provision of reservation services for safe and secure parking for trucks and commercial vehicles.

Article 16 of the Directive establish the creation of an ITS advisory group for close collaboration with stakeholders and Member States: this includes major stakeholders such as ITS service providers, associations of ITS users, transport and facilities operators, representatives of the manufacturing industry, social partners, professional associations and local authorities.

Also, it's worth to mention a standard regulation launched by ISO (International Organization for Standardization) in 2015 in relation to ITS. **ISO 14813-1:2015**[18] is in itself, by its nature, advisory and informative. It is designed to assist the integration of services into cohesive reference architecture, plus interoperability and the use of common data definitions. Specifically, services defined within the service groups shall be the basis for the definition of "use cases", "user needs" or "user service requirements" depending on the methodology being used to develop the resultant ITS architecture, along with the definition of applicable data within data dictionaries, as well as applicable communications and data exchange standards.

[18] https://www.iso.org/standard/57393.html

3 Case studies market & stakeholders analysis

3.1 Framework for the market research of the NEWBITS Case Studies

3.1.1 Representativeness of the NEWBITS case studies in the (C-)ITS market

As it was described in WP2, the most important characteristics of the NEWBITS case studies are the capability of creating a network of stakeholders (key for the development of future work in both this and later work packages) as well as the willingness of the stakeholders to actively participate in the project. All four NEWBITS case studies fulfil these requirements.

Along with this, the case studies fully cover the different ITS market segments (by type market segmentation as it was selected as representative for the project) as it is depicted in the following table:

	ATMS	ATIS	ATPS	APTS	CVS
CS1	X	X			
CS2	X	X	X	X	X
CS3	X	X			
CS4	X	X		X	X

Table 1 Coverage of the ITS market segments (by system) by the NEWBITS case studies

The NEWBITS case studies also cover (or are potentially really close to it) big part of the ITS market trends listed in section 2.3 of this document such as connected vehicle (CS2, CS4), big data (CS1, CS2, CS3, CS4) and smart cities (CS1, CS2, CS4)

The specifics for each case study showing their potential for the market penetration:

- **Case study 1:** represents a good opportunity for NEWBITS project to take and explore as an example of advancing ITS applications and applying them in social services which can benefit city communities. For the purpose of WP4, aiming at developing sustainable business models, the case study could expand the market to a national level as it could be implemented in other university campuses, cities or industrial zones.
- **Case study 2:** this case study has a clear business model already defined and localised but it has a great potential of being extrapolated to other municipalities and therefore reaching many other drivers and road transport operators. The most interesting part is not only its scalability but also the implicit potential of growth through the creation of future value-added services by third parties which could both re-shape the current model and create new opportunities offering these services to citizens and industry and thus generating a variety of new business models.
- **Case study 3:** the case study is a B2B solution aiming at providing an overall improvement of the supply chain in freight transport (containers) from the sea to the hinterlands. The case study has great opportunities of commercialisation and is pretty open in the services it can offer to different customers, with high chances of customisation and different potential business models (fee-for-service, integration, service customisation, value added services, data exploitation, etc.).

- **Case study 4:** similarly to case study 2, this case study is much localised but right now it only covers part of the complex and large railway network in the UK. It offers the potential to enter the market expanding its services to other railway lines in the UK (which is already a big market itself) and some of the components could be used in other countries too, creating (even with a reduced scope) potential business models / opportunities outside UK.

3.1.2 Framework

The methodology for the market and stakeholders' analysis has been shared in all four case studies in their different steps except for those in which their own nature make them different (mainly the definition of the demand and supply side within the market analysis).

This report includes the following parts per case study:

- **A case study definition**, so the reader can have an idea about the basics of the case study without needing to consult the taxonomy developed in D2.3 [45].
- **A market analysis**, including:
    - An overview of the current and potential market, showing general market information in order to shape the landscape of the market closer to the case study.
    - A Segmented analysis definition of the market demand and supply side, identifying the different actors in both sides and showing their relation and potential market penetration. In this step, given the different nature of the case studies (CS1 and CS2 are more B2C oriented meanwhile CS3 and CS4 are B2B) each of them has followed different approaches based in the characteristics of the supply and demand side for the case study.
    - A PESTEL analysis, complementing the general (C-)ITS PESTEL analysis in section 2.4 with the specifics of the case study.
    - A SWOT analysis, evaluating the strengths, weaknesses, opportunities and threats of the case study.
- **A stakeholders' analysis**, including:
    - The identification of the case study stakeholders' groups, creating an inventory of organizations, institutions, etc. having some relationship with the case study.
    - Identification of the stakeholders' interest and characteristics, selecting the specific stakeholders from each group and extracting information through interviews. Each stakeholder has been defined by:
        - Stakeholder name
        - Stakeholder group
        - Stakeholder definition
        - Role
        - Interests/Objectives
        - Needs
        - Cost structure
        - Revenue model
        - Outputs
        - Inputs

This detailed information about each stakeholder can be found in Appendix 1 Stakeholders interest and characteristics.

- Assessment of the stakeholders considering their importance and influence, based in the information gathered from each stakeholder. Each stakeholder has been evaluated using the following criteria:
  - Influence
    - High Influence (H): other stakeholders always consider the opinions, wishes and issues raised by this stakeholder. The stakeholder usually has a clear opinion.
    - Medium influence (M): other stakeholders sometimes consider the opinions, wishes and issues raised by this stakeholder. The stakeholder offers and opinion if asked for it.
    - Low influence (L): other stakeholders barely consider the opinion of this stakeholder or the stakeholder rarely expresses an opinion.
  - Importance
    - High importance (3): the success of the case study can't be reached without the involvement of the stakeholder.
    - Medium importance (2): the success of the case study is possible without the stakeholder but it will experience significant difficulties or the case study will not be as successful as it was initially envisioned.
    - Low importance (1): the success of the case study is possible without the stakeholder but the majority of the other stakeholders would prefer this stakeholder to be involved.

  Considering the result values of this evaluation, a visual diagram was created and the stakeholders were classified in primary, secondary and tertiary stakeholders.

- Mapping and characterising relations and dependences between stakeholders, creating a visual diagram and explaining the interrelation between stakeholders as well as the value flows.

- **A competitors' assessment**, where the main features for the case study are listed in order to identify the actors which are providing similar services/products and could potentially compete with them. The most relevant competitors have been selected from the full list included in the Appendix 2 Competitors identification
- The resulting **value chain**[19] of each case study based in the information gathered in the market and stakeholders' analysis.

[19] Porter, Michael E. (1985). Competitive Advantage: Creating and Sustaining Superior Performance.

3.2 Case Study 1

3.2.1 Definition

After a failed attempt to recover administrative support from two municipalities in the Barcelona province in deploying a sustainable intercity mobility solution, University VaoPoint Mobility (CS1) offers a second level carpooling service for access to university campuses. CS1 aims to increase the average occupation and achieving a rational use of cars in a university environment with high levels of daily influx of private vehicles. It offers an intelligent carpooling service for daily mobility to the campus, where members of the university community can access numerous carpooling offers. In addition to traditional cost savings on sharing transportation expenses, VaoPoint promotes the reduction of users' carbon footprint and decrease traffic congestion by promoting high-occupancy vehicles.

The project initiated by an SME (Aslogic) has been piloted in its first city trial/deployment to members of the university community at the Autonomous University of Barcelona (UAB) for access to the campus. UAB's mobility plan includes promoting collective transport, journeys by bicycles as well as achieving more rational use of private vehicles matching the goals of VaoPoint. UAB campus get filled up with over 13,000 vehicles of a very low occupation index: 1.2 people per vehicle - the same average as that of the metropolitan region of Barcelona. CS1 primary objective is to reduce the number of cars accessing the campus, which in turn reduces users' carbon footprint (CO2) and pollution.

The innovative platform was jointly developed by Aslogic and the Logistic and Aeronautics unit of the UAB under the Framework Programme 7 EU-funded project "frontierCities"[20]. "frontierCities" aims to promote the use of FIWARE technologies (through the awarded projects) and the uptake of developed mobility applications as well as to support SMEs and start-ups to develop Smart Mobility applications for cities across Europe[21].

CS1 objectives rely mainly on three aspects:

- Efficiency: Matching users to vehicles and minimising as much as possible trajectory deviations.
- Comfort: Encourage social preferences matching of users, avoid campus pathway bottlenecks and guarantee access to parking area.
- Environmental issues: Reduce the carbon footprint (CO2) and pollution as a result of the reduction in the number of cars used.

These objectives have been validated at the UAB with a measurable impact of an increase in car occupancy factor. This in consequence, has reduced the number of vehicles accessing the campus facilities through different control systems, in which a real-time information sharing mechanism is critical for the robustness and resilience of the ITS service. CS1 proposes a differential innovation, since it introduces a new service in an existing market that can reduce the flow of vehicles into the university campus, but also can be applied to other transit scenarios with similar problems outside of the University such as interurban mobility and industrial parks.

[20] Source: fronierCities|VAOPOINT
[21] http://www.fi-frontiercities.eu/frontiercities-2

3.2.2 Market analysis

3.2.2.1 Analysis of current and potential market

Car-sharing market potential has increased recently as a result of expansive sharing economy. For instance, total global revenue for car-sharing services is forecast to reach US$6.5 billion by 2024, with the Asia Pacific region taking the largest share at 34 percent. Europe continues to be a very strong market with an estimated 32 percent of the total. Car-sharing services revenue in North America is expected to drop to 23 percent of the global total by 2024. Latin America, the Middle East and Africa continue to lag behind in this industry [46].

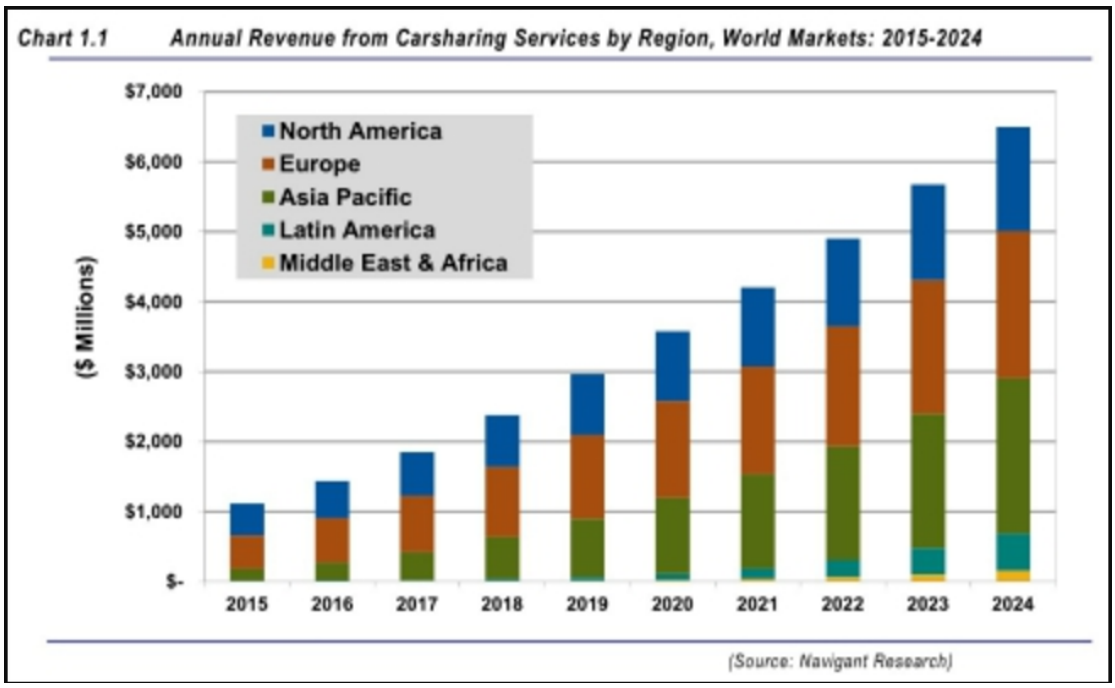

Figure 19 Geographical distributions of revenues from car-sharing

3.2.2.2 Segmented analysis definition of market demand and supply side

The pilot of VaoPoint took place at the UAB main campus in Bellaterra (Barcelona, Spain). UAB has developed and is implementing a mobility plan promoting collective transport, journeys by bicycles as well as achieving more rational use of private vehicles matching the goals of VaoPoint.

Demand side

The most relevant information regarding the demand side are summarised in the following table:

DEMAND SIDE	Numeric Answer	Explain if necessary
Students number		

DEMAND SIDE	Numeric Answer	Explain if necessary
Number of existing students (academic year 2016/17)	46,769	Registered students
Number of upcoming students (academic year 2017/18), Increase (+) Decrease (-) No change (0)	0	The admission quota is not expected to undergo any drastic changes in the following years
Employees number		
Total Number of employees	6,024	
Number of admin employees	2,348	
Number of academic staff	3,676	
Numbers of vehicles used	13,000	
Index of occupation	1.11	

Table 2 CS1 details about the demand side

The demand, outlined by the pilot scheme, varies depending on the user group whether these are students, administrative staff, or academic staff working in the university, which depends heavily on work/class schedule. There is a high demand among the administrative staff group because they mostly share the same schedule and as such, find it easier to carpool. However, the administrative staff only constitutes a small percentage of the total population, just over 2,000. On the other hand, there is practically no demand in the academic staff group because of their spontaneous work schedule and possibly better income. Naturally, the student group constitutes the highest demand by virtue of their population (over 40,000), and not because of their class schedule, which in most cases can be sporadic.

Supply side

The most relevant information regarding the supply side of the case are summarized in the following table:

SUPPLY SIDE	Numeric Answer	Explain if necessary
Campus size	262.6 hectares	Bellaterra (main campus)
Number of campuses (1 or 2)	6	Main campus is only considered with the most academic activity

SUPPLY SIDE	Numeric Answer	Explain if necessary
Parking sizes of campuses	9.6 hectares	Parking areas
Number of vehicles	39,790	A daily average of 39,790 vehicles enter and leave the campus
	47,499	Working day average
	20,519	Holiday average
Ownership of cars	46.1%	Of university community owns a car
Expected increase of vehicles' numbers	0	
Expected increase of campus size	0	
Revenues from offered services		Revenues are generated through a licencing model. Platform developer obtains revenues via its licence. No revenues for the university (free parking space in the campuses)
Costs(one off payment)	€8,639.40	UAB bought an initial single licence; Parking space – no maintenance expenses; Software maintenance at present is considered a recurrent cost that could be shared between university partners. It is not considered the cost of adapting routers to extend the matching service.
Which routes (please explain)	To and from the university campus from any origin or to any destination	Popular destinations: Barcelona, Sabadell, Terrassa, Sant Cugat, Cerdanyola del Valles

Table 3 CS1 details about the supply side

From this table, we can see that the supply for car-sharing has a huge potential to expand, the parking areas are nearly 10 hectares and the daily average of cars entering and exiting

them is a little bit less than 40,000 as a total number of cars that enter or exit per day. The level of private ownership of cars is also very high 46.1%, but 53.9% of the university community do not own a vehicle. Technically, the car-sharing as an offered service should be gradually becoming a more popular means of transportation in the future, since any increase in cars entering the university's campuses (above 40,000) would not find a parking space.

In more details, CS1 presents a case where the supply curve for parking seats is inelastic and totally vertical, fixed at the size of 9,6 hectares or 39,790 cars parked daily in the main campus of the university. Oppositely, the demand curve is elastic and flexible – students, admin and academic staff work with different work schedules – this theoretically would allow a high degree of utilisation of the carpooling services. In practice, it seems to be more complex as it may require a change of consumer choices. If we consider the students to be the main customers of the carpooling services (46,769), the parking equilibrium appears to be at the number of daily parked cars, 39,790 in the campus, or nearly a car per student. This is illustrated also by the low Index of Occupation (1.11), which provides an evidence of no external factors at the moment to push up students to change their consumer choice of a transport mode. In addition, a proportion of the students would be using the public transport too in order to reach the campus. So, there are four alternatives:

I. Using a private car on themselves.
II. Using public transportation (buses, trams, metro system).
III. Cycling and walking.
IV. Car-sharing.

Potentially the car-sharing could utilise over 13,000 cars (see demand side table), where students or admin staff of the university may share a car to reach the campus.

Demand and supply relationship

In order to demonstrate both curves on a diagram, the simplest case is taken into consideration – the supply curve is inelastic (in blue) and the demand curve is elastic with q^o the optimal number of cars parked (the equilibrium parking space on a daily average basis). Since there is no charge for the services, both curves will cross at price equal to 0. In this case, the only option to generate revenues is through decreasing the supply to less than q^o, or move the supply curve to the left (in black) to decrease the parking space. If the supply is increased beyond the current optimal level, to boost demand further, the demand curve will cross the supply curve in the negative areas, which means that to stimulate customers the firm will have to pay them monetary fees.

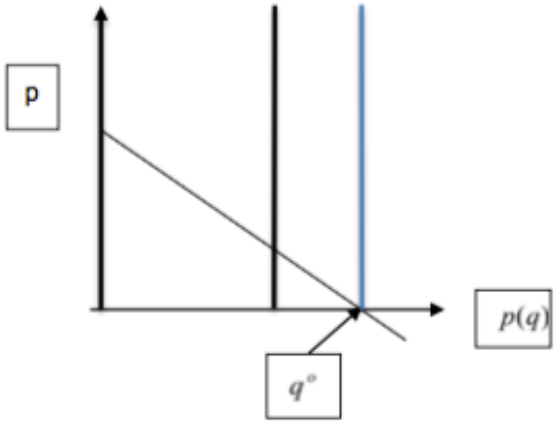

Figure 20 CS1 Demand and supply curves

It appears in CS1 that a way to stimulate any increase of car-sharing demand is via rewarding the users of this service. The Autonomous University of Barcelona, mobility unit, have established a rewards model without any monetary compensation, purely based on a guaranteed parking space (see rewards model figure). This is still an incentive for the users to utilise the carpooling services, but does not seem to be sufficient to attract more vehicles that can be used by 2-3 students together.

Rewards Model	
	Guaranteed/reserved parking space is the only reward offered at the time of pilot
Points collected	0
Monetary rewards (Euro)	0
Timing (24/7 or less)	Study/working hours
Fee charges (Euro)	0

Figure 21 CS1 rewards model

As this CS1 is still at a piloting level, the main stakeholder Aslogic, is expected to provide data justifying the real impact of the services. Changing customer choices is a complex process, and sometimes it requires marketing and public campaigns. For the purposes of the pilot, a social marketing campaign was designed and executed by one of the stakeholders, Websays, using a social net management tool. They deployed an active listening tool to analyse social media data on topics related to carpooling. Other communication plans for the pilot includes posters, flyers, leaflets and email communications at university's campuses.

Target market

The approach taken in this section considers the need for any business to understand the structure of their markets, what the local customers need or require. In particular for CS1, its

pilot deployment at a specific environment (university campus) and in a specific location (Barcelona, Spain), bring the need to have a clearer view on the demographics of Spain.

Considering the innovative platform was developed under the umbrella of "frontierCities", this pilot can be re-implemented in other university campuses, Spanish cities or industrial zones. Therefore, the customer groups will be analysed on a national level to expand our knowledge about the population classification and target groups.

Callcredit Information Group in the United Kingdom produces CAMEO Tables[22] that cover countries of Europe, and internationally, providing detail information that allows consumers to be classified consistently across markets. The segmentations are done on demographics and social factors. In addition, they produce a single global classification and specify 25 different consumer types on the basis of two key factors – life-stage and affluence (income).

The CAMEO Tables for Spain (South Europe, see Appendix 3 CAMEO tables) provide a more dynamic picture of the local population. There are distinctive differences between the North and South of Europe. The tables are based on data from the latest Spanish Census at Census Tract level. It has been designed at a small area level. The applied variables are:

- Presence of adults aged over 60, presence of children.
- Household size; Occupation; House size; Housing costs.
- Income focus and Education.

They have identified 10 key groups:

Key Group	***Description***
Group 1	Affluent Urban Neighbourhoods
Group 2	Wealthy Households nearing & enjoying retirement
Group 3	Affluent Family Neighbourhoods
Group 4	Comfortable Home-owning Neighbourhoods
Group 5	Comfortable Households nearing & enjoying retirement
Group 6	Comfortable mixed tenure households
Group 7	Less affluent mixed households
Group 8	Less affluent mature households
Group 9	Poorer family neighbourhoods
Group 10	Poorer mature rural communities

Table 4 Market segments of Spain (source: CAMEO Spain)

To identify customer groups and their needs usually one can differentiate by a range of factors such as:

- Differentiated by income;
- Differentiated by age;

[22] See at: www.callcredit.co.uk

- Differentiates by sex (male or female)
- Differentiated by household groups, ethnic groups or urban/rural population.

The methodology applied in CS1 for defining the customer groups (see **Table 5 CS1 Spanish customer target groups**) is based in the CAMEO division of Spain since the most important factors would be the presence of children, their age group and income levels as a potential increase of the forthcoming student market.

Key Group (% of total)	***Description***	***Presence of Children***	***Income Levels 100=average***
Group 1 9.15%	Affluent Urban Neighbourhoods	Very High, 0-9 years old	About 130
Group 2 12.03%	Wealthy Households nearing & enjoying retirement	Below Average, 0-9 years old	About 126
Group 3 9.19%	Affluent Family Neighbourhoods	Above Average, Mixed	About 118
Group 4 4.13%	Comfortable Home-owning Neighbourhoods	High, 5-14 years old	About 113
Group 5 14.82%	Comfortable Households nearing & enjoying retirement	High, 5-14 years old	About 105
Group 6 15.13%	Comfortable mixed tenure households	Average, 0-9 years old	About 101
Total Above Average: 65%	From Gr. 1 to Gr. 6	Above statistical mean	101 - 130
Group 7 10.44%	Less affluent mixed households	Average, Mixed	About 97
Group 8 9.69%	Less affluent mature households	Average, Mixed	About 91
Group 9 10.05%	Poorer family neighbourhoods	Average, Mixed	About 80
Group 10 5.38%	Poorer mature rural communities	Below Average, Mixed	About 50
Total Below Average: 35%	From Gr. 7 to Gr.10	Below statistical mean	50 - 97

Table 5 CS1 Spanish customer target groups

The first six groups have income levels of above nation average, which means a higher propensity to move or commute, and with a presence of children above nation average which creates the foundations for a potential increase of student markets in the future. As there are also foreign students in Spain coming from other EU-member states, the growth potential for the local university sector appears positive because on top of foreign flows of students, there is about 65% of the total population that live with means above average. The last four groups are characterised by income levels below nation average and the presence of children is around average or below, in total these four groups constitute about 35% of the local population. Their propensity to commute is limited, so their children could be more open to car sharing or using public transportation.

3.2.2.3 PESTEL analysis

CS1 presents a case where the establishment of analysed market niches is institutionally driven in order to improve urban mobility and reduce CO2 emissions. National and European institutions envisaged this market opportunity of boosting the implementation of ITS apps and fostering a change in cities' consumers' behaviour. It illustrates how the political, economic, social and technological factors can be entangled to solve every-day mobility issues.

This section will refer to the U-MOB Life Project23 in which the UAB (Universitat Autonoma de Barcelona) is a partner, and it is based on the "European strategy on urban environment" and Frontier Cities24, They supported the pilot project to promote the use of FIWARE technology, a platform created by the EU, and supports SMEs to develop Smart Mobility applications for cities across Europe25.

Another initiative relating to the university communities in Spain is Conference of Rectors of Universities – CRUE Spain, which assesses universities in Spain in terms of their contribution to sustainability and social responsibility. It enforced a system of indicators to measure the progress of Spanish universities when it comes to their environmental and sustainable activities. About 31 universities participate in this framework[26].

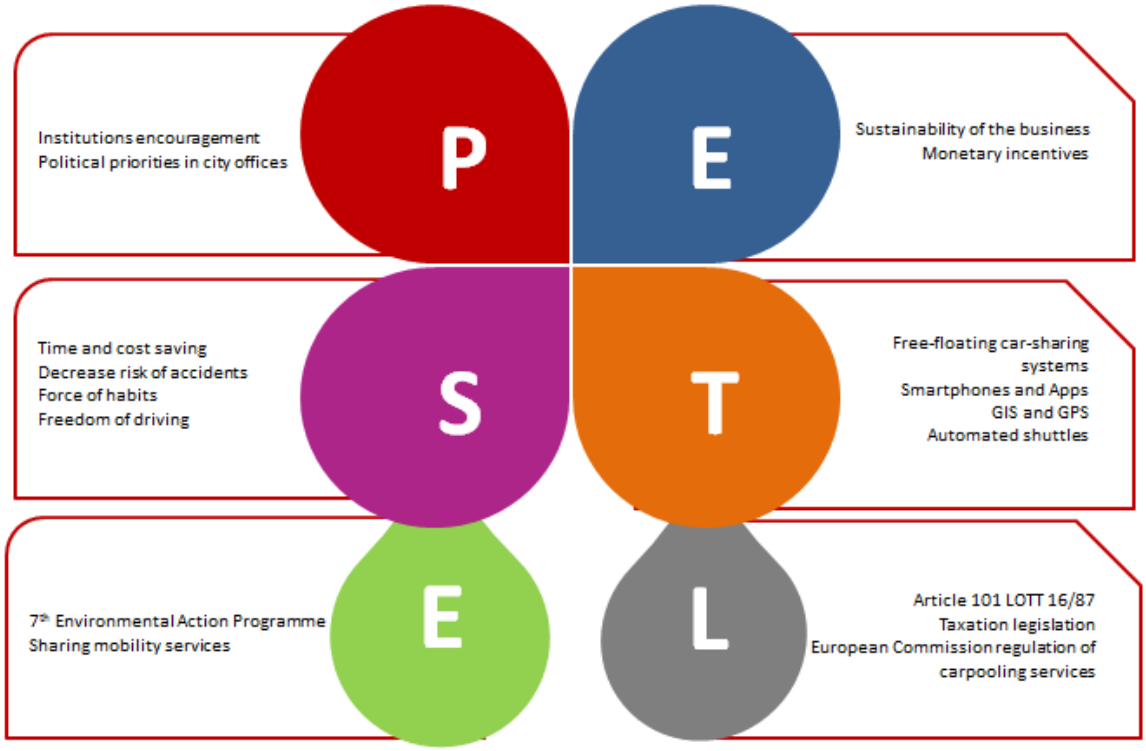

Figure 22 CS1 PESTEL

[23] http://u-mob.eu/project/
[24] http://www.fi-frontiercities.eu/
[25] http://www.fi-frontiercities.eu/single-post/2016/10/04/FIWARE-technology-supports-a-Belgian-SME-in-monitoring-air-pollution-in-Brussels-%E2%80%93-and-exp
[26] http://crue.org/Sostenibilidad

Political factors

The CS1 presents a case where the establishment of the analysed market niche was institutionally driven in order to improve urban mobility and reduce any CO2 emissions. National and European institutions envisaged this market opportunity of boosting the implementation of ITS apps and fostering a change in cities' consumers behaviour.

Unfortunately, the initial pilot originally intended as an intercity solution was halted due to the change in political power after the municipal elections in Catalonia. As a result, the project lost institutional support in Barcelona and Sabadell municipalities, which were the primary clients. Since the pilot project was supported by frontierCities, it was no longer plausible to align the commercial needs or calendar of frontierCities with new rounds of meetings to recover the required local administration support.

Therefore, it was decided to develop and deploy a second version of the platform dedicated to a university community (UAB in this case) having a high influx of private vehicles. Partially this was fostered by the CRUE framework, which requires from all universities to improve their environmental performance. While the pilot trial was focused at the UAB main campus, the environmental agenda is global.

Naturally, political priorities in City Offices often are difficult to influence and change, however, this pilot trial was benefited by the CRUE Spain priorities. It also adds value to the results and encourages its replication in other European cities.

Economic factors

Economic barriers to carpooling services would relate to the sustainability of the business. Therefore, the incentives provided to the customers or in CS1 the rewards model are essential for the viability of this market. Since the pilot trial used a rewards model without any monetary compensation, the case per se does not show how critical this rewards model is. However, another campus – Sabadell, where the pilot was extended to – provided evidence of an economic obstacle to the rewards model as free parking spaces were easily available outside the university campus. This campus is situated in a suburb area where car parking appears to be unproblematic. To avoid such obstacles, the rewards model will have to provide monetary incentives, so that students are still attracted to car-sharing and as such decreasing carbon emissions.

Social factors

In CS1, the customers' attitude to the carpooling services does not constitute any barrier to the market entry of new providers of this service. If any, it will only make the existing competition more severe, but the customers' attitude will not stop companies from entering this market.

In a more general landscape, car-pooling would positively affect social warfare by [47]:

- Abating level of emissions of polluting agents (mainly CO2) thus partially reducing both the environmental problems and the health diseases which are significantly correlated with the emissions.
- Abating the number of circulating vehicles, especially in peak-hours, to and from the city centres, restoring conditions for more effective public transports.
- Reducing road congestion and average waiting time in traffic jams, thus saving a significant amount of time currently wasted.
- Decreasing the aggregate risk of car accidents and enhancing safety in car circulation.
- Curbing the exponentially increasing need for new parking places in the cities and, more generally, for bigger and larger road infrastructures, with savings in social costs.

Social benefits from a behavioural perspective could be the changes in cultural and social habits or in people's mentality. The force of habits and the psychological satisfaction from driving, the sensation of feeling free are social and irrational human behaviours working against a more extended car-pooling practises [47].

Technological factors

New ICT tools have appeared in the car-pooling market allowing the introduction of free-floating car-sharing systems, which operate without dedicated pick up and drop off stations. Free-floating systems are more flexible, smartphones and the development of dedicated apps allow registered clients to easily locate the closest car of the fleet and then leave it at their final destination. These ITS tools also facilitate payment and access to information. The uptake of smartphones, Global Information Systems (GIS) and Global Positioning Systems (GPS) makes possible to match passengers and drivers. Users book their trips via a platform and pay via a gateway. The use of automation and C-ITS has led to the emergence of new approaches and services such as "robot taxis" or automated shuttles. The European project CityMobil2 proposed an on-demand service transport at the university campus of EPFL in Lausanne[27] via a dedicated mobile app. [48].

Environmental factors

The political importance of urban issues is demonstrated in the "7th Environmental Action Programme" (7EAP)[28], where the priority is that by 2050 the European citizens should be living well, within the limits of this planet. There are a number of environmental activities that go across different Directorates General of the Commission that relate to cities and urban mobility. Unquestionably, the need for any market tool that will reduce the use of private cars and encourage citizens to utilise public transportation or car sharing in the cities is justified as long as it leads to decreasing carbon emissions and improving quality of life. Therefore, the political priorities of the European Commission and the national governments are well stated in policy documents that relate to climate change, greening transportation, urban mobility and smart cities strategies.

[27] http://www.citymobil2.eu/en/City-activities/Large-Scale-Demonstration/West-Lausanne-region/
[28] http://ec.europa.eu/environment/urban/index_en.htm

The European Cities and Regions networking for innovative transport solutions in the European Mobility Week 2017 also expressed their point of view about environmental impact of sharing mobility services [48]:

"*Shared mobility services can make it easier for people to choose cycling, public transport, shared shuttles or a combination of these modes over driving. A vehicle fleet, for example a car-sharing fleet, is more likely to consist of electric, natural gas or hydrogen vehicles than a comparable fleet of privately owned cars.*"

Legal factors

As the UAB manages their properties and campuses, there are no licences or legal issues. The campus is based out of the city and is backed by the following legislation: Article 101 Ley de Ordenación de los Transportes Terrestres 16/87 de 30-7.

Article 101 of the current Spanish Transportation legislation [49]: "Private transportation is qualified as such if it is used for personal or domestic transportation needs of the owner or close relatives. […] Under no circumstances, will the private driver receive any kind of direct or indirect remuneration except for food money or transportation costs".

This legal requirement means that car-sharing services in Spain should not charge any business rates. In the university campuses this is not a problem since universities are "not-for-profit" organisation universally, and during the pilot scheme VaoPoint provided the carpooling options on a volunteering basis. In this respect, as long as the services are offered by the university communities for their own purposes for free, there are no licences and legal issues in Spain. This will be the case anywhere in Europe. The university community members do not earn income from driving their own car and sharing it with someone else, which does not add any issues to dealing with taxation legislation either. There is an advantage now of using existing platforms that make it easier for community members to organise trips to and from the university campuses.

Theoretically once the CS1 becomes operational in the cities or to/from industrial zones in Spain and elsewhere, the car-sharing services will have to be based on the business principles of any commercial legislation. Any "business-for-profit" have to be registered with the Company House or their alternatives institutions in Europe to follow the taxation legislation. Plus, any trades, crafts and taxi services have to be registered with the city hall in the respective city for acquiring licences, which guarantees to the customers certain standards from the offered services. These health and safety standards are usually monitored by the local authorities or any other nationally-based organisation that is specialised for such purposes.

In addition, the European Commission monitors and regulates the carpooling services, which requires: "Service providers should only be obliged to obtain business authorisations or licences where strictly necessary to meet relevant public interest objectives. Absolute bans of an activity should only be a measure of last resort. Platforms should not be subject to authorisations or licences where they only act as intermediaries between consumers and those offering the actual service (e.g. transport or accommodation service). Member States should also differentiate between individual citizens providing services on an occasional

basis and providers acting in a professional capacity, for example by establishing thresholds based on the level of activity"[29].

The European consumer law also ensures that consumers can receive a high level of protection from unfair commercial practices, while not imposing any disproportionate obligations on private individuals who only occasionally provides the services. Generally, the European Commission encourages collaborative platforms to continue sharing information voluntarily to fight illegal content online and improve trust between businesses and consumers.

3.2.2.4 SWOT Analysis

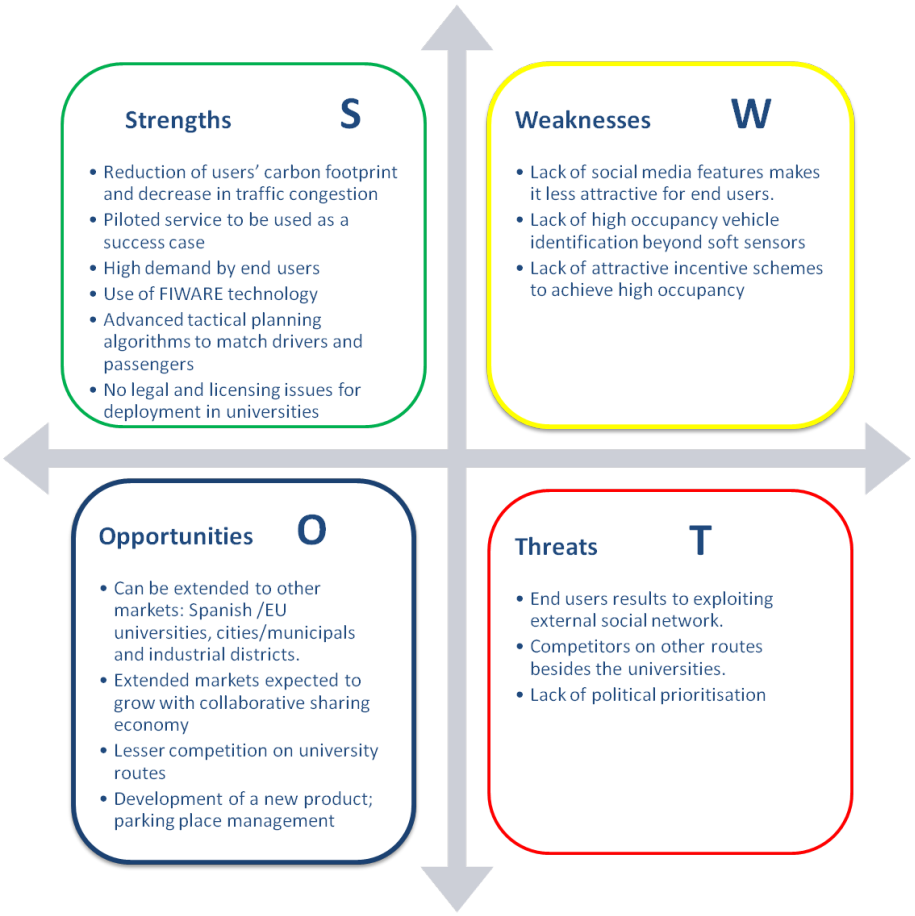

Figure 23 CS1 SWOT

Strengths

- The service intends to reduce carbon footprint of users and decrease traffic congestion by promoting high-occupancy vehicles.
- The piloted service will serve as a success case to be used as a platform to increase the credibility in future dealings with City councils.

[29] "A European Agenda for Collaborative Economy", https://ec.europa.eu/docsroom/documents/16881/attachments/2/translations

- The CS has potential of reaching a high number of end-users at the university level. The market is growing and there is a big demand for this type of services.
- The use of an open standard cloud-based infrastructure (FIWARE technology) for cost-effective creation and delivery of Future Internet applications and services.
- The deployment of advanced planning algorithms used for matching drivers and passengers without the need for users' intervention. It takes into account the social preferences of users and introduces a penalty mechanism to fine deterring users (repeated lateness), amongst others.
- It is not intended to be a for-profit service. Drivers are not expected to make profit from passengers. The platform that makes it easier for community members to organise trips to and from the university campus. Car owners-drivers (university community members) do not earn income unlike the Uberpool etc. having professional drivers that functions more like a taxi service.

Weaknesses

- The service lacks social media features that make it less attractive for end users.
- The service would require high occupancy vehicle identification beyond the soft sensors currently used in the pilot, in order to be able to be deployed in other markets like the industrial districts.
- The reward model on offer, currently based on guaranteed access to parking area is still not sufficient on its own to attract users to the carpooling service. Effective incentive campaigns and reward mechanism must be constantly re-designed and/or adapted to preserve end-users. Reward mechanism should be alive to avoid end-users to exploit the contacts on their own.

Opportunities

- CS1 presents the potential to be extended from university towards other markets such as cities/municipals and industrial districts.
- With the collaborative sharing economy legislation, currently being debated at the EU level, the extended markets are expected to grow which presents a great opportunity for uptake.
- There are a few number of ITS service applications specifically developed for use at the university level.
- With the pilot service linked with access to parking as a reward mechanism, there exists an opportunity for the development of a new product (parking places management).

Threats

- End users results to exploiting external social network after a number of initial contacts with paired-up users.
- Outside the university arena, there is stiff competition with already established services with sound business models offering routes in cities and targeting similar customer groups.
- The potential market for these systems hardly involves the public administration, and in particular the local authorities. Political engagement in these contexts on this kind

of investment is not always guaranteed, but it is necessary to promote policies that foster carpooling services.

3.2.3 Stakeholders analysis

3.2.3.1 Identification of stakeholders' groups, their characteristics and interest

This section aims to identify the relevant stakeholders' group involved in the pilot phase of the case study. Overall, a total of 8 distinctive groups were identified following consultations with the main stakeholders along with the scrutiny of the project document:

- **Cities:** in the context of VaoPoint, cities refer to university governing bodies that make decisions regarding the territorial management of the infrastructure, facilities, and services within the campus. They are responsible for facilitating the deployment of the ITS service by promoting policies to foster carpooling to reduce number of vehicles. A typical university campus shows the same logistic problems as small cities.
- **Transport authority:** in the same context, they act at the same level as a public transport authority within the area of architecture and urban planning charged with the territorial mobility management of the university campus. They promote mobility management within the campus, ensuring the readiness of the campus infrastructure to support effective deployment.
- **Academia:** they act as a catalyst for the exchange of knowledge and innovative research among industry partners, in order to enable technology transfer of research activities in innovative transport solutions to the industry.
- **ITS service providers:** they are considered the enabler of IT solutions in the field of transport, addressing the development and deployment of decision support systems aimed to improve and optimise the performance of transport systems.
- **Funding body:** funders provide financial support to develop smart mobility applications, and help accelerate new research and prototypes into market-ready technologies.
- **ITS associations:** the association is a network of universities' mobility working groups aimed at fostering cooperation between universities, providing universities information to apply sustainable mobility policies, and facilitating the sharing of best practices among its members.
- **Social media marketing companies:** they raise awareness through the social media to engage end users in the pre- and post-deployment in terms of assessment of inventive schemes, acceptability, etc.
- **End users:** these are citizens or businesses that are consumers of the ITS service. On the one hand, the role of end-users in the innovation process is considered paramount, and the importance in tailoring their preferences to the service offering, as well as determining users' acceptability level to facilitate adoption. On the other hand, end users can derive maximum benefit from the exploitation of the service for cost reduction purposes and sustainable mobility.

It should be noted that the potential stakeholders intended to participate in the first phase of the project and those envisaged for the extension of the service to other markets (intercity and industrial district mobility) are also listed without further explanations on their roles and

importance. For these potential markets, other stakeholders that must be considered are municipals, public transport authorities and ICT service providers. The following figure shows the stakeholders' groups involved in the VaoPoint case study.

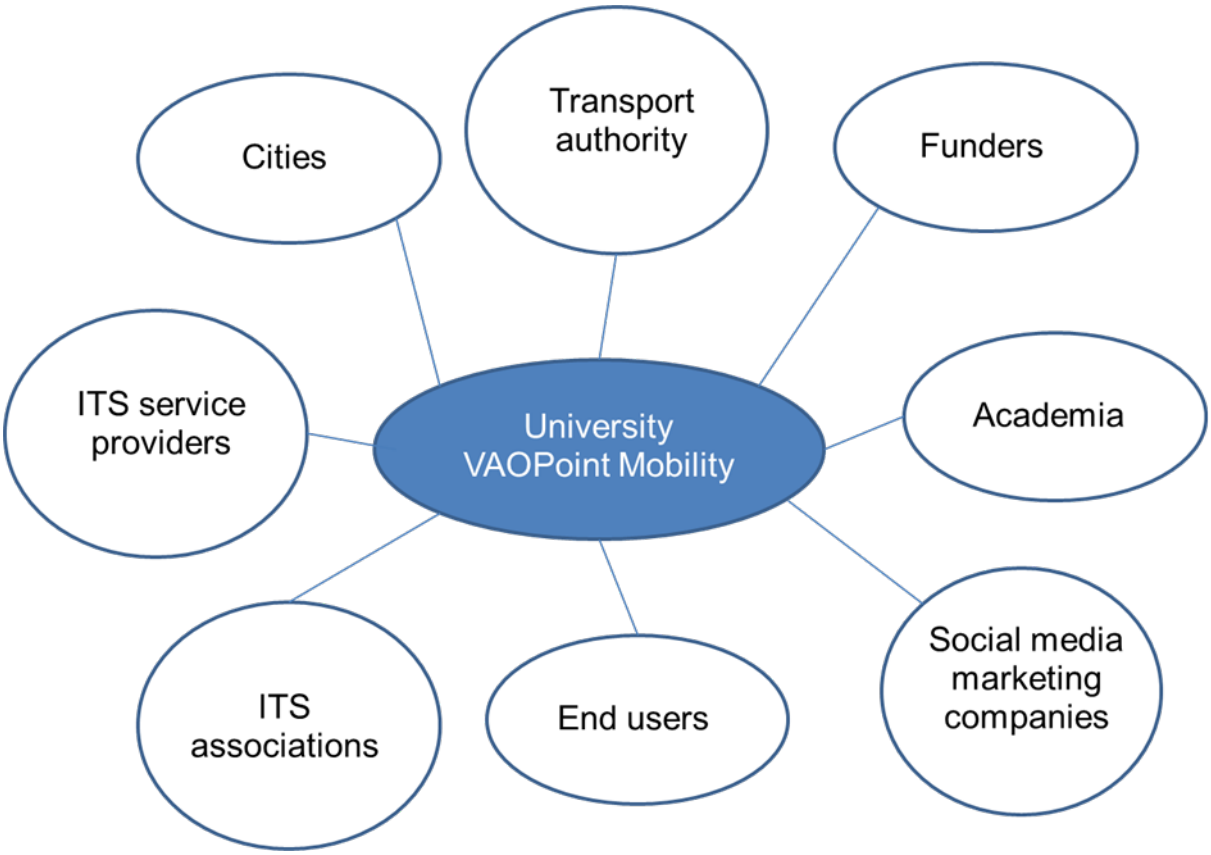

Figure 24 CS1 stakeholders groups

For each of the stakeholders' groups, the specific stakeholders have been identified as follows:

- **Cities:** UAB Management
- **Transport authority:** UAB Mobility Unit
- **Academia:** UAB Living Lab CORE, UAB Logistics and Aeronautics Unit
- **ITS service providers:** Aslogic S.L.
- **Funding body:** FrontierCities
- **ITS associations:** CRUE (Spanish Universities Association)
- **Social media marketing companies:** Websays
- **End users:** Members of the university community (students, administrative staff, academic staff).

FrontierCities does not only provide funds, but also offers technical support and business advice for the acceleration of new research and prototypes into market-ready technologies. Its ambitious services range and offering include:

- A widened Smart Cities scope
- A strengthened Grantee Acceleration Programme

- An Outreach Service to FI-PPP P2 & P3 research results
- A dedicated Financing and Partnerships Acceleration Service
- A new Cities Programme dedicated to supporting and developing the network of cities trialling and deploying FIWARE-enabled solutions

As one of the primary stakeholders, the UAB Mobility Unit provides technical support to the UAB management (governing) body on the design of UAB mobility policies, as well as the appropriate planning and management tools to maximise accessibility to the campus in the most sustainable, efficient and integrative way possible. The unit is also responsible for parking management and maintenance of public space.

Aslogic provides ITS/data services, and the research and transfer of new technologies. The other function includes the provision of IT support to UAB Mobility Unit by identifying transport needs and market opportunities.

The UAB Management facilitates the acquisition of licence for deployment and infrastructure readiness together with the mobility unit for service provision. The UAB Living Lab CORE facilitates the deployment of the service in the university. They act as intermediary between the IT Services Unit and UAB management.

The UAB Logistics and Aeronautics Unit role is to design and develop innovative decision support algorithms for both tactical and operational planning problems on the application (e.g. matching) according to the policies defined by other stakeholders. CRUE promotes best practices of transport and mobility in Spanish universities and encourage collaboration between universities. Websays engage end-users through a constant analysis of their opinions and feelings regarding VaoPoint services and the acceptability of incentives.

Additional details on the stakeholders' interests and characteristics can be found in Appendix 1 Stakeholders interest and characteristics. This table gathers more in-depth information of each stakeholder in order to understand their impact and influence.

3.2.3.2 Assessment of stakeholders determining their influence and importance

This section provides an assessment of the stakeholders for importance and influence in CS1 given the information gathered from them (which can be found in Appendix 1 Stakeholders interest and characteristics). The main interests and degree of impact/influence of each stakeholder on CS1 are given in the following table:

Stakeholder	**Interest**	**Estimated influence**	**Estimated importance**
UAB Management (UAB MAN)	Functional innovative solutions to ensure sustainable mobility on campus. Reduce the number of vehicles	M	2
UAB Mobility Unit	Promote sustainable mobility values and	H	3

Stakeholder	Interest	Estimated influence	Estimated importance
(UAB MU)	solutions in the university campus. Reduce the number of vehicles.		
UAB Living Lab CORE (UAB CORE)	Increase the positioning and visibility of technological transfer in the fields of urban mobility. Support citizen participation policies in the smart city context.	L	2
UAB Logistics and Aeronautics Unit (UAB LOGA)	Technology transfer of research activities in innovative transport solutions.	H	2
Aslogic S.L.	Empower transport operators/users/rulers/administrations with cutting-edge ITS solutions implemented as cloud services, thereby removing access barriers and unjustified investments.	H	3
FrontierCities	Promote the use of FIWARE technologies through the awarded projects. Promote the uptake of developed smart mobility applications.	M	2
CRUE	Improve the accessibility to university campuses. Promote a sustainable, safe and inclusive mobility model that is more efficient.	L	1
Websays	Keep a constant monitoring of end-users social network trends in mobility aspects. Identify new mobility trends in other markets. Turn VaoPoint customers into brand advocates. Assess incentive mechanisms to maintain VaoPoint end-users engaged.	L	1
End users	Cost reduction for commuting to/from the campus. Encourage sustainable mobility values.	M	2

Table 6 CS1 stakeholders' influence and importance

The importance-influence matrix of this assessment is given in the following diagram:

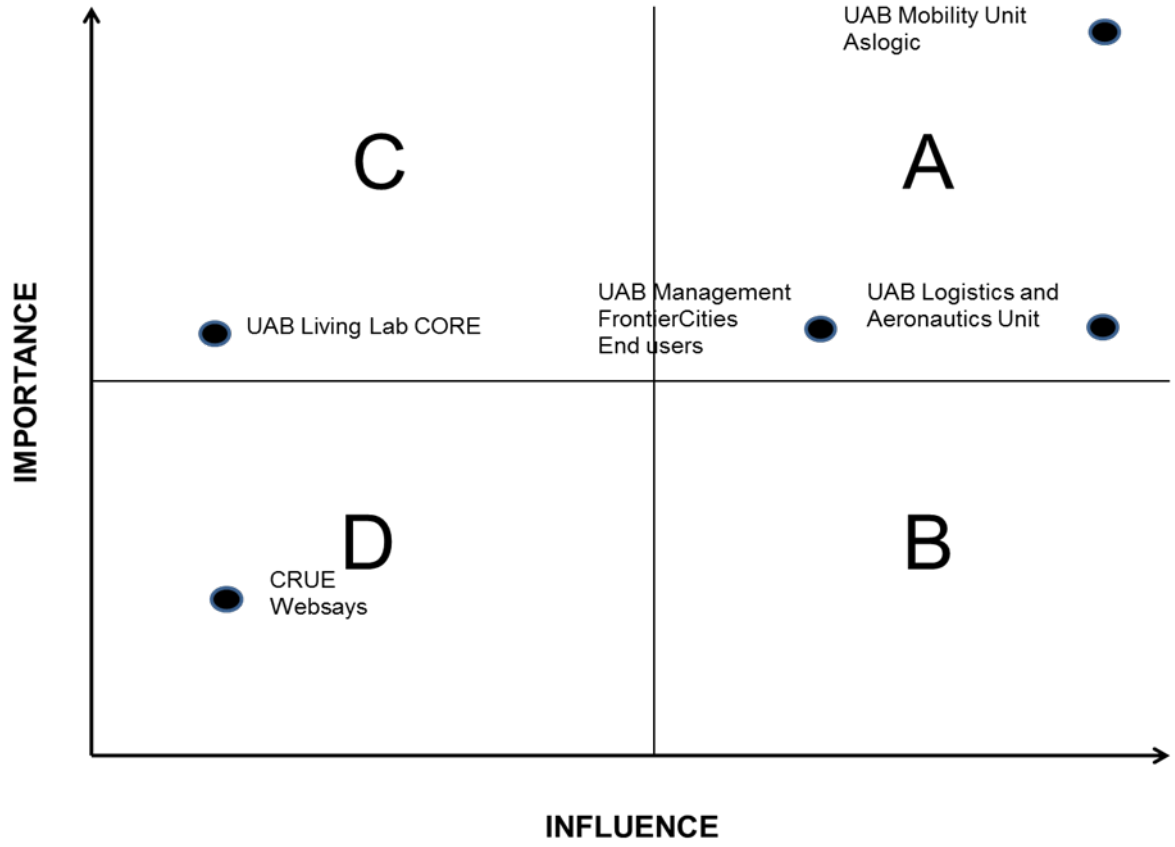

Figure 25 Importance-influence mapping of CS1 stakeholders

Based on the positions of the stakeholders within the matrix, the primary stakeholders in the order of importance and influence are UAB MU, Aslogic, and UAB LOGA. They can be considered the project initiators as they can influence positively the rest of the stakeholders.

UAB MAN, FrontierCities, and end users are the secondary stakeholders of CS1, because they constitute the primary source of funding for the infrastructure, the project execution, and the sustainability of the platform. They play a major impact in the success of the CS from the pre-deployment phase to commercialisation. The importance of end users cannot be overemphasised because the benefits to be derived will depend on the critical mass for adoption. CRUE and Websays are the tertiary stakeholders with relatively low importance and influence in affecting the decisions of stakeholders.

In terms of cooperation, a good and close working relationship must be established between the stakeholders in quadrant A. The successful implementation of the ITS service revolves around these stakeholders. Meanwhile, the interests of UAB CORE in quadrant B must be protected since they are the negotiation interface between the ITS services Unit and platform developer (Aslogic) for access provision to data. They also act in the best interest of the UAB community to facilitate the deployment of the service through the acquisition of licence. Since the involvement of the stakeholders in quadrant D (CRUE, Websays) is somewhat low, the other CS stakeholders can do without their opinions. Nonetheless, the influence/importance

of CRUE is expected to change drastically if we are to consider the extension of the service to other markets (Spanish universities) at national level.

3.2.3.3 Mapping and characterizing relations and dependences between stakeholders

This section maps the interactions between stakeholders taking into account the input-output dependencies. **Figure 26 CS1 stakeholders' interactions** represents the different value flows and interaction in terms of monetary, knowledge, policy, technology, and data services. The end users are the mains consumers of a number of value flows (such as technology and mobility policies) produced by other stakeholders.

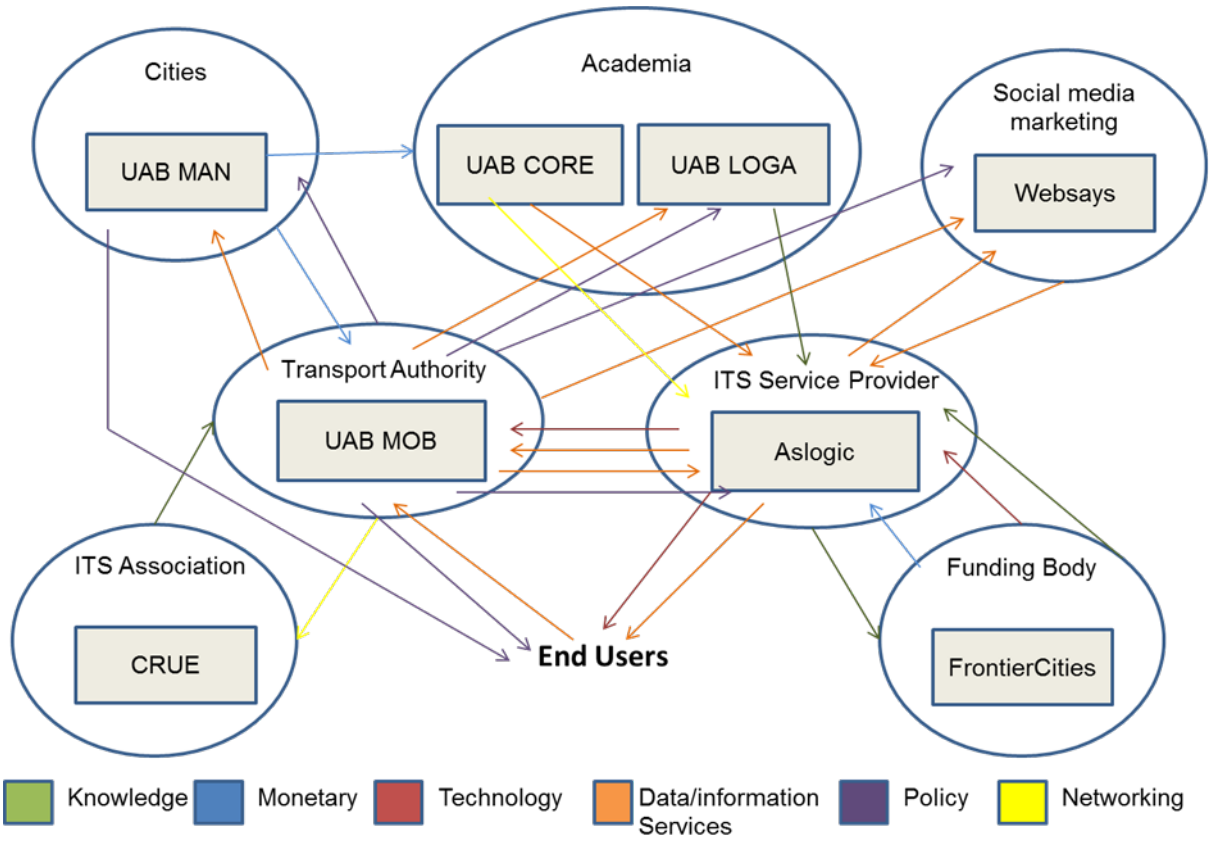

Figure 26 CS1 stakeholders' interactions

From the figure, the transport authority is the main producer of mobility policies and needs, incorporating reports on users' acceptability level. They provide the know-how on mobility, design mobility plans and disseminate VaoPoint to other European Universities through the EU funded LIFE project and at the ITS association level. This knowledge is then passed onto Cities, ITS service provider, academia, and finally, the end users. Since different universities at CRUE have been implementing different carpooling services, the results (knowledge) of different pilots and experiences can help the evolution of the CS.

The scientific knowledge produced by the research institute is used to develop the state-of-the-art decision support algorithms integrated into the technological platform developed by the ITS service provider. This platform also runs on another technology (service-oriented

architecture) offered by the funder to promote the development of smart mobility applications for sustainable mobility. The resulting value proposition is the ITS service with an integrated mobility policies and rules, in which passengers and drivers fit their mobility demands. For informed decision making, the social media marketing company produces mobility trend knowledge unfolded from social data analysis about mobility in the university context.

3.2.4 Competitors assessment

The objective of this section is to evaluate the existing competition of the carpooling service, any potential threats and commercial solutions deployed in the market. There are alternative competitive options that are equally attractive to sharing a car, and parking services in the university's campuses offered in our case study for Barcelona.

The main features of the CS1 are listed in the following table:

Features	**Description**
End-to-end itinerary planning (physical routes)	*Traveller can choose preferred modes; online service provides optimised end-to-end itineraries, e.g. quickest, cheapest, less Greenhouse Gas (GHG) modes.*
Real-time itinerary planning	Online service monitors execution of itinerary on all modes, calculates actual versus planned service quality, identifies and notify service incidents and degradation as support services
Interchange & on-route assistance	For multi-modal trips, provides specific information and guidance at mode-to-mode interchanges, and during each leg informs about stops/stations, connections, etc.
Traffic control in the cloud	Traffic control operations are hosted in the Internet, in secure virtual traffic signal controllers and virtual traffic centre, leaving local systems the task of providing safety controls and communications. Virtual components and data are accessible anywhere to authorised personnel, while local units guarantee reliability.
Cooperative traffic	Ad-hoc networks are created in the cloud between clusters of vehicles and the traffic management infrastructure, offering drivers a recommended speed to avoid stopping, and adapting the traffic signals to the real demand, in real time.

Table 7 CS1 main features

In the case of CS1, sharing a car as a market service offered by the carpooling collaborative platforms, there are three major considered competitors to VaoPoint in Spain. Of course, other companies also operate on this market such as Blablacar, Amovens and Vulog that have international commercial practices and have already established themselves well with a customer base of more than 0.5 million (see Appendix 2 Competitors identification). They also have a large revenue basis for expanding their businesses worldwide. However, for the

purposes of CS1, we would consider only three networks of companies that have emerged recently and would potentially be competing on the same routes.

- FES EDIT tested their applications in a similar context to the VaoPoint pilot, but they already expanded to cover the routes to industrial zones. It emerged from a pilot test of “e-hitchhiking” or Electronic hitchhiking that took place in 2010/11. It developed software that allows the option of ordering a free seat in a car without the need to book in advance. The pilot trial was run at the University of Girona.
- Shotl Transportation S.L was a spin-off of an R&D project “Real time optimisation system for door-to-door passenger transport through vehicle sharing based on a mobile platform through the application of heuristic algorithms”. The project was co-funded by the Spanish national authorities under the National Plan for Scientific research and Technological innovation 2013-16. It also received funding via the Horizon2020 scheme. At the moment, it runs as a small sustainable business only on the territory of Spain. It is registered as a SME company with less than 10 employees. This competitor clearly illustrates how an R&D idea can be successfully utilised in a small running business.
- uberPOOL has evolved from a private funding scheme with a U.S origin and a business model that has established a practice in Europe too. The idea of developing an app to match the black cabs initially began in 2008, and then expanded to covering taxi services in the cities. As a sustainable business model, we will consider UBER, because: first, it competes with the Spanish car sharing services on the urban and rural routes of Spain, secondly the company does not own the vehicles but exploits the private cars of drivers, and thirdly it demonstrates how a nationally-based business model could expand and settle in cross-border territories, which will be valuable for WP4.

Generally, to estimate whether two products or services are competing for the same market share, one has to assess their substitutability. If two offered services have a high elasticity of substitution, then it is certain that they are competitors. If their substitution is inelastic, then the two companies even offering similar services are not considered to be competitors. Therefore, we would take into consideration only the substitution of the car-sharing on the same routes. If competitors offer similar routes in the same urban or rural zones of Spain, and they target the same customer groups (the less affluent customers such as students; population living on/below the average means), then they are major competitors. If the car-sharing services target differing customer groups then they operate in the high-end or the low-end of the market, and as such do not compete directly for the same market share.

If only the pilot trial of VaoPoint at the main campus of UAB is taken into consideration, then there is hardly any competitor to the VaoPoint platform, apart from the public transportation. If however we consider an expansion of the trial to a more commercial case operating in the city areas and industrial zones, then VaoPoint faces significant competition from three other major groups of companies providing the car-sharing services on the same or similar physical routes, although they have developed their own digital platforms and applications.

In CS1, no commercial solutions were deployed for developing this niche of the transport market in/around Barcelona. Typically, such services can expand in the big metropolitan areas where the urban mobility needs to be optimised and reduce the use of private cars, as well as there is an observable high degree of diversification of the city population. Since the

Autonomous University of Barcelona have been involved in the spin-off of this research, no commercial solutions have been really developed and deployed in our analysed market niche. The platform and web applications were programmed and designed by the University's logistic research unit under a EU-funding scheme. Aslogic (the platform developer) together with the Logistics and Aeronautics Unit of the UAB provided knowledge on algorithms and policy implementation.

Beyond the pilot, these developments can be commercialised with a possible advanced ITS/C-ITS applications or an enhanced version of the existing apps that can maintain this carpooling service profitable, and thus expand the car-sharing not only among students, but also to cities and district areas where the choice of mass transit solutions is limited (for instance, schools and hospitals). The technical potential of the apps may foster a bigger expansion of the demand for sharing a car as usually younger people search for affordable services driven by technology and also sharing fun with their own friends or classmates.

3.2.5 Value chain resulted from CS1

The resulted value chain for VaoPoint can be seen in the following figure:

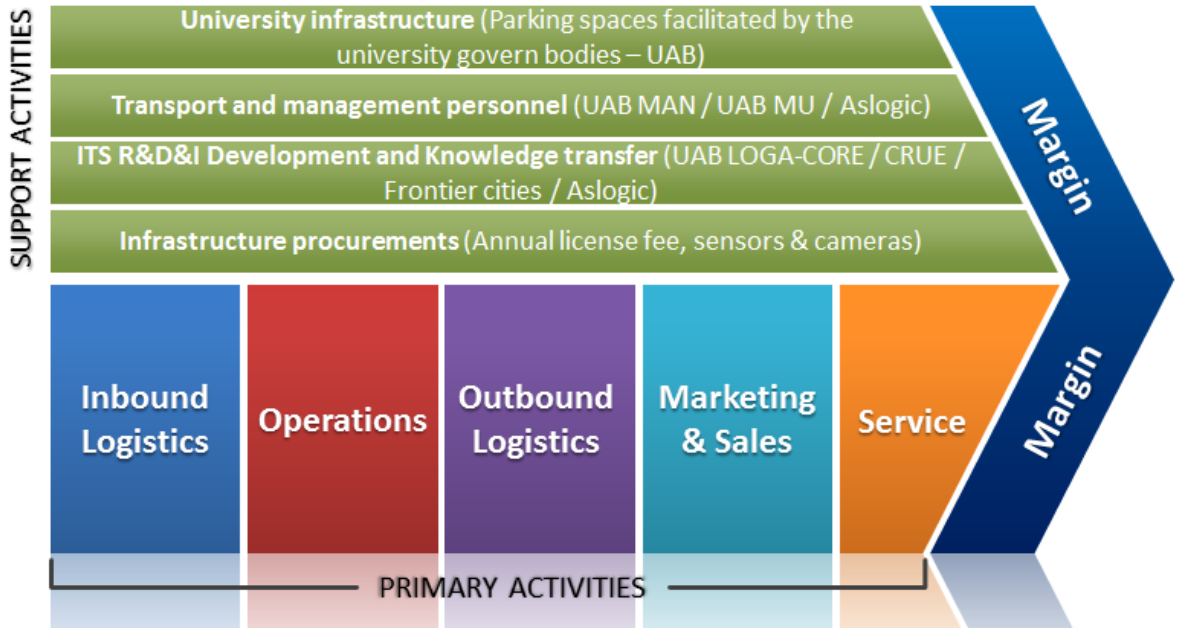

Figure 27 CS1 value chain

The primary activities, based in the creation, manufacture, distribution and sale of the product or service:

Inbound logistics

For VaoPoint, the data from the end-users, this is, students, academic staff and administrative employees are the inputs for the system along with information about the parking spaces. The end-users provide data to the platform (subscription + data for the car matching service) in order to get the final service. The sensors deployed in

the parking spaces are providing data so the service of guaranteed parking can be offered.

In a potential landscape where the platform is also provided to other campuses or industrial areas, the input for the system would still be the end-users data (users of the VaoPoint platform) and the parking facilities data (more likely gathered through sensors and cameras in the parking spaces).

Operations

VaoPoint platform operate with the data provided by the end-users in order to perform the matching between the available cars and the users demanding carpooling services minimising trajectory deviations and maximising economic efficiency.

In a scenario where the parking space is more demanded (either because the parking space is restraint or the number of vehicles operating in the facilities is bigger than the parking spaces) the system will work matching the data provided by the parking space sensors in order to book “assured parking spaces” to the platform users.

Outbound logistics

Right now, the output of the VaoPoint as the first service provided by the platform is matching the available cars with the users demanding carpooling services. This provides an immediate benefit for the end-users (reduction in costs and time in their trip) and general benefit (reduction in carbon footprint, reduction in bottlenecks).

The other service provided by the platform is offered to the end-users regarding parking space. The platform provides guaranteed parking space if the user shares the car with other platform users, providing good savings for several users (considering they are sharing the vehicle).

A hypothetical third service (not exploited yet) could be the offering of users’ insights/data to thirds parties so they can use this data for other purposes (statistics, data mining, etc.). This should be of course under the appropriate terms of privacy and security.

Marketing & sales

The processes in order to sell the product (some of them have been already put in practise) and compete with other solutions already in the market:

- Social media campaigns (through Websays, a social media marketing company).
- Showcase of the platform services.
- ITS service providers integrating new services or products to the mobility offer of the UAB campus.
- Engage more users through rewards strategies.

It is important to note that other areas where the parking space is more limited (such as industrial zones, technological parks or theme parks) and/or the demand is very

variable (theme parks) would potentially require less effort than the pilot site since the end-users' necessity is more evident.

Service

The activities in order to maintain the value of the product, classified as after-sale services:

- Active listening of end-users' opinions and feelings about the solution.
- Assess incentive mechanism to maintain end-users engaged.

The support activities:

Firm infrastructure

The main infrastructure of VaoPoint is the parking facilities provided by the University Government bodies. All the general activities required in order to keep the parking spaces operational like management, legal and finance activities are included here.

Human resources management

The transport and management entities are in charge of these activities. The UAB Management (in cooperation with the UAB Lab) provides the staff deploying the service in the university. The UAB Mobility Unit personnel manages the tool and offer technical support along with the management and maintenance of the parking and public space. This requires the management and training of this part of the staff.

Aslogic as a SME is in charge of providing ITS/data services, the research and transfer or new technologies supporting the UAB Mobility Unit.

Technology development

These activities are related to ITS R&D&I (Research and Development and Innovation) and knowledge transfer. The UAB Logistic and Aeronautics Unit and Aslogic develop support algorithms for the application. CRUE promotes best practises and collaboration between universities and FrontierCities provides funds, technical support and business advice.

Procurement

VaoPoint license, which is acquired by the UAB Management along with the maintenance costs (or updates purchase) of the solution. The other purchase in order to provide the services is the "sensing" infrastructure (sensors, cameras, etc.).

As a conclusion of the value chain, it is foreseen that the major cost for the primary activities are located in the operations. The bigger the demand, the more computational power the platform will require and the more software & hardware infrastructure (servers, cloud services) will be needed. This could be mitigated working in performance optimisations and back-up systems.

The inbound logistics and the outbound logistics parts (data gathering and service delivery) are web based and usually operated by the end-users from their smartphones, so there should not be any big variation in costs here. Marketing and sales could involve some initial big investment in order to make the end-users aware of the existence and benefits of the solution but it is supposed to stabilise at some point, mainly because this kind of applications (once they win the initial impulse) are usually well promoted in social networks by the end-users themselves. Services as after-sale services could benefit of some investment in order to impulse the platform initially and foster customers' loyalty.

3.3 Case Study 2

3.3.1 Definition

Case study 2 refers to the C-ITS applications implemented in the past few years in the city of Verona, with particular reference to the activities of the EC (European Commission) Compass4D project. Verona is located in the Veneto region, northern Italy, with approx. 265.000 inhabitants. It is the second largest municipality in the region.

Prior than the Compass4D pilot application, Verona city early introduced a traffic management platform in the traffic management centre (TMC), where autonomous ITS systems and applications exchange data and are coordinated by a higher-level subsystem.

Such a system included OMNIA, an ITS platform that supports an open architecture where any ITS system can be integrated within the platform, independently of the supplier product or technology. This system acquires all the traffic measures and stores it in the central system archive together with their estimated statistical profile such as traffic volumes, speed, etc. and traffic related data (e.g. signal plan, clearance capacity, turning proportions etc.). More than 150 intersections in Verona were connected with this platform. The system also included MISTIC, an Info mobility platform or Town Supervisor for cooperative traffic monitoring in the traffic management centre (TMC), and UTOPIA, a traffic management control system that provides adaptive traffic control strategies. Moreover 33 variable message signs in the urban were implemented for parking info (urban), traffic info and collective routing.

With the Compass4D pilot application, started in 2013, part of the city, in particular the main corridor and arteries, has been equipped with a cooperative RSU (Roadside Unit) system, made up of 25 ETSI 5G compliant units, OBUs (On-Board Unit) for various vehicles, and some cameras for the safety application, due to provide an Energy Efficient Intersection Service (EEIS).

Basically, an EEIS provides advice to optimize how vehicles pass through a crossroads. Both energy and emissions are saved, avoiding any unnecessary acceleration or braking from the driver of the vehicle. To achieve this, a bi-directional radio communication system is used between the traffic light control system and the equipped vehicles.

Traffic Light Status Information is transmitted by the traffic light control unit to incoming vehicles. Inside the vehicle, the driver receives information on when the traffic light changes, either in the form of a countdown or as a speed board. This information allows the driver to anticipate the next manoeuvre and to modify its driving mode, for example decelerating when a red light turns green and therefore does not need to stop.

Moreover, in this framework, a web application has been developed for mobile devices, allowing an increasing number of users access to numerous mobility data. The web service has been provided through 4G communication service (for “day-one” C-ITS application), through the collaboration with the national telecom operator and project partner, Telecom Italia.

Due to Compass4D implementations, new services have been provided to users: Speed Advisor System (GLOSA system), Road Hazard Warning (RHW) service, Road Works Warning (RWW), and Red light violation function. Also included in the service bundle is the implementation of TSP (Transit Signal Priority) service.

The RHW System aims to prevent collisions in case of abnormal or blind queues, and Road Works Warning aims to prevent similar circumstances. Speed Advisory instead aims to improve driving behaviours due to prevent vehicles stopping at red lights: the objective is to make smoother the traffic stream, reducing energy consumption and pollution, but also improving mean speed while reducing peak speed which can be useful also to improve road safety; moreover, the same technology is useful to prevent red light violations, but also to detect it.

The case-study objectives rely mainly on three aspects: safety, efficiency (energy, level of service) and environmental issues (reducing CO2 and pollutant). These objectives are intended to be pursued by improving the urban traffic performances, through improving driving behaviours and control systems, thanks to the specific cooperative-ITS system implementation.

3.3.2 Market analysis

3.3.2.1 Analysis of current and potential market

EEIS services may be considered part of a bundle of ITS services, market characterised by the presence of ITS services to drivers (Advanced Driver Assistance Systems), Intelligent Speed Adaptation services and Infomobility services in general.

The current market demand for EEIS is significant. According to Technavio, a market research analysis company, the global traffic lights market is deemed to grow steadily during the period 2017-2021 at a Compound Annual Growth Rate (CAGR) of about 6% [50].

The research institute stresses as the increased investments towards the development of road transport infrastructure is one of the major factors that will have a positive impact on the growth of the traffic signals market in the coming years.

In Europe, as part of the Advanced Driver Assistance Systems applications, Infomobility and in-vehicle intelligent speed adaptation systems, potential market size may be significant as well. The Advanced Driver Assistance Systems (ADAS) concern with vehicle-based intelligent systems which could improve road safety in terms of crash avoidance, crash severity mitigation and protection, and automatic post-crash notification of collision; or indeed integrated in-vehicle or infrastructure based systems which contribute to reduce energy consumption and more in general congestion level [51].

Intelligent Speed Adaptation (ISA) is an in-vehicle system that uses information on the position of the vehicle in a network in relation to the speed limit in force at that particular location. ISA can support drivers in helping them to comply with the speed limit everywhere in the network. This is an important advantage in comparison to the speed limiters for heavy good vehicles and coaches, which only limit the maximum speed.

Information on time to-green when stopped at a red light, speed advice for green phase and road events ahead (incidents, traffic jams) allow the driver to anticipate the next manoeuvre and to modify its driving mode, for example decelerating when a red light turns green and therefore does not need to stop.

Globally, market research analysis at Technavio predicts that the global advance driver assistance system market will grow steadily during the next four years and post a CAGR of almost 20% by 2020 [52].

Infomobility is an interesting market, in terms of potential value, forecasted in Italy to grow in double digits from 2017 on. Infomobility is part of a ITS market whose revenues tripled with respect to 2014, when it was about €500 million. Italy's intelligent transport systems market is now estimated at €1.5 billion, and forecasts indicate that the average growth rate will be 13.8%, starting next year. Infomobility services (€136 million in 2014) are among the three top investment catchers, showing the highest revenue (together connected car technologies (€323 million) followed by traffic management (€260 million), and electronic ticketing (€134 million) [53].

3.3.2.2 Segmented analysis definition of market demand and supply side

The Verona case study is characterised by two components:

- Traffic light network infrastructure integrated in the Urban Traffic Control (UTC) system UTOPIA; introduced since 2005 on homogeneous territorial areas from the point of view of the characteristics of traffic flows and traffic conditions. The UTC UTOPIA, managed by Mizar Automazione Spa, allows two types of activity:
    - The acquisition of real-time traffic data.
    - Planning and simulation.

  There are currently 60 centralised traffic lights in the city (see map).

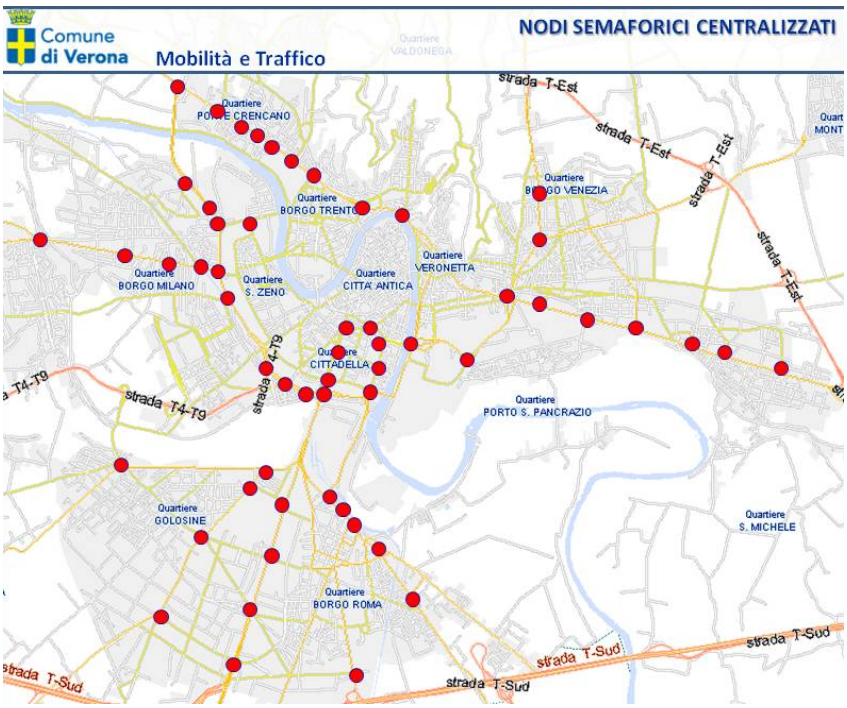

Figure 28 Verona traffic map. Source: Verona Municipality website (http://www.comune.verona.it)

- The presence of an Infomobility infrastructure, for data communication between real-time traffic situation and UTC. The EEIS service as provided within the Verona Pilot, integrates Dynasim traffic simulator in charge of Verona road traffic simulation, SWARCO Omnia ITS integration platform (TMC) integrating UTOPIA UTC module and a Co-operative back-end for the I2V communication.

The segmentation of market demand and supply side can be outlined as follows.

Demand side

There are two major groups identified in the demand side, the first group being road transport operators and drivers and the second group added value services users.

- Road transport operators and drivers: this group includes both road transport operators, e.g. road freight forwarders or road local public transport operators, and transport system users (drivers). Despite the different point of views and interests, the both groups share the same benefits from efficient and intelligent traffic lights systems. For example, ensuring that emergency vehicles and heavy trucks could pass through junctions more often on a green light can reduce travel times and cut fuel consumption, as well as reducing the kind of collisions that so often occur at intersections. In Helmond (The Netherlands), the implementation of the FREILOT (Urban Freight Energy Efficiency Pilot) project resulted in test vehicles being stopped at traffic light controlled intersections just 6% of the time, rather than 13% before. That contributed to a 13% reduction in fuel consumption and a 2.6% increase in the average speed of Heavy Duty Vehicles (HGVs) through the test routes. Fire engines, meanwhile, which were given even greater priority, enjoyed an even bigger speed improvement of 8%.
- Added value services users: the same Municipality or a third-party service provider, under a contract agreement with the municipality can develop and offer added value services to all the transport system users. Congestion status, suggested diversions, routing to parking access to demand responsive bus schemes, shared taxis, car sharing and car-pooling, on-demand city logistics services, etc. are examples of Infomobility services managed through ITS applications in which citizens play an important role as beneficiaries. Thus, some services nowadays provided for free by municipalities could become in future value-added services for citizens willing to pay for that. In particular, citizens living in remote areas, or people with reduced mobility can benefit from on-demand transport services, or business demand segment from tailoring transport services and saving time (e.g. through multimodal trip planners and real-time information services).

The values for the demand side have been extracted from different sources:

- The values for road transport operators and drivers (along with the population information) have been extracted from the Eurostat Transport Database [54].

- The traffic values have been extracted from the TomTom traffic index for Verona city [55].

The most relevant information regarding the demand side is summarised in the following table:

DEMAND SIDE	**Numeric Answer**	**Explain if necessary**
Drivers		
Number of private cars	159,285	Number of private cars registered in Verona
Number of registered cars per 10,000 population	603.4	Number of registered car per 10,000 population in Verona
Average increase in the number of private cars per year (from 1992 until today)	400	
Road transport operators		
Number of lorries (in the Veneto region)	322,381	
Number of trailers and semi-trailers (in the Veneto region)	37,152	
Number of motor coaches, buses and trolley buses (in the Veneto region)	6,950	
Traffic		
Extra travel time due traffic congestion	19% (19 mins per day, 74 hours per year), 2% increase since last year.	
Congestion level morning peak	30%	Increase in morning peak travel times compared to a free flow situation (uncongested)
Congestion level evening peak	34%	Increase in evening peak travel times compared to a free flow situation (uncongested)
Congestion level in highways	9%	Increase in highway travel times compared to a free

DEMAND SIDE	Numeric Answer	Explain if necessary
		flow situation (uncongested)
Congestion level in non-highways	25%	Increase in non-highway travel times compared to a free flow situation (uncongested)

Table 8 CS2 details about the demand side

Supply side

The supply side is composed by traffic control systems manufacturers and ICT service providers along with the municipalities which could be seen as externality but are still a very relevant part of the market.

- Municipalities: Municipalities are among the main stakeholders interested in the delivering of the service. For example, in order to improve the urban mobility, based on the European Commission agenda in relation to the national strategies for ITS directives, the Municipality of Verona decided to initiate a fast action to deliver solutions in response to the new challenges that have emerged in recent years with respect to climate change, energy policy, air quality legislation and the difficulties of tackling congestion. In October 2008, the city of Verona joined the Covenant of Mayors, sponsored by the European Commission as part of the Campaign for Sustainable Energy in Europe. In April 2011, it adopted the Environmental energy plan, which contained guidelines and strategic objectives in the field of energy, then in October 2011 it approved the Action Plan for air quality and remediation. This was based on the result of two years of work of the municipal offices, with aid of the technical and scientific support of the University of Trento, ARPAV of Health Units, and 17 municipalities that have joined the agreement. The Plan undertook structural measures to counter air pollution, among which the provision of EEIS was an important step. More in general, municipalities or local institutions are key customers of the EEIS applications and at the same time, they are service providers for them (being this the main reason to consider them in the supply side of the market).
- Traffic control systems manufacturers: EEIS are targeted to be integrated by Original Equipment Manufacturers (OEMs) of traffic control systems. Thus, OEMs would be interested in understanding how EEIS interfaces with their systems, how it improves the operational capability of their traffic control system and the optimization technology behind its operations.
- ICT service providers: SMEs operating as system integrators and ICT solutions developers in different related-EEIS services fields are interested in the implementation and deployment of the applications. They are data transmission services and applications, mapping intersections services, big data on traffic flows, validation and calibration of mobility behaviour forecast.

The values for the supply side have been extracted from different sources:

- The savings have been extracted from the integrated Platform for Mobility Management (OMNIA) in case of the time and pollution values [56].
- The costs offer both the values for the Compass4D pilot in Verona as well as the estimated costs of a virtual city simulated with the characteristics of several medium sized urban areas across Europe [57].

In this context, the most relevant information regarding the supply side is summarised in the following table:

SUPPLY SIDE	**Numeric Answer**	**Explain if necessary**
Savings		
Reduction in travel time	28.9%	Reduction in travel time using OMNIA
Reduction in pollution	14.45%	Reduction in pollution using OMNIA
Costs		
Traffic light and vehicle hardware & installation in the Verona Pilot	€360,000	Costs for the Verona Pilot
Annual O&M costs in the Verona Pilot	€24,000	Annual cost for the operation and maintenance of the infrastructure in Verona pilot
Acquisition and installation cost / unit RSU	€7,500	In a simulated city with the characteristics of several medium sized urban areas across Europe.
Acquisition and installation cost / unit OBU	€1,100	In a simulated city with the characteristics of several medium sized urban areas across Europe.
Back office initial investment (only once)	€25,000	In a simulated city with the characteristics of several medium sized urban areas across Europe.
Annual O&M costs	€20,000	In a simulated city with the characteristics of several medium sized urban areas across Europe.

Table 9 CS2 details about the demand side

Demand and supply relationship

To demonstrate the demand and supply curves in a diagram, the demand curve (in red) per-se is growing really slow (the number of private drivers and the population in Verona along with the transport operators' vehicles) and therefore is represented as an inelastic curve. The other factor is the price of the services, in the current model for Verona, the services are provided for free to the end-users, causing the curves to cross at price equal to 0. In a hypothetical future, the solution could offer additional services changing the model to a fee-for-service, causing the supply curve (in blue in the current model) to move to the left (in black). This will move the equilibrium point from cero to a point based in the opinion of the buyers (drivers and transport operators) of how much services are they willing to buy at a certain price in relation with the amount of services supplied by the market (service providers) at a certain price.

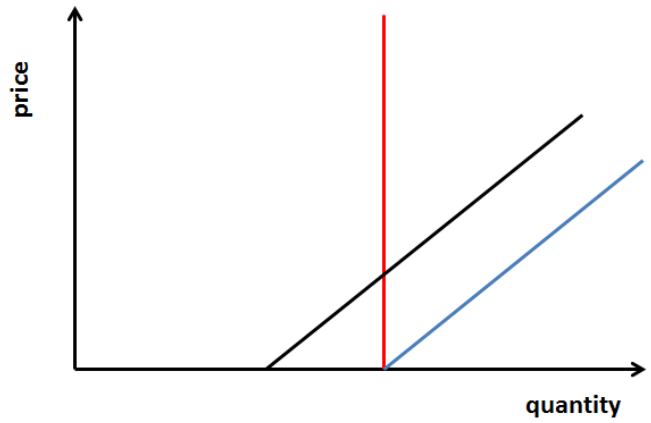

Figure 29 CS2 Demand and supply curves

The demand side is growing really slow based in the private cars numbers which are the most common vehicle in Verona roads. The population of the city is also growing very slow (from 255,821 habitants in 1992 to 265.000 habitants today) which confirms the private cars information and also indicates that the road transport numbers are not going to experiment any big change either.

Congestion levels are steady too, with only a 3% increase in the last 5 years (although last year registered the bigger increase, 2%).

Under the current model, where the municipality of Verona is acquiring the necessary infrastructure and assuming the costs in order to provide the services for free to the citizens, the decision about increasing this infrastructure or not could be taken based in the potential total cost of congestion. Based in the information from INRIX about the impact of congestion in Europe [58], the estimated costs of congestion for Verona in the next 10 years will be €215 million euros (or €21.5 million euros annually if we split them in a lineal way). Obviously, this is only an estimation but it helps somehow to calculate the potential impact of increasing the already deployed infrastructure.

Aside of this, the potential creation of value added services could open a brand-new scenario which will be very relevant for the supply side even though the demand side does not vary too much. In this case, any ICT service provider could benefit from the creation of these services and the offering to the citizens. Since this is not included in the scope of the case

study, no relevant data were provided about this scenario but its potential makes it worth mentioning.

Target market

As already mentioned previously, a potential target market for Verona could be its own municipality based in the costs savings from the congestion values and estimations for the city.

Since the solution is also potentially applicable to other municipalities not only at national level but also at European level, the scope has been extended to all Europe.

In Verona, in 2016, congestion was responsible for 19 minutes of extra time lost, according to the TomTom analysis (see the below picture).

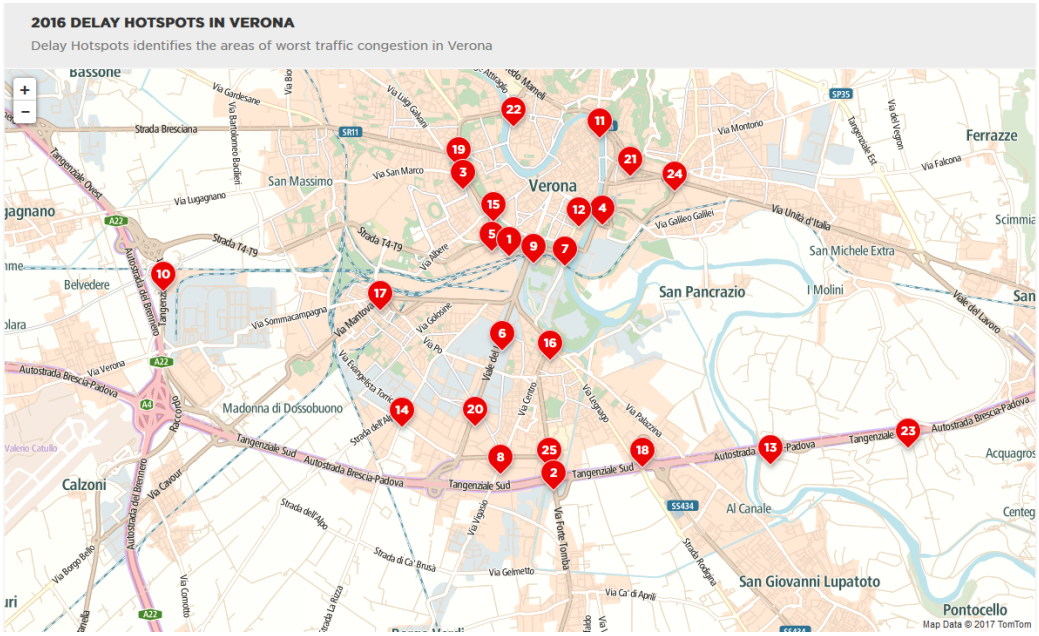

Figure 30 2016 Delay hot-spots in Verona. Source: https://www.tomtom.com/en_gb/trafficindex/city/VER

At European level, the potential demand for EEIS can be estimated through the information delivered in a recent report from a consultancy [58]. The study considers bottlenecks in European roads from congestion episodes detected through proprietary data from different sources covering over five million miles of road, and combining it with our other data sources including global parking, fuel, point of interest, public transport, and road weather information. The analysis identifies traffic hotspots in European roads, which are the product of the average length (in kilometres), average duration (in minutes) and the number of occurrences of traffic jams at these traffic hotspot locations.

Based in this information, the definition of customer groups:

Key group	Numeric Answer	Explain if necessary

Key group	Numeric Answer	Explain if necessary
Verona roads		
Number of hotspots (2016)	19	A potential bottleneck is detected when Increase in overall travel times when compared to a Free Flow situation.
EU Urban areas		
Number of Urban areas	123	Major EU urban area with more than 250,000 inhabitants
Number of hotspots (2016)	45,000	The detection of bottlenecks is based on comparisons of speeds to reference speeds, which are the proxy of the free flow or uncongested speed. A potential bottleneck is detected when speeds on a segment drop to 65% of the reference speed, and a bottleneck is published if speeds stay below 65% and causes 120 seconds of delay.

Table 10 CS2 customer target groups

Urban areas with more than 250,000 inhabitants can be considered as customers of the CS2 solution that can relieve traffic conditions over 45,000 hotspots. Big urban areas can also benefit of financial capacity to invest in smart infrastructure.

3.3.2.3 PESTEL analysis

The analysis of forces and environment underlying the design and provision of EEIS services is carried out through the PESTEL approach, an acronym for Political, Economic, Social, Technological and Legal factors, which identifies the critical factors to deploy the service. With reference to the speed assistance systems in particular, and EEIS services in general, this section of the case study is based on the contribution from B.van Aren and al[30], providing relevant insights on the matter.

[30] B. Van Arem J. Vreeswijk, K. Malone "Deployment Scenarios for Speed Assistance Systems", 2008

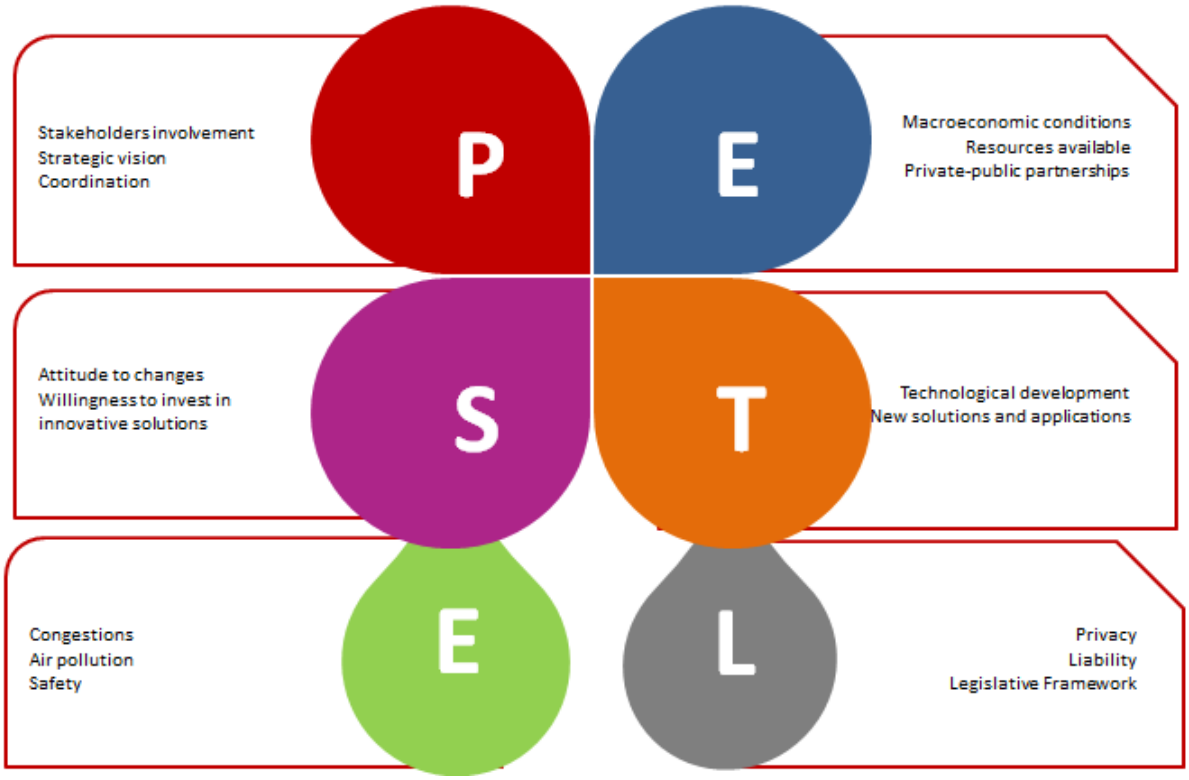

Figure 31 CS2 PESTEL

Political factors

The multi-stakeholder environment of (cooperative) systems is found very complex and a barrier when it comes to the deployment of these systems. There is a need for better organization, a leading coordinator, and a Code-of- Practice. A clear vision and a strategic view are also needed. Indeed, sometimes stakeholders operating in the same domain suffer of conflicting objectives.

Economic factors

A positive macroeconomic environment, i.e. resource available for investment, represents a basic pre-condition for the implementation of EEIS. Public financing is indeed necessary, and in presence of budget constraints, the establishment of public-private partnerships may be an answer.

Social factors

Currently, users as well as policy makers are often unaware of the existence, the benefits and the development of Advanced Driver Assistance Systems and EEIS. After awareness, system acceptance becomes very important for systems to be successful. Generally,

advisory systems are preferred over controlling ones, whereas supporting systems are preferred over enforcing ones. Also, the importance of the Human Machine Interface (HMI) has to be considered. Feedback from the system, the feeling of being in control of the vehicle and the possibility to overrule the system are key elements from the perspective of the driver. Finally, a system has to be affordable. This is not restricted to the price of the system, but also depends on the economic situation and the societal need of a system. In such a context, the willingness to invest in innovative solutions by local government represents an important factor.

Technological factors

On a strategic level, it is often assumed that technology is not the limiting factor for the deployment of EEIS systems. However, in numerous cases the technology is still too unreliable, unstable or not even released yet. Furthermore, non-technical components like speed limit maps and databases are yet not fully available and reliable. Once market penetration of EEIS systems reaches some significant level, a lack of standardization can lead to significant problems like inoperability and string stability problems.

Environmental factors

Environmental factors may influence the decision to implement EEIS. In particular, concerns about congestion at given intersections, and related air pollution episodes, may induce local government to design EEIS solutions. Safety at hot spots may also be considered as an important factor leading to the implementation of EEIS solutions.

Legal factors

Liability, legislation and privacy are identified as the most critical issues for system success. Liability, involving financial cost is most important as systems can never make it to market unless this is solved. Legislation problems are easily to overcome since the law simply does not suppose that driver tasks are performed by technology instead of the driver. With respect to privacy particularly the industry foresees problems when data communication between vehicles and infrastructure exposes the whereabouts of a vehicle or person. It is feared that the information will be used for other purposes than intended, like enforcement.

3.3.2.4 SWOT Analysis

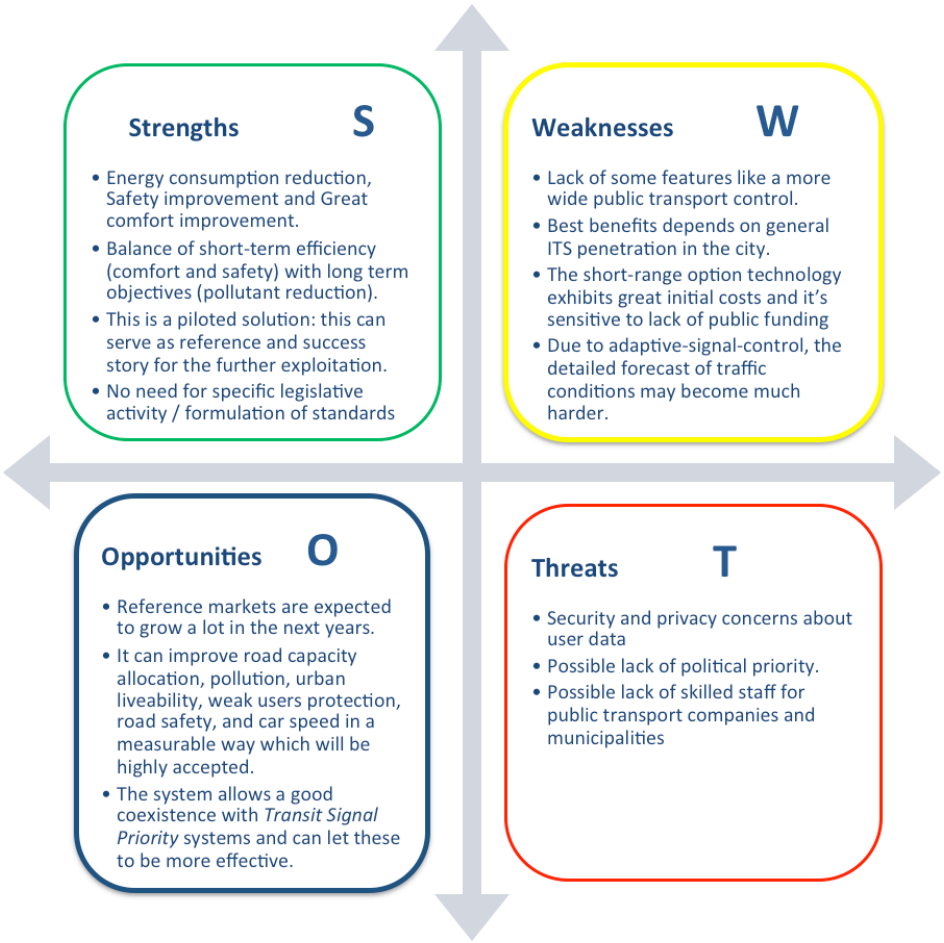

Figure 32 CS2 SWOT

Strengths

- The system allows for energy consumption reduction, safety improvement and great comfort improvement which are directly evident to end-users. It produces a high involvement of end-users.
- The solution balances short-term efficiency (comfort and safety) with long term objectives (pollutant reduction).
- The solution has been piloted and this can serve as reference and success story for further exploitation.
- The system doesn't require any specific new legislation or any new formulation of standards.

Weakness

- The system lacks some useful features (which can be incorporated in latter stages) like a more extended and robust public transport control.
- Best benefits of such system are related to a previous existing TMC system, which has to be robust even about the phenomena-sensing (data and measurements) and

even about implemented control methods and models (with a proper calibration of control/optimization/simulation methods, which may involve predictive features). The system introduction is thus sensitive to the previous general ITS penetration in the city and to the lack/presence of existing ITS infrastructures.
- The short-range technology (one of the two options considered) exhibits great installation costs and it's sensitive to lack of public funding.
- Due to adaptive-signal-control, the detailed forecast of traffic conditions may become much harder.

Opportunities

- Reference markets (ITS and Traffic Management Systems) are expected to grow a lot in the next years.
- Many cities have the following increasing problems: road capacity allocation to optimize, pollution to reduce, urban liveability to improve, weak users to protect, road safety to increase, car speed to enforce. The considered technology is capable to produce immediate and measureable benefits for all these issues, so that it can gain a great acceptability by cities administrator and citizens.
- There's a profitable interaction with road public transport systems, as the system not only allows a good coexistence with Transit Signal Priority systems, which have been used also in the pilot, but also an improvement of the latter by reducing the cars' queuing at traffic lights and, in general, lowering the uncertainty of private traffic flow conditions. However, since the road flows' detailed forecast may become harder due to local-adaptive control, the coexistence must be carefully conceived and designed.

Threats

- Security and privacy concerns about user data.
- Possible lack of political priority: the potential market for those systems hardly involves the public administration, and in particular the local authorities. Political engagement in these contexts on this kind of investment is not always guaranteed.
- Possible lack of skilled staff into public transport companies and municipalities (in certain local contexts).

3.3.3 Stakeholders analysis

3.3.3.1 Identification of stakeholders' groups, their characteristics and interest

In order to identify the case study stakeholders, the working team met with the case study leader through some brainstorm sessions. As a result, the entire stakeholders groups' structure for the case study was identified:

- **Cities:** they are the public bodies which administrates the urban settlement by the public-interest and political point of view. They can provide evaluation respect public interests, such as urban wellness and environmental issues.

- **Automotive suppliers:** they are manufacturer that produces cars and vehicles. They can provide evaluations about business and market viability, but also on some environmental aspects.
- **Original Equipment Manufacturers:** they produce original hardware and software to implement the C-ITS service. They can help assess about all the aspects of the project, mainly (but not only) regarding technological and organizational issues.
- **Transport operators:** they are companies providing public transport services, such as bus lines, tramways, metro services, etc. They can provide data that can be used for local area traffic Expert Group on Urban ITS, including benefits for the use of cleaner vehicles, e.g. electrical vehicles for last mile distribution, when possible.
- **End users:** they are the final customers of the market. They can provide evaluation on comfort and general improvements of the system, and give assessments of how their needs are satisfied.
- **ICT service providers:** they are companies providing ICT and telecommunication services. They can provide data about connectivity, market penetration and technological issues.

Here in the following a diagram showing the whole stakeholders' grouping structure:

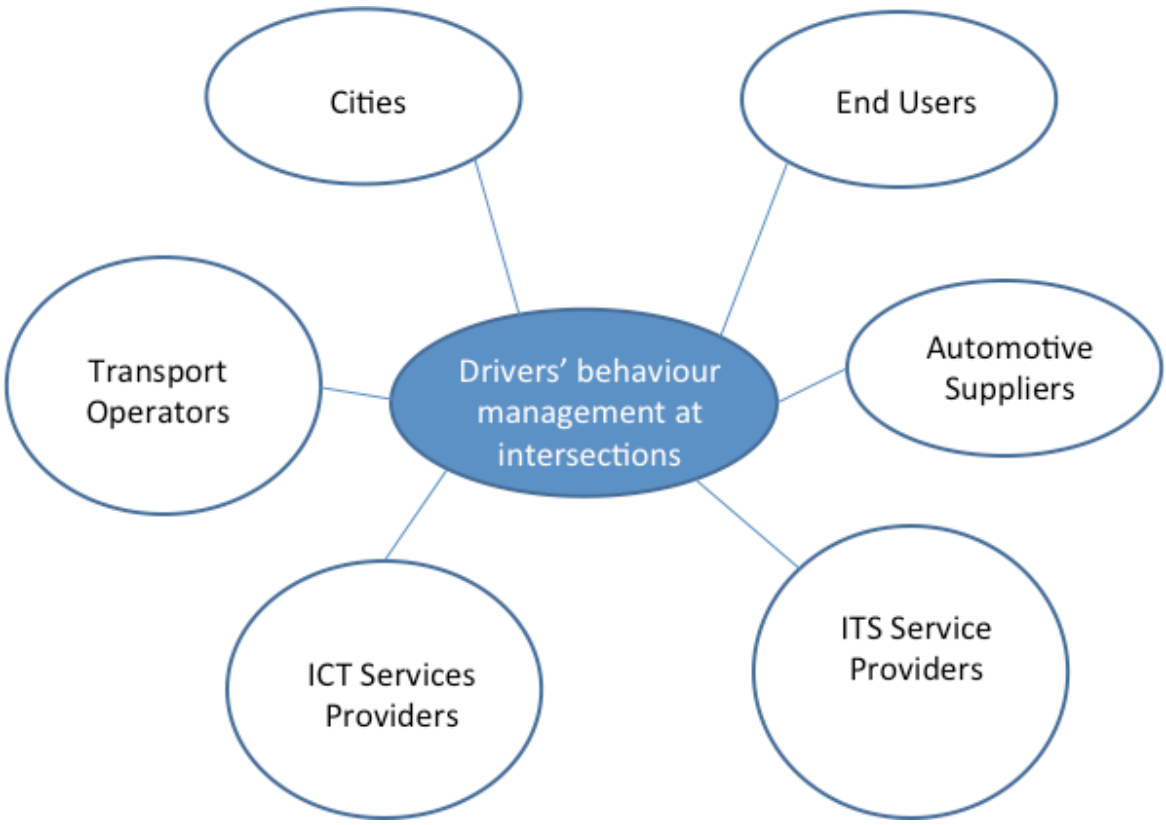

Figure 33 CS2 stakeholders groups

For each of the stakeholders' groups, the work team identified specific stakeholders, which are listed in the following:

- **City:** Municipality of Verona
- **Automotive supplier:** AUDI

- **ITS service provider:** SWARCO MIZAR
- **Public Transport operators:** ATV Bus Operator, Taxis
- **End users:** Citizens of Verona and surroundings
- **ICT service provider:** TELECOM ITALIA

The Municipality of Verona is the public body that administrates the city, moreover such municipality provided the coordination for the whole pilot.

AUDI is the automotive company which provided some cars for the municipality, equipped with specific C-ITS devices, which were used into the pilot.

SWARCO MIZAR instead is company that produces ITS hardware, such as signals, controllers, UTC (Urban Traffic Control), control methods and algorithms. The company acted as the main actor of the pilot, providing signalization, UTC, and all fixed ITS hardware.

TELECOM ITALIA is the largest Italian mobile communication operator, and provided the mobile communication service for the long-range communication option (4g mobile connectivity).

Moreover, ATV is the only urban public transport operator, and it used TSP (Transit Signal Priority) services provided with the pilot by innovative ITS technology; sharing a similar role, some taxis were equipped with specific OBUs and used some of the services provided with the pilot, due to make them able to benefit of GLOSA (Green light optimized speed advisory), RHW (Road Hazard Warning) and RWW (Road Works Warning) services.

Finally, the citizens were the final user of the whole system, directly as car driver or as taxi or bus passenger.

Stakeholders' objectives mainly rely on business and traffic improvement benefits. In particular traffic improvements such as travel time reduction, safety increase, pollution reduction, are objectives shared by Municipality, Taxis and Citizens. Travel time reduction is important also for ATV, since such improvement on bus services allows for a more efficient usage of vehicles and money. SWARCO MIZAR, AUDI and TELECOM ITALIA instead shares objectives which relies on market development opportunities, but also on branding, general marketing and business consolidation.

3.3.3.2 Assessment of stakeholders determining their influence and importance

This section provides an assessment of the stakeholders for importance and influence in CS2 given the information gathered from them (which can be found in Appendix 1 Stakeholders interest and characteristics).

In order to assess the influence, the stakeholders' power to influence the case study outcome was considered, both positively and negatively. An influent stakeholder who does not feel the need for the implementation of the case study can lead to a conservative position meanwhile an influent stakeholder who does feel the need for the implementation of the case study can help keep pace in the development and can positively influence other stakeholders.

The main interests and degree of impact/influence of each stakeholder on CS2 are given in the following table:

Stakeholder	**Interest**	**Estimated influence**	**Estimated importance**
Municipality of Verona	Fluid traffic, safety improvement, travel time reduction	H	3
ATV	Travel time reduction, better use of buses	M	2
Taxi Operators	Fluid traffic, safety improvement, travel time reduction	L	1
Citizens	Fluid traffic, safety improvement, travel time reduction	L	2
AUDI	Future Market development, Branding	L	3
SWARCO MIZAR	Market Development, Business Consolidation	M	3
TELECOM ITALIA	Future Market development, Branding	M	3

Table 11 CS2 stakeholders' influence and importance

The importance-influence matrix of this assessment is given in the following diagram:

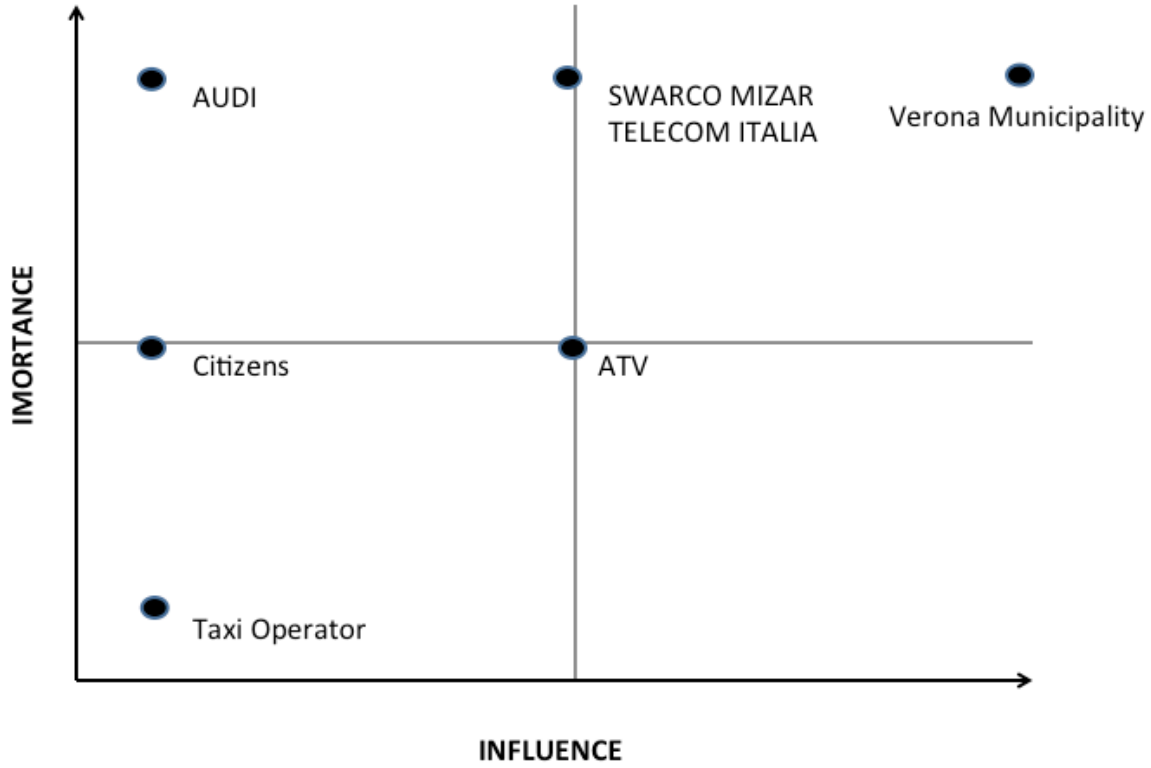

Figure 34 Importance-influence mapping of CS2 stakeholders

Some considerations can be carried on about the **importance** assessment:

MUNICIPALITY, SWARCO MIZAR, AUDI and TELECOM ITALIA were considered to be of utmost importance (Level 3) as providers of essential hardware and know-how for the realization of the project itself. The highest importance was found in the Municipality of Verona, because without its participation the whole project would not have taken place. ITS hardware was provided by SWARCO MIZAR, while vehicles equipped with OBU was provided by AUDI, necessary for the core application of C-ITS with short-range communication. The absence of TELECOM ITALIA would have prevented long-range communication with 4G technologies suitable for C-ITS services, but the same services would remain applicable and fully assessable by using short-range communication provided by other stakeholders.

Citizens and ATV have been recognized as having a medium importance (level 2): their absence from the study case would have produced limited success but would have not prevented the implementation of the same case. A failure in ATV participation would have made virtually impossible to implement the TSP (Transit Signal Priority) service, but nevertheless make the other C-ITS services available. Moreover, the contribution of the citizens is assessed on the basis of their ability to participate in the decision-making process and about apriority and posterior assessment: their contribution is capable to produce great utility, but not so great that their absence would prevent the realization of the expected system.

Finally, taxi operators were of the minimum importance (level 1) because their absence would not prevent the implementation of all planned ITS services in any way, cause the latter could be applied and evaluated using vehicles of other stakeholders.

Some other considerations can be carried on about the **influence** assessment:

Influence was assessed considering the power to influence the case study outcome producing clear opinions, wishes and issues, which have been considered by other stakeholders.

The highest level of influence has been recognized into Municipality of Verona, since it coordinated the whole process.

A medium level of influence was observed about ATV, SWARCO and Telecom since they all acted on the core technology and provided necessarily clear opinions and issues.

Finally, Taxis, Citizens and Audi showed the lowest level of influence, since they didn't provide remarkable opinion or participation.

3.3.3.3 Mapping and characterising relations and dependences between stakeholders

In this case-study, interactions between stakeholders are complex and of different natures. Not only, in fact, the input-output characterization of each actor in term of products (goods and services) shows different kind of products being exchanged, but also the economical flows between the actors are various and strongly asymmetrical.

Products and Value flows are briefly depicted in the following scheme:

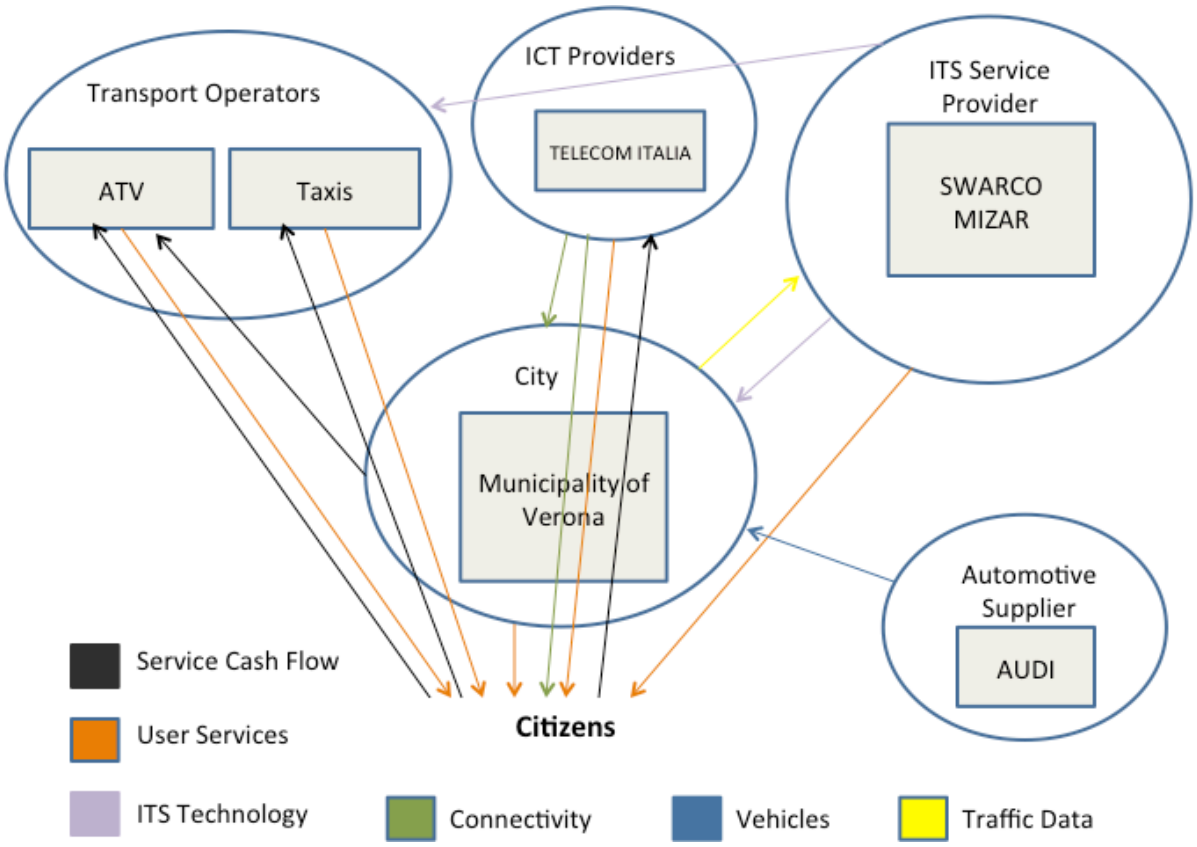

Figure 35 CS2 stakeholders' interactions

In a central position there is the Verona Municipality, since it's the owner and operator of the C-ITS system, so in this way it interacts with each other stakeholder.

Citizens are the receiver of all user-services produced: focusing on the C-ITS environment, such services are produced by SWARCO MIZAR (through its technology) and basically, are GLOSA, RHW and RWW services which are directly provided through the citizens' personal mobile device (long range communication option using 4G mobile connectivity). The same services or similar (e.g. TSP), are provided to Taxis and ATV's buses but in this case, they can't be considered as user services since they're used by commercial operators, and they are delivered through supplied specific hardware which is installed onto the recipients' vehicles.

ITS services are not the only user-service provided to citizens. The public buses and taxis are user-services too, along with the mobile-band and the urban road network, provided respectively by ATV, Taxis consortium, TELECOM ITALIA and the Municipality of Verona.

Most of the ITS services provided contain or use traffic data produced by the system itself, but traffic data were also provided by Municipality to SWARCO MIZAR, to set up the system, calibrate and operate it.

The connectivity is the core-asset provided by TELECOM ITALIA, directly to final users and also to the Municipality, as the owner of the C-ITS system; and cars are the good provided by AUDI directly to the Municipality.

Finally, it is worth to mention the cash flows between stakeholders, due to operations and service provision: citizens pay for user-services directly to ATV, to Taxis and to TELECOM ITALIA. Moreover, ATV also receives moneys for service by the Municipality.

Other money is exchanged due to system installation and set-up costs, but those exchanges are not depicted in figure.

Is to distinguish how the various stakeholders obtain their operating incomes: to this aim is mandatory to highlight that Municipality and citizens didn't expect any revenue, but only benefits. From all stakeholders, only ATV, Taxis and TELECOM ITALIA have a direct revenue by collecting fares from users during operations (while the ATV bus operator also gets a subsidy from the Municipality), while their costs (vehicles, energy, labour, etc.) are mainly external respect to the stakeholder system. ATV also declared to have suffered some important installation-related costs, referable to planning activity, hardware and cartography. SWARCO MIZAR, as an equipment manufacturer, only could have an initial income (from the public bodies, including the Municipality) because the sales of the hardware and the installation-related services, but didn't have any kind of revenue during operations of the system.

3.3.4 Competitors assessment

The main features of the CS2 are listed in the following table:

Features	Description

Features	Description
Traffic light network infrastructure	The traffic light network allows the acquisition of real-time data along with planning and simulation of traffic flows and traffic conditions. Traffic control operations are hosted in the Internet, in secure virtual traffic signal controllers and virtual traffic centre, leaving local systems the task of providing safety controls and communications. Virtual components and data are accessible anywhere to authorised personnel, while local units guarantee reliability.
Intelligent Speed Adaptation services and info-mobility services	For multi-modal trips, provides specific information and guidance at mode-to-mode interchanges, and during each leg informs about stops/stations, connections, etc. Ad-hoc networks are created in the cloud between clusters of vehicles and the traffic management infrastructure, offering drivers a recommended speed to avoid stopping, and adapting the traffic signals to the real demand, in real time.

Table 12 CS2 main features

Looking at the features of the CS2, the main competitors will come from data providers (mapping, traffic flows, bid data), traffic light system providers and intelligent speed adaptation services and info-mobility service providers at EU level.

The main competitors for CS2 are:

- SIEMENS supplies all elements for the effective control of urban traffic from a single source, to cities all around the world. They provide hardware and software solutions which improve the traffic flow, reduce traffic emissions and enhance road safety. They offer controllers, signal heads, smart detection, enforcement and tolling solutions, etc.
- INDRA is one of the main global consulting and technology companies and a world leader in the development of comprehensive technological solutions in transport and traffic. INDRA smart mobility division produces global solutions for road traffic improving the management of road infrastructures and vehicles themselves. INDRA offers measures to improve mobility on roads and in cities, as well as comprehensive supervision and control systems for urban traffic lights, road tunnel installations and highways. Solutions include the design, engineering, production and development of applications and maintenance, using an open approach and standard to be adapted to the client's specific needs.
- PTV Group improves mobility and transport by using world-class software, data and scientific know-how gained from four decades of experience in planning and optimizing the movement of people and goods. Recognized as global market player, PTV helps cities, companies and people save time and money, enhance road safety and minimise the impact on the environment. PTV support smooth traffic flow and more than 2500 cities use PTV solutions. PTV software is used to develop the European transport model, which encompasses all passenger transport and freight

movements in Europe. Currently more than 700 staff worldwide is committed to driving the high performance of PTV products.

- HERE is a company providing mapping data and related services to individuals and companies, owned by a consortium of Audi, BMW, and Mercedes. The company manages location contents, such as road networks, buildings, parks and traffic patterns. Such contents are licensed along with navigation services and location solutions to other businesses such as Alpine, Garmin, BMW, Oracle and Amazon.com. In addition, HERE provides platform services to private smartphones It provides location services through its own HERE applications, and also for GIS and government clients and other providers, such as Microsoft Bing, Facebook and (formerly) Yahoo! Maps. HERE have maps in nearly 200 countries, offers voice guided navigation in 94 countries, provides live traffic information in 33 countries and has indoor maps available for about 49,000 unique buildings in 45 countries.
- TomTom produces traffic, navigation and mapping products. TomTom also makes action cameras, GPS sport watches, fleet management systems, and location-based products. TomTom's has four business units: Consumer, Automotive, Licensing and Telematics through which it sells and licences its technology and products. TomTom's Consumer business is focused on creating location-based products that give consumers the knowledge they need to get where they want to go. Their consumer activities are focused on the drive and sports categories; products include PNDs, GPS sports watches and smartphone navigation applications. TomTom consumer products strive to be smart and have intuitive user interfaces, strong GPS performance and innovative design and features. TomTom's automotive business provides modular components (maps) and traffic and navigation software to car manufacturers and Tier 1 head unit vendors. Each component can be integrated as a stand-alone product, or combined into the Connected Navigation System. TomTom's Licensing branch sells TomTom map, traffic and navigation software. It also offers cloud-based products and platforms that allow developers access to create location-enabled applications for businesses and governments. TomTom Telematics is the business-to-business division of TomTom and has been operating since 2005. This arm of TomTom specialises in telematics, providing vehicle tracking, navigation, two-way communications, job scheduling and report-logging capabilities to organizations. In 2010, TomTom said that it was providing its service to over 125,000 vehicles operating in Europe. Telematics offers fleet management solutions for commercial fleets and is also a partner for the insurance industry to provide usage-based insurance products. Telematics' WEBFLEET Software-as-a-Service (SaaS) solution allows integration with third-party applications and offers information security certified to ISO 27001 standards.

Looking at the competitor degree of substitution, i.e. the likelihood of competitors to share the same market target, and therefore to compete for the same customers/clients, the following table shows the situation concerning the Verona case study. Doing that, we refer to the full list of competitors, as provided in Appendix 2 Competitors identification.

Type of service	**Degree of competition/complementarity**	
Traffic control systems: Energy Efficient Intersection	High competition: SIEMENS, PTV, INDRA, Q-	

Type of service	Degree of competition/complementarity	
Service	Free, RS Industries Competition, Kapsch TrafficCom in traffic lights provision, traffic information systems	
Info-mobility services	High competition: HERE. Aegis ITS Provision of telecommunication and in-vehicle services	Complementarity: TomTom: possibility of cooperation for providing mapping services. Vulog: cooperation in the market niche of in-vehicle devices for telecommunication

Table 13 CS2 main competitors

The table shows that the CS2 services must face highly competitive solutions in the field of EEIS, in particular from big vendors of ITS infrastructure, both hardware and software: SIEMENS, PTV, etc.

Instead, in the area of Info-mobility services, there is room for synergy and cooperation with SMEs providing telecommunication services, mapping, in-vehicle devices for telecommunication and V2I communication.

3.3.5 Value chain resulted from CS2

The resulted value chain for CS2 can be seen in the following figure:

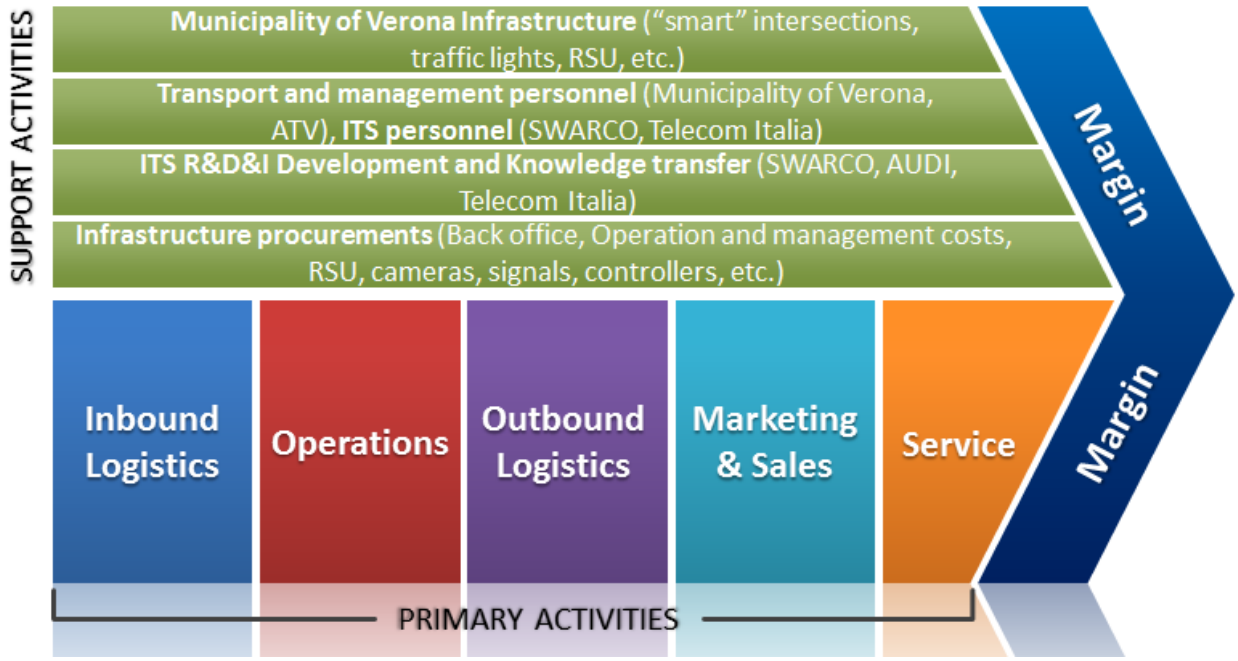

Figure 36 CS2 value chain

The primary activities, based in the creation, manufacture, distribution and sale of the product or service:

Inbound logistics

For CS2, the data coming to the RSU (Roadside Units), OBU (On-Board Unit) and cameras which allow the acquisition of real-time traffic data are the inputs for the system.

This kind of infrastructure is the base input for a system deployed in any potential location, feeding the system, which provides a bundle of ITS services. As the system is somehow modular, the potential customer could decide to install only the infrastructure needed for some part of the full set of services, going from a partial deployment (only with some part of the services available) to a full deployment (which will allow offering all the services of the system).

Operations

The CS2 solution deployed in Verona is composed of several systems and applications in coordination with the traffic management centre of Verona where they exchange data and are coordinated by a higher level sub-system. Those systems allow the acquisition of traffic measures and offer statistical profiles along with traffic related data (OMNIA), Info mobility services and cooperative traffic monitoring (MISTIC), traffic management control (UTOPIA) and as part of the Compass4D pilot in Verona, Energy Efficient Intersection Services (EEIS), Speed Advisory System (GLOSA), Road Hazard Warning (RHW) services, Road Works Warning (RWW) and red light violation functions.

Outbound logistics

The output of the CS2 in Verona are all the ITS services provided by the platform, which is composed by several systems. The platform provides immediate benefits regarding the traffic congestion, reducing costs and delays for the drivers (both private driver and road transport operators) and reducing emissions (CO2).

Along with this, the platform provides several services for the end-users (as mentioned previously, EEIS, GLOSA, RHW, Red light violation, etc.). Some of these services need the presence of an OBU in the vehicles (OBUs are really cheap devices, going usually for less than 10€) in order to benefit from the advantages provided by the system.

Similar to CS1 the exploitation of the data managed by the system represents and big opportunity. In this case, since the system stores valuable traffic data, the appropriate agreement with the data owner could allow third parties to benefit of the provision of data services or even develop value added services with further functionalities which could be offered to end-users with commercial purposes.

Marketing & sales

As part of the Compass4D project, the solution has been disseminated to a wide audience and using several channels. Social media (Twitter, LinkedIn), videos, press releases and webinars where used in order to make aware users, experts, decision makers and transport companies about the benefits of the solution.

In case of a change in the business model (going for a fee-for service model) or in the hypothetical case of the value-added services development, the solution could benefit of a different marketing campaign in order to reach even more public. Social media campaigns and some reward strategies (such as discounts in the service for a period of time or the offering of free OBUS to the end-users) could be highly beneficial.

Service

The activities in order to maintain the value of the product, classified as after-sale services:

- Active listening of end-users' opinions and feelings about the solution.
- Assess incentive mechanism to maintain end-users engaged.

The support activities:

Firm infrastructure

The main infrastructure of CS2 has been provided by the Municipality of Verona, where more than 150 intersections were connected with the platform and 60 centralised traffic lights are present in the city. The management of this infrastructure (legal and finance activities) is under the responsibility of the Municipality of Verona.

The municipality is also in charge of the legal, finance, quality, etc. activities in the CS2.

Human resources management

The Municipality of Verona managing the whole platform along with the staff from ATV are the main entities in charge of the activities right now.

Further deployments of the solution (either deploying more infrastructures or developing new functionalities for the platform) would require intervention of the Municipality's partners SWARCO and Telecom Italia.

Technology development

The activities are related to ITS R&D&I (Research and Development and Innovation) and knowledge transfer. SWARCO MIZAR develops control methods and algorithms for the platform along with ITS hardware such as signals and controllers; Telecom Italia is in charge of the connectivity technology and knowledge (mainly for the long-range communications) meanwhile AUDI is providing all the knowledge about on-board devices and vehicle C-ITS devices.

Procurement

The BackOffice, which is acquired by the Municipality of Verona along with the operation and maintenance costs of the solution and the ITS infrastructure deployed (RSU, cameras, signals, controllers, etc.) are the purchases needed in order to provide the services to the end-users.

The conclusions of the value chain are that a big part of the costs for the primary activities are in the acquisition and deployment of the infrastructures needed in order to provide the services, which could be located in the inbound logistic operations. These costs are also proportional of the size of the place where allocated, since they will require more infrastructure the bigger (or complex) the place is.

This will also affect the operations, since the amount of data managed by the platform will require more computational power but initially the advancement in this technology and the reduction of hardware prices will make these costs secondary in comparison with the initial acquisition of infrastructure. The operation and maintenance costs are also not very high.

Since the service delivery (outbound logistics) is provided either through the end-users' smartphones or through the OBU (as it was mentioned earlier, OBUs are really cheap devices), the costs associated with these activities are very low.

The first steps of the solution should be reinforced with a strong marketing campaign in order to maximize the number of end-users using the platform services. This will increase both the direct (economical) and indirect (social, environmental) benefits along with accelerating the arrival to the point where the investment is returned and the solution starts being profitable.

3.4 Case Study 3

3.4.1 Definition

The subject of case study 3 (CS3) is a project called “Synchro-modal container transport corridor Rotterdam-Limburg". Synchromodality refers to the possibility of choosing the most optimal transport modality at transhipment points. To allow for this, real-time information is needed on the transport chain. In the project of case study 3 a platform is developed to share real-time data on container transport from deep sea terminal Rotterdam to warehouses in Limburg (NL) (see **Figure 37**). The data collection involves tracking of the seagoing ships heading for Rotterdam, container handling in the port of Rotterdam, inland ship and truck transport and handling of the containers at the inland terminal and eventually at the warehouse. The scope of the project excludes the last mile from warehouse to final destination. Better insight in arrival of containers in Rotterdam and the rest of the logistic chain allows for better planning and shorter transport times. Currently it can take about 10 days to ship the container from Rotterdam to Limburg, of which it is moving less than 24 hours. There is a lot of potential to reduce transport time by decreasing the amount of idle time. The project under study aims at proofing the principle with a research platform and to convert it to an operational platform by service providers.

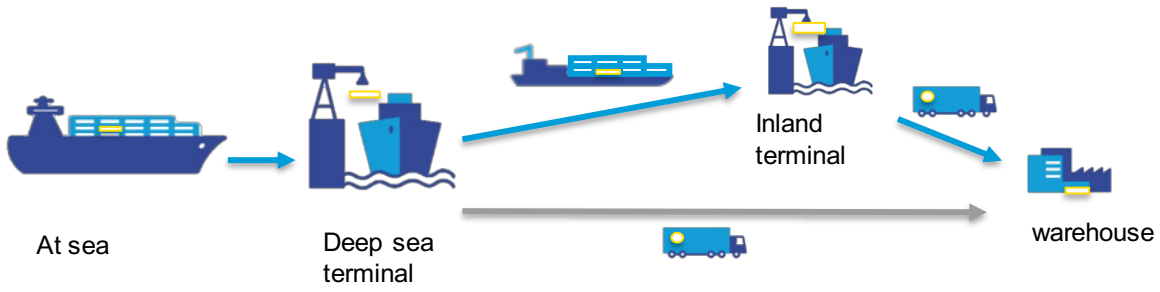

Figure 37 Schematic representation of transport chain with containers track and traced

The main objective of the project is to give good insight in the status of containers from sea to warehouses in the hinterland. This allows to:

- Reduce slack[31] in the planning; often containers remain on the terminals longer than necessary due to lack of information. The ambition is to reduce the maximum transport time from 10 to 6/7 days,
- Improve transport operation: by optimally plan resources and work teams, providing accurate and reliable delivery times and reduction of unreliable and long waiting times at terminals, and
- Reduce ad-hoc communication between different parties in the supply chain.

Overall the service will support synchro-modal transport and increase the share of inland waterway transport due to improved planning possibilities.

[31] Slack in the planning takes into account the uncertainty in transport time.

The innovation of the project is provision of real-time data to logistic planners on the complete chain of container transport from sea to hinterland, combining information of several different sources and data owners (see **Figure 38**). The service includes information of seagoing ships, deep sea terminals, inland waterways, trucks and inland terminals on:

- Planning
- Position of trucks and ships
- Container status, e.g. customs

The service is currently in the pilot phase, with a terminal operator, a warehouse operator and a shipper as pilot customers. At this stage of the development the question arising is which type of stakeholder is going to exploit the service and which (type of) customers are going to take the product. An attractive business model is needed.

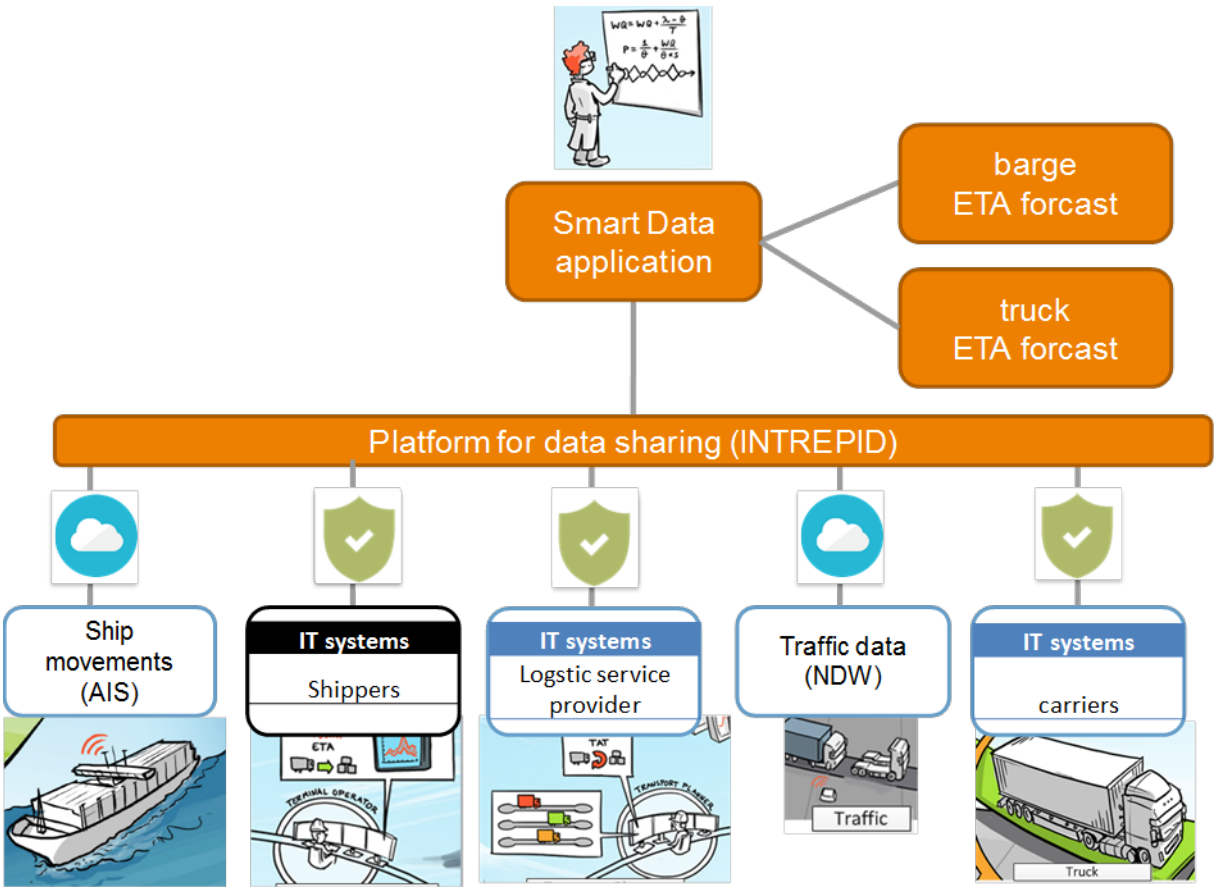

Figure 38 Schematic representation of the platform (source: TNO)

In the initial phase of the project, which ran in 2016, a demonstrator has been developed which has shown that it is technically feasible to track containers using Automatic Identification System (AIS) data of ships and truck GPS data. In this first phase a terminal operator, warehouse operator and shipper delivered the shipment information that was key to this service.

The project is currently in its second phase where a pilot is being set up. The goal is to broaden and expand the service. This is done by including more container information from container handling at the deep-sea port, including new inland terminals and by attracting additional customers (logistics companies). Furthermore, the platform is transferred into a

more professional platform. For this purpose, additional stakeholders have been involved which include ICT/ITS companies and the Port of Rotterdam. At this stage of the development the question arising is which (type of) stakeholder could exploit the service and what types of customers are interested. The answer to the question is key to make the service ready for exploitation after the pilot study. Knowledge about the supply and demand side of the service is needed to generate an attractive business model. Also, the use of the service will require to (eventually) changing processes to actually act upon the identified improvement opportunities.

The upcoming exercises will provide an initial picture of the circumstances in which the project of CS3 is situated currently. It will touch upon question such as: “Which company will exploit the service? Who are the main customers? Who are the main competitors?” This document will provide early answers to these questions based on stakeholder consultations, review of documentation and internet research.

3.4.2 Market analysis

3.4.2.1 Analysis of current and potential market

The track and tracing system developed in the project “synchromodal container transport corridor Rotterdam-Limburg" is in essence a freight management system that provides real-time information on container transport, thereby allowing for better planning and more efficient use of inland waterway transport to the hinterland. This section will give more information first on the developments in the global freight management market and secondly on the container market, focussing in the end on developments in inland waterway container transport from Rotterdam to Limburg.

Global freight management systems market

According to recent studies the global freight management market has great potential [59] [60]. It is expected to grow from US$18.69 billion in 2016 to US$53.91 billion in 2021 by a compound annual growth rate (CAGR) of 23.60% over the forecast period. Especially two regions are important potential markets for global freight management systems: North America which holds the largest market share of global freight management systems owing to the constantly growing third-party logistics industry in the region. While on the other hand the Asia-Pacific region is projected to witness the fastest growth during the forecast period due to growing inter- and intra-trade among different Asian countries. Increasing operational and maintenance costs of transport, growing traffic congestion, more cargo thefts and raising climatic concerns are challenges for the freight management market that ask for ICT solutions to make the transport system safer, more efficient, more reliable, and more environmentally friendly. CS3 is about such an ICT solution in the market segment of freight information systems.

Container transport market

Between 1995 and 2009, world container traffic has tripled in volume from 137 to 432 million TEU[32] at an annual growth rate of 9%. In 2014, world container port traffic accumulated to a total of 680 million TEU [61]. With increasing containerization of goods and decreasing related costs for handling of goods, a continuous long-term growth in maritime container freight shipments is expected [62].

The Netherlands holds a strong position in terms of logistics; this is reflected by the position of Rotterdam as the largest seaport in Europe. The container throughput in Rotterdam amounted 12.4 million TEU in 2016 [63] and is forecasted at 18 million TEU in 2035 [64]. The number of containers transhipped to and from to the hinterland equals approximately 8.40 million TEU (in 2015) and has been growing by 25% in the period 2005-2015 [65] [66].

In 2015 53% of the containers from and to Rotterdam were transported by road, 36% by inland waterways and 11% by rail. The share of inland waterways and rail in container transport has grown in the period 2005-2015 at the expense of road transport. During the period container transport by inland waterways has increased by 48%, rail by 40% and road by 10% [66].

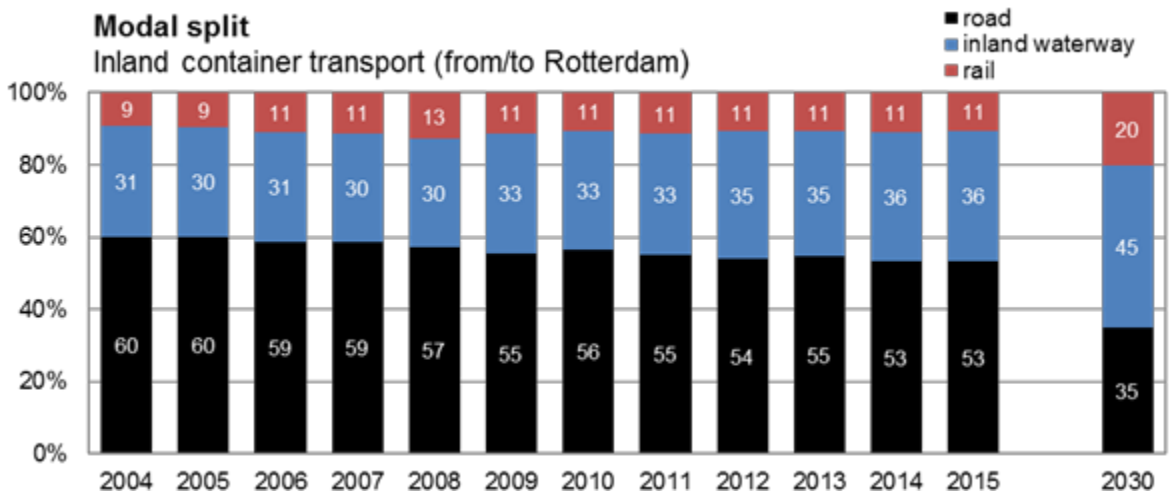

Figure 39 Modal split for container transport in TEU at Port of Rotterdam 2004-2030

The Port of Rotterdam has the ambition to decrease the share of road transport from and to the terminals at the Maasvlakte to 35% in 2030 to ensure the accessibility of the port. Forecasts for 2030 therefore assume an increased modal share for inland shipping (45%) and rail (20%) (See Figure 39) [67]). Taking into account the projected growth rate of container transport, the containers transported by inland waterways to the hinterland is estimated to grow by almost 70% between 2015 and 2030.

Inland container terminals

In line with the rise in container traffic at Dutch deep sea ports such as Rotterdam, inland ports are becoming more important in global supply chains [68].

[32] The twenty-foot equivalent unit TEU is a unit to express container volume.

The Dutch inland waterway network currently holds a total of 30 inland terminals [69]. On average the sea container transhipments in the Netherlands by inland waterways have increased by 14% in the period 2011-2014, reaching 6 million transhipments in 2014 (including 3 mill. in Rotterdam). In the provinces Friesland, Gelderland, Overijssel and Limburg the growth was even over 30% in this period (Buck Consultants International, 2016).

Recent studies modelling freight transport found that the Dutch container terminals will have sufficient capacity to handle container transport up to 2020, partly due to planned investments in almost all major terminals. Still, due to expansion of container terminal and scheduled services, the geographic reach of container transport via inland waterways is increasing [64].

3.4.2.2 Segmented analysis definition of market demand and supply side

The platform developed in the pilot of Case Study 3 combines planning information of shipper, warehouse operator and terminals with real-time location data of seagoing ships, trucks and inland waterway barges to give insight in planning and the actual status of the container. In addition, the system gives the estimated time of arrival of a container based on the actual status, historical and actual traffic data. The pilot phase focuses on the corridor Rotterdam-Limburg with a shipper in consumer electronics, its warehouse operator/freight forwarder and an inland terminal operator/transporter in Limburg. This section assesses the target market for exploitation of the service based on the relationship between demand and supply in the pilot phase.

Figure 40 Corridor of Case Study 3 (Source: TNO)

The segmentation of market demand and supply side can be outlined as follows.

Demand side

There are three major groups identified on the demand side of the service in the pilot phase: i) shippers, ii) inland terminals and iii) warehouse operators.

- Shippers: The ITS service of CS3 allows to improve the logistic efficiency of container transport from deep sea port to the warehouse of the shipper. The shipper is the final consumer of the logistic service from deep sea to warehouse and therefore benefits from improvements in the logistic chain. The main benefits for the shipper are reduction of slack and travel time, and higher travel time predictability. These direct benefits, in turn, can result in lower stocks and better services to the shipper's customers.
- Inland terminal: The inland terminal organizes transport by barge from deep sea terminal to the inland terminal and finally to the warehouse by truck. The inland terminal needs information from the deep-sea terminal on the arrival of the sea boat and the status of the container at the deep-sea terminal. With this information, the inland terminal can better plan the barge and the activities at the inland terminal.
- Warehouse operators: The warehouse operator/freight forwarder is hired by the shipper to arrange the transport from the port of Rotterdam to the warehouse in Limburg. Better knowledge of the container status on the track Rotterdam – Limburg allows for better planning, optimizing transport options and reduces communication about the container status with inland terminal and shipper.

The most relevant information regarding the demand side is summarised in the table below, where the information is estimated based on stakeholder consultation and public information (so the information should be used as indicative):

DEMAND SIDE	**Numeric Answer**	**Explain if necessary**
Shippers		
Number of containers	1600-1800	Number of TUE per year. Calculated from 800-900 containers that are mostly 40 feet (2 TEU).
Share of containers by barge	97%	Share of containers transported by barge from Rotterdam in the last year[33].
Share of containers trucked	3%	Share of containers transported completely by truck from Rotterdam to warehouse in the last year
Warehouse operator (Limburg)		

[33] The transport of containers from the inland terminal to the warehouse takes 10km and it is done by truck too.

DEMAND SIDE	Numeric Answer	Explain if necessary
Number of containers	4,000-6,000	Number of container unloaded at warehouse per year. This might correspond to 8,000-12,000 TEU assuming 2 TEU containers.
Inland terminal		
Container capacity (TEU per year)	125,000	Number of handlings per year. Data based on consultation.
Current container handling (TEU/ year)	80,000	Container transhipments per year expressed in TEU [8]
Number containers received by barge from shipper	1,600-1,800	Number of TEU per year. Calculated from 800-900 containers that are mostly 40 feet (2 TEU).

Table 14 CS3 details about the demand side

Supply side

The supply side consists of ITS/ ICT service providers. In the pilot phase, the ITS service is coordinated by TNO while other ICT and ITS companies are delivering parts of the service and data to the integrated system. The role of the ITS/ ICT service providers in the exploitation phase of the service has not been settled yet, but their interest is in running the platform as a service to the shippers, inland terminals, and/ or warehouse operators and possibly also the deep-sea terminals.

The most relevant information regarding the supply side is summarised in the table below. The savings and costs are estimates of the authors based on information gathered from stakeholders and public information. At this stage in the project only rough estimations can be made and the figures should be interpreted as indicative.

SUPPLY SIDE	Numeric Answer	Explain if necessary
Savings		
Travel time reduction (days)	2-3	Realistic reduction in travel time according to stakeholders
Benefits of travel time reduction (€/ TEU)	7-25	Estimated benefits for travel time reduction based on less container rent, less trucking and cash flow benefits

SUPPLY SIDE	Numeric Answer	Explain if necessary
Costs		
Investment costs (€/ year)	50,000-200,000	Investment costs based development of the current demonstration platform to commercial software and to synchronize data with new customers. The estimation is the investment costs would be amortised in 4 years.
Variable costs (€/ year)	250,000-750,000	Cost for hardware (hosting), software maintenance and updating, and helpdesk function. The helpdesk cost is the most dominant cost factor.
Data costs (€/ year)	15,000-22,000	Cost for receiving AIS, GPS and traffic data (estimated based on Fleetmon website, NDW website and stakeholder consultation).
Total costs (€/ year)	315,000- 920,000	

Table 15 CS3 details about the supply side

Demand and supply relationship

To demonstrate the demand and supply curves in a diagram, the demand curve (in red) is elastic based in the amount of TEU managed by the actors in the demand side (shippers, inland terminals and warehouse operators). In the pilot phase for the CS actors, the services are provided for free, causing the curves to cross at price equal to 0. In the market phase, the solution could offer its services based in a fee-for-service based in a flat fee per TEU, represented by an elastic supply curve, and causing the supply curve (in blue in the current model) to move to the left (in black). This will move the equilibrium point from cero to a point where demand (amount of services bought by logistics companies at a certain price) and supply (amount of services supplied by service providers at a certain price) are in equilibrium.

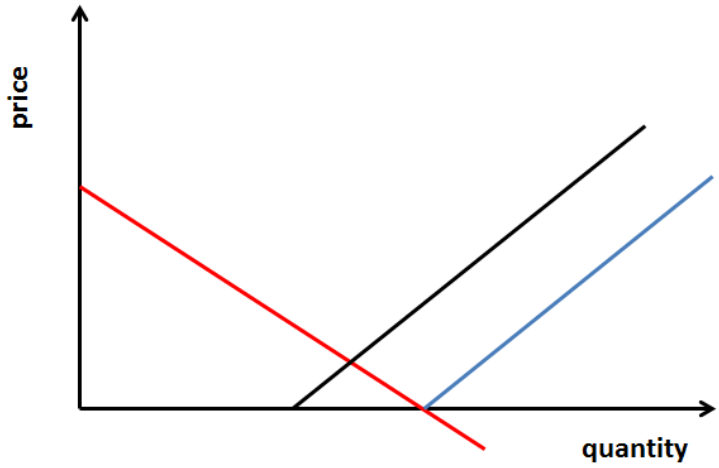

Figure 41 CS3 Demand and supply curves

At the moment, the service is in the pilot phase and is offered for free to the supply chain partners of the shipper as pilot customers. The benefits for the supply chain partners still need to be fully demonstrated (the pilot is ongoing) and will come to full expression when the system is applied to more customers.

When fully operational, the service offers benefits to different parties involved in the supply chain. ITO (the inland terminal operator) is able to improve its internal operations as it has a better overview of the whereabouts of the container. They can reduce transport times and improve the service they offer to the shipper, that has ordered the container. The warehousing party is able to better plan its operations since they know at what time containers will arrive. The shipper will have the container content sooner in the warehouse. In the end the shipper can benefit from shorter lead times to get their products to the market. In addition, the container rental period can be decreased by 1-3 days and last minute organized truck transport from deep sea port to warehouse can be reduced. Quantification of the benefits is difficult at this stage as the benefits have not been fully demonstrated. However, the reduced transport time is estimated to deliver at least 7 to 25 Euro benefits per TEU, taking into account 1 day reduction in container rent, reduction of 50% in trucking and shorter lead times to the market for 5% of the products (see supply side table). The benefits in the logistic chain depend on several factors such as the kind of goods. For high value goods, such as electronics, the benefits are expected to be higher.

The costs for the service (see supply side table) exists of investment costs (further development of commercial software, API developments for data exchange) , variable cost (such as hardware hosting, software product sustenance, helpdesk services) and data costs (such as AIS data, truck GPS data, traffic data). Many cost items are not exactly known and depend on factors such as existing knowhow of the company that will commercialize the service, and market size and scale advantages. A first estimate is that yearly costs for the service are in the order of €315.000 – 920.000 per year, assuming a limited number of shippers (ca. 30) serviced by the system.

Taking the estimated costs of €315.000 – 920.000 per years and assuming customers of the service (either inland terminal, shippers or freight forwarders), are willing to pay up to €15 per

TEU (base on the benefits of €7-25 per TEU, see demand table) for the service, the service will be profitable at a volume of 20,000-60,000 TEU per year. This corresponds to 15-40 shippers of similar size as the shipper of electronics or the containers imported by inland terminal ITO.

Several of the type costs become less important when the volume increases. Investment costs, fixed costs (AIS subscription), programming for additional partners will all decrease when the demand increases. The investment and fixed costs will be divided over a larger number of customers, reducing the average costs. When additional partners are using the service, it will become less cumbersome to include their data streams due to previous experiences. There are decreasing marginal costs as volume increases. This means that at higher container/ customer volumes the service might be offered at lower prices.

The demand curve is influenced by the added value of the service. For some customers, such as shipper of high value goods, it is very important to have detailed information about the shipment of containers. The service can offer them more benefits and they might be willing to pay more than others. When the price of the service lowers, more companies involved in the supply chain are willing to pay for the service as it offers more benefits than its costs. The demand will increase when prices decrease.

The above figures are based on rough estimated, but give an indication that the service can be profitable at relatively limited number of shippers being serviced. As the project is in the pilot phase it is difficult to assess the costs and benefits and how the benefits will be allocated to the stakeholders in the supply chain. In addition, benefits other than reduction in costs are possible, such as improved service, less stress etc.

Target market

The services offer benefits to different stakeholders involved in the supply chain of container transport by barge from the port of Rotterdam to inland terminal and finally to warehouses. The benefits of the service are not limited to inland terminals warehouse operators/ freight forwarders or shippers in Limburg but are ultimately interesting for all container transport by barge to inland terminals in the Netherlands (see also analysis of current and potential market).

Following this rationale, it is sensible to assume that the target market of the service incorporates the complete hinterland container transport of the port of Rotterdam via inland waterways. 1.5 million TEUs are shipped from the port of Rotterdam each year. These containers are going through approximately 30 terminals, which serve approximatively 750-1500 shippers (see table below). The potential to include additional parties is large as the platform is based on open source platform which is designed to easily implement existing data formats. Other than compatibility of data formats with the platform there are no large restraints to include additional companies. The pilot project focuses on information provision for about 800 containers a year. There is thus a large market potential that could be exploited.

Key group	Numeric Answer	Explain if necessary

Key group	Numeric Answer	Explain if necessary
Shippers and terminal in the hinterland of the port of Rotterdam		
Containers delivered to the hinterland through the port of Rotterdam by inland waterways	1.5 million	From [66] assuming a ratio of 50/50 for loaded and unloaded containers (total handled is 3 million)
Number of shippers receiving oversea containers	750-1500	Estimate assuming 1000-2000 TEU per year on average per shipper
Number of inland container terminals in the Netherlands	30	Container terminals from [70]

Table 16 CS3 customer target groups

Other options

In the end the system might be interesting for inland terminals abroad (e.g. Germany) and for rail container terminals. Another expansion is possible by focusing on other large container ports like the port of Hamburg or the port of Antwerp. The platform also could provide a good basis to develop further services, such as planning assistance.

3.4.2.3 PESTEL analysis

Case Study 3 increases the information to make optimal transport decisions for the transport of containers from the port of Rotterdam to Limburg. The service allows optimizing the modal split of hinterland transport, which relates to national and international objectives to promote optimal and sustainable transport. Sustainable transport is influenced political, economic, environmental and social elements.

Another element that is affected by external factors is the use of an open source data model by CS3 that allows better combining of various data flows from several stakeholders. This ICT solution is influenced by several external factors including technical and legal issues with data security and privacy. The following figure shows these important external factors that influence the service followed by an explanation of those.

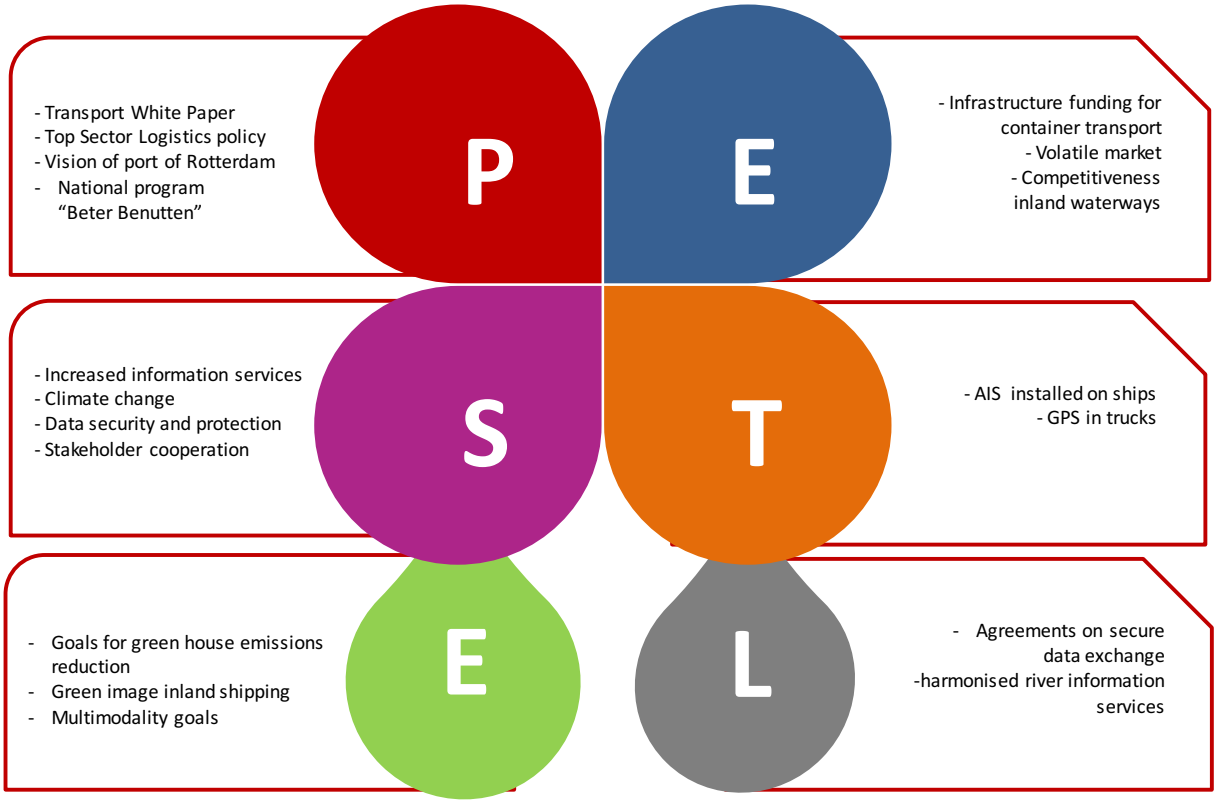

Figure 42 CS3 PESTEL

Political factors

Several political factors are influencing the CS3 due to its potential impact on the competitiveness of the logistical chain and the alignment with sustainable transport objectives. On a national and European level, there is increasing attention for optimizing the transport decision process. In the 2011 transport White Paper Roadmap to a Single European Transport Area [71] the European commission highlights the goal to increase the shift to waterborne transport. Optimising the transport decision requires detailed knowledge which is what CS3 could offer. By cutting slack the transport time of waterborne transport can be shortened, which makes waterborne transport more competitive compared to other forms of transport.

On a national scale, several initiatives promote the optimisation of the transport decision chain. Within the national program Top Sector Logistics, government and industry support research and market initiatives that increase the efficiency and sustainability of transport. The national program "Beter Benutten" aims for optimizing the use of existing infrastructure, such as inland waterway infrastructure.

The service can contribute to shift more containers to inland waterways, which also fits the ambition of the Port of Rotterdam to decrease the share of trucks in the hinterland transport.

Economic factors

To meet growing demand in container transport the Dutch government has strengthened the port of Rotterdam by constructing a new port area (Maasvlakte II) in the framework of the

Rotterdam Mainport Development Project [72] Subsidy programs for the construction of inland terminals covering up to 25% of the total investment costs further contribute to a rapid development of the waterborne infrastructure in the Netherlands [73]. In the case of the extension of the Port of Rotterdam (Maasvlakte II), the Port of Rotterdam Authority included a minimum share of inland waterways of 45% as an obligatory requirement in its bidding documents for terminal operations [63]. This can be regarded as a particularly important measure strengthening the market position of inland navigation.

Container shipping in general is an increasingly volatile market [74] due to imbalanced demand and supply. Correspondingly, the turnover in inland navigation witnesses' fluctuations in container turnover of up to 20% from one year to the other. High price fluctuations in turn put pressure on the margins of shipping companies [75]. ITS-services improving the efficiency of inland waterway transport may improve the margins.

At deep sea terminals, inland container vessels and ocean-going ships are un-/loaded at the same quays. Due to a lack of contracts and mutual performance obligations between port terminals and owners of inland container vessels, inland vessels often experience longer waiting times. This effect is becoming more severe when transhipment volume increases also since inland vessels often need to collect containers at multiple terminals. Inland shipping companies therefore need to calculate extra time which has a negative effect on their competitiveness with other hinterland transport modes [76].

The competitiveness of freight transport through inland waterways further depends on the availability of cargo (high TEU-volumes). With increasing demand, inland waterways can gain in attractiveness due to lower transport cost (economies of scale) [63].

Social factors

In the logistic sector, there is increasing attention for shipment information, as is shown by the AberdeenGroup (2013) who find that supply chain visibility is the most important improvement point[34]. This amplifies that the attitude of logistical operators towards track-and-trace of container transport has improved. Measures promoting the exchange of shipping information across different transport modes are therefore becoming more and more crucial for inland shipping to survive competition with road freight transport.

The main challenge for creating a track-and-trace service for sea containers is to combine the information of several sources. Contract arrangements often restrict sharing data for privacy reasons. There are ways to overcome these issues, but this requires cooperation between stakeholders to renew agreements on data sharing.

Another social factor besides the attitude towards real-time shipment information is increased attention for sustainability. The service will lead to an optimization of the transport decision where inland shipping is the preferred option. This option puts less pressure on the environment which results in social support.

[34] https://www.gs1.org/docs/visibility/Supply_Chain_Visibility_Aberdeen_Report.pdf

Technological factors

The service developed in CS3 makes use of the automatic identification system (AIS) for tracking seagoing ships and inland vessels and GPS for tracking of trucks. The service benefits from the fact that seagoing vessels and most inland ships are equipped with an AIS transponder due to regulation [77]. Also, more and more trucks are equipped with a GPS tracking device.

Traffic data is analysed and predictions (in terms of estimated time of arrival) are provided to the end-users, using Internet of Things, big data and wireless communications among other technologies, topics covered in the general (C-)ITS PESTEL analysis in this document.

Environmental factors

Synchromodal container transport aims to allow for a higher share of inland waterways at the expense of road transport. The better planning should allow for a higher share of containers transported by inland waterways and should circumvent last minute deliveries by road. From an environmental point of view, inland waterway transport is valued for its lower contribution to climate change. Transport by inland waterways can easily reduce CO2 emissions by more than 50% as compared to road transport [78]. Although air polluting emissions of inland waterways are often higher than for road transport, inland waterways transport is considered to be more environmentally friendly.

Legal factors

Data security is an important legal factor. The functioning of the service depends on real-time data included in the platform. Contracts restrict the inclusion of certain data sources with privacy sensitive information. Therefore, second best options or work-arounds are used to obtain the necessary data. Updates of contracts or the use of APIs ensuring good data governance could ensure the inclusion of privacy sensitive information in the future.

The EU framework Directive 2005/44/EC [79] provides rules for the use of harmonised river information services (RIS) thereby enabling cross border compatibility of national systems. As a result of this regulation the AIS system has been introduced for inland shipping.

3.4.2.4 SWOT Analysis

Figure 43 CS3 SWOT

Strengths

- A strength of the service is the use of a data platform which allows the stakeholders to exchange data in order to have real-time information of the shipment
- The service includes vital information of a variety of data sources including shippers, terminal operators and warehouse operators to synchronize their activities. This means they can optimize transport decisions. This will reduce slack and required resources.
- Real-time tracking of shipments has been demonstrated, which is the main important feature of the service.
- The service supports goals set by the Port of Rotterdam and the Dutch government to increase inland waterway transport.

Weaknesses

- Currently, Deep sea terminal data is not directly accessible due to data sensitivity related restrictions that still need to be solved. Part of the container movements can therefore not be displayed in the ideal way.

- There are certain gaps in AIS data coverage. As a result, the vessel is 'missing' for part of the route and therefore the location is not shown correctly.
- The demonstrator has shown that it is possible to provide real-time information of the container. These results are limited to only one shipper and warehouse operator. Only limited demonstrated results are available on cost, benefits and data compatibility of additional sources.
- There is no clear business model yet. This results in a uncertainty for companies interested in supplying this service.

Opportunities

- Rail transport could possibly be included as well.
- More terminals, shippers and warehouse operators can be included which greatly expands the market size.
- Additional features can be added. For example, weather information and planning assistance. Planning assistance needs the input of the current track-and-trace service and will add value to the current service.
- Demand for container transport is expected to increase, offering more potential users

Threats

- There is a threat for a chicken-egg problem for the required investment to operationalize the service. IT organisations are not sure if there is enough demand for the service, while many logistical companies are not willing to invest as there are no demonstrable results.
- Security and privacy concerns might turn out to be too difficult to overcome which results in an incomplete picture of part of the logistical chain.

3.4.3 Stakeholders analysis

3.4.3.1 Identification of stakeholders' groups, their characteristics and interest

For CS3 the main stakeholders involved are parties in the supply chain of container transport. These stakeholders are actively participating in the service as well as several IT companies and external parties. In total ten parties actively participate in the pilot phase of the service. In order to structure the analysis, we have identified relevant stakeholders' groups for the parties involved in the pilot phase. Overall, a total of 8 distinctive groups were identified following consultations with the main stakeholders along with the scrutiny of the project document.

- **Shippers**: Shippers are companies that initiate the shipment, and pay for logistic services delivered by shipping companies, terminals and warehouse operators. They are benefitting from improved logistics services enabled by track-and-trace services.
- **Terminal operators**: Terminal operators are responsible for transhipments of containers from one mode to the other mode. In this case at the deep-sea terminal containers are transhipped from deep sea to hinterland modes. At the inland terminal from barge to truck. In addition, inland terminals can organize or perform the transport to and from the inland container terminal.

- **Warehouse operators**: Companies that operate a warehouse facility for shippers. In this case, they also partially plan the transport to the warehouse. They have interest in real-time information on the status of the containers in order to optimize their operations. Warehouse operators are important end-users as they can use the service to better plan their operations.
- **Research organisations**: Organisation in this category are responsible for research and innovations. The innovations in this case study relate to combining data from different sources and to bring the relevant stakeholder together. Their responsibility is to ensure the set up and functioning of the service. They provide and combine existing knowledge in transport and ITS.
- **ITS/ ICT service providers**: ITS service providers are considered the enabler of IT solutions in the field of transport, addressing the development and deployment of decision support systems aimed to improve and optimise the performance of transport systems. ICT service providers provide IT solutions including programming, software development and Internet of Things among. They do not have specific knowledge or history with transport applications.
- **Governmental promotor/Funding body**: Funders provide financial support to develop smart mobility applications, and help accelerate new research and prototypes into market-ready technologies.
- **Regional Development Company**: RDC has knowledge and a broad network in the logistics sector. Therefore, they are, together with other stakeholders, active in promoting the project and finding partners to scale-up.
- **Port authority**: The port authority is responsible for the safety and functioning of a port. It offers information and other services to its clients, which are vessels, terminals and shipping companies among others. They also have interest in efficient and sustainable hinterland transport to optimize the functioning of the port.

The following diagram shows the stakeholders' grouping structure:

Figure 44 CS3 stakeholders groups

For each of the stakeholders' groups, the specific stakeholders have been identified. Most of the stakeholders are described in an anonymous way for privacy reasons:

- **Shipper**: Shipper electronics
- **Terminal operator**: ITO
- **Warehouse operator**: Operator warehouse in Limburg "Warehouse L"
- **Research organisation**: TNO
- **ITS/ ICT service providers**:
  - ITS company offering fleet management systems for trucks ("FleetM")
  - ITS company offering track-and-trace service for truck transport ("TrackT")
  - ITS company offering port data on container status ("Portdat").
  - Company experienced in software and hardware development ("ICTdev").
- **Governmental promotor/Funding body**: Dinalog
- **Port authority**: Port of Rotterdam
- **Regional Development Company**: LIOF

The shipper imports high value electronic goods which are shipped from China towards the Dutch hinterland. The shipper is interested in reduced shipping time and slack and in a higher predictability of the travel time. This can lead to a reduced need for warehousing and a better service to the customers of the shipper. The shipper has hired Warehouse L to plan its transport, and ITO to organize the transport of its containers from Rotterdam to the warehouse.

ITO operates an inland terminal where containers are transhipped from and on to barges. They organize the transport by barges from Rotterdam to the inland terminal in Limburg and the truck transport from terminal to the warehouse in Limburg. Containers that are delayed in Rotterdam will be transported by truck in order to meet the deadline set by the shipper.

The operator of the warehouse in Limburg "Warehouse L" is a freight forwarder offering several logistic services, including a warehouse facility in Limburg. Warehouse L is hired by the shipper to organize the transport of containers from the inland terminal to Limburg and to take care of unloading the containers and storing the products in the warehouse. The goods will be pick-up for distribution to the clients of the shipper. Real-time information on the container status will help to optimize their operations.

TNO manages the development of the service into the pilot phase and has developed the first demo version of the platform. TNO also investigates the business case in order to promote future commercialisation of service of CS3. As TNO is a research organisation they will not bring the service to the market themselves. Currently it is investigated which party can take this this role. TNO is experienced in development of new products, managing pilot projects with several stakeholders and brings technical knowledge on transport and ICT.

The main stakeholders have managed to set up a working demonstrator. In order to construct a functioning pilot several ITS companies have been included. ICTdev is an IT company interested in software and hardware development and expanding its business to the transport market. They are bringing knowledge to further develop the platform to a commercial product using open trip model (OTM). FeeltM deliver the real-time information from the board computers of trucks of ITO to TrackT. They deliver information from trucks between the inland terminal and shipper as well as the deep-sea terminal and shipper. TrackT in turn is experienced with real time mapping of trucks. They share their software to monitor the status of trucks and their frontend is used to present the results generated by the data platform. They also share their expertise on the software development in OTM. As a result of the core activities, Portdat has data of the different deep sea terminals within the port of Rotterdam. Portdat gives insight in the estimated/actual times of arrival of vessels at the deep-sea port, the customs status and transhipment status to relevant stakeholders.

Dinalog is a Dutch public-private organization which stimulates innovate projects in logistics. It is funding and promoting projects that have the potential to make freight transport more efficient or durable.

The Port of Rotterdam is the port authority. It is responsible for managing the daily operations of the port as well as managing the interests of its partners.

LIOF is a Regional Development Company for the Dutch province of Limburg. With logistics defined as one of the top sectors in the region, the RDC has a good knowledge and a broad network in this sector.

3.4.3.2 Assessment of stakeholders determining their influence and importance

This section provides an assessment by the authors of the stakeholders for importance and influence in CS3 given the identified interests and characteristics table in Appendix 1 Stakeholders interest and characteristics. The main interests and degree of impact/influence

of each stakeholder on CS3 during the pilot phase are given in the following table. This situation might change during the exploitation phase, depending on the direction chosen.

Stakeholder	**Interest**	**Estimated influence**	**Estimated importance**
Shipper high value consumer goods (electronics)	- Optimisation of integrated logistical chain (10 - 6/7 days) reductions of hidden costs in transport chain (slack and unnecessary communication) - Optimise planning and reliability due to better information about shipment and delays - Lower stock of goods due to more efficient planning Better service provision for clients	M	3
ITO	-Having a single overview/visualising of information about maritime vessel, barge and truck - Reason of delay (can we solve this?) - would like to have unloading time of maritime vessels included - Shorter transhipment times on terminal - more effective loading of inland barge - less coordination	H	3
Warehouse L	- Total overview of containers and ETA's - more efficient use of own resources - reductions of ad hoc communication - reductions of hidden cost due to slack an ad hoc communication - less stress in the transport chain -> steadier stream of goods rather than peeks - more time to deal with actual emergencies - Able to match requests customers with transport decisions, and being able to adjust to actual changes in transport - Knowing as long in advance as possible when containers arrive	M	2
TNO	- Successful project - To develop the service for operationalisation	H	3

Stakeholder	Interest	Estimated influence	Estimated importance
	- Matching the objectives: The main goal of the project is to gain a better efficiency performance, especially more reliable transport times. To do so smart data will be used.		
Track T	- To expand their business to inland shipping	M	2
Portdat	- improve service for port community - Look for additional features - more rapid throughput times - optimal re-use of information	L	3
FleetM	- increased knowledge with synchromodal transport - increased service for costumers - improved information in transport movements	L	1
ICTDev	- offer ICT knowledge to new area	M	2
Dinalog	- increase logistic efficiency - less truck kilometres (sustainability) - meaningful knowledge gathering - successful project	L	2
LIOF	- Strengthening the region with logistic innovations - Strengthening the corridor Mainport – Hinterland - Strengthening the existing multimodal infrastructure, with ICT as a fourth modality	L	2
Port of Rotterdam	- improvement of provided services for port stakeholders - adapting to (future) market needs - Reducing shipment times (improved efficiency)	L	3

Table 17 CS3 stakeholders' influence and importance

The importance-influence matrix of this assessment is given in the following figure:

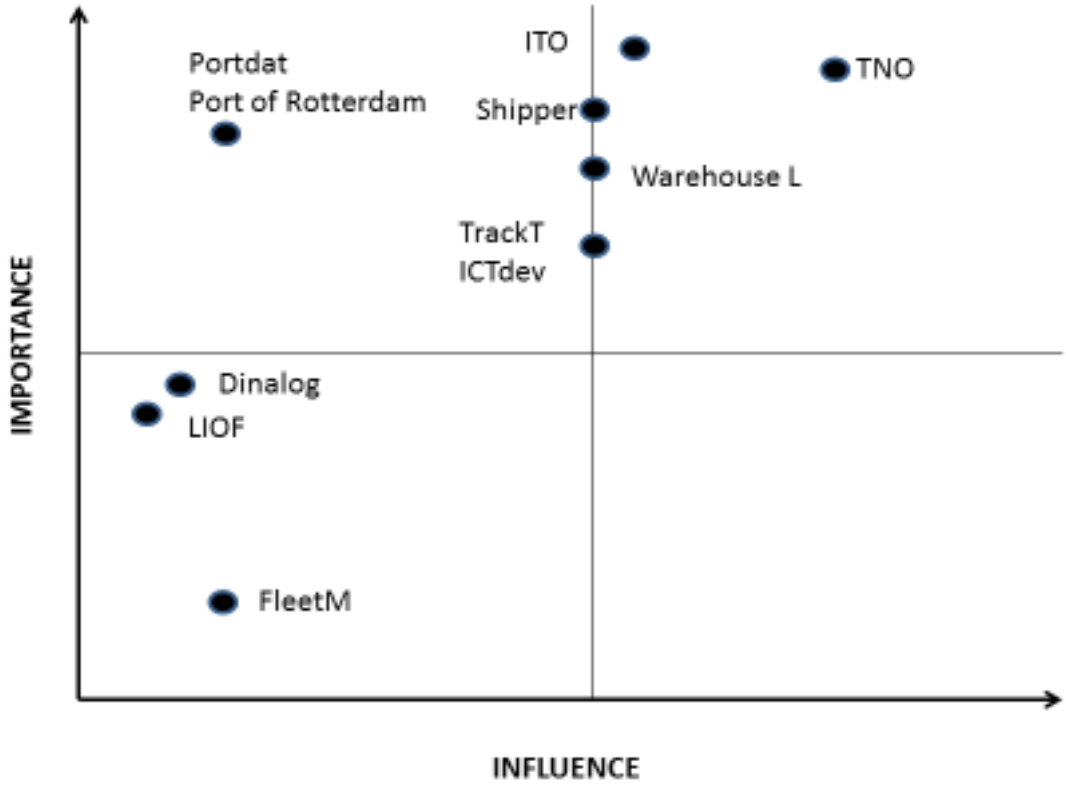

Figure 45 Importance-influence mapping of CS3 stakeholders

Initial stakeholders

The table and figure above indicate four initial stakeholders: TNO, the shipper, inland terminal and the warehouse operator Warehouse L. TNO is the main initiator of the project. TNO is coordinating the development of the technology and investigating commercialisation by third parties. At this stage TNO is of high importance and high influence. The shipper, ITO and Warehouse L are the main users of the service in the pilot phase. The planning data and knowledge on the requirement of the system are key for the service development, which makes them stakeholders with high importance. ITO also delivers important information via their own system based on data from the port of Rotterdam. The shipper, ITO and Warehouse L also have influence on the development of the service as the service is developed based on their feedback.

Other stakeholders

TrackT and ICTdev are stakeholders with high importance as they are directly involved in the development of the platform. ICTdev contributes to the further development of the platform, whereas TrackT brings real-time truck information from their software system and delivers the front-end of the platform for the users. They are therefore rather important and influence the development of the service. Portdat and the Port of Rotterdam are very important as they have influence on the availability of data from the deep-sea port. These data are key for the stakeholders. Their influence is limited as they are not directly involved in the development of the system and are not direct customers of the service. Monetary funding is provided by

Dinalog. LIOF brings and a network to find additional customers for the service. FleetM provides information of the on-board units of trucks. The support provided by these latter stakeholders is important for the functioning of the service, though not crucial.

Outlook

The importance and influence of stakeholder will change during the commercialisation process of the service. TNO currently manages the system. In the commercialisation phase this role needs to be taken over by another party, which will become more influential and important. The importance and influence of other parties might change depending on the direction the new managing party possibly takes. Key functionalities could be outsourced to IT companies, who become important and possibly influential in the process. Shippers and/ or terminals may take the role as launching customer which will give them more influence and importance.

3.4.3.3 Mapping and characterizing relations and dependences between stakeholders

The relations between stakeholders in this case study can be seen in the following scheme:

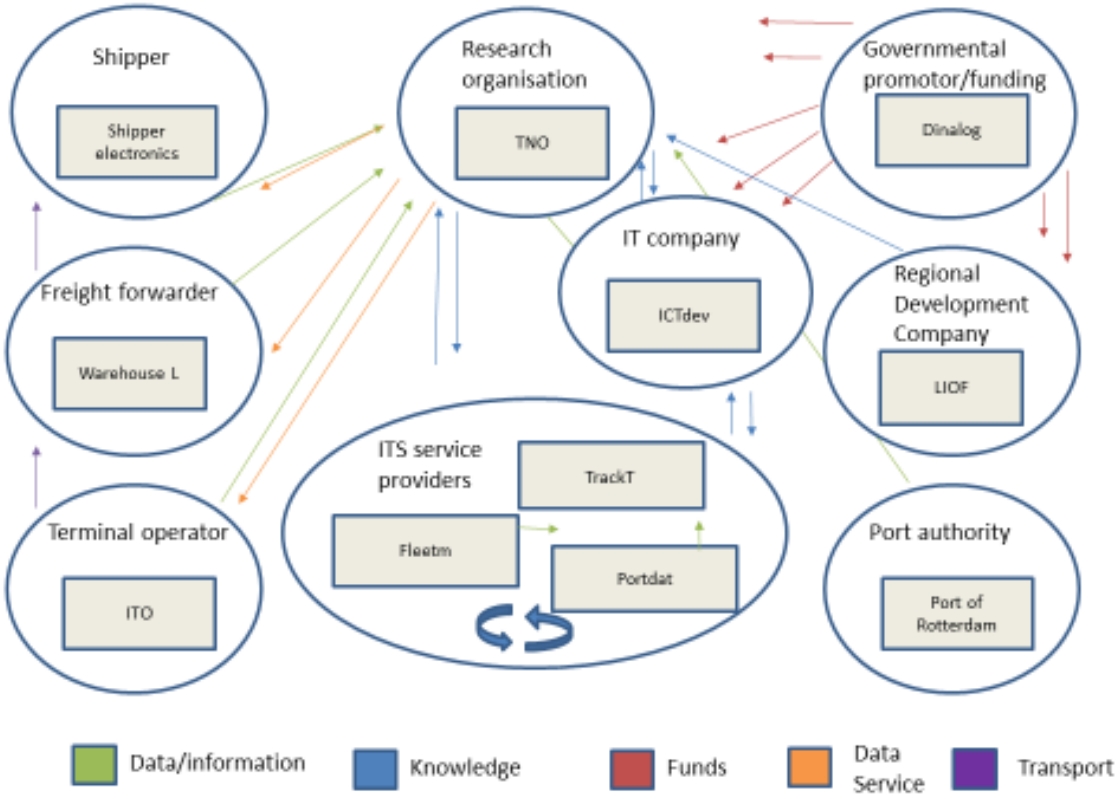

Figure 46 CS3 stakeholders' interactions

In the current situation TNO is the managing organisation of the service development in CS3. The logistical companies provide planning data to TNO, visible by the three green lines on the left side. TNO processes these data, combine them with other data and enrich the data to generate real time shipment information and estimated time of arrival. This real-time

shipment service is delivered back to the logistical companies, as is visible by the orange lines. In parallel with the shipment information, there are actual containers transported between the different parties in the supply chain, visualized by the purple line. The right side of the pictures shows the supporting stakeholder.

TNO is the managing organisation and the figure should be viewed as such. Most relationships and flows are coming from or going towards TNO. Several of the required data provision or IT services are outsourced to IT(S) service providers. This is visible in the exchange of knowledge between TNO and ITS companies represented by the blue lines. TNO has developed the initial platform and is assisted by the IT company to develop an open platform that can communicate via APIs with data from the ITS service providers. The ITS service providers share data, knowledge and ITS services. After the pilot phase, monetary flows will compensate any outsourced work, this is not visible in the figure. In the pilot phase companies rely on funding by Dinalog and own contributions. The red lines represent the funding from Dinalog to all stakeholders involved. In the exploitation phase the main revenues are expected to come from the end-users of the service, which might be shippers, freight-forwarders or terminal operators.

The supporting stakeholders on the right side of the scheme will deliver data, knowledge or other forms of promotion to the main stakeholder which currently is TNO. Depending on the arrangement they might be compensated during the exploitation phase. This could be in the form of funding, knowledge or access to the service. In the current pilot phase, there is no explicit compensation.

3.4.4 Competitors assessment

The following section analyses alternative products and services that compete with the developed ICT platform for the same market share and focuses on solutions that are already deployed in the market. The main functionality of the ICT platform of CS3 is the possibility to track containers during shipping along the entire supply chain through the integrated collection of data from various sources. This section therefore focuses on analysing other entities that offer similar ICT platforms or web-based services to track containers during shipping in general and at the same time predicting container arrival at a final destination. As this platform consists of two main features, competitors for both features were investigated in parallel.

Features	Description
Tracking and tracing of containers	ICT platform sharing real-time information on the position of containers time while being carried on seagoing ships and inland waterway vessels through AIS as well as carried on trucks via GPS
Forecasting of container arrival	ICT platform predicting arrival time (ETA) of containers at an interim or a final destination (deep sea or inland terminal, warehouse)

Table 18 CS3 main features

The three main criteria to assess the level of competitiveness versus CS3 include the options (a) to track containers in real-time along the entire supply chain, (b) to forecast their arrival time at all stages of the supply chain, as well as (c) to provide this service for freight transport from port-to-hinterland.

In fact, there are two strong competitors for CS3 that offer solutions with a similarly comprehensive set of functions, which are:

- **DLDS**: a joint venture between the Government of India and the Japanese IT service provider NEC Corporation formed end of 2015 to leverage ICT across the Indian Logistics Sector towards increasing efficiency in the supply chain. Their flagship product is a container tracking system called Logistics Data Bank (LDB) that uniquely integrates tracking information from various agencies across the supply chain in the Western logistics corridor in India and provides near real-time information on a container's location visualized on Google Maps as well as the estimated delivery time. Very similar to CS3, LDB integrates not only information from transporting vehicles (trucks, trains) but also from port terminals, toll plazas, inland container depots (ICD), container freight station (CFS), and the Indian freight operations information system (FOIS), an application to track freight trains and handle the billing and revenue collection.
  According to DLDS, key success factor for the LDB has been the participation of major parties along the supply chain at the initial development stage. LDB can therefore now serve various customer groups which include shipper consignees, shipping lines, port terminal operators, rail, combined transport operators and truck companies. On the technical side, the tracking functionality requires a temporary RFID (Radio-frequency Identification) tagging of all containers to be monitored and the installation of RFID readers across all entry and exit gates of ICDs, CFS and toll plazas in order to capture container information while in transit. The service is available via an online search function. Delays in container transport are identified and alert notifications sent to the user via e-mail or SMS. In addition, DLDS offers comparative metric-based analyses allowing customers to assess logistics performance. Major benefits of the system comprise an improved container movement visibility for port-to-hinterland shipments, an increased efficiency of transhipment operations, and reduced logistics costs. DLDS can help reduce the transportation lead-time by five days, resulting in estimated annual savings of US$ 3.2 billion. LDB operations have been launched at Jawaharlal Nehru Port of Mumbai (JNPT), the largest container port of India, in July 2016 serving container transhipments at JNPT covering all of its 4 port terminals. To provide the back-end IT infrastructure, the user is currently charged a fee of Rs 125 (approx. €1.65) per container. So far, DLDS provided monitoring for 70% of India's container volume handled equalling approx. 4.8 million containers transhipped at the 4 port terminals of JNPT. Although container tracking with the LDB is so far limited to inland freight transport on railways and roads, the functionalities could be expanded to follow containers on inland waterways with limited effort. Further, although DLDS is so far exclusively operating in the Western logistics corridor in India, their solution could be transferred to other regions. Negotiations with ports in south India have already been initiated recently to further expand the project.

- **Ocean Insights** (OI): a young logistics start-up from Hong Kong with main offices in India and Germany. Ocean Insights' container tracking tool combines container liner schedules and carriers' container tracking information with public AIS vessel tracking data, but does not include additional port-related data. The web-based container tracking platform gives a full overview on shipments across all carriers. It provides real-time information on container and vessel location including status changes and delay warnings. Their solution is a pure data-driven container tracking solution for sea freight. They use data from shipping companies as well as AIS real-time vessel position data for their service. Their software can depict global supply chains and, for example, automatically notify customers when there are delays. As such their tool combines both the tracking of a container location and the prediction of its arrival time in an integrated solution. Despite being primarily developed for ocean shipping and therefore port-to-port freight monitoring, the integration of AIS-data enables this tool to be compatible for port-to-hinterland monitoring through inland waterways as well and is thereby one of the most relevant competitors for CS3. OI has even made first hands-on-experience tracking containers on inland waterways for a customer from the chemical industry, which is located in the Ruhr area, and transports most of its export shipments to Antwerp, where they are loaded onto seagoing container ships. To OI's knowledge, they offer the world's most precise, purely data-supported container tracking system in the market. They can provide their data via interfaces, also in SAP transport management systems, among others, which is often desired by their customers. According to OI, they are currently the only provider in the market that can properly link satellite AIS data with tracking data from the shipping companies. Another unique feature is the way they process the data - this special mechanism is a major contributor to the ability to generate automatic "exception" messages. The product is already commercialized. Ocean Insights counts several hundred customers from various industries in more than 20 countries. Usually, their customers have a significant sea freight volume (>10,000 containers per year). Their billing model is transaction-based, i.e. for each container, which a customer of OI traces, a fee is charged. The effective cost of using their service is therefore quite variable. Most customers pay approximately € 3,000 and more per month, whereas very large customers pay significantly higher amounts. Some of the world's largest freight forwarders are among their customers as well as companies from the chemical, automotive and consumer goods industries. Further global scaling and development of their business model is underway. In addition, OI is also working with software companies that have integrated OI's tracking data into other applications. The information has been obtained through personal communication with Robin Jaacks, Sales Director, Ocean Insights, Rostock.

Besides DLDS and Ocean Insights, there are other entities that offer similar solutions with fewer functions that may still compete for the same market as CS3, if additional functionalities become available or if these companies gain access to the Dutch market. Second strongest competitors include:

- **CargoNet:** a privately-owned company, based in India, founded in 2000 with customers all over the world that is offering real-time Cargo tracking software with a pre-alert function. Similarly, as CS3, the software tool enables customers to obtain a precise estimated delivery time of their cargo. It enables multi-branch and multi-modal

shipment integration and offers a customized shipment tracking for import and export segments both for air and sea. Although their services currently focus on port-to-port freight transport, monitoring of port-to-hinterland operations through inland waterways seems to be available upon request. CargoNet's tracking solution therefore has to be considered as a future competitor for CS3. Cargo Tracking offers different modules with customized features adjusted to the needs of their respective clients (oversea agents, consignees, shippers). The product is commercialized and available in four different packages ranging from a package with basic features for US$ 1,000 per month to a package with advanced features for US$ 4,000 per month.

- **INTTRA**: a privately held U.S. shipping technology company that has been in the market for more than 15 years. With more than 100,000 customers that book and ship containers INTTRA is offering one of the largest multi-carrier e-commerce platforms for the ocean freight transportation. INTTRA Track & Trace represents one of INTTRA's core services and enables freight forwarders and shippers to instantly track the locations of their shipments by container number, carrier booking number, bill of lading reference number, and purchase order number or by INTTRA number. It provides data from 50+ of the world's leading carriers covering 35% of the world's ocean shipping container moves. Data can be retrieved through a web platform with an easy-to-use user interface and multi-criteria search functions. Status notifications for multiple parties can be activated and INTTRA offers a 24/7 customer support in 7 languages. So far, INTTRA has focused its business merely on ocean shipping, hence monitoring of port-to-port shipments. Through acquisition of the young EU container tracking company Avantida based in Belgium beginning of 2017, INTTRA is currently expanding its service portfolio by offering inland distribution services, i.e. for monitoring of port-to-hinterland shipments. Avantida is specialized in tracking empty containers and helps cut costs for carriers and transport companies. In addition, Avantida will also provide access for INTTRA to seven European markets, including Belgium, The Netherlands, Germany, France, Italy, Portugal and Spain (Inttra, 2017). As such, the INTTRA Track & Trace service has to be taken into account as a future competitor for CS3.

In the Netherlands, there is no direct competition at the moment for the same service. However, there are comparable initiatives being developed, of which the exact status is unknown at the moment. It can be expected though, that there will be competition for exploiting the service or similar services in the Netherlands once the service is developed.

3.4.5 Value chain resulted from CS3

The resulted value chain for CS3 can be seen in the following figure:

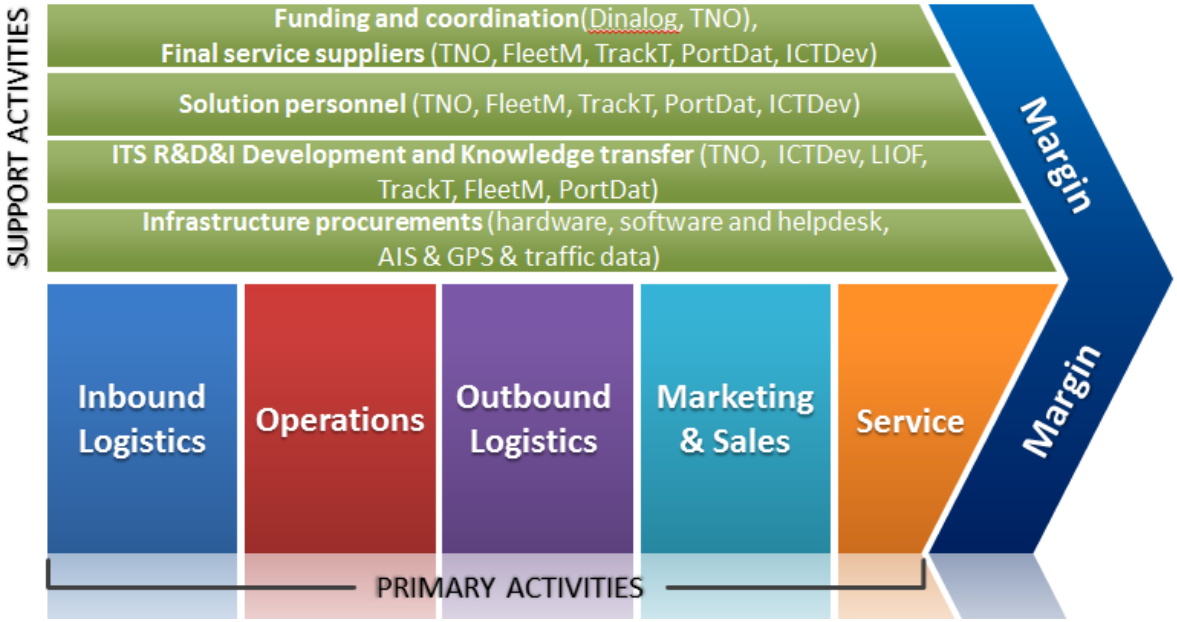

Figure 47 CS3 value chain

The primary activities, based in the creation, manufacture, distribution and sale of the product or service:

Inbound logistics

For CS3, the input to the platform comes from different sources: barges AIS, trucks GPS, the traffic data coming from the government traffic agency and the container information coming from the sea terminal and the inland terminal (also including planning information from the shipper and warehouse operator).

Operations

The data gathered is received by the data sharing component of the platform and then operated by the smart data application where the track-and-trace functionality is performed along with the algorithms in charge of the ETA (Estimated Time of Arrival) calculations.

Outbound logistics

There are two main outputs from the platform in the pilot phase: the track and tracing of containers and the forecasting of container arrival. These results are delivered to the platform customers (demand side actors) in an appropriate dashboard designed for their purposes.

Being a B2B-oriented case study, there is a big potential of further data exploitation and synergies. The data managed by the platform could be offered via API or web service so it could be integrated with different customers' legacy systems in order to optimise their operations. For customers without presence of legacy systems, a personalisation service could be offered by the ICT stakeholders developing the solution.

Also, since the data managed by the CS3 solution is business-related, it could be offered to third parties for other purposes (such as statistics, data mining and business advice). Again, this should be undertaken considering the appropriate terms of privacy and security.

Marketing & sales

Since the case study is not yet in the market (but close to it) and once the role of each stakeholder developing the solution is clear, some processes should be taken in order to sell the product:

- Showcase of the platform services to other potential business customers.
- Business oriented social media campaigns.
- ITS service providers integrating new services or products to the platform.
- Advertising campaign.

Since the service is oriented to big business (the more volume of containers managed by the customer the bigger the benefit the solution provides), it could be very interesting to design some kind of reward or incentive strategy for SMEs. The "personalised solution" approach could also attract some customers with low level of automatization in their operations.

Service

The activities in order to maintain the value of the product, classified as after-sale services:

- Active listening of customers' opinions and feelings about the solution.
- Being a business oriented case, and since business customers are especially concerned about the privacy and safety of the information, assuring their customer data has the highest level of protection against cyber-crime, identity breach and other breaches of security.

The support activities:

Firm infrastructure

The main activities about accounting, legal, finance, quality, etc. where initially undertaken by Dinalog (as funding body) and TNO (as project coordinator). Once the solution is commercialised, one or several of the stakeholders will be in charge of these activities.

Human resources management

Initially as part of the pilot, staff of TNO and the private supply partners (FleetM, TrackT, PortDat, ICTDev) were in charge of the human resource management activities.

The final solution body owner will be in charge of the human resources management activities and will imply staff from all the stakeholders involved in the solution development and deployment.

Technology development

The activities are related to ITS R&D&I (Research and Development and Innovation) and knowledge transfer. TNO and ICTDev are the stakeholders developing algorithms for the solution; FleetM, TrackT and PortDat are data providers, along with transferring knowledge (and software development) about track-and-trace and fleet management. PortDat is a data provider also transferring knowledge about container management (times, custom status, etc.). LIOF provides a network and knowledge of logistic companies in the region.

Procurement

The hardware costs (hosting), the software maintenance and updating, the helpdesk function along with the costs of acquiring AIS, GPS and traffic data, are the costs and purchases needed in order to provide the services to the end-users

As a conclusion of the value chain, it is foreseen that the major cost for the primary activities are located in the operations. The more customers of the solutions, the more computational power the platform will require and the more software & hardware infrastructure (servers, cloud services) will be needed. Since the platform is providing data based in real-time information, the platform needs to be optimised in order to provide a good service to customers, no matter how much data needs to be managed. This could be alleviated allocating dedicated infrastructure to big customers (or providing it as an additional service).

There is a big opportunity of creating added value in the outbound logistic, offering personalised services to the customers depending on their specific necessities. The solution could benefit of an advertising campaign and showcase of the product features to business customers.

3.5 Case Study 4

3.5.1 Definition

A vast range of data exists within the railway industry, and their availability continues to increase as a result of uninterrupted data collection processes across the industry. The initial phase of this project, which ran between 2013 and 2014, explored the feasibility of using the data available within the railway industry to inform new mechanisms to assure safety and security of customers, staff and the public in an industry where the interdependence between physical and digital environments is set to grow exponentially over the next few years.

This case study "KEEP SAFE" addresses the need to use experts' knowledge when analysing data to inform decision making in the railway industry. In particular, the case study uses data and experts' knowledge to serve three overarching purposes within the British railway industry:

- Infrastructure management: Fault prognostics and predictive maintenance.
- Customer safety: Reducing the risk of accidents due to system failures.
- Business performance: Reducing disruptions caused by unplanned maintenance and repairs.

The project was structured in two phases:

1. Phase 1. Theory development (2013-2014): focused on developing a method for eliciting knowledge from experts and use that knowledge in data analysis;

   Phase one was based on the challenges derived from the availability and increasing nature of a vast range of data within the British railway industry as a result of uninterrupted data collection processes across the industry. At this stage, the project explored the feasibility of using the data available within the railway industry to inform new mechanisms to assure safety and security of customers, staff and the public in an industry where the interdependence between physical and digital environments is set to grow exponentially over the next few years. This phase of the project delivered a small-scale solution which served as a proof of concept for a safety predictive tool. Using knowledge elicitation techniques, and involving leading industry and academic safety experts, the project created a series of models of railway data and safety, and then developed a metadata-driven, safety-focused model of railway operation and performance; a prototype software tool that uses metadata models for the prediction of safety-related faults was also developed.

2. Phase 2. Pilot, practical implementation (March 2017-present), consists of an implementation of the method in practice, an initiative funded by Network Rail to turn every train into an infrastructure monitoring train.

   On completion of its first phase, the approach to data analysis developed by KEEP SAFE were adopted by one of the initial partners to run a pilot study on how to turn every train into a monitoring train. The new project focused on the collection and analysis of infrastructure data to inform decision making. The new phase, currently underway, becomes both a validation of the method initially developed and a solution of a practical problem the railway industry is facing: improvement of the infrastructure

monitoring mechanisms to support predictive maintenance and provide a better and safer service to the public.

To achieve its aims the project has relied on two main technologies for the following purposes:

- Data collection and secure storage. Sensors are placed on trains to capture V2I data, which is data related to the interface between the train and the railway network, e.g. overhead electrification. The data is then transmitted from the train to a secure server at Coventry University using the Internet.
- Data analysis and visualisation: Using among others the approach initially developed by KEEP SAFE, the data is analysed using experts' views and the outputs are fed back to the industry in a visual form for inspection and decision making.

The case study is currently being implemented with an ultimate aim to deliver a system which allows railway infrastructure owners to collect raw data and turn it into a visual artefact that will inform decision making. Such visual representation of the data is informed by experts' knowledge and therefore enables engineers to identify areas where potential failure modes are being developed and plan for their timely repair. This is supported by an Information Technology infrastructure which is placed at the University.

3.5.2 Market analysis

3.5.2.1 Analysis of current and potential market

UNIFE and Roland Berger sixth edition of the World Rail Market Study (WRMS) provides a comprehensive overview of the rail supply market's development. The market study is based on a survey conducted in the 60 largest rail markets worldwide and includes the testimonies of UNIFE members and rail experts from all around the globe [80].

According to UNIFE WRMS the world rail market volume hit a record level of nearly €160 billion in 2015 and in the coming years the market volume will grow 2.6 percent per year on average worldwide and reach €185 billion in 2021. Asia Pacific will continue to account for the biggest portion of the growth (32%), followed by Western Europe (26%). Western Europe is top in the growth stakes with 3.1 percent, just edging ahead of Africa/Middle East with 3 percent. Asia Pacific's growth averages 2.6 percent, with Russia/CIS bringing up the rear with 0.9 percent.

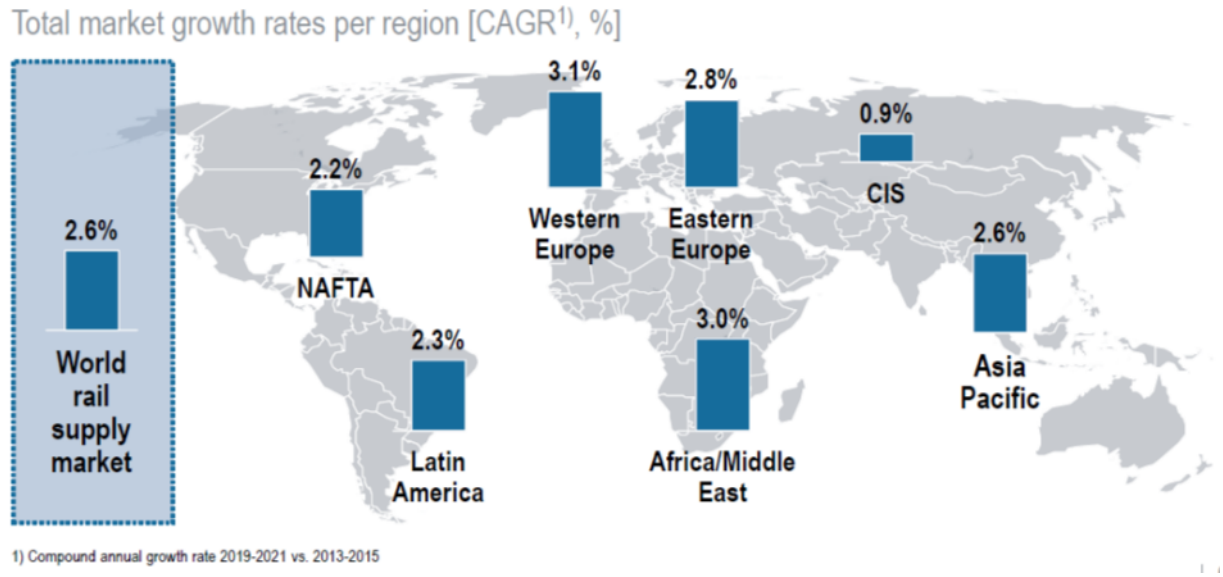

Figure 48 World rail supply market

In the rail transport market in the UK, The supply side of the market is Network Rail, overall infrastructure operator which controls and makes available for exploitation by private companies the existing and new infrastructure (rail lines, routes).

Network Rail is the owner (via its subsidiary Network Rail Infrastructure Ltd which was known as Railtrack plc before 2002) and infrastructure manager of most of the rail network in England, Scotland and Wales. Network Rail is an arm's length public body of the Department for Transport with no shareholders, which reinvests its income in the railways. Network Rail's main customers are the private Train Operating Companies (TOCs), responsible for passenger transport, and Freight Operating Companies (FOCs), who provide train services on the infrastructure that the company owns and maintains [81].

Train operating companies, is the demand side which compete severely to get the right to exploit specific routes.

3.5.2.2 Segmented analysis definition of market demand and supply side

The "KEEP SAFE" case study is characterised by the following component that are elaborated in the following sub sections.

Figure 49 segmented analysis of the market of “KEEP SAFE” pilot

It is important to understand that the UK rail maintenance market has changed drastically in the last year (in 2016), where Network Rail lost the sole control of rail maintenance which now is shared with private operators like Virgin, Southern, ScotRail and other operators for the first time in the history [35] [36] [37].

Therefore, the maintenance costs in each regulatory route have been allocated to franchises in proportion to the total variable usage charge paid by each franchisee in that route. The variable usage charge rate (£ per train kilometre) is calculated based on a train’s engineering characteristics and the wear and tear that a train causes to the track and is therefore an appropriate cost driver. In 2014-15, the allocation was based on train distance travelled in a route and a GB-level VUC figure for each franchise. This assumed that a franchise operating in more than one route had a homogeneous train fleet (train class and train length). For a given train class, if the franchise operated short, slow-running trains on one route and longer, fast trains on another, costs would have been over allocated to the slow route. In 2015-16, there was a refinement of the methodology to use a route-level VUC for each franchise, which overcomes some of this limitation [82].

In this context, the supply side “KEEP SAFE” solution is considered even when there are other stakeholders involved in the deployment of the solution as: “Rail Network” which provided funds; Alstom transport supplied trains and Serco provided ITC services. The deployment of ITS solutions for the railway industry is quite complicated and heavily regulated including other stakeholders as well.

[35] "Network Rail to be stripped of control over Britain’s train tracks as operators will win power to improve services"
[36] Rawlinson, Kevin (2 December 2016). "Network Rail to lose sole control of rail maintenance". The Guardian. Retrieved 27 January 2017.
[37] "Network Rail 'to be stripped of monopoly over running Britain's railway tracks'"

"Virgin Trains" is considered in the demand side but not as service providers for passengers/companies, since it is out of this scope of this project, but as a "KEEP SAFE" service consumer.

Demand side

"KEEP SAFE" was implemented in the LNW – London North Western route from London to Carlisle. The CS4 demand side rises from "Virgin Trains", a TOC, so that can provide services to their passengers. "Virgin Trains" as TOC require, among others, better railway lines so their trains can run and transport passengers. As it is shown in **Table 19 CS4 details about the demand side** the total track length is 4,500 miles that include 325 route miles and one operating route. The train services per day are approximately 6,000 and the annual rail passenger journeys more than 245 million.

The most relevant information regarding the demand side is summarised in the following table:

DEMAND SIDE	Numeric Answer	Explain if necessary
Track length	4,500 track miles and 325 route miles	
Number of operating routes	One route	It's the LNW – London North Western route from London to Carlisle.
Train services per day	6,009	
Annual rail passenger journeys	246.5 m	

Table 19 CS4 details about the demand side

Supply side

In the supply side of the pilot project examined in CS4, only "KEEP SAFE" solution is included though, they are also other stakeholders involved. "Rail Network" provides funds, Alstom transport supplied the trains (rolling stock) and Serco provided ITC services which provide the solution to Virgin Trains (which is in the demand side in the CS). Other stakeholders (Office of Rail Regulation and RSSB provide regulation etc. "Rail Network" is considered an externality but in the supply side, since it supplies funds and the pilot rail line.

The most relevant information regarding the demand side is summarised in the following table:

SUPPLY SIDE	Numeric Answer	Explain if necessary
Savings		

SUPPLY SIDE	Numeric Answer	Explain if necessary
Reduction of maintenance cost	Up to 12%	
Increase network availability	Up to 20%	
Improve maintenance efficiency by reducing the number of maintenance work due to failure in elements.	10%	
Costs		
Data analytics	€45,000	
Project implementation	€80,000	The project is implemented as part of a greater European initiative called 'Transforming transport'. This budget relates to the implementation of the whole pilot in UK, coordinated by Network Rail.

Table 20 CS4 details about the supply side

Demand and supply relationship

To demonstrate the demand and supply curves in a diagram, the demand curve (in red) is elastic based in the contract of the franchise (TOC, FOC) with Network Rail for the routes where the franchise is operating and the total variable usage charge, which will constitute variable maintenance expenditures for the franchise. In the current model for Virgin, the predictive maintenance services are provided for free, causing the curves to cross at price equal to 0. In a hypothetical future, the solution could offer its services based in a fee-for-service, which could be based in the proportion of the total variable usage paid by the franchise, represented by an elastic supply curve, and causing the supply curve (in blue in the current model) to move to the left (in black). This will move the equilibrium point from cero to a point based in the opinion of the buyers (drivers and transport operators) of how much services are they willing to buy at a certain price in relation with the amount of services supplied by the market (service providers) at a certain price.

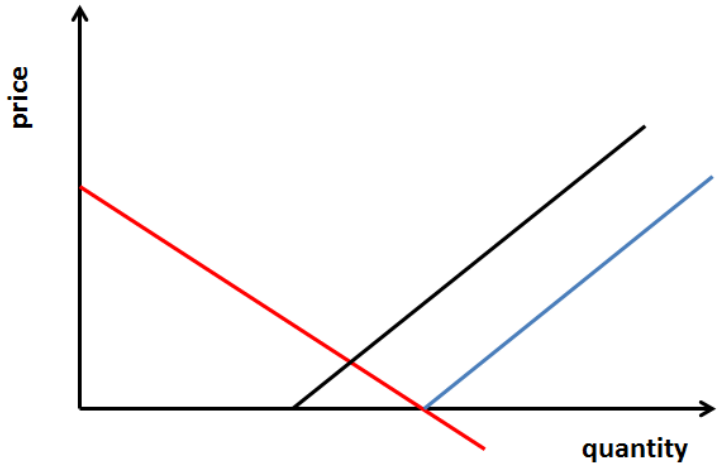

Figure 50 CS4 Demand and supply curves

The demand for solutions for monitoring and predictive maintenance in the market of railway lines will increase due various reasons. Some of the key reasons that support this foreseen increase are:

- The continuous increase of usage of the rail as one of preferred medium of transport, especially in Great Britain.
- Increasing demand by TOC and FOC for high quality railway lines so they can provide better services to their customers (passengers and freights).
- Increase pressure by TOC and FOC to maximise their profits by decreasing their costs.
- The adoption of more high speed trains in more railway lines requiring the highest quality of lines.

“KEEP SAFE” appears an innovative solution to fulfil the above foreseen demand for better railways via the adoption of predictive maintenance, since the reduction of maintenance cost is up to 10%. The solution not only, has proved via the pilot, that technically is feasible to be implemented but the results from the analysis of the collected data has identified points in the railway line that require maintenance actions. “KEEP SAFE” in the context of CS4 appears a successful project, initiated by Academia and included stakeholders from industry, public and end users.

The value created by the pilot project makes it potentially capable to be a profit-making C-ITS method / service. From the performed analysis, and available data, has not been possible to justify if the “KEEP SAFE” solution can be offered as a standalone solution to the market or has to be integrated as a component in an integrated solution for railway monitoring.

Target market

The “KEEP SAFE” method / solution, proposes a solution targeting the railway market in Great Britain but as a B2B integrated solution created by private companies/research organizations and offered to the railway operators. The demand side of the market is

constituted by the railway operators and the railway lines. The target market for the method /service is considered difficult to be exactly defined since is a multi-factor demand. The three key factors affecting the demand for the “KEEP SAFE” solution are:

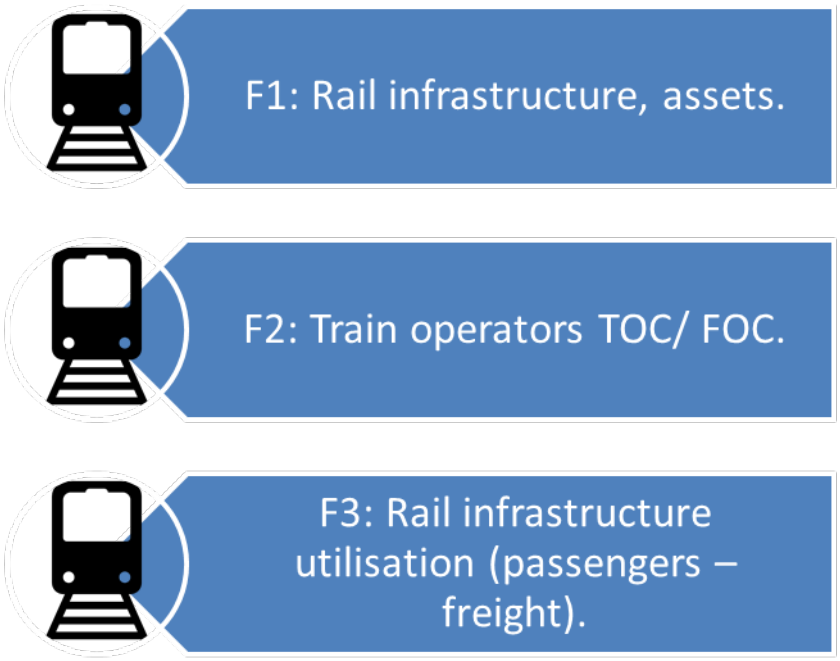

Figure 51 CS4 Demand key factors

- F1: Rai infrastructure, assets

The following table provides the key characteristics of the rail infrastructure network in Great Britain[38] [39][81]:

Year	Route open for traffic	Route Open for Passenger & Freight Traffic	Route Open for Freight Traffic Only	Track kilometres
2009-10	15,753	14,482	1,271	31,073
2010-11	15,777	14,506	1,271	31,108
2011-12	15,742	14,506	1,236	31,063
2012-13	15,753	14,504	1,249	31,075
2013-14	15,753	14,504	1,249	31,092
2014-15 (r)	15,760	14,506	1,254	31,120
2015-16 (p)	15,799	14,552	1,247	31,194

Table 21 Great Britain characteristics of the infrastructure of the rail network.

[38] Network Rail official website https://www.networkrail.co.uk/
[39] Office of rail and road, UK http://orr.gov.uk/statistics/published-stats/statistical-releases

Symbols: (:) Data not available or Operator not in service; (r) Data revised; (p) Provisional data.

- F2: Train operators

The next figure presents the total number of train & freight operating companies established in five years' time intervals. As the linear trend line shows the number of companies appears growing in the near future:

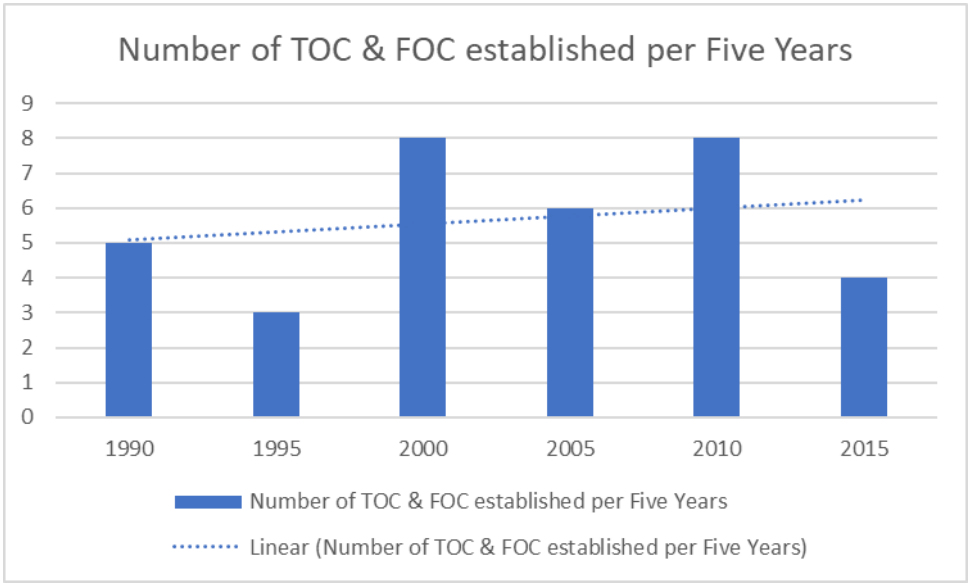

Figure 52 Number of TOCs & FOCs established per five years.

- F3: Rail infrastructure utilisation

The following table and figure shows the total passenger-kilometres in the period 2006-2016. Total passenger-kilometres represent the transport of one passenger using rail over one kilometre[40].

Freight train kilometres are the actual mileage in kilometres operated by FOCs on Network Rail infrastructure. The data is sourced from Network Rail's Track Access Billing System (TABS) and covers only the mileages charged through TABS. Competition between freight operators means we would expect a greater level of variation in mileage from year to year than in the passenger market. Not all freight operators have been in operation throughout the time-series, therefore total year on year comparison should be treated with caution.

Calendar year	Number of franchised passenger kilometers travelled (billions) [59]	Number of actual freight train kilometers (million km) [61]

[40] Glossary:Passenger-kilometre, Eurostat http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Passenger-kilometre

Calendar year	Number of franchised passenger kilometers travelled (billions) [59]	Number of actual freight train kilometers (million km) [61]
2010	53.3 billion km	58.65 million km
2011	55.9 billion km	81.58 million km
2012	58.1 billion km	80.72 million km
2013	59.1 billion km	84.00 million km
2014	61.8 billion km	81.99 million km
2015	63.6 billion km	69.76 million km
2016 (p)	65.0 billion km	67.94 million km

Table 22 Number of franchised passengers and freight kilometres in Great Britain[41].

Symbols: (:) Data not available or Operator not in service; (r) Data revised; (p) Provisional data.

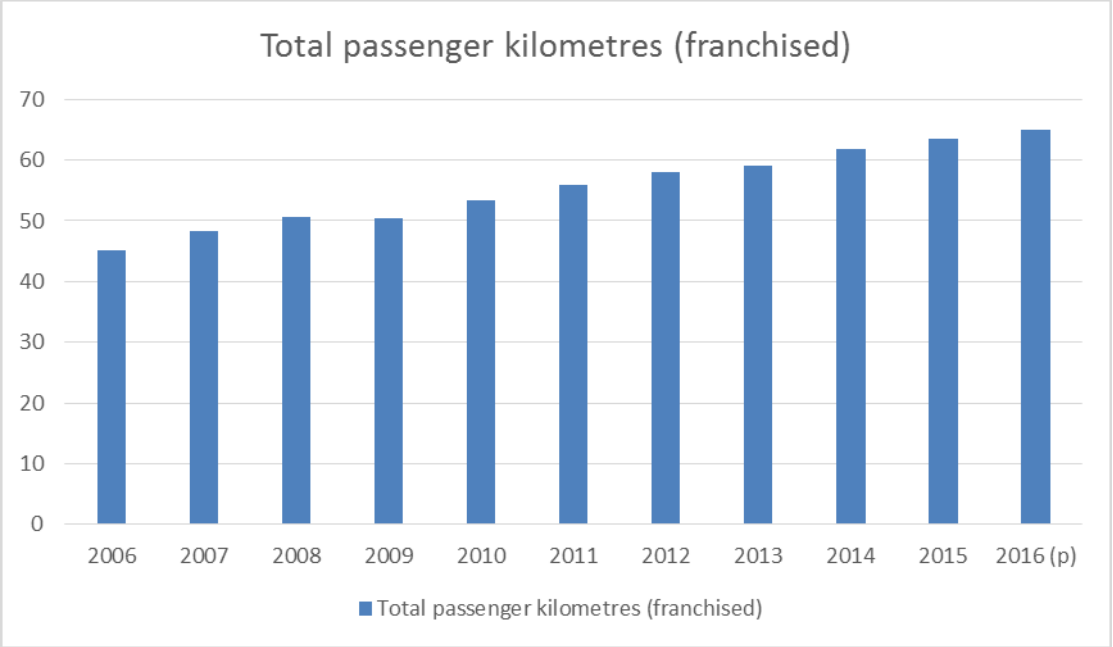

Figure 53 Total franchised passenger kilometres travelled (billions) in Great Britain 2016-2017[41]

All these 3 factors are complemented by the total income and expenditures and government funding flows in Great Britain in the last years, which can be seen in the following figure:

[41] Sources: LENNON ticketing and revenue database, Train Operating Companies (TOCs), Office of Rail and Road (ORR) and Department for Transport (DfT)

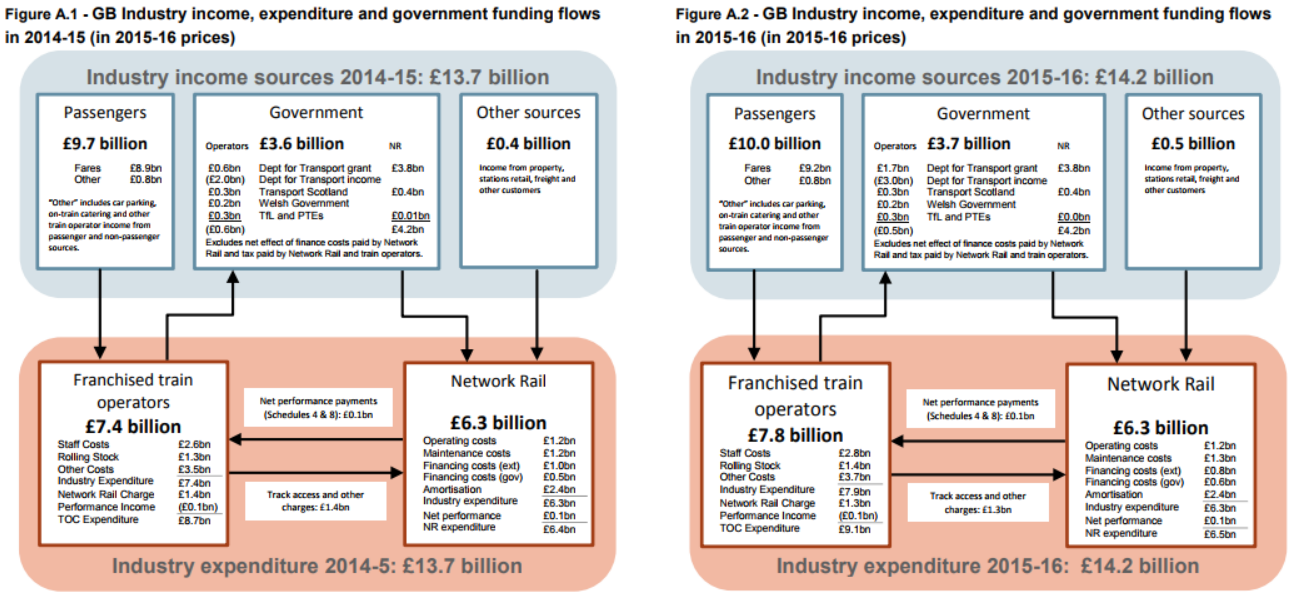

Figure 54 GB industry income, expenditure and government funding flows 2014-2015 and 2015-2016 [82]

From the above data the potential market (customers) are the other TOCs and FOCs operating the rail lines, based in:

- The change in the maintenance market from 2016 onwards moving from Network Rail to the private operators.
- The increase in the number of passengers and cargo.
- The increase in the number of TOCs and FOCs.

"KEEP SAFE" provides an innovative solution to predictive maintenance which is more cost efficient rather than the usual scheduled maintenance. The "KEEP SAFE" solution provides a reduction in these maintenance costs in a market with growing demand for such solutions/ methods.

3.5.2.3 PESTEL analysis

Case Study 4 presents a pilot study which turns every train running on a line into an infrastructure monitoring train, with the additions of sensors and cameras that collect and transmit data, allowing for the predictive maintenance of the overhead line equipment (and by extension the line) before any damage makes the line inoperable and creates delays.

The PESTEL analysis that follows below provides information on the case study from a Political, Economic, Social, Technological, Environmental and Legal Perspective. This allows for an overview of the factors that might affect the case study or that might be affected by it, and their importance for generalizing the pilot and making wide use of its outcomes.

In this case, the pilot has extremely important and innovative technological components, a crucial social aspect, a potentially high economic benefit for a relatively low cost, some interesting political implications, and potentially important benefits in the long term future for the legal and environmental aspects. This is described in detail below.

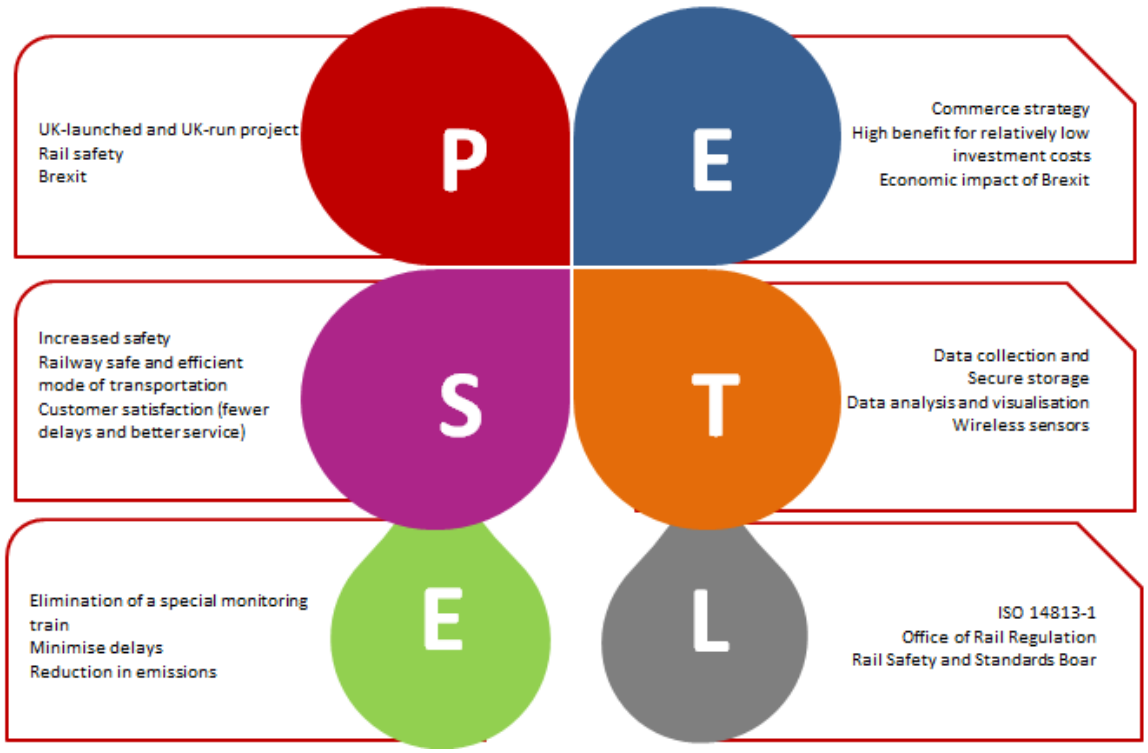

Figure 55 CS4 PESTEL

Political factors

The project was originally funded by the UK Railway Safety and Standards Board (RSSB) and a follow-up consortium is funded by Network Rail.

It was launched to address three key challenges within the railway industry: 1) the safety of passengers, staff and communities, 2) the relationship between data security and railway safety, and 3) the predictive maintenance of railway infrastructure.

Network Rail has been carrying out large scale infrastructure projects since 2009[42]. Network Rail, the owner and infrastructure manager of most of the British rail network, funded the project and created the consortium consisting of major rail companies (train manufacturers, train operators, railway regulatory bodies), with the participation of the government and citizens, and managed by Coventry University.

This large and diverse consortium was successfully managed, with a productive working relationship between members. Since this was a UK-launched and UK-run project, external political factors, such as potential political instability caused by Brexit, did not have any noticeable impact, and are unlikely to have any detrimental impact in future initiatives of this type. Brexit, however, can result in EU funds and projects that support the development of

[42]Source: EC: Fifth report on monitoring development of the rail market

railway infrastructure or safety initiatives not being implemented in the UK, and the UK no longer being governed by European ITS directives and legislation, issues which will be considered in the relevant sections.

Economic factors

The cost of the initial project as funded by the Railway Safety and Standards Board was £35,000 of UK public funding. The practical implementation that followed is being funded by Network Rail at a cost of £50,000 of private funding.

In general, despite a prevailing popular perception of public transport being on a decline, infrastructure expenditure in the EU, including renewal and enhancements, has constantly increased, nearly doubling from 2011 to 2014. In fact, the total infrastructure expenditure has been highest in the UK and France, where infrastructure managers have to catch up with the years of under-investment having at the same time significant enhancements projects ongoing [43]. The case study represents such a case of an increased investment and enhancement of railway infrastructure.

However, the case study can also be considered as a solution for other rail networks and countries in Europe and beyond, so the economic side can be examined in terms of commerce strategy, market viability, and barriers and enablers for market entry. In this case, the main barrier is the cost of collecting data, which may be considerable as it requires the modification of infrastructure required to fit sensors, but the principal enabler, the cost-saving introduced by this solution, is also very important, and a major incentive for following this approach.

The benefits of application of the project outcomes lead to direct economic benefits in terms of predictive maintenance and consistency of the service. For this reason, it can be considered an excellent case for replication by other countries and/or rail networks. The benefits can be quite considerable for a relatively low investment cost.

A potential drawback, from the economic side, is the potential impact of Brexit. While the case study was funded by private as well as UK public funding and did not have any direct connection with EU initiatives or funding, the EU can co-finance or support rail investment projects through the Cohesion Fund, the European Regional Development Fund, the Connecting Europe Facility, the European Investment Bank and the European Fund for Strategic Investments. More than €33 billion in grants under the current EU financial framework (2014-2020) has been allocated to rail investment[44]. Brexit will eventually prevent the UK from accessing such funds, at least by the time of the next EU financial framework.

Social factors

[43]Source: EC: Fifth report on monitoring development of the rail market
[44]Source: EC: Fifth report on monitoring development of the rail market

The project itself has a clearer social impact (i.e. increased safety) and the citizens are its main beneficiaries. An improved safety has a direct impact on society and its perception of the railway as a safe and efficient mode of transportation.

The railway is already one of the safest modes of transportation, with the fatality risk for a rail passenger in the EU in 2013 being 16 times lower than for a person travelling by car, and railway safety continuing to improve between 2010 and 2014[45]. Of course, any further increase in safety by such initiatives, as well as increases in punctuality and reliability, which are also among the its outcomes, is expected to have increased social benefits and to result in a more favorable perception of the railways.

More specifically, the increased safety provided by the case study can lead to a positive social impact, reflected by improved customer satisfaction, improved levels of compliance, improved business performance, less cancellations and delays, an increased availability of service, increased customer satisfaction.

Similar projects and initiatives are expected to have a positive social impact in terms of level of services, customer satisfaction and positive perception of the railways.

Technological factors

The impact of technological factors is central to this case study, as it relies on the implementation of new technologies to increase railway safety, and efficiency. The project relies on the collection of data from trains belonging to the train operator “Virgin Trains”, running across a long distance, on the London-to-Liverpool stretch of the West Coast Main Line- and the communication of that data via WAN (wide area network) for processing at Coventry University. The project represents a major innovation, as it turns every train into an infrastructure monitoring train for the purpose of predictive maintenance (and, ultimately, improved safety), with a V2I system that monitors the condition of the overhead line equipment (OLE). Predictions are based on the interaction between the train and the overhead line equipment, and serve to identify physical locations where faults may be developing, so that repair teams can perform the required maintenance before the service needs to be disrupted.

While the monitoring is confined to the overhead line, it can indirectly capture any other importance issues, such as the condition of the tracks, intersections, trains, obstacles or water on the tracks, which have an effect on the collected data. As trains return to London, the collected data are transferred via the Internet to an FTP server of Coventry University, to be analyzed by the University and shared with all the stakeholders involved in the project.

Specific implementations, such as the one being applied in the London-North West section of the British railways, rely on both a short-range and wide-range communication. Sensing technologies include the use of satellites for location, cameras for video recording, sensors for various parameters of the trains and environment. The hardware used includes central

[45]Source: EC: Fifth report on monitoring development of the rail market

units in trains and particular locations, as well as the sensors on the trains. The decision procedure is based on the use of algorithms.

Overall, the project relies mainly on the technologies of: 1) data collection and secure storage and 2) data analysis and visualization, which in turn make use of several component technologies including: short and wide-range wireless communication, satellites, cameras, sensors, central units and algorithm-based decision procedures.

More specifically, regarding such technologies, wireless sensor networks are a crucial technology that is finding important applications in all fields. The sensors are, in effect, thousands of low-cost, low-power nodes, which can sense the environment. In effect, wireless networks act as the senses of a huge nervous system that allows real world information to be felt, stored and analysed in an ICT system [83].

In the case study, a network of monitoring devices, including sensors and cameras, gets information about some physical parameters from the environment and stores them, until they are dispatched to the Coventry University server, where they can be analyzed, when the trains reach London. The sensors are located on the top of the train engine, and the cameras allow the correlation of the recorded picture with the recorded location. Cameras are also fitted to record video and provide engineers with a better understanding of the issues.

Once the data collected by the sensors reaches its destination, it is analyzed and visualized using big data analytics. The large numbers of sensors used gather a huge amount of data from trains and the environment, data that cannot be stored and dealt with by traditional data processing software, or approaches. As a result, big data analytics are used to process the data using algorithms that, ultimately, produce the data that can be used to formulate a predictive maintenance strategy for rail infrastructure. The Apache Hadoop, an open-source software framework for the processing of big data datasets, is used by Coventry University for the data analytics. The outputs are then provided to the railway industry for decision making in terms of predictive maintenance. In effect, the infrastructure owner, Network Rail, is notified when there are sections or parts of the overhead line which require maintenance.

Environmental factors

Transport represents almost a quarter of Europe's greenhouse gas emission and it is the main cause of air pollution in cities. Emissions caused by rail travel depend on several factors, such the source of energy / propulsion used and the load of a train, and can therefore vary greatly, from below 5g of CO2 per passenger to over 50g per passenger.

The case study can have a positive environmental impact, even if that is a long term aim. The elimination of the need for a specific monitoring train by the installation of a monitoring equipment on regular trains has a positive –even if relatively small- environmental impact in terms of decreased rail traffic, emissions and energy consumption.

An even more important benefit in terms of decreased rail traffic emissions and energy consumption, however, can be provided by the increase of efficiency, fewer and smaller delays, and the optimization of rail traffic provided by the increased safety monitoring of the railway infrastructure. The data collected from monitoring can be potentially used for the optimization of the train routes and this can reduce energy use and emissions.

Legal factors

Directive 2010/40/EU, is primarily concerned with ITS for road use and coherent operation across border, and will case to affect the UK once Brexit takes effect.

In addition, ISO has launched a standard regulation in 2015, ISO 14813-1:2015[46], with an advisory and informative nature, designed to assist in the integration of ITS services into a cohesive reference architecture, with interoperability and the use of common data definitions.

Apart from this, the project has taken place within the current railway legislation framework of the UK and EU, both in terms employment regulations and safety regulations.

The project is essentially under the legal supervision of two key UK organizations. The Office of Rail Regulation (ORR)[47], a non-ministerial government department that is responsible for ensuring that railway operators in Britain comply with health and safety law, and the Rail Safety and Standards Board (RSSB)[48], an independent not-for-profit company limited by guarantee, owned by rail industry stakeholders, including Network Rail, infrastructure managers, train operating companies and rolling stock companies.

The case study required roughly two years to go through regulatory issues and acquire the necessary permissions that approve changes to the trains created by the installation of the servers and cameras.

The impact of the case study is expected to improve railway safety and efficiency and can therefore, on the long term, result in the improvement of railway safety standards in the UK, including the minimum railway safety standards legally required. Perhaps such a higher level of railway safety monitoring can become mandatory at some point in the future.

[46] https://www.iso.org/standard/57393.html
[47] http://orr.gov.uk/
[48] https://www.rssb.co.uk/

3.5.2.4 SWOT Analysis

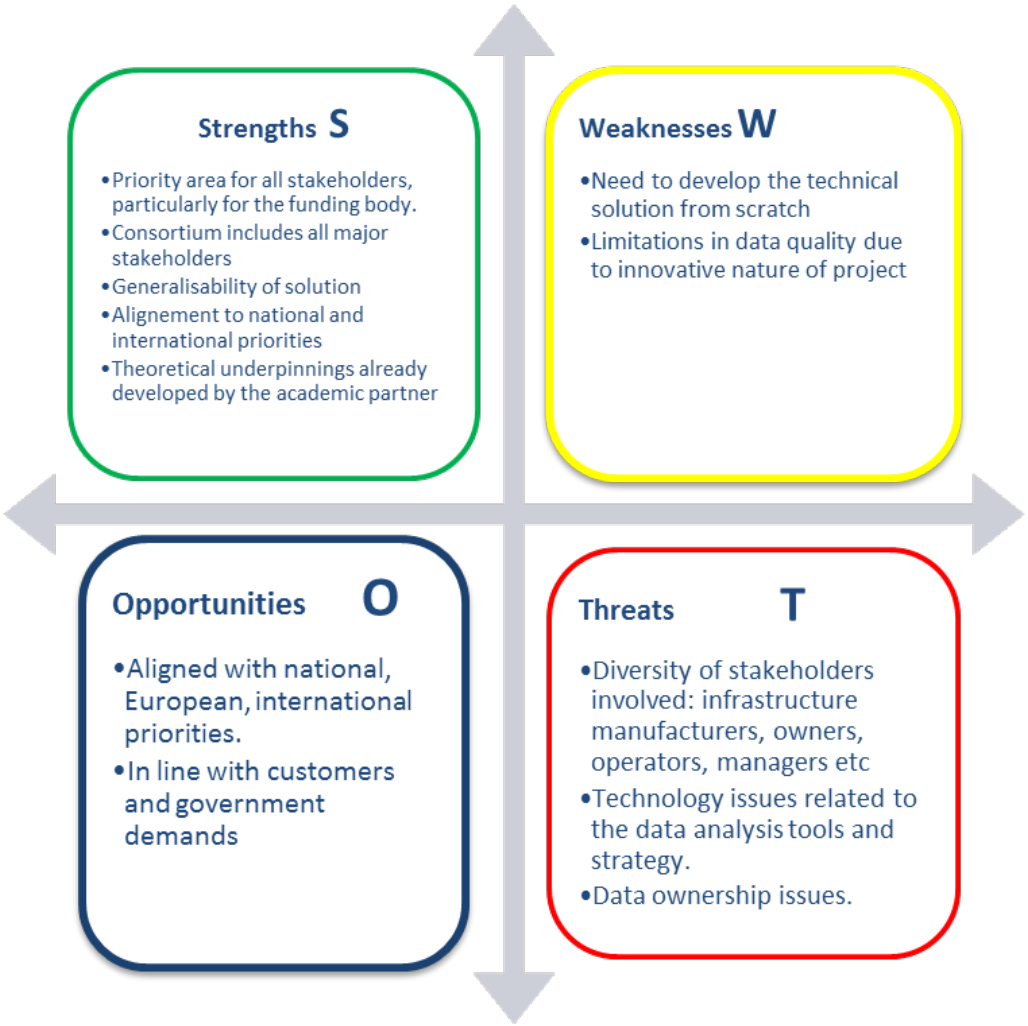

Figure 56 CS4 SWOT

Strengths

- A cross-industry consortium work to address a number of priority areas for all stakeholders and for the railway industry. These include the need for improvements in:
    - The safety of rail workers by minimising the time spent trackside.
    - The safety of rail passengers by identifying trends toward asset failure.
    - The reliability of services by minimising downtime and service interruptions.
    - Cost efficiency by prioritising preventative maintenance on assets based on a number of factors.
    - Service capacity by minimising disruption.
- The case is part of a wider initiative and has been preceded by theoretical developments and an understanding of its importance for all stakeholders.

Weaknesses

- There is no similar precedent to the solution and therefore it is to be developed from its foundations.
- The quality of data, amongst other factors, challenges, the development process.

Opportunities

- The fact that the proposed solution is aligned with trends in the use of data for decision making in the infrastructure management arena at all levels (from local to national and international levels) represents an opportunity for this initiative.

Threats

- A diverse group of stakeholders are responsible for the quality of the data and the decisions made on the basis of its analysis.
- Big data analysis faces a number of challenges related to both the technology and the management dimensions.
- As in a variety of contexts, data ownership and related issues need to be successfully addressed throughout the development and future management of the solution.

3.5.3 Stakeholders analysis

3.5.3.1 Identification of stakeholders' groups, their characteristics and interest

There has been agreement between the different parties involved in this case study that organisations within the Railway Industry are the key stakeholder of the project. The following stakeholder groups within the railway industry were identified for the case study:

- **Train manufacturers:** they build trains.
- **Railway infrastructure owners:** they own the railway infrastructure.
- **Train operators:** they operate and manage trains and train journeys to offer the transport service to the public.
- **Organisations delivering services:** they offer services in the transport sector which are directly relevant to the railway.
- **Railway regulatory bodies:** government organisations that regulate the rail transport sector.
- **Railway industry organisations:** organisations supporting and advising companies and operators in the rail transport sector.
- **Research organisations:** they collect and analyse the data about transport in general and railway service in particular.

The following diagram shows the whole stakeholders' grouping structure:

Figure 57 CS4 stakeholders groups

For each of the stakeholders group, specific stakeholders have been identified as per below:

- **Research organisations:** Coventry University.
- **Train manufacturers:** Alstom Transport.
- **Railway owners:** Network Rail.
- **Train operators:** Virgin Trains.
- **Organisations delivering services to the railway:** Serco.
- **Railway regulatory body:** Office of Rail Regulation (ORR).
- **Railway industry organisation:** Railway Safety and Standards Board (RSSB).

Coventry University is a public research university with campuses in Coventry (where the large majority of the university operates), Scarborough (in North Yorkshire) and London. With a proud tradition as a provider of high quality education and a focus on multidisciplinary research, the University has established a robust academic presence regionally, nationally and across the world.

Alstom Transport is a world leader in integrated transport systems. In the UK and Ireland, they operate across over 20 sites and employ more than 2,500 people. Every day, around a third of all rail journeys in the UK are made on Alstom trains. They keep Virgin's West Coast Main Line service running for around 34 million passengers every year and service over 100 tube trains a day on London's Northern Line, carrying nearly 1 million passengers daily.

Network Rail owns and operates the railway infrastructure in England, Wales and Scotland on behalf of the nation: this is 20,000 miles of track; 40,000 bridges and viaducts; and thousands of tunnels, signals, level crossings and points. They are a public company, answerable to the Government via the Department for Transport (DfT), and runs the day-to-day railway through 9 devolved, geographically based businesses, called routes.

Virgin Trains is a train operating company in the United Kingdom. They operate long-distance passenger services on the West Coast Main Line between London, West Midlands, North West England, North Wales and Scotland.

Serco specialise in the delivery of essential public services. Within the UK and Europe they work across public service sectors in Justice, Immigration, Healthcare, Defence, Transport and Citizen Services.

Office of Rail and Road is a non-ministerial government department with around 280 staff. As an independent regulator, they operate within the framework set by UK and EU legislation. They protect the interests of rail and road users by improving the safety, value and performance of railways and roads.

Railway Safety and Standards Board supports members and stakeholders in driving improvements in health and wellbeing and delivering a safer, more efficient and sustainable rail system.

Stakeholders' objectives mainly rely on the need to avoid disruption to services due to failures in the infrastructure. Such disruptions have a large cost (safety, financial, reputation) for the industry and its stakeholders, and could be predicted and avoided with the right tools and strategy. In addition to this, such data-based tools and strategies become an imperative as technology drives developments in transport, particularly in the intelligent transport systems arena.

3.5.3.2 Assessment of stakeholders determining their influence and importance

The CS4 stakeholders' possible influence and importance have been assessed. The outcome evaluation is depicted in the following table:

Stakeholder	**Interest**	**Estimated influence**	**Estimated importance**
Coventry University	Coventry University Group is implementing "Creating Better Futures", their Corporate Plan for 2021 that has four pillars: • Education and student experience • Research • International • Enterprise and innovation The Corporate Plan is underpinned by cross-cutting corporate priorities: • Investment, infrastructure and finance • State-of-the-art campus network	H	3

Stakeholder	Interest	Estimated influence	Estimated importance
	• People and organisational development Sustainability and corporate social responsibility will be embedded in all their activities.		
Alstom Transport	Reinforce worldwide presence and better meet the needs of customers in local markets. Provide the most comprehensive range of systems, signalling equipment and services in each area of the rail industry. Innovate to achieve differentiation and gain a competitive edge. Ensure flawless contract execution and reduce the carbon footprint of products and operations. Strengthen the Alstom culture by encouraging entrepreneurial spirit and diversity in every shape and form.	L	2
Network Rail	Provide the best possible service to everyone who relies on the railway (passengers, the train and freight operating companies and businesses nationwide). This means delivering a safer, more reliable railway, with greater capacity and efficiency, a railway that connects more people to more places, safely and quickly.	H	3
Virgin Trains	Offering passengers faster, easier, better train journeys.	H	3
Serco	Serco purpose is to be a trusted partner of governments, delivering superb public services, that transform outcomes and make a positive difference for citizens.	H	2
Office of Rail and Road	• A safer railway: protect passengers, the workforce and the travelling public. • Better customer service: deliver a better deal for passengers in respect of	M	2

Stakeholder	Interest	Estimated influence	Estimated importance
	compensation for delays. • Value for money from the railway: improve efficiency and boost value for money for taxpayers, fare payers and funders. • Better highways: this include reduction in the number of people killed or seriously injured, improvement of road user satisfaction, savings on capital expenditure. • Promoting a dynamic and commercially sustainable rail sector: consider options for route based regulation and for an effective charging and incentives regime for Network Rail. • High performing regulation: develop and apply proportionate, risk-based regulation.		
Railway Safety and Standards Board	• Health and safety: Establish a framework and systems that promote health and safety collaboration and inform decisions to reduce risk and harm. • More efficiency: Update standards, modernise systems and publish research yielding benefits. • Sustainability: Embed sustainability principles in industry strategies, collate and share best practise to publicly show rail as a sustainable system.	M	2

Table 23 CS4 stakeholders' influence and importance

The importance-influence matrix of this assessment is given in the following diagram:

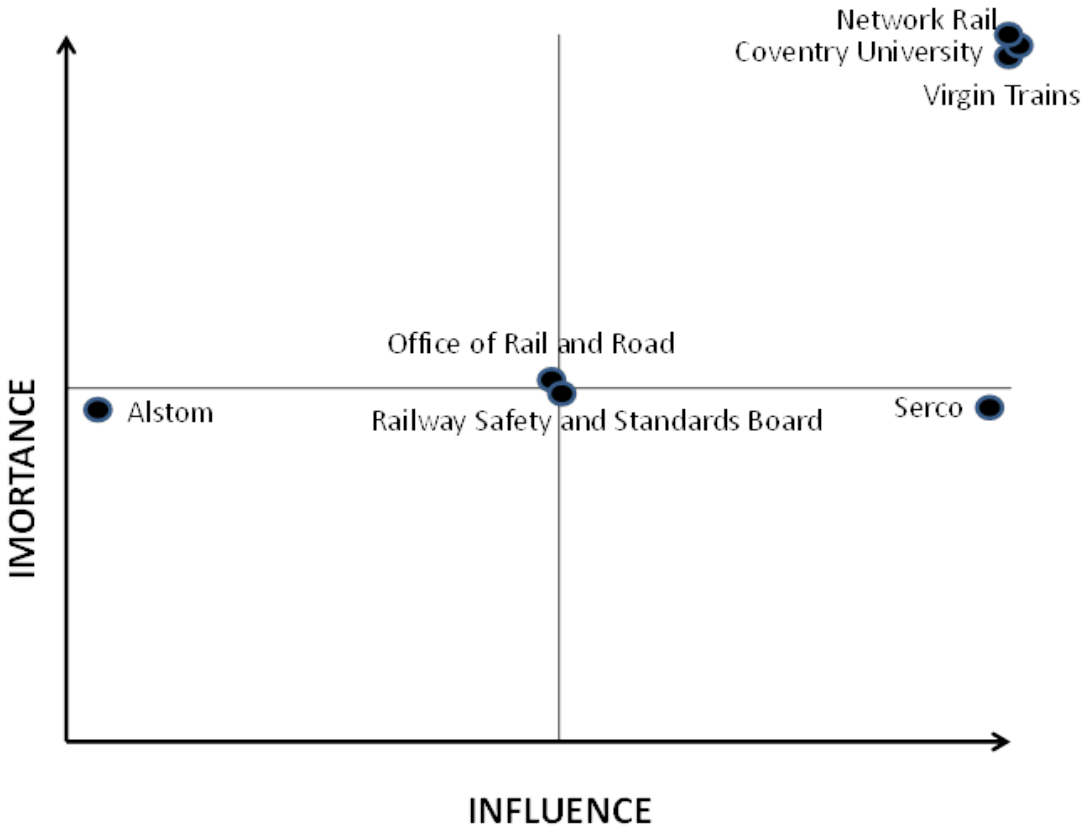

Figure 58 Importance-influence mapping of CS4 stakeholders

As we can see in the diagram, the three key stakeholders of this case study in terms of both influence and importance are Network Rail (owners of the trains and the infrastructure being monitored), Virgin Trains (trains operators) and Coventry University as the custodians and analysts of the infrastructure data.

Other stakeholders (Alstom Transport and Serco) played a key role during early stages of the project in the fitting and calibration of the sensors that would allow for the infrastructure data to be collected from trains.

Regulators (ORR, RSSB) remain important as the umbrella under which every transformation is implemented.

Thus, all stakeholders play a key role in terms of their ability to influence the direction of the project, keeping a balance between the tactical and strategic nature of their importance with the ultimate aim to improve the safety of passengers, staff, communities, the railway infrastructure and the business in general.

3.5.3.3 Mapping and characterizing relations and dependences between stakeholders

There is a wide range of interactions between the different stakeholders, which are not limited to this case study but take place outside of this particular project. All stakeholders are either key players within the British railway industry or somehow able to influence its developments in some specific areas such as technology.

However, within this specific case study the stakeholders interact in a range of complex forms. Value flows between the stakeholders are briefly depicted in the following scheme:

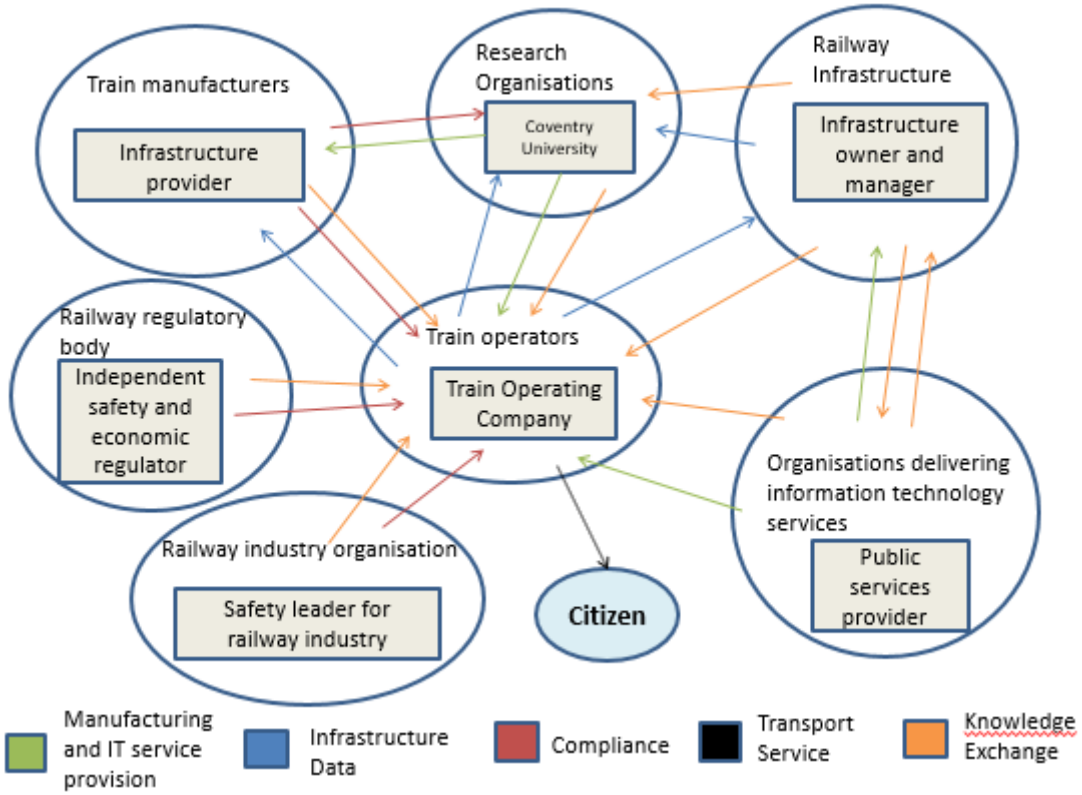

Figure 59 CS4 stakeholders' interactions

The diagram shows the role of each stakeholder in some of the functions that are required for the aim of providing the railway users (i.e. Citizens also added to the diagram for illustrative purposes) with the Transport Service. The functions represented range from the manufacturing of trains to IT provision to infrastructure data generation and sharing for decision making, all of which is regulated by the appropriate industry and government bodies.

The provider of new vehicles, maintenance, signalling and parts to the UK rail industry ensures compliance of any on-board solution with national standards set out by government independent safety and economic regulators.

The organisation providing IT services plays a key role in setting up the data collection mechanisms in trains to ensure that the quantity and quality of data are in line with the requirements of the initiative.

Research organisations such as Coventry University play a dual role consisting of guaranteeing the security and availability of the data collected by all parties and doing the analysis that will ultimately inform decision making in infrastructure owners (Network Rail) and train operators (Virgin Trains).

Train Operating Companies involved in the initiative play a key role and interact with most stakeholders. They are responsible for gathering the data from trains and transmitting it to Coventry University for storage, cleansing and analysis. They interact with the IT service

provider to schedule any required operation of the data collection mechanism. They relate to the railway infrastructure owner and manager and with the train manufacturer as and when required by their role as train operators. And ultimately, they offer citizens a timely and safe transport service as regulated by government.

Overall, each stakeholder represented in the diagram plays an integral role within the ecosystem that is the railway industry in the delivery of a safe and secure transport service to the public, which capitalises in the value of the latest developments in information technologies.

3.5.4 Competitors assessment

The KEEP SAFE case study is addressed to two kinds of stakeholders: 1) the Rail Industry and 2) the passengers, as predictive maintenance and passengers' safety are the main scopes of the KEEP SAFE project. Though, for the scope of the NEWBITS project and the developing of the appropriate business model, it is decided not to take the travellers into consideration, as this case study has mainly a B2B approach.

The specific case study is characterised by the peculiarity of being a solution, a product by its own and as the CS leaders suggested that it should be addressed as one feature, we are looking for competing companies/products on the topic of: "infrastructure monitoring train". Additionally, we are going to identify competitors to the IT solution, in other words the technology provided by Coventry University.

The main features of the CS4 are listed in the following table:

Features	**Description**
Infrastructure monitoring train / predictive maintenance	The approach is to turn every train into an infrastructure monitoring train in which infrastructure data is collected, analysed and sent for decision making following the predictive maintenance concept
Big Data Analytics	Technology enabling internal and external data to generate insights that support maintenance decisions

Table 24 CS4 main features

Thus, the search and identification of potential competitors will be based according to the above features breakdown. According to CUE, the CS4 leader, there are no "competitors" as such in the UK (because this project was organized by Network Rail, owner and manager of most of the country's rail network). So, this has been approached on a global scale, assessing similar models/cases of railways safety monitoring in other countries in the EU or worldwide. Digital technologies can get us away further, from condition based and scheduled maintenance to the predictive one, leading to anticipating potential asset failures before something goes wrong. Cognitive computing, for example, can transform the transport industry by leveraging the hidden power of internal and external data to generate insights that improve the customer experience and manage operations successfully It is apparent, that world leading companies have accomplished a lot lately in the certain field exploiting the breaking through in ICT and operate worldwide. Also, major engineering companies have

implemented “measuring” trains for monitoring rail assets, although there is great variety of the data acquired and the technologies used it seems though, from the cases and solutions identified, that there is no other paradigm using sensors on the top of a train in order to capture data related to the overhead electrification system.

After a thorough search, it has been concluded that the most significant competitors are the following:

- DB Systemtechnik - Monitoring the infrastructure using regularly scheduled trains [84]. DB Systemtechnik is the engineering office of the Deutsche Bahn AG, the German railway company. It provides technical support with its expert knowledge as a competent partner for the corporate group, but also increasingly operates on the worldwide railway market. Regarding this case study, it has applied on the German Railway Network a small number of regular, scheduled trains, equipped with measuring systems and sensors are used for monitoring the infrastructure. With this system there is continuous inspection of the infrastructure, detection of faults, use of evaluation algorithms and data processing leading to efficient planning of maintenance. DB Systemstechnik is undertaking contracts in many countries and UK, as the testing programme for the next generation of intercity trains for UK. Lately, the DB Systemtechnik Group has been enhanced with software competences due to the new subsidiary infraView. On the basis of the infraView BigData platform, solutions in the field of Predictive Maintenance are being offered.
- Ansaldo STS – A Hitachi Group Company: Train and Infrastructure Monitoring Platform [85].
  Ansaldo STS is a public company listed on the Milan Stock Exchange the Italian Stock Exchange. It is a leading company operating in the sector of high technology for railway and urban transport. It operates in the design, implementation and management of systems and services for signalling and supervision of railway and urban traffic, as well as lead contractor. Ansaldo STS is headquartered in Genoa and has over 3,951 employees in 28 different countries. The 51% of the share capital is held by Hitachi Rail Italy Investments shareholder. The company produces a range of systems and devices to monitor the conditions of railway infrastructure. The Train and Infrastructure Monitoring Platform collate and analyse data from Wayside Train and Infrastructure Monitoring Systems. The specific measurements collected are correlated with the corresponding train, vehicle and trackside infrastructure which enables operators working remotely from monitoring locations to identify, verify and make decisions whenever monitored parameters fall outside "normal" ranges.
- IBM [86]: The leading multinational technology company through its large portfolio of services and products offers also Predictive Maintenance Analytics for travel and transportation. Especially in the rail industry, IBM has implemented solutions all around the world. This kind of solutions captures sensor data and utilizes analytics to scan for issues thousands of times a second to predict which parts will fail—which helps prevent equipment failure from becoming an even bigger issue. Alerts are created and can then be displayed on a tablet, smart phone or browser with recommended corrective actions that can be taken using interactive tools that perform root cause analytics and process improvements. Latest solution is Maximo [87], which in combination with all kinds of data can identify irregularities and forecast a range of asset performance risks before trouble ever arises. Implemented in

Taiwan, where Taiwan High Speed Rail Corporation collects data from existing monitoring and telemetry systems and uses Maximo in order to build an advanced equipment maintenance system.

- SIEMENS [88] has invested the past years a lot in Intelligent Rail Systems as a pillar of Intelligent Infrastructure, engaging on 2013 the “Rail on Track” programme [89]. Additionally, the Maintenance Services ensures the operational readiness of vehicles and rail infrastructure. Whether it’s for overhead contact wires, signalling, interlocking or level crossings, multiple units, locomotives, metros, light rail transit, or trams, a broad portfolio of modular solutions gives the necessary flexibility to boost the efficiency and cost-effectiveness of rail systems. In June 2017, SIEMENS acquired the MRX Technologies Group, headquartered in Perth, Australia, and is further expanding its offering in the field of predictive maintenance based on digitalization. The MRX Technologies Group has been offering services for manufacturers and operators of rail systems since 1996. The company has a comprehensive portfolio for the digitalized condition monitoring of rolling stock components and rail infrastructure. It delivers extensive measurement data used to optimize the maintenance of rail systems and make them more cost-efficient. Siemens holds a leading position in the rail industry for supplying rolling stock, infrastructure and services from a single source. As the first company in the rail industry, Siemens operates a special centre in Munich, Germany – the Mobility Data Services Centre. Masses of data continually collected and transmitted from rolling stock and trackside equipment is analysed in a central diagnostics system at this centre. On the basis of these analyses, early forecasts of system failures are made and recommendations for acute or scheduled maintenance are sent to technicians in the Siemens depots as well as to the operators.

The above presented companies appear to be threatening to KEEP SAFE, as DB Systemtechnik and Ansaldo operate already in the UK Rail, providing already other services. DB Systemtechnik additionally, operates regular trains for monitoring purposes, the method proposed by KEEP SAFE. Technology giants such as IBM and SIEMENS provide advanced solutions for predictive maintenance and have great expertise in the rail industry. Especially SIEMENS has acquired just this year an Australian company specialising in monitoring and inspection systems in the railway industry, which has also offices in UK.

Other existing solutions for infrastructure monitoring/predictive maintenance that are identified but are in pilot stages or not commercialized yet are presented in the Appendix 2 Competitors identification.

3.5.5 Value chain resulted from CS4

The resulted value chain for CS4 can be seen in the following figure:

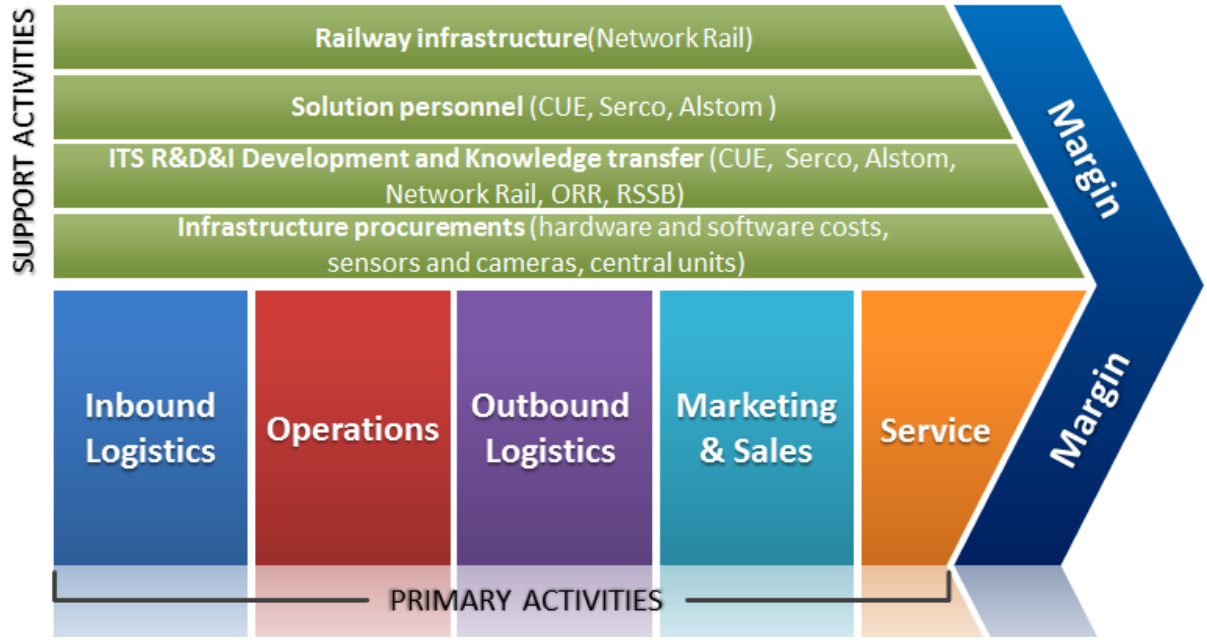

Figure 60 CS4 value chain

The primary activities, based in the creation, manufacture, distribution and sale of the product or service:

Inbound logistics

In KEEP SAFE the data coming from the sensors deployed in the trains are the main input of the platform along with the information coming from the cameras and central units located in the trains and several locations of the rail infrastructure.

Operations

KEEP SAFE solution operates in a secure server with the data provided using algorithms based on a metadata-driven, safety-focused model of railway operation and performance.

Outbound logistics

Right now, KEEP SAFE outputs are mainly related with the predictive maintenance of the railway infrastructure, offering a reduction in unplanned maintenance and repairs which leads to an increased availability of service and therefore, to a higher customer satisfaction and business performance.

Additionally, the solution provides an increase in the railway safety, a direct impact in the society and their perception of the railway.

Marketing & sales

The processes in order to sell the product and compete with other solutions already in the market:

- Social media campaigns, mainly for business audiences but also reinforced with details based on public audiences.
- Showcase of the platform services to other potential customers (other TOCs and FOCs operating in the same and other rail lines).
- ITS service providers integrating new services or products to the KEEP SAFE solution.

Since the pilot is funded by the Network Rail, there is a really good chance of the entity fostering the solution to other potential franchises of the UK rail network which ultimately will benefit all the entities owning and operating such network.

Service

The activities in order to maintain the value of the product, classified as after-sale services:

- Active listening of end-users opinions and feelings about the solution (both private franchises and general public (travellers and freight end customers).
- Personalised service based in the customer necessities.

The support activities:

Firm infrastructure

The ultimate responsibility about the legal, finance, control, public relations, etc. activities is located in Network Rail as infrastructure owners.

In case the solution is commercialised outside the UK, this responsibility should be accounted for the solution owner (which could be a partnership among the pilot stakeholders).

Human resources management

Staffs from CUE, Serco and Alstom are in charge of developing and deploying the solution in the rail infrastructure and managing the tool, more specifically, CUE is in charge of the data analytics, Serco provides ICT services and Alstom integrated transport services. Both Serco and Alstom were essential during the deployment and calibration of the sensors in the trains.

Technology development

These activities are related to ITS R&D&I (Research and Development and Innovation) and knowledge transfer. CUE develops the algorithms for data analytics and predictive maintenance results, Serco provide ITC technology and knowledge, Alstom integrated transport services meanwhile the public entities such as Network Rail, ORR and RSSB provide funds and knowledge about regulation and standards.

Procurement

In order to provide the predictive maintenance services, the “sensing” devices need to be purchased (sensors, cameras) along with the hardware and software costs.

As a conclusion of the value chain for KEEP SAFE, it is foreseen that the major cost for the primary activities are located in the operations. The sensors, cameras and infrastructure are not really a high costs overall compared with the potential savings the solution offers. The inbound and outbound logistics does not seem to be or experiment a raise in the costs actually.

Marketing can highly benefit of the intervention of Network Rail promoting the solution to other operators. This could be reinforced with a travellers advertising campaign in order to further raise the social aspects of the solution.

3.6 Gender analysis of the NEWBITS Case Studies

This section focuses on identifying any possible gaps in gender relations and roles in the context of the validated case studies. As already elaborated in D1.1, the gender analysis plan in NEWBITS follows a checklist approach in which a set of gender-focused questions is introduced in a number of WPs tasks to determine the consideration of gender dimension. Similar to the D2.3 case, the questions specifically oriented to this deliverable as defined in D1.1 are given as follows:

a. Potential consumers of technology and services have different characteristics. What role, if any, do gender play with regard to the case studies?

b. Having framed the application areas of the case studies, do the contexts suggest different patterns of use by different groups of potential consumers (men-women)?

c. Might different groups of potential consumers (men-women) have different expectations regarding interface, features and functions?

d. Is there a risk of excluding certain groups (men or woman) through the case study design?

e. What are the relevant gender variables to consider market conditioners for the case studies, and what information is relevant or we don’t know or understand concerning gender?

In the case of the e) question, the response will be elaborated in D3.3 once the users’ preferences are analysed and identified.

3.6.1 CS1 gender dimension

In CS1, potential consumers of the carpooling services can be men or woman indistinctly with similar patterns of use in both cases. The CS1 solution does not require (or is not expected) different features or functionality neither it excludes in his design any group (men or women).

3.6.2 CS2 gender dimension

CS2 end-users are both men and women driving and/or working in the Municipality of Verona and the gender supposes no difference in the usage patterns. The information is provided the same way and using the same interfaces and functionalities to both groups (men and women).

3.6.3 CS3 gender dimension

CS3 as a B2B solution is aimed to business rather than individual persons. Potential customers of the service (shippers, inland terminals and warehouse operators) do not have different characteristics or roles depending of their gender and the functions and use of the solution is designed equally for both groups.

It is possible that the very end-users (as per the individual persons buying and receiving the content of the freight transport) could have different preferences in the features and interfaces of a potential value added service using some of the solution data, but that is well outside the scope of the case study and anyway unknown at this moment.

3.6.4 CS4 gender dimension

CS4 is also a B2B solution but in this case with a more direct impact in the public (travellers of the railway). The predictive maintenance technology and solution does not imply any different role, interface or functionality based in the gender and there is no risk in excluding any group neither is foreseeable that different groups (men or women) can have different expectations from the solution.

4 Conclusions

The (C-)ITS market is changing rapidly and its affected by several inherent factors along with other external factors in close relation with the (C-)ITS landscape. Topics like urbanisation, energy and a digital single market are changing the parameters of our surroundings and are shaping the near future into a brand new world.

The European Union is taking several initiatives in order to tackle the rapid evolution of the general mobility and transport situation (Transport White Paper, Urban Mobility Package, EU smart cities initiatives, strategy for a Digital Single Market, among others) and developing new regulations and action plans for the specific deployment of Intelligent Transport Systems in Europe.

NEWBITS project is also facing this challenge, aiming at providing a deep understanding of this ever-changing world, analysing the current markets, trends and initiatives and developing potential new business models and incentives in order to accelerate the (C-) ITS deployment.

The NEWBITS case studies have been carefully selected and validated as representative of this ecosystem, covering several transport modes (road, maritime and rail transport), all the market segments selected for the project (ATIS, ATMS, ATPS, APTS and CSV) and are clear candidates for the project final purposes. As a result of the market and stakeholders' analysis and the resulting value chain, the four case studies could be summarised as follows:

- Case study one is a carpooling service deployed in the campus of the Universitat Autonoma de Barcelona with a B2C approach. The market situation locates the main customers of the solution in Spain extending the service to other campuses and industrial areas, although the solution is potentially scalable to any other city of region in Europe. The resulting value chain of the case study locates the highest cost in the operations activities and the solution could highly benefit of an initial investment in making the end-users aware of the existence of the solution.
- Case study two is a traffic light infrastructure integrated in the Urban Traffic Control and an Energy Efficient Intersection Service (EEIS) deployed in the Municipality of Verona. It has a B2C approach where the solution is applicable to any of the 45,000 delay hot-spots in Europe. The inbound logistics activities are the main costs deduced from the value chain affecting the operations activities too. The solution can take advantage from a strong marketing campaign increasing the direct and indirect benefits and accelerating the profits of the solutions.
- Case study three is a synchromodal track-and-trace solution including a forecasting of container arrival service located in the corridor Rotterdam-Limburg. The solution compounds a B2B model for shippers, inland terminals and warehouse operators. There are big opportunities in Netherlands for the solution (several shippers and around 30 other inland terminals are operating in the country) and the solution is applicable to other deep sea – inland corridors outside the country. The value chain locates the highest costs in the operations activities and shows a great business potential with several models for the commercialised solution.
- Case study four is a predictive maintenance solution deployed in the London North Western route from London to Carlisle. The solution is clearly defined for the UK market with high potential to be expanded to other rail lines and other train and freight

operators operating in these lines. The value chain shows the highest costs coming from the operation activities and the solution benefits of having an important stakeholder (Network Rail) able to promote the solution to the rest of the rail lines and operators in the UK market.

This information and the stakeholders' characterisation and inter-relation identification constitute the perfect basis for the development of the conjoint analysis for the end-users preferences as well as for other project work packages.

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Appendices

Appendix 1 Stakeholders interest and characteristics

Case study 1

UAB Mobility Unit	
Stakeholder group	Transport Authority
Stakeholder definition	Act at the same level as a public transport authority within the area of architecture and urban planning charged with the territorial mobility management of the university campus.
Role	Provide technical support to the UAB management (governing) body on the design of UAB mobility policy as well as the appropriate planning and management tools to maximise accessibility to the campus in the most sustainable, efficient and integrative way possible. Planning and management of UAB mobility Responsible for parking management. Maintenance of public space. Subsidies to collective public transport
Interests/Objectives	Promote sustainable mobility values and solutions in the university campus. Promotes car-pooling linked with incentive. Ensure high occupancy vehicles - strategic line
Needs	Access to funding: Budgetary resources to reach objectives and goals. Apparently, the territorial coverage of the campus is not perceived as a city from funding institutions' perspective. The university is meant to be a city but does not possess a city entity, does not function like a city. By law, it is not recognized as a city. Cannot opt for grants/concessions to promote sustainable mobility like every other city/municipal. Fund sourcing is usually done through the municipal Political conviction - parking is not a paid service To offer service as a cost.
Costs structure	Services/Expenses are paid for by the university management for road improvement, transport, security, lighting; Costs about 6 million euros/annum. Maintenance costs for a parking space is about 70 euros/annum.
Revenue model	No revenue model as such as the unit does not generate income (offers free parking services), except for parking rent to commercial buses. They rely primarily on the funding sources of the university coming from public institutions
Outputs	Report on mobility needs and acceptability level of users. Provide the know-how on mobility. Design mobility plans. Dissemination of VaoPoint to European Universities through the EU funded LIFE project and at CRUE level
Inputs	Stakeholders should assume their responsibility and invest. Tight collaboration with municipal, public administrations, and transport operators on mobility plans. Exchange of information.

UAB Management	
Stakeholder group	City/Government
Stakeholder definition	University governing body that make decisions regarding the territorial management of the infrastructure, facilities, and services within the campus
Role	Facilitate the acquisition of licence for deployment. Infrastructure readiness for service provision
Interests/Objectives	Fully functional innovative solutions to ensure sustainable mobility on campus Reduction in the number of vehicles
Needs	Funding to support the efficient running and maintenance of the platform.
Costs structure	The 2015 budget after expenditure settlement amounts to €312M from which: 66.61% accounts for personnel costs, 15.3% for purchase of current asset and service, 10.48% for investments, 5.16% for current transfers, and 2.43% for variation assets, financial liabilities and capital transfers
Revenue model	UAB's income is spread over three areas: teaching (tuition fees), research (public funding grants), and transfer activities (patents, transfer of research results to industry). According to the 2015/2016 annual report, there was a 72% increase in the resources obtained within the framework of the European Horizon 2020 programme for research grants, with almost 14.5 million Euros, and over 22 million Euros obtained in the National Plan. The UAB also had a turnover of more than 25 million Euros for services offered and the signing of 640 agreements with companies and institutions
Outputs	Funding acquisition to support continuous service existence
Inputs	Report on mobility needs and acceptability level of users. The know-how on mobility. Mobility plans design.

UAB Living Lab CORE	
Stakeholder group	Academia
Stakeholder definition	A research network on Smart and sustainable cities where different research groups, departments, centres and campus infrastructures develop their joint capacities to create new multidisciplinary research activities.
Role	Facilitates the deployment of the service in the university. Acts as an intermediary between the IT Services Unit and UAB management
Interests/Objectives	Increase the positioning and visibility of technological transfer in the fields of energy management and urban mobility Support citizen participation policies in the smart city context
Needs	Collaboration with other stakeholders Development of innovative solutions for smart and sustainable cities
Costs structure	
Revenue model	
Outputs	Stakeholder acquisition of licence Facilitate the living lab environment Negotiation between internal stakeholders
Inputs	

Aslogic	
Stakeholder group	ITS Service Provider
Stakeholder definition	Is an SME IT enabler in the field of transport logistic, it addresses the development and deployment of DST aimed to improve and optimize the performance of logistics operations
Role	Provide data services Provide ITS services Provide ITS consultancy services

Aslogic	
	Research and Transfer of new Technologies Provides IT support to UAB Mobility Unit, by Identifying transport needs and market opportunities
Interests/Objectives	Empower transport operators/users/rulers/administrations with cutting-edge ITS as cloud services removing access barriers and unjustified investments
Needs	A market share increase is a must to maintain VaoPoint quality services. To truly engage end-users using the ITS platform to satisfy mobility needs, Aslogic should have access to other stakeholders to design incentive policies to maintain the interest and foster dissemination policies to attract new users. This scalability would help to obtain budgetary resources to implement and maintain the ITS functions and services. A change of regulation would help to solve the payment for the service.
Costs structure	
Revenue model	VaoPoint is a tool provided to universities, policy-makers and administrations (public or private). Revenues come from them in concept of VaoPoint license/use
Outputs	Technology Digital and transport services New standards for VaoPoint interoperability Mobility data
Inputs	User data and preferences (related to mobility needs) Authentication services (when applied in closed communities such as University campus)

UAB Logistics and Aeronautics Unit	
Stakeholder group	Academia
Stakeholder definition	Along with scientific contributions to the logistics modelling, simulation and optimization, UAB LOGA aims to transfer its technology to give a proper answer to the operational and strategic decision making in industrial and transportation activities.
Role	Design and development of decision support algorithms for both tactical and operational planning problems on the platform (e.g. matching) according to the policies defined by other stakeholders (UAB Mobility Unit)
Interests/Objectives	Technology transfer of research activities in innovative transport solutions
Needs	Research funding
Costs structure	
Revenue model	The unit does not generate revenue. All income proceedings from tuition fees of enrolled students and research grants are centrally managed by the university governing body.
Outputs	Scientific knowledge State-of-the-art decision support algorithms
Inputs	Policies/rules given by UAB Mobility Unit Exchange of knowledge

FrontierCities	
Stakeholder group	Funder and promoter
Stakeholder definition	FrontierCities is an EU funded project which supports SMEs and start-ups to develop Smart Mobility applications for cities across Europe
Role	Provide funding Identification of potential markets for introduction of the product to market niche. FrontierCities does not only provide financing, but also it offers technical support and business advice. Its ambitious services range and offering include: - a widened Smart Cities scope - a strengthened Grantee Acceleration Programme - an Outreach Service to FI-PPP P2 & P3 research results - a dedicated Financing and Partnerships Acceleration Service - a new Cities Programme dedicated to supporting and developing the network of cities trialling and deploying FIWARE-enabled solutions Acceleration of new research and prototypes into market-ready technologies

FrontierCities	
Interests/Objectives	FrontierCities is a quantum leap in the scope, ambition and service of the Acceleration & Incubation process of FIWARE SMEs and Start-ups. The FIWARE Community is an independent open community whose members are committed to materialise the FIWARE mission, that is: “to build an open sustainable ecosystem around public, royalty-free and implementation-driven software platform standards that will ease the development of new Smart Applications in multiple sectors”.
Needs	To pair interested cities with web-developers, SMEs and start-ups, by creating a space to test and deploy their smart mobility application while European cities will get a taste of various applications that can cater for their specific mobility issues
Costs structure	FrontierCities will provide EUR 1.6 million in grant funding across two Open Call strands (FI-TECH and MAG Grants) to SMEs and start-ups to develop and commercialise FIWARE-powered smart-cities applications
Revenue model	No revenue model as such is defined.
Outputs	Marketing strategy ideas (events for promoting the app) The FIWARE platform provides a rather simple yet powerful set of APIs (Application Programming Interfaces) that ease the development of Smart Applications in multiple vertical sectors. The overall approach of FIWARE technology includes: the shared protocols, a common language, and the vision of catalysing the interactions within the Internet of Things. It eases the development of technology.
Inputs	FrontierCities and the structure of the FIWARE Community encourages all forms of contributions relating in the broader sense to the smart-cities domain

CRUE (Spanish Universities Association)	
Stakeholder group	ITS Association
Stakeholder definition	A network of Spanish universities aimed at providing universities information to apply sustainable mobility policies
Role	Promotes best practices of transport and mobility in Spanish universities.
Interests/Objectives	The mobility group of CRUE aims to improve the accessibility to university campuses, so that the maximum number of people who want to study or work on them can do so under acceptable cost and time conditions and in the most sustainable way, promoting a sustainable, safe and inclusive mobility model that is more efficient
Needs	Collaboration between Spanish Universities
Costs structure	
Revenue model	No revenue model as such is defined.
Outputs	Provision of tools, in the form of bibliographic and technical resources in order to provide universities with useful references for the implementation of their policies. Promotion of VaoPoint in European Mobility week
Inputs	Active participation of Spanish universities

Websays	
Stakeholder group	Others (Social media marketing company)
Stakeholder definition	Websays is an IT company specialized in data analysis from social networks.
Role	Engage end-users through a constant analysis of their opinions and feelings regarding VaoPint services and the acceptability of the incentives
Interests/Objectives	Keep a constant monitoring of end-users social network trends in mobility aspects. To identify new mobility trends in other's markets To turn VaoPoint Customers into Brand Advocates To assess incentive mechanisms to maintain VaoPoint end-users engaged Leader in social data analysis technologies
Needs	Budgetary resources to provide an appropriate service. Mobility data analysis in order to evolve their services considering new social trends. Human Resources to guide and keep alive the mobility social networks Their infrastructure is modern but they need to adapt the semantic analysis to each particular field for a better understanding of preferences.
Costs structure	
Revenue model	Websays provide assessment services to public companies (%), private companies (%) and individual customers (%).

Websays	
	It is open to different collaboration strategies to penetrate through VaoPoint in the mobility data analysis sector
Outputs	Social data analysis technologies Aggregated data about mobility in the university context Mobility trends : preferences and shortfalls
Inputs	Access to different data sources For effective assessment on segmented incentive mechanism access of non-anonymized data Information about mobility policy details at UAB

Members of the university community (students and employees)	
Stakeholder group	End users
Stakeholder definition	End users comprising students, administrative staff, and academic staff
Role	
Interests/Objectives	Cost reduction for commuting to/from the campus Encouraging sustainable mobility values
Needs	
Costs structure	
Revenue model	
Outputs	
Inputs	

Case study 2

Municipality Of Verona	
Stakeholder group	City
Stakeholder definition	It is the public body which administrates the city
Role	The city provided coordination for the pilot
Interests/Objectives	Fluid traffic, safety improvement, travel time reduction
Needs	Skills, technological knowledge, high level professionals
Costs structure	The city has to pay to maintain roads and to acquire ITS platforms, and to contribute to Public Transport Services
Revenue model	Basically the city pursues social and environmental objectives
Outputs	Road Capacity, pre-existing ITS services, Traffic and works data
Inputs	Innovative ITS services

ATV	
Stakeholder group	Transport Operator
Stakeholder definition	It operates all urban buses in the city
Role	The Transport Operator used Transit Signal Priority provided with the pilot
Interests/Objectives	Travel time reduction, better use of buses

ATV	
Needs	With new technologies offer fast transports and probably attract more customers. Growing infrastructure to expand the bus fleet and services. Appropriate infrastructure to provide real-time data. Data analysis in order to evolve their services to fulfil the citizens needs
Costs structure	The operator main costs are on Vehicle, fuel and Personnel. Suffered costs are: €40.000 for improve central and on-board systems; €150.000 used in unification of urban and suburban networks with coherent rules; €40.000 were spent in cartography
Revenue model	Transport Operator revenues are partially due to fare collection, and to a specific payment by the Municipality
Outputs	Public Transport Service
Inputs	TSP (Transit Signal Priority) Service

Taxi Operators	
Stakeholder group	Transport Operator
Stakeholder definition	They operates taxis in the city
Role	Some taxis were equipped with specific OBUs and used some of the services provided with the pilot
Interests/Objectives	Fluid traffic, safety improvement, travel time reduction
Needs	
Costs structure	The Taxis main costs are on Vehicle and fuel
Revenue model	Revenues are due to fare collection
Outputs	Individual Transport Service
Inputs	Pre-existing and Innovative ITS services

Citizens	
Stakeholder group	End users
Stakeholder definition	They are the customer of the services
Role	Citizens could use the services provided with the pilot by downloading and installing a mobile APP (long-range communication option). Citizens' benefits were also general fluid traffic, safety improvement and public transport travel times reduction.
Interests/Objectives	Fluid traffic, safety improvement, travel time reduction
Needs	Comfort, Safety, Economy, Participation.
Costs structure	
Revenue model	Citizens don't have direct revenue but they receive various advantages.
Outputs	
Inputs	Road Capacity, Transport Services, Pre-existing and Innovative ITS services, Mobile connectivity

AUDI	
Stakeholder group	Automotive Supplier
Stakeholder definition	The company build cars
Role	The company built and provided the cars equipped with a specific OBU, suitable for the pilot

AUDI	
Interests/Objectives	Future Market development, Branding
Needs	
Costs structure	Costs are the one typical into automotive industry
Revenue model	In a business context, the company sells cars.
Outputs	Vehicles
Inputs	

SWARCO MIZAR	
Stakeholder group	Original Equipment Manufacturer
Stakeholder definition	The company produces ITS hardware, such as signals, controllers, UTC, control methods and algorithms.
Role	The company acted as the main actor of the pilot, providing signalization, controllers, UTC, and all fixed ITS hardware
Interests/Objectives	Market Development, Business Consolidation
Needs	
Costs structure	
Revenue model	OEM Revenue is in term of direct payment from the Municipality due to the operated service, and in term of future Market Development
Outputs	Innovative ITS Services
Inputs	Traffic and Works Data

TELECOM ITALIA	
Stakeholder group	ICT service provider
Stakeholder definition	The company provides the mobile communication service all over the nation
Role	The company provided the mobile communication service for the long-range communication option (4g mobile connectivity)
Interests/Objectives	Future Market development, Branding
Needs	
Costs structure	
Revenue model	ICT operator revenue is due to telephonic rates
Outputs	Mobile Connectivity
Inputs	

Case study 3

TNO	
Stakeholder group	Research organisation
Stakeholder definition	TNO is a Dutch organisation focussing on applied scientific research. Its focus areas are: Energy; industry; Healthy living; Defence, security, safety, urbanization.
Role	Project leader Technical knowledge experts
Interests/Objectives	Successful project To develop the service for operationalisation Matching the objectives:

TNO	
	The main goal of the project is to gain a better efficiency performance, especially more reliable transport times. To do so smart data will be used.
Needs	funding for project external party to operationalise the service stakeholders that can provide additional knowledge and skills interested parties that are willing to implement the service (scale up) good collaboration of all parties
Costs structure	The main costs of TNO are direct project cots (70 million) and personnel (270 million)
Revenue model	TNO has three main sources of finance. Firstly the Dutch government provides funding for research (176 million), secondly TNO is hired by companies and governments (255 million). Thirdly, subsidiaries contribute around 100 million.
Outputs	ITS service using a data platform. Track and trace service on container transport from deep sea to warehouse in hinterland. Actual location and estimated time of arrival. TNO delivers technical knowhow and project management Business model development
Inputs	planning information of inland terminal, deep sea terminal and shipper AIS- datalink of ship movements GPS-datalink of truck movements stakeholder commitment and collaboration

Warehouse L	
Stakeholder group	Warehouse operators
Stakeholder definition	Warehouse L is a logistical operator who offers a variety of transport services throughout the world. The also offer warehouse facilities
Role	They provide data and use of the real time information to better plan their activities to get the container from inland terminal to the warehouse where the container is unloaded
Interests/Objectives	- Total overview of containers and ETA's - more efficient use of own resources through improved planning - reductions of hidden cost due to slack an ad hoc communication - less stress in the transport chain -> more steady stream of goods rather than peeks - more time to deal with actual emergencies - Able to match requests customers with transport decisions, and being able to adjust to actual changes in transport - Knowing as long in advance as possible when containers arrive
Needs	Real time container information
Costs structure	Personnel costs, cost of warehouse operations
Revenue model	offering logistical services
Outputs	Action on planning for getting container from inland terminal to warehouse. Warehouse operations for shipper (emptying containers) Planning data delivered as input for service
Inputs	Track and trace service information. Estimated time of arrival. Information on arrival of container at inland terminal. ATA container arrival Rotterdam

ITO (inland terminal operator)	
Stakeholder group	Terminal operators
Stakeholder definition	ITO has several barge terminals for inland shipping in the Netherlands and Belgium. They over barge services, container storage facilities and truck services
Role	Data provider (planning data and container handling at terminal)/user of the real time data
Interests/Objectives	-Having a single overview/visualising of information about maritime vessel, barge and truck - Reason of delay (can we solve this?)

ITO (inland terminal operator)	
	- would like to have unloading time of maritime vessels included - Shorter transhipment times on terminal - more effective loading of inland barge - less coordination
Needs	Maritime vessels and sea terminal information most relevant Information of transhipment in seaport
Costs structure	Personnel costs, cost of terminal operations
Revenue model	offering terminal and related services
Outputs	information on transhipment of goods, storage, and information provision Shipment of container from Port of Rotterdam to Warehouse L
Inputs	Track and trace service information, estimated time of arrival. Handling information of container at deep sea terminal

Shipper electronics	
Stakeholder group	Shipper
Stakeholder definition	This company his active in electronic high value consumer goods and ships products from China to a ware house in Limburg.
Role	Provider of planning data. End user of the system. Pilot client (facilitator) of the service in the pilot projects
Interests/Objectives	- Optimisation of integrated logistical chain (10 - 6/7 days) - reductions of hidden costs in transport chain (slack and unnecessary communication) - Optimise planning and reliability due to better information about shipment and delays - Lower stock of goods due to more efficient planning - Better service provision for clients
Needs	information of shipment (whereabouts of containers) To know when containers are ready for warehouse operator to pick up at inland terminal Estimated time of arrival and actual time of arrival wants to know if a faster shipment was possible (hindsight) Decrease of delays and last minute truck transport
Costs structure	probably same as other high value good producers
Revenue model	sales of electronic equipment
Outputs	Electronic goods Report of shipment information. Planning data as input for service
Inputs	Track and trace service information, handling information estimated time of arrival

TrackT	
Stakeholder group	ITS service provider
Stakeholder definition	IT organisation (SME) which products integrate real-time traffic information in primary business processes.
Role	IT service providers
Interests/Objectives	May expand their business to inland shipping
Needs	Business expansion
Costs structure	
Revenue model	
Outputs	Visualisation of real time transport information

TrackT	
Inputs	Data from open platform constructed by TNO and ICTdev, truck information from FleetM

Portdat (Port data provider)	
Stakeholder group	ITS/ICT service providers
Stakeholder definition	Portdat is a port community system allowing companies to benefit from a multitude of intelligent services for simple and efficient information exchange between different stakeholders of the port community in Amsterdam and Rotterdam. It enables all participants to optimise their logistics processes.
Role	Data provider
Interests/Objectives	- improve service for port community - optimal re-use of information
Needs	
Costs structure	The costs are for the set up and operation of variety of services
Revenue model	Portdat is a non-profit organization. Companies only pay a fee for the use of services with demonstrable added value. These costs are fairly minor compared to the advantages offered by the services.
Outputs	A variety of services for port operations Data platform of port operations
Inputs	Data of individual port users

FleetM	
Stakeholder group	ITS/ICT service providers
Stakeholder definition	TrackT develops software, hardware and services for transport sector. Special focus lies on Fleet management system, which it has provided for trucks of ITO
Role	Data provider
Interests/Objectives	- serving client ITO - increased service for costumers
Needs	Business expansion
Costs structure	main costs are most likely personnel and hardware
Revenue model	sales of ICT services
Outputs	Truck location
Inputs	Planning data, truck identification

ICTdev	
Stakeholder group	ITS/ICT service providers
Stakeholder definition	ICTdev offers software and hardware solutions with a special focus on telecommunications.
Role	IT Service providers
Interests/Objectives	- offer IT knowledge to new area
Needs	Business expansion
Costs structure	
Revenue model	ICT software and hardware services
Outputs	APIs to allow for combination of the different data sources for inland shipping route
Inputs	planning information of inland terminal, deep sea terminal and shipper AIS- datalink of ship movements

ICTdev	
	stakeholder commitment and collaboration

Dinalog	
Stakeholder group	Governmental promotor/Funding body
Stakeholder definition	Dutch institute for advanced logistics. Government funded innovation program aimed at logistics. Provides advices and financial support as well as the support of research and development
Role	Funder
Interests/Objectives	- increase logistic efficiency - less truck kilometres (sustainability) - meaningful knowledge gathering - successful project
Needs	Strong logistic sector
Costs structure	
Revenue model	
Outputs	Funding
Inputs	project plan; improved efficiency and sustainability in hinterland transport

LIOF	
Stakeholder group	SME promotor
Stakeholder definition	LIOF is a Regional Development Company. With logistics defined as one of the top sectors in the region, LIOF has knowledge and a broad network in this sector. Therefore, they are, together with other stakeholders, active in promoting and finding partners to scale-up.
Role	Network connection to scale-up.
Interests/Objectives	- offer new service for clients in network/region - Improving competitiveness of the Limburg region
Needs	New business for local entrepreneurs
Costs structure	probably financial support and personnel
Revenue model	LIOF is owned by the Dutch state and the province of Limburg. Both have a share of 50%.
Outputs	Network and business support
Inputs	Business opportunities and knowledge exchange of information

PoR (Port of Rotterdam)	
Stakeholder group	Port authority
Stakeholder definition	Port of Rotterdam is the organisation governing the port of Rotterdam, the largest port in Europe. Its main tasks are: - ensuring competitiveness of the port of Rotterdam - Ensuring high quality of port services - long term development strategy - maintenance and operation of port - ensuring swift and reliable shipping
Role	Knowledge/algorithms
Interests/Objectives	- improvement of provided services for port stakeholders

PoR (Port of Rotterdam)	
	- adapting to (future) market needs - Reducing shipment times (improved efficiency)
Needs	Time and willingness to commit to the project This requires a clear added value of the service
Costs structure	Total costs of the port of Rotterdam are about 450 million (contrasting 660 million in revenues). Main costs are personnel, depreciations of active, exploitation costs and costs for loans. Each are about 1/4 of total costs
Revenue model	The port of Rotterdam's main revenues are from contracts (rents) and port dues. Both around 300 million euros
Outputs	All port operations and related knowledge
Inputs	Improved efficiency of hinterland transport

Case study 4

Coventry University	
Stakeholder group	Research organisation
Stakeholder definition	Coventry University is a public research university with campuses in Coventry (where the large majority of the university operates), Scarborough (in North Yorkshire) and London. With a proud tradition as a provider of high quality education and a focus on multidisciplinary research, the University has established a robust academic presence regionally, nationally and across the world. Through its links with leading-edge businesses and organizations in a variety of industries, Coventry University is able to offer its 24,000+ students access to work placement opportunities and state-of-the-art equipment and facilities in all disciplines from health, sport science and performing arts to industrial design, engineering and computing. Coventry is also recognised internationally for its expertise in peacebuilding, serious games and disaster management, and for the world-leading calibre of its engineering and design graduates, particularly in the automotive field.
Role	The university focuses on multidisciplinary research and comprises 4 faculties: the Faculty of Arts & Humanities (that includes 3 schools, the School of Art and Design, the School of Humanities and the School of Media and Performing Arts); the Faculty of Business and Law (incorporating the Business School and the Law School); the Faculty of Engineering, Environment and Computing; and the Faculty of Health and Life Sciences. It also manages a number of commercial subsidiaries that provide business services to local and national organisations. Coventry University is the coordinator of the KEEP SAFE project.
Interests/Objectives	Coventry University Group is implementing "Creating Better Futures", their Corporate Plan for 2021 that has four pillars: • Education and student experience • Research • International • Enterprise and innovation The Corporate Plan is underpinned by cross-cutting corporate priorities: • Investment, infrastructure and finance • State-of-the-art campus network • People and organisational development Sustainability and corporate social responsibility will be embedded in all their activities.
Needs	Cooperation with other stakeholders.
Costs structure	According to the Annual Report 2016/16, in the year to 31 July 2016, the Board reports a surplus for the year of £28.6M achieved through continued targeted growth in tuition fee income driven by increased student recruitment, control in growth of operational pay and non-pay costs and targeted investment in new activities that will help the future delivery of the corporate plan aims. The income of the university comes mainly from tuition fees and education contracts (almost 77%) and funding body grants (about 10%); other sources are research grants and contracts (almost 3%), other income (about 9%) and Investment income (about 1%). The expenditure is mainly on staff costs (almost 53%) and other operating expenses (almost 40%); other types of expenses are depreciation (almost 5%) and interest and other finance costs (about 3%).
Revenue model	The income of the university comes mainly from tuition fees and education contracts (almost 77%) and funding body grants (about 10%); other sources are research grants

Coventry University	
	and contracts (almost 3%), other income (about 9%) and Investment income (about 1%).
Outputs	Education, Research, Business Services.
Inputs	Financial resources (from tuition fees, education contracts, funding body grants, research grants and contracts).

Alstom Transport	
Stakeholder group	Train manufacturer
Stakeholder definition	Alstom is a world leader in integrated transport systems. In the UK and Ireland, they operate across over 20 sites and employ more than 2,500 people. Every day, around a third of all rail journeys in the UK are made on Alstom trains. They keep Virgin's West Coast Main Line service running for around 34 million passengers every year and service over 100 tube trains a day on London's Northern Line, carrying nearly 1 million passengers daily.
Role	Alstom develops and markets systems, equipment and services for the transport sector. They offer a complete range of solutions (from high-speed trains to metros, tramways and e-buses), passenger solutions, customised services (maintenance, modernisation), infrastructure, signalling and digital mobility solutions.
Interests/Objectives	Reinforce worldwide presence and better meet the needs of customers in local markets. Provide the most comprehensive range of systems, signalling equipment and services in each area of the rail industry. Innovate to achieve differentiation and gain a competitive edge. Ensure flawless contract execution and reduce the carbon footprint of products and operations. Strengthen the Alstom culture by encouraging entrepreneurial spirit and diversity in every shape and form.
Needs	Partnership with local players for joint ventures.
Costs structure	Between 1 April 2016 and 31 March 2017, Alstom booked €10.0 billion of orders (51% from Europe) leading to a new record-breaking backlog of €34.8 billion. Over the same period, sales were up 6%, amounting to €7.3 billion (56% from Europe). Net income (Group share) reached €289 million. Alstom invested €150 million in capital expenditures in fiscal year 2016/17. The majority of orders (55%) and sales (43%) come from rolling stock.
Revenue model	Alstom is a French multinational company. The majority of revenue comes from sales.
Outputs	Equipment and services in urban and main line transport (trains, signalling, services and infrastructure).
Inputs	Specific skills (to work on a specific contract/project).

Network Rail	
Stakeholder group	Railway owner
Stakeholder definition	Network Rail owns and operates the railway infrastructure in England, Wales and Scotland on behalf of the nation: this is 20,000 miles of track; 40,000 bridges and viaducts; and thousands of tunnels, signals, level crossings and points. They are a public company, answerable to the Government via the Department for Transport (DfT), and runs the day-to-day railway through 9 devolved, geographically based businesses, called routes. The routes manage the railway network in their area and work closely with their local train operating companies. Each route is a big complex business in its own right, employing thousands of people and responsible for billions of pounds of expenditure every year. The routes are supported by a handful of central services that provide a national framework.
Role	Operation, maintenance and development of Britain's railway. Management of the national rail timetable and 18 of the largest stations in England, Scotland and Wales. Funding the practical implementation of the KEEP SAFE project.
Interests/Objectives	Provide the best possible service to everyone who relies on the railway (passengers, the train and freight operating companies and businesses nationwide). This means delivering a safer, more reliable railway, with greater capacity and efficiency, a railway that connects more people to more places, safely and quickly.
Needs	Working with local train operating companies and other partners across the rail industry.
Costs structure	According to the Network Rail Annual Report and Accounts 2016, their performance was as following: £6,098m Revenue in the year £2,712m Operating costs £411m Profit before tax

Network Rail	
	£41.6bn Net debt £6,684m Capital expenditure £6,684m Capital expenditure As a not-for-dividend organisation, they don't pay out dividends to shareholders: any profits is invested straight back into improving the railway. Network Rail is funding the practical implementation of the KEEP SAFE project at a cost of £50,000.
Revenue model	As a public sector arm's length body, Network Rail retains the commercial and operational freedom to manage Britain's railway infrastructure in England, Wales and Scotland within regulatory and control frameworks. They are subject to independent regulation by the Office of Rail and Road (ORR) and their income is a mix of direct grants from the UK and Scottish Governments, charges levied on train operators that use the network, and income, mainly from commercial property estate. The governments specify what they need from Britain's railway and how much they can afford to contribute; the ORR sets a framework that specifies the level of fixed income Network Rail is allowed to charge and assesses the efficient level of expenditure that they need to run the business and deliver the regulated outputs. It also determines how much revenue they need. In summary, the sources of Network Rail income are: 70% Network grants from the Department for Transport and Transport Scotland; 25% Track access income from train operating companies and freight operating companies (11% from fixed track access charges to operators, 14% from variable charges to train operators; their income from operators can be increased for outperformance or reduced by compensation paid to them for under-performance); 5% Income from commercial property (national property and station retail portfolio of over 8,200 properties).
Outputs	Railway services (operation, maintenance and development). Management of the national rail timetable. Management of 18 stations.
Inputs	Financial resources (grants from the Department for Transport and Transport Scotland; charges from train operating companies and freight operating companies; income from commercial property).

Virgin Trains	
Stakeholder group	Train operator
Stakeholder definition	Virgin Trains is a train operating company in the United Kingdom. They operate long-distance passenger services on the West Coast Main Line between London, West Midlands, North West England, North Wales and Scotland.
Role	Fast, frequent passenger train services on the West Coast Main Line, serving major towns and cities including London, Birmingham, Manchester, Liverpool and Glasgow (their fleet of state-of-the-art trains includes 52 Pendolinos and 21 Super Voyagers, that run at speeds of up to 125mph).
Interests/Objectives	Offering passengers faster, easier, better train journeys.
Needs	Franchise from the government.
Costs structure	According to ORR's 'GB rail industry financial information' publications, the Total Operating Costs for Virgin Trains West Coast in 2014/15 were £874.2m; the Allocated Network Grant for the same year was £420.4m; for a total of £1,294.6m.
Revenue model	Virgin Trains is owned by Virgin Rail Group that was formed by the Virgin Group to bid for rail franchises in the UK during the privatisation of British Rail. Virgin Trains was one of the franchises won. The general industry income sources are: the passengers for fares and others (car parking, on train catering, etc.); the government; other sources (property, stations retail, freight, etc.). The general industry expenditure is on staff costs, rolling stock, network rail charges and other costs.
Outputs	Train services.
Inputs	Franchise from the government.

Serco	
Stakeholder group	Organisation delivering services
Stakeholder definition	Serco specialise in the delivery of essential public services. Within the UK and Europe they work across public service sectors in Justice, Immigration, Healthcare, Defence, Transport and Citizen Services.
Role	Government services to citizens.

Serco	
	Support services to defence organisations. Healthcare support services. Border control and immigration services. Services across the justice system. Management of transport systems around the world, from air and sea to road, and with a particular focus on rail.
Interests/Objectives	Serco purpose is to be a trusted partner of governments, delivering superb public services that transform outcomes and make a positive difference for citizens.
Needs	Joint ventures with commercial partners and customers. Strategic partners to deliver services as part of a consortium, as prime contractor or a subcontractor, to bring together companies with the skills to meet the precise requirements of a bid.
Costs structure	According to 2016 full year results, Revenue including discontinued operations was £3,048m. Trading Profit was £100.3m and Underlying Trading Profit was £82.1m. The UK Central Government division includes UK operations in Defence, Justice & Immigration and Transport. Revenue for 2016 was £678.6m. Underlying Trading Profit was £52.2m. UK Central Government represented around £300m of the Group's aggregate total value of signed contracts during the year. The UK & Europe Local & Regional Government division includes UK Health and UK and European Citizen Services sectors. Revenue for 2016 was £696.5m. There was an Underlying Trading Loss of £6.5m. This represented around £750m of the Group's aggregate total value of signed contracts during the year. Corporate costs relate to typical central function costs of running the Group, including executive, governance and support functions such as HR, finance and IT. These costs in 2016 were £43.5m. The Group has three major governmental customers which each represent more than 10% of Group revenues. The customers' revenues were £1,233.7m for the UK Government, £623.1m for the US Government and £581.4m for the Australian Government.
Revenue model	Serco provide government services to citizens, funded by taxpayers. The Group has three major governmental customers which each represent more than 10% of Group revenues. The customers' revenues were £1,233.7m for the UK Government, £623.1m for the US Government and £581.4m for the Australian Government.
Outputs	Advise policy makers. Design innovative solutions. Integrate systems. Deliver front-line services.
Inputs	Financial resources from bids, contracts, government programmes. Specific skills to meet the precise requirements of a bid.

Office of Rail and Road	
Stakeholder group	Railway regulatory body
Stakeholder definition	ORR is a non-ministerial government department with around 280 staff. As an independent regulator, they operate within the framework set by UK and EU legislation. They protect the interests of rail and road users by improving the safety, value and performance of railways and roads.
Role	Functions for rail (Scotland, Wales and England): • Keep Britain's railway safe • Hold Network Rail to account • Protect consumer interests • Provide clear information about railway funding and industry performance • Make sure that passenger and freight train companies have fair access to the rail network • Regulate the High Speed 1 route and Channel Tunnel • Advise and assist governments on rail issues • Keeping markets under review Functions for road (England only): • Hold Highways England to account • Monitor performance • Secure value for money • Monitor road user satisfaction

Office of Rail and Road	
	• Advise and assist government on road issues
Interests/Objectives	• A safer railway: protect passengers, the workforce and the travelling public. • Better customer service: deliver a better deal for passengers in respect of compensation for delays. • Value for money from the railway: improve efficiency and boost value for money for taxpayers, fare payers and funders. • Better highways: this includes reduction in the number of people killed or seriously injured, improvement of road user satisfaction, and savings on capital expenditure. • Promoting a dynamic and commercially sustainable rail sector: consider options for route based regulation and for an effective charging and incentives regime for Network Rail. • High performing regulation: develop and apply proportionate, risk-based regulation.
Needs	Collaboration with stakeholders in the sector.
Costs structure	ORR has a budget of about £30m each year. According to their Business Plan 2016/17, they have distinct lines of funding: a safety levy, which pays for all health and safety work; an economic licence fee, which pays for economic regulation; and a direct grant from the Department for Transport for the work on highways regulation. 70% of outgoings are pay. As part of their overall turnover, £2.55 million is set aside for their work as the Highways Monitor. They also generate income beyond the UK rail industry levy and government funding for the Highways Monitor. The total income from their rail and roads functions was £31.4 million in 2016-17: 51% rail safety; 41% rail economic; 8% roads.
Revenue model	ORR is funded by the rail industry through licence fees and safety levies; while their road functions are funded by the Department for Transport.
Outputs	• Rail regulation: Health and safety (e.g. Information on passenger safety; Advice and guidance on occupational health matters for railway managers and employees; Annual health and safety report; etc.); Economic regulation (regulation of Network Rail and railway networks separate to the national network operated by Network Rail, including the Channel Tunnel and High Speed 1); Protecting consumers (overseeing consumer facing obligations); Promoting competition (e.g. market studies; investigating companies who are in breach of competition law; etc.); Access to the network; Licensing; Publications and Consultations. • Highways Monitor: Economic monitoring (monitor of Highways England and its management of the strategic road network); Publications and Consultations. • Information for the public: information for railway passengers such as train fares, train station car park charges; safety-related issues such as station platform gaps and crowding on trains; service disruption; and information about your train journey). • Statistics: statistics about railway performance, rail usage and safety. • News and media: news, speeches, presentations, articles, press release and statements, newsletters, blog.
Inputs	Financial resources (levies, licence fees and grant from the Department for Transport).

Railway Safety and Standards Board	
Stakeholder group	Rail industry organisation
Stakeholder definition	Through research, standards, analysis and insight, RSSB supports members and stakeholders in driving improvements in health and wellbeing and delivering a safer, more efficient and sustainable rail system.
Role	• Support members in the GB rail industry to cooperate to achieve their objectives. • Provide support and facilitation for cross industry activities such as supporting cross industry working groups and committees. • Play a key role in helping industry manage system safety including measuring safety performance and managing risk • Manage industry-wide programmes of research, development and innovation in cooperation with Department for Transport, Network Rail and other partners. • Develop and publish appropriate standards and guidance to help the industry meet legal obligations flexibly and efficiently. • Achieve clarity about working with Technical Specifications for Interoperability and coordinating input to the development of TSIs. • RSSB funded the initial KEEP SAFE project.
Interests/Objectives	• Health and safety: Establish a framework and systems that promote health and safety collaboration and inform decisions to reduce risk and harm. • More efficiency: Update standards, modernise systems and publish research yielding benefits. • Sustainability: Embed sustainability principles in industry strategies, collate and share best practise to publicly show rail as a sustainable system.
Needs	Collaboration from members and stakeholders in the sector.
Costs structure	According to the last Annual Review 2015-2016, RSSB's operating income grew by 7% during 2015/16 to £48.7m (2014/15 £45.5m). The main driver for this increase was income in respect of membership levy and for Innovation. Operating expenditure increased by 4% to £49.1m. Future Railway activities incurred expenditure approaching £13.4m. Research and Development activities incurred

Railway Safety and Standards Board	
	expenditure approaching £9.5m. Staff costs remained the most significant single element of RSSB's cost base with payroll and other staff costs totalling £25.3m. Overall there was an operating loss of £0.4m. The main driver for this loss was the charge for the year relating to the employers share of the net interest on the defined benefit liability of the pension scheme. RSSB funded the initial KEEP SAFE project: this was £35,000 of UK public funding.
Revenue model	RSSB is a not-for-profit company owned by major industry stakeholders. The company is limited by guarantee and is governed by its members and a Board. Its operating income arises from a mix of membership levies, grants from the Department for Transport and miscellaneous receipts from various goods and services.
Outputs	• Tools & models (e.g. CCTV toolkit; Common Safety Targets, Indicators and Methods; Health cost benefit analysis support tool; Vehicle Track Interaction Strategic Model; etc.) • Guidance (e.g. Accident investigation; Safety Management System principles; Managing drivers on routes undergoing significant change; etc.) • Consultancy & support (e.g. Health & wellbeing resources; Railway Industry Supplier Approval Scheme; Accreditation services; etc.) • Industry systems (e.g. National Incident Reporting Online; Industry Shared Risk Database; Platform distances database; etc.) • Reports (e.g. Rail Technical Strategy; Annual Safety Performance Report; Data quality initiatives; etc.) • Training (e.g. Train Driver Training programme; Non-Technical Skills Forum; Human factors awareness course for incident investigators; etc.) • Standards (e.g. Requirements Management Database; Proposals register; Rule Book and other operational publications; etc.) • Networks, groups & conferences (e.g. European working groups; Fatigue Risk Management Forum; Operational Risk Conference or webinar; RSSB Innovation Programme; etc.) • Research (e.g. Rail Research UK Association; SPARK) • News (e.g. Passenger platform safety campaign; etc.)
Inputs	Financial resources (levies from members and grants from the Department for Transport).

This project has received funding from the *European Union's Horizon 2020 research and innovation programme under the European Union's Horizon 2020 research and innovation programme* under grant agreement No 723974

Appendix 2 Competitors identification

Case study 1

Bla Bla Car	**Name: BlaBlaCar**
Website	https://www.blablacar.es/
Type (SME / Large corporation)	SME, based in Paris
Description	Designed for long distances and geared toward drivers looking to fill empty seats during journeys they would have been making anyway. Members must register and create a personal online profile, which includes ratings and reviews by other members, social networks verification, and rate of response.
Revenue Model	BlaBlaCar takes a flat cost + a % of trip price
Number of Users	>20 M.
Free for users	No
Commercialised	Yes
Strengths	Pictures, reviews and profiles are examined to ensure the confidence of the community, and to offer a reliable, high quality service.
Weaknesses	The challenge is to convince passengers to spend several hours locked in a car with a stranger. Focused on long-distance trips, which means that they target different customer groups across the market range.

uberPOOL	**Name: UberPool**
Website	https://www.uber.com/es-ES/ride/uberpool/
Type (SME / Large corporation)	Large corporation, San Francisco U.S.

Description	Uber is a large company operating in 633 cities worldwide. UberPool is a carpooling service started in 2014 matching raiders who are traveling in the same direction
Revenue Model	UberPool gets money from each trip as a percentage of the total fare.
Number of Users	>1 M.
Free for users	No
Commercialised	Yes
Strengths	UberPool being part of Uber gets some of their advantages, being well known as one of them and its technology focus as another.
Weaknesses	Same than blablacar, the challenge is to convince passengers to spend some time in a car with a stranger. There are some users which prefer other Uber services rather than UberPool, strangely creating inner competition.

	Name: Vulog
Website	http://vulog.fr/
Type (SME / Large corporation)	SME, based in France
Description	VULOG offers in-car technology and a modular software platform that allows mobility operators to implement all types of Car Sharing services (public, corporate, etc.), covering Round Trip, One Way and Free Floating Car Sharing systems and all vehicle types, offering a high-quality user experience and ensure efficient management of the service. Offers a configurable on-board touch screen that facilitates the deployment of a Car Sharing service and allows a tailored service to be offered: PIN code, interactive user manual, real-time booking management, navigation, company site locator (for corporate Car Sharing), fuel card management, key management, speaker/microphone, etc. User Front End (website and smartphone applications): Vehicle

	booking and selection, email/SMS confirmation, personal dashboard, reports sent to management, etc.
Revenue Model	Sales
Number of Users	VULOG currently supplies its solution in Europe and North America to a wide range of entities: Car Sharing pure players, car rental companies, public transportation operators, car manufacturers, local authorities and fleet managers
Free for users	No
Commercialised	Yes
Strengths	VULOG's in-car technology is developed to comply with automotive industry standards, working with car manufacturers to certify its vehicle installation process. Successful real cases.
Weaknesses	-

amovens pro driving change	**Name: amovenspro**
Website	http://pro.amovens.com/en
Type (SME / Large corporation)	SME, located in Spain
Description	Amovens offers companies, universities, and all sorts of organizations an easy and efficient way to show they care about sustainable transportation. Amovens can help employees, students or members share rides, save money, and cut CO2 emissions.
Revenue Model	Free for users Pricing for companies and public administration (standard plan, premium solution).
Number of Users	> 500.000
Free for users	Yes
Commercialised	Yes
Strengths	Offers tailored solutions for companies, universities and public administration.

	Also, peer-to-peer car rental.
Weaknesses	-

	**Name: FES_EDIT**
Website	http://www.fesedit.cat/
Type (SME / Large corporation)	Is regional initiative in Spain to share car for short trips.
Description	The application gives an option for the driver and passenger to make an agreement about the travel conditions, so it is possible to travel for free or a low price. It operates in: Catalonia: 5 university campuses – University of Barcelona; Politechnic University of Catalonia; University of Vic; Rovira University; Catalonia Government building in Girona Other regions: University of Zaragoza
Revenue Model	
Number of Users	
Free for users	
Commercialised	
Strengths	
Weaknesses	

	Name: Shotl Transportation S.L.
Website	https://shotl.com/
Type (SME / Large corporation)	SME, Sant Cugat del Valles, Barcelona.
Description	The application allows to find other passengers that are travelling in the same direction. It resembles a city shuttle service. There is a trip price less than €5.
Revenue Model	
Number of Users	
Free for users	
Commercialised	
Strengths	
Weaknesses	

Case study 2

	Name: Q-Free
Website	https://www.q-free.com/
Type (SME / Large corporation)	International Company with headquarters in Norway.
Description	Q-Free is a leading global supplier of products and solutions within the global Intelligent Transportation Systems (ITS) market. The company provides class-leading Tolling, Parking, Traffic Management and Connected ITS (C-ITS)/Connected Vehicle

	solutions. It has a presence in all major ITS technology areas. These solutions, together with a broad, and in many cases unique, range of sensors for infrastructure, vulnerable road user and environmental monitoring, enable Q-Free to supply ITS which address all road infrastructure financing, operating and condition-monitoring needs.
Revenue Model	Sells different ITS products, around 600 million annual revenue
Number of Users	
Free for users	No
Commercialised	Yes
Strengths	
Weaknesses	

RS Industries (Israel) Advanced Traffic Systems	**Name: RS Industries**
Website	http://www.rs-traffic.com/EngHome/HomePage
Type (SME / Large corporation)	SME, Israel.
Description	RS INDUSTRIES is a leader **in providing traffic control solutions** since 1971. About 50 very high skilled human resources team is capable of transforming **complex technological challenges** into simple implementable tasks. **Areas of specialization:** Traffic management system Traffic-light management system control Tunnel management system Highway management system Electronic signs on roads Traffic surveillance systems Toll and billing systems
Revenue Model	
Number of Users	
Free for users	No

Commercialised	Yes
Strengths	
Weaknesses	

	**Name: Aegis ITS**
Website	https://www.aegisits.com/
Type (SME / Large corporation)	Member of Econolite group.
Description	Aegis provides services across the ITS project life cycle – from design through maintenance and operations. Recent successful projects include signal system deployment for large metropolitan areas, development of citywide networks for ITS using fibre and wireless technologies, and delivery of maintenance services for major transportation authorities. Focusing on infrastructure-based ITS solutions, the company's capabilities extend to freeway and arterial applications. Agencies at both the state and local level have selected Aegis ITS as their provider of choice for systems software, communications, and integration of a broad array of field devices.
Revenue Model	Sells different ITS products, around 600 million annual revenue
Number of Users	
Free for users	No
Commercialised	Yes
Strengths	
Weaknesses	

	**Name: PTV Group**
Website	http://www.ptvgroup.com/en/
Type (SME / Large corporation)	Large company, Germany

Description	PTV Group improves mobility and transport – by using world-class software, data and scientific know-how gained from four decades of experience in planning and optimizing the movement of people and goods. Recognized as global market player with German technology, PTV helps cities, companies and people save time and money, enhance road safety and minimise the impact on the environment. Based on a unique expertise in every facet of mobility, PTV support smooth traffic flow (more than 2500 cities use PTV solutions). PTV software is used to develop the European transport model, which encompasses all passenger transport and freight movements in Europe. Currently more than 700 staff worldwide is committed to driving the high performance of PTV products.
Revenue Model	Sells software solutions and consulting services for traffic and transportation, mobility and logistics. “Vision Traffic Suite”, their transport planning software and “PTV Map&Guide”, their program for route planning, comprise the PTV product portfolio.
Number of Users	More than 2,000 customers over 90 countries use the Vision Traffic Suite.
Free for users	No
Commercialised	Yes
Strengths	
Weaknesses	

kapsch challenging limits	**Name: Kapsch TrafficCom**
Website	https://www.kapsch.net/it/ktc
Type (SME / Large corporation)	Large company, Austria
Description	Kapsch TrafficCom is a provider of **intelligent transportation systems (ITS)** in the segments of toll collection, traffic management, safety and security, smart urban mobility and connected cars. The end-to-end solutions of Kapsch TrafficCom cover the entire

	value creation chain of its customers as a one-stop shop, from components and design to the installation and operation of systems. The core business comprises the development, installation and operation of electronic toll collection and traffic management systems. References in 44 countries on all continents have made Kapsch TrafficCom a globally recognized ITS provider.
Revenue Model	Sells road telematics and ITC services. €908.8 million revenue in 2015.
Number of Users	
Free for users	No
Commercialised	Yes
Strengths	
Weaknesses	

	**Name: Indra**
Website	http://www.indracompany.com/
Type (SME / Large corporation)	Large company, Spain
Description	INDRA Smart Mobility Provides global solutions for road traffic for Improving the management of road infrastructures and vehicles themselves. INDRA offer measures to improve mobility on roads and in cities, as well as comprehensive supervision and control systems for urban traffic lights, road tunnel installations and highways. Solutions include the design, engineering, production and development of applications and maintenance, using open approach and standard to be adapted to the client's specific needs. Many systems have been implemented across other than Spain, continents and countries.
Revenue Model	
Number of Users	

Free for users	No
Commercialised	Yes
Strengths	
Weaknesses	

SIEMENS	**Name: Siemens**
Website	https://www.siemens.com/it/it/home.html
Type (SME / Large corporation)	Large company, Germany
Description	The principal divisions of the company are Industry, Energy, Healthcare and Infrastructure & Cities, which represent the main activities of the company. The company is a prominent maker of medical diagnostics equipment and its medical health-care division, which generates about 12 percent of the company's total sales, is its second-most profitable unit, after the industrial automation division. Siemens and its subsidiaries employ approximately 362,000 people worldwide and reported global revenue of around €75.6 billion in 2015 according to their annual report.
Revenue Model	Sales
Number of Users	5.000 light signal systems connected in 18 countries
Free for users	No
Commercialised	Yes
Strengths	SIEMENS has 100 years of experience in the implementation of pioneering technologies Full-scale traffic control centres are often too costly for small towns. SIEMENS has created a web-based traffic control centre you can control via your PC, tablet PC or smartphone.
Weaknesses	

	Name: TomTom
Website	https://www.tomtom.com
Type (SME / Large corporation)	Large company, Netherlands
Description	TomTom NV is a Dutch company that produces traffic, navigation and mapping products. TomTom also makes action cameras, GPS sport watches, fleet management systems, and location-based products. TomTom's has four business units: Consumer, Automotive, Licensing and Telematics through which it sells and licences its technology and products. TomTom's Consumer business is focused on creating location-based products that give consumers the knowledge they need to get where they want to go.
Revenue Model	Sales
Number of Users	>1.5 million
Free for users	No
Commercialised	Yes
Strengths	
Weaknesses	

	Name: HERE
Website	https://here.com/en
Type (SME / Large corporation)	Large company, Netherlands

Description	HERE is a company that provides mapping data and related services to individuals and companies. It is owned by a consortium of German automotive companies (namely Audi, BMW, and Mercedes). Here captures location content such as road networks, buildings, parks and traffic patterns. It then sells or licenses that mapping content, along with navigation services and location solutions to other businesses such as Alpine, Garmin, BMW, Oracle and Amazon.com. In addition, Here provides platform services to smartphones running Android, iOS, Windows, Firefox OS, Fire OS, Ubuntu Touch and Sailfish OS and previously for Nokia's platforms Asha and Symbian. It provides location services through its own Here applications, and also for GIS and government clients and other providers, such as Microsoft Bing, Facebook and (formerly) Yahoo! Maps. Here has maps in nearly 200 countries, offers voice guided navigation in 94 countries, provides live traffic information in 33 countries and has indoor maps available for about 49,000 unique buildings in 45 countries
Revenue Model	
Number of Users	
Free for users	No
Commercialised	Yes
Strengths	
Weaknesses	

Case study 3

CargoNet™ Web Centric Logistics Software	**Name: CargoNET Cargo Tracking**
Website	http://www.gocargonet.com
Type (SME / Large corporation)	I Code Technologies pvt.Ltd. - Design and development firm with 10-50 employees. Founded in 2000. Headquarter: Bangalore, India

Description	CargoNET offers a customized cargo tracking software which can be integrated in a customer's own website and which enables real-time cargo tracking from the time the order is placed until the final destination is reached, and is applicable for air, ocean and land freight.
Revenue Model	There are four packages which can be chosen with different features: (1) Package with basic features for one single user (US$1,000 per month) (2) Package with premium features for 2 users (US$1,500 per month) (3) Package with professional features for 5 users (US$2,500 per month) (4) Package with advanced features for up to 10 users (US$4,000 per month) The subscription is possible for a contract duration of 3 months, 6 months (with discount of 4%) and 1 year (with discount of 10%).
Number of Users	Not indicated
Free for users	Only the shipment status is available for the open public via the Cargo Tracking common access module
Commercialised	Yes
Strengths	• Provides real-time cargo tracking from place of origin until final destination • Enables multi-branch and multi-modal shipment integration • Is applicable for air, ocean and land freight transport • Offer shipment tracking with pre-alert function (automatic email, SMS notification) and estimated delivery time of their cargo (ETA) • Enables tracking of shipments by shipment type, shipper/consignee name, container number, shipment dates or any other criteria the client wants to have specified • Enables customers to retrieve online shipping-related documents such as air waybills, bills of lading, invoices, etc. • Offers different modules with customized features adjusted to the needs of respective clients (e.g. oversea agents, consignee or shipper) • Offers unlimited number of shipment tracking processes • Tracking software can be integrated in customer's own

	corporate website • 24/7 customer support via online chat, telephone and e-mail
Weaknesses	• Focuses on shipment tracking via air, ocean and land (coverage of inland waterways apparently still under development) • Focuses on port-to-port freight transport only (not yet: port-to-hinterland) • Option to follow container transport on inland waterways is not clearly advertised (may be under development)

cntracking	**Name: Cntracking Customized Tracking System**
Website	www.cntracking.com
Type (SME / Large corporation)	Start-up with 10 employees. Founded in 2014. Headquarter: Izmir, Turkey CNTR Inc. operates in the Technology Development Zone of Dokuz Eylul University.
Description	Cntracking.com is a customized container tracking system, which can be integrated in a customer's own website and allows to track own customers' containers. The tool also supplies transit times of container lines for more than 500.000 routes.
Revenue Model	There are two possible packages as payment options: (1) Advanced package at US$69/month or US$699/year, designed for exporters, importers & traders • Integrates container tracking module in own website and track own customers • Sends automatic tracking notifications emails with own company's logo • Sends arrival notices and notifications 3 and 7 days prior to arrival in order to decrease the demurrage and warehousing risks in favor of own customers (2) Professional package at US$ 99/month or US$ 999/year, designed for freight forwarders • Has advanced features • Monitors all own shipments in an integrated dashboard • Eases and accelerates own tracking operations • Provides statistical data about own shipments
Number of Users	Registered users on website: 22840 (15.8.2017) CNTR counts on customers all over the world, among them being transport and logistics service providers and freight forwarders.

Free for users	Trial version: 15 days are free
Commercialised	Yes
Strengths	• Provides customizable dashboard for tracking can be integrated into customer's own website • Can track over 90 container lines and 900 container ports • Supplies transit time of container lines for more than 500,000 routes • Provides notification and alert functions • Able to send arrival notices and notifications 3 and 7 days prior to arrival in order to decrease the demurrage and warehousing risks in favour of own customers • Container tracking e-mails can automatically be sent with the company's logo • Allows freight forwarders to monitor all their shipment and derive statistical data about their shipments with the aim to ease and accelerate their tracking operations • Offers customer support via live chat
Weaknesses	• Focuses on ocean freight transport (unimodal) • Focuses on port-to-port freight transport only (not: port-to-hinterland) • Lacks forecast function predicting container arrival times (ETA)

	Name: DLDS Logistics Data Bank System
Website	https://www.ldb.co.in/containersearch
Type (SME / Large corporation)	DMICDC Logistics Data Services Ltd. a joint venture company of the Delhi Mumbai Industrial Corridor Development Corporation Limited, India and NEC Corporation, Japan. Founded in 2015, Headquarter: New Delhi, India.
Description	Logistics Data Bank (LDB) is an online tracking system for containers, to facilitate easy tracking and effective utilization to import/export companies. LDB is an overarching solution that integrates the information available with various agencies across the supply chain to provide detailed near real-time information within a single window. It provides a web-based container search function by container number, visualized on GoogleMaps, identifies delays and sends notifications to the user via e-mail or SMS. Each container is equipped with an RFID tag and tracked in real-time by RFID readers installed across all entry and exit gates of toll plazas, inland container

	depots, or container freight stations. The container movement is recorded and shared with the LDB system. The LDB system covers the entire movement of containers from Jawaharlal Nehru Port of Mumbai (JNPT) through rail or road till the inland container depot and container freight station in the Western logistics corridor of India. Main customers comprise: central & state governments, shippers/consignees, container train operators, inland container depots/ container freight stations, truck operators
Revenue Model	Service charge of Rs 125 per container handled (approx. € 1.65) for the provision of the IT infrastructure of the LDB system.
Number of Users	So far, 70% of the container traffic in India serviced by the LDB system, equalling approx. 4.8 million containers handled.
Free for users	No
Commercialised	Yes (service fully operative since July 2016)
Strengths	• Integrates data from various sources (vehicles: truck, trains; port terminal; inland container depots) • Enables real-time tracking of single or groups of containers via GoogleMaps • Covers the entire supply chain from port to the hinterland • Enables customers to obtain an estimated delivery time of their containers • Offers a pre-alert function like automatic email or SMS notification • Enables users to provide value added services including comparative metric-based analyses to assess logistics performance • Reduces transportation lead-times by five days translating into estimated annual savings of US$ 3.2 billion • Offers customer service via telephone, website and email
Weaknesses	• So far provides the service in the Western logistics corridor of India only (with on-going expansion to the country's southern region) • Focuses on rail and road freight transport from the Jawaharlal Nehru Port of Mumbai (tracking on inland waterways is not included so far) • Requires temporary RFID-tagging of containers

INTTRA	**Name: INTTRA Track & Trace**
Website	http://www.gocargonet.com
Type (SME / Large corporation)	SME with 300 employees, Founded in 2000. Headquarter: Parsippany, NJ, USA INTTRA is a privately held U.S. based shipping technology company acting as a software and information provider for the ocean shipping industry, combining its own network with multiple parties to empower customers in improving their business in the ocean trade process. Its full service comprises one of the largest multi-carrier e-commerce platforms for global ocean freight transportation.
Description	INTTRA Track & Trace represents one of INTTRA's core services and enables **freight forwarders and shippers** to instantly track the locations of their shipments by container number, carrier booking number, bill of lading reference number, and purchase order number. With INTTRA Track & Trace, one can access all carrier-provided updates (vessel load status, departure and arrival information) for all own shipments across 50+ leading carriers. Data can be retrieved through a web platform with an easy-to-use user interface and multi-criteria search functions. Features comprise: • Advanced tracking – users search by PO, carrier, date range, location, latest country or event, vessel, and voyage • Available through web interface or EDI[49] data feed • Customized data – see only the data you want to receive • Confidentiality – users must be a coded party on the Booking Request or B/L[50] • Timely customer notification – multiple parties can receive status events • 24/7 customer support in 7 languages
Revenue Model	No pricing information listed.
Number of Users	Connecting 225,000 shipping professionals with more than 50 leading carriers and 120 plus software alliance partners More than 100,000 customers that book and ship containers
Free for users	No
Commercialised	Yes

[49] EDI = electronic data interchange, a computer-to-computer exchange of business documents in a standard electronic format between business partners
[50] B/L = bill of landing, a contractual document issued by a carrier to the shipper

Strengths	• Easy-to-use user interface in a single platform to manage shipment • Status notifications • Provides data from 50+ of the world's leading carriers covering 35% of the world's ocean shipping container moves • Data feeds in UN-standards formats • Customer support (technical guides, live chat) • Expansion of service portfolio to inland distribution services through recent acquisition of the young EU container tracking company Avantida based in Belgium beginning of 2017 • Extended access to seven European markets, including Belgium, Netherlands, Germany, France, Italy, Portugal and Spain through acquisition of Avantida
Weaknesses	• So far business merely focused on ocean shipping • No real forecasting function for the arrival of containers

OCEANINSIGHTS	**Name: Ocean Insights Container Track & Trace**
Website	https://www.ocean-insights.com/container-track-and-trace/
Type (SME / Large corporation)	Start-up; 30 employees, in cooperation with Riege Software Founded in 2012 in Hong Kong. Headquarter: Rostock, Germany, Ocean Insights is an international, provider of smart software solutions for the cargo industry, with offices in India and Germany, is operating on global scale, providing data and intelligence for the logistics industry to improve visibility and transparency in ocean freight.
Description	Web-based container tracking platform giving a full overview on shipments across all carriers. Ocean insights try to combine container liner schedules and carriers' container tracking information with neutral AIS vessel tracking data. Consolidates and evaluates ocean freight information for the logistics industry Features: • Shipment directory list all current and past shipments • Ship locations provides real-time satellite-based ship tracking
Revenue Model	Transaction-based billing model (fee per tracked container) Costs vary depending on number of containers tracked:

	On average: €3,000 / month or more
Number of Users	Not indicated Some of the largest freight forwarders worldwide (>10.000 containers per year) Companies from chemical, automotive, and consumer goods industries
Free for users	No
Commercialised	Yes
Strengths	• Real-time information on container and vessel location across all carriers Event monitoring and altering (status changes and delay warnings) • Prediction of container arrival time • Ready-to-use web application Option for integrating tool in existing in-house IT through web-service API • Analytics tools to monitor key performance indicators (Shipped volume, delays, on-time performance) • Customized reports on ocean freight statistics • Collaborations with software companies to integrated OI's tracking data into other applications
Weaknesses	• Major focuses on sea freight (but option to follow inland waterway freight transport is functional) • No inclusion of port-related container tracking information

	**Name: SeaRates Container Tracking**
Website	https://www.searates.com/about/container-tracking/
Type (SME / Large corporation)	Large company with 850 employees, Founded in 2005. Headquarter: New York City, USA, with total of 10 offices in different regions worldwide. In cooperation with Google Maps. SeaRates is an international freight forwarder and broker offering a full range of logistic services and software tools in global freight, main business in arranging the international cargo delivery from 1m³ or 50 kg till shiploads. Similar to booking accommodation online, SeaRates - for international deliveries, allows customers to get prices online,

	and book shipments directly from the website.
Description	Container tracking system allows user to define the current position of the container on the world map (Google Maps) and determine the port and the time spent in port of congestion. To track the location of the container, the user needs to specify container number and shipping line. The result will be displayed on the map showing the current location of the container. SeaRates tracking system is also utilizing AIS for the tracking of ships. Logistic Route Planner allows users to add any point of shipment to the route (city, port, terminal) and plot the shipping route. This function can be fully integrated into a customer's website along with the container tracking application and allows users to define the current position of a container, to display routes of cargo moving, ports of transhipment on GoogleMaps, transit time and any other additional information.
Revenue Model	Container Tracking tool as app application for customer's own website. Single license: US$499 (one-time payment) Logistic Route Planner Single license: US$550
Number of Users	Not indicated
Free for users	Trial version (upon registration)
Commercialised	Yes
Strengths	• Appealing easy-to-use search engine and user interface • Results display on world map of GoogleMaps • Transparent pricing system • Clear instructions of how to install the application (download) • Customer support (live chat) in 5 languages
Weaknesses	• Container tracking limited to 18 shipping lines (according to public website) • Logistic Route Planner although being applicable for all modes of transport (air, land, multimodal), it only provides information on the current location of a container and apparently cannot predict arrival times at for a certain location.

Case study 4

	Name: DB Systemtechnik
Website	https://www.db-systemtechnik.de/dbst-en/start/
Type (SME / Large corporation)	Company "with limited liability" (GmbH in German), based in Germany
Description	DB Systemtechnik offers tailor-made services for rail vehicles, their components, infrastructure and interface. It is the engineering office of the Deutsche Bahn AG, the German railway company but not only serves as an expert partner to support Deutsche Bahn with its expertise, but is also increasingly active in the international railway market.
Revenue Model	Revenues of €117 million in 2016, 900 employees. Model not identified
Number of Users	Sites located in Germany, Austria, France and UK
Free for users	No
Commercialised	Yes
Strengths	They have measuring vehicles that can be used for many different purposes. They are a powerful engineering service provider on the English market also, due to their subsidiary in UK, the ESG Rail. Additionally, new solutions in the field of Predictive Maintenance are being offered, due to the infraView Big Data platform, product of the new subsidiary: infraView.
Weaknesses	Not identified

Ansaldo STS	**Name: Ansaldo STS – A Hitachi Group Company**
Website	http://www.ansaldo-sts.com/en/index
Type (SME / Large corporation)	Large corporation
Description	Ansaldo STS is a public company headquartered in Genoa. The 51% of the share capital is held by Hitachi Rail Italy Investments shareholder. Ansaldo STS is a leading company operating in the sector of high technology for railway and urban transport. The Company operates in the design, implementation and management of

	systems and services for signalling and supervision of railway and urban traffic, as well as lead contractor.
Revenue Model	Depending on the customer's request or on the type of order, Ansaldo STS is able to operate in either the Railway or Urban Transport Systems market as a prime contractor, a technological integrator, a provider of components and services in the market of signalling, or a provider of operation and maintenance services for urban transport systems. Ansaldo STS can leverage its sound net financial position and innovate its profitability model by introducing pay per use formulas on long-term contracts, thus optimising the total cost of ownership for its key customers Ansaldo STS has over 3,951 employees in 28 different countries. Revenue in 2016 came to €1,327.4 million, compared to €1,383.8 million in the previous year.
Number of Users	The company operates worldwide as lead contractor, system integrator and supplier "turnkey" of the most important projects of mass transportation in metro and urban railways.
Free for users	No
Commercialised	Yes
Strengths	It is the only company listed both on the main board of the Italian stock exchange, FTSE MIB (which includes Italy's most highly capitalized concerns) and in the Star segment, which groups companies of excellence according to specific requisites, (liquidity, corporate governance and transparent disclosure).. For decades, Ansaldo STS has been a worldwide Pioneer in the railway industry. As an expert in Railway, Mass Transit and Freight signalling and turnkey projects, Ansaldo STS manages all of the phases of a project, from the design to the manufacturing and installation, testing and commissioning and operations and maintenance, independently of network size and complexity. Ansaldo STS is capable of aligning its solutions to any rolling stock supplier and is flexible in the design and creation of a selected solution.
Weaknesses	Unknown

Bentley Advancing Infrastructure	**Name: Bentley**
Website	https://www.bentley.com/en
Type (SME / Large	Large corporation

corporation)	
Description	Bentley Systems is a software development company that supports the professional needs of those responsible for creating and managing the world's infrastructure. Bentley delivers solutions for the entire lifecycle of the infrastructure asset, tailored to the needs of the various professions.
Revenue Model	Bentley has more than 3,000 colleagues in over 50 countries and more than $600 million in annual revenues.
Number of Users	
Free for users	No
Commercialised	Yes
Strengths	Operating in UK for some years now and the specific solution is being used by Network Rail
Weaknesses	The Rail Predictive Maintenance Solution doesn't take into consideration data from the vehicle and electrification system but historical and current infrastructure measurements (along with other external factors)

UNIVERSIDAD DE MÁLAGA | uma.es	**Name: Universidad of Malaga, Spain, Language and Computer Science Dpt.**
Website	http://www.uma.es/ https://link.springer.com/content/pdf/10.1007%2F978-3-319-04166-7_10.pdf
Type (SME / Large corporation)	HEI - Public
Description	**RAISE: RAIlway Infrastructure Health Monitoring Using Wireless SEnsor Networks**. A research based application using WSNs has been presented in conference paper. The WSN collects information about the structural health and behaviour of the infrastructure when a train travels along it and relays the readings to a base station. The base station then uses the next trains as a data mule to upload the information. The WSN makes use of a publish/subscribe based middleware called PS-QUASAR to significantly simplify the task of developing the application and to allow new nodes to be added on-the-fly. The resulting code has been simulated using the Cooja simulator. The Contiki test editor plugin has been used to control the simulation and to actually simulate the movement of

	the train.
Revenue Model	Non-existing
Number of Users	A prototype testing on a railway bridge using simulator has been implemented. The script simulates 20 trains passing over the bridge, one every 60 seconds
Free for users	Yes, for the time being
Commercialised	No
Strengths	From the results obtained in the test with the application prototype, it is foreseen that the application scenario is actually feasible. An advantage is also that a large number of nodes can be deployed in the scenario without the need for wiring. The use of PS-QUASAR has proven to be invaluable as it automatically handles the Quality of Service requirements specified at the application layer and substantially simplifies the task of programming WSN applications.
Weaknesses	Not applied in actual trains. There are still issues that need to be tackled, such as which specific sensors to use in the sensor nodes and how the way in which they are deployed can affect the accuracy of the readings. There are also several issues and behaviours that have not been captured by the simulators such as the influence of the bridge's infrastructure or the speed of the train on the performance of the sensor radio that require further consideration

	**Name: Carnegie Melion / University of Pennsylvania.**
Website	http://www.cmu.edu/ http://www.upenn.edu/ http://utc.ices.cmu.edu/utc/tier-one-reports/Beilak_TSETFinalReport.pdf
Type (SME / Large corporation)	HEI - Public
Description	**Infrastructure Monitoring from an InService Light Rail Vehicle**. A research project exploring a data-driven approach for monitoring rail infrastructure from the dynamic response of a train in revenue-service. Rail inspection is performed by analysing vibration data collected from an operational passenger train. The high frequency with which passenger

	trains travel each section of track means that faults can be detected sooner than with dedicated inspection vehicles, and the large number of passes over each section of track makes a data-driven approach statistically feasible.
Revenue Model	
Number of Users	The project has been applied in two of Pittsburgh's light rail vehicles and has been monitoring the rail system from the vibrations in the operational vehicle over the last 3 years.
Free for users	
Commercialised	No
Strengths	From the results of this project, it appears that vehicle-based monitoring could be a low cost approach for monitoring infrastructure. It has been possible to detect changes on an operational system using just a single sensor on a train in revenue service.
Weaknesses	Until now, only data recorded on parts of the line that are supported on firm ground has been analysed.

	**Name: IBM**
Website	https://www.ibm.com/us-en/
Type (SME / Large corporation)	An American multinational technology company, with operations in over 170 countries. Warren Buffett's Berkshire Hathaway is one of IBM's largest shareholders
Description	IBM manufactures and markets computer hardware, middleware and software, and offers hosting and consulting services in areas ranging from mainframe computers to nanotechnology. Among the many fields/industries in which operating is the travel and transportation. With its cognitive computing technology IBM changes the future of transport radically.
Revenue Model	IBM has a range of revenue models for its Marketplace: Tiered, Recurring, One-time and Free. A revenue of $79.92 billion (2016)
Number of Users	Not identified

Free for users	No
Commercialised	Yes
Strengths	IBM has developed predictive maintenance software solutions that access multiple data sources in real time to predict asset failure or quality issues in order to organisations avoid costly downtime and reduce maintenance costs. Cognitive systems have unique capabilities to harness data to deliver insights that improve railway operations. Operates in UK among the 170 countries.
Weaknesses	Not identified

SIEMENS	**Name: SIEMENS**
Website	https://www.siemens.com/global/en/home.html
Type (SME / Large corporation)	Large corporation
Description	Siemens AG is a German conglomerate company headquartered in Berlin and Munich and the largest industrial manufacturing company in Europe with branch offices abroad. It is a global powerhouse in electrical engineering and electronics and has around 360,000 employees.
Revenue Model	Revenue was €79.64 billion (2016)
Number of Users	It has operations in around 190 countries and approximately 285 production and manufacturing facilities.
Free for users	No
Commercialised	Yes
Strengths	As it has acquired the MRX Technologies Group, headquartered in Perth, Australia, is further expanding its services in the field of predictive maintenance based on digitalization. SIEMENS has invested the past years a lot in Intelligent Rail Systems as a pillar of Intelligent Infrastructure, engaging on 2013 the “Rail on Track” programme. Siemens holds a leading position in the rail industry for supplying rolling stock, infrastructure and services from a single source. As the first company in the rail industry, Siemens operates in Munich, the Mobility Data Services Centre.

Weaknesses	Not identified

Appendix 3 CAMEO tables

Quick Reference Table

This table provides a quick overview of the classification and the predominant characteristics found within each of the 42 categories and 10 groups.

CAMEO Code	CAMEO Int'l Code	CAMEO Spain Category	Household %	Demographic Profile								
				Presence of Children	Child Age	Index of Age 20-39	Index of Age > 60	Presence of One Person Households	Presence of Three+ Person Households	Migration Since Birth	Foreign Born Index	Foregin Born Origin (Top 2)
1		Wealthy Society	9.15									
1A	12	High Flying Families	1.95	Very High	0-9	124	46	Below Average	Average	High	66	EU/Americas
1B	13	Big City Slickers	2.71	Average	0-9	102	103	Low	Average	High	108	Americas/Africa
1C	13	Suburban High Life	2.40	Average	Mixed	91	105	Average	Average	Average	80	EU/Americas
1D	14	Wealthy Established Professionals	2.10	Below Average	Mixed	85	127	Average	Average	Low	61	Americas/EU
2		Urban Affluence	12.03									
2A	11	Affluent City Singles	2.06	Low	0-9	113	101	High	Low	Average	163	Americas/EU
2B	13	Educated Urbanites	3.59	Below Average	Mixed	96	117	High	Low	Below Average	124	Americas/EU
2C	14	Professional Suburbia	2.80	Below Average	0-9	98	117	Average	Below Average	Average	165	Americas/EU
2D	15	Mature Money	3.57	Low	Mixed	83	131	Average	Average	Average	65	Americas/EU
3		Well-Off Communities	9.19									
3A	22	Flourishing Family Suburbs	0.69	Very High	0-9	160	39	Below Average	Average	Average	57	EU/Americas
3B	23	Cosmopolitan Neighbourhoods	2.00	Below Average	Mixed	110	93	Low	High	High	148	EU/Americas
3C	23	White Collar Families	3.02	Above Average	Mixed	102	94	Below Average	Average	High	91	Africa/Americas
3D	24	Rural Retreats	3.47	Average	Mixed	94	102	Above Average	Average	High	108	EU/Africa
4		Comfortable Families	4.13									
4A	22	Pre-school Professional Broods	1.36	High	0-4	187	27	Below Average	Average	Average	70	EU/Americas
4B	23	School Run Households	1.19	High	Mixed	107	58	Low	Average	Average	55	EU/Americas
4C	24	Mature Commuter Families	1.58	High	5-14	94	80	Below Average	Average	High	92	EU/Americas
5		Dynamic Neighbourhoods	14.82									
5A	32	Comfortable Commuter Families	1.71	High	0-9	136	57	Average	Average	High	97	EU/Africa
5B	33	Big Family Barrios	2.18	High	5-14	88	65	Low	High	Above Average	45	EU/Americas
5C	33	High Density Households	1.82	Average	5-14	86	79	Low	High	Average	51	EU/Americas
5D	34	Settled City Dwellers	1.83	Below Average	Mixed	94	102	Low	High	Above Average	53	EU/Americas
5E	33	Middle Income Melting Pot	2.47	Average	Mixed	107	96	High	Low	Above Average	223	EU/Americas
5F	35	Retiring to the suburbs	4.81	Below Average	Mixed	86	124	Average	Average	Average	122	EU/Americas
6		Middle Income Households	15.13									
6A	32	Young Family Start-ups	3.92	High	0-9	133	63	Below Average	Average	Average	101	EU/Africa
6B	32	Diverse Neighbourhoods	1.96	Average	0-9	122	83	High	Below Average	High	316	Africa/Americas
6C	33	Media España	4.74	Average	Mixed	103	92	Average	Average	Average	107	EU/Africa
6D	35	Ageing Rural Communities	4.51	Low	Mixed	79	135	Above Average	Average	Below Average	66	EU/Africa
7		Provincial Communities	10.44									
7A	42	Rural Working Families	3.58	Average	Mixed	104	92	Below Average	Average	Average	103	EU/Africa
7B	43	Small Town Skilled Workers	4.30	Average	Mixed	102	100	Average	Average	Average	130	EU/Americas
7C	45	Educated Elders	2.56	Low	Mixed	86	130	Average	Average	Below Average	56	Americas/EU
8		Modest Means	9.69									
8A	41	Multicultural Singles and Couples	0.67	Average	Mixed	116	74	High	Average	High	249	EU/Africa
8B	42	Established Village Communities	4.72	Average	Mixed	104	91	Below Average	Average	Low	66	Africa/EU
8C	43	Blue Collar Urban Families	2.15	Average	Mixed	104	95	Low	Above Average	Low	63	Americas/Africa
8D	45	Rural Retirees	2.15	Low	5-14	57	180	High	Low	Below Average	144	EU/Europe (Non-EU)
9		Stretched Families	10.05									
9A	52	Cramped Young Families	0.97	Above Average	Mixed	118	66	Below Average	Above Average	Below Average	105	EU/Africa
9B	53	Tourist Town Workers	3.45	Average	Mixed	103	86	Below Average	Above Average	Below Average	62	EU/Americas
9C	53	Lower Income Environs	2.03	Average	Mixed	105	87	Average	Average	Below Average	89	EU/Africa
9D	44	Rural Fringe	2.51	Average	Mixed	95	107	Average	Average	Low	53	EU/Africa
9E	54	Employment Endeavours	1.09	Below Average	Mixed	94	122	High	Below Average	Average	131	Americas/EU
10		Struggling Society	5.38									
10A	53	Stretched Service Sector Families	2.40	Average	Mixed	103	96	Below Average	Above Average	Low	74	Americas/EU
10B	54	Struggling Urban Households	1.23	Below Average	Mixed	94	117	High	Average	Average	105	EU/Americas
10C	55	Low Income Rural Communities	0.85	Low	5-14	83	120	High	Below Average	Average	83	EU/Africa
10D	55	Agricultural Adversity	0.76	Low	Mixed	75	145	Above Average	Average	Low	38	EU/Americas
10E	55	Remote retired couples	0.13	Low	Mixed	73	148	Above Average	Average	Low	24	EU/Americas
XX		Unclassified / No data	0.00									

CAMEO Code	CAMEO Int'l Code	CAMEO Spain Category	Household %	Property			
				Urban / Rural	Housing Type	Property Size	Tenure (Top 2)
1		Wealthy Society	9.15				
1A	12	High Flying Families	1.95	Mixed	Single Dwelling Building	Average	Mortgaged/Own Outright
1B	13	Big City Slickers	2.71	Urban	Mixed	Small	Own Outright/Mortgaged
1C	13	Suburban High Life	2.40	Urban	Single Dwelling Building	Large	Own Outright/Mortgaged
1D	14	Wealthy Established Professionals	2.10	Urban	Mixed	Average	Own Outright/Mortgaged
2		Urban Affluence	12.03				
2A	11	Affluent City Singles	2.06	Urban	Multi-Dwelling Building	Small	Own Outright/Rented
2B	13	Educated Urbanites	3.59	Urban	Mixed	Small	Own Outright/Rented
2C	14	Professional Suburbia	2.80	Urban	Multi-Dwelling Building	Small	Own Outright/Mortgaged
2D	15	Mature Money	3.57	Urban	Mixed	Average	Own Outright/Mortgaged
3		Well-Off Communities	9.19				
3A	22	Flourishing Family Suburbs	0.69	Urban	Single Dwelling Building	Average	Own Outright/Mortgaged
3B	23	Cosmopolitan Neighbourhoods	2.00	Urban	Mixed	Average	Own Outright/Mortgaged
3C	23	White Collar Families	3.02	Mixed	Single Dwelling Building	Average	Own Outright/Mortgaged
3D	24	Rural Retreats	3.47	Rural	Single Dwelling Building	Average	Own Outright/Mortgaged
4		Comfortable Families	4.13				
4A	22	Pre-school Professional Broods	1.36	Mixed	Single Dwelling Building	Average	Own Outright/Mortgaged
4B	23	School Run Households	1.19	Urban	Mixed	Average	Mortgaged/Own Outright
4C	24	Mature Commuter Families	1.58	Rural	Single Dwelling Building	Large	Mortgaged/Own Outright
5		Dynamic Neighbourhoods	14.82				
5A	32	Comfortable Commuter Families	1.71	Rural	Single Dwelling Building	Average	Own Outright/Mortgaged
5B	33	Big Family Barrios	2.18	Urban	Single Dwelling Building	Large	Mortgaged/Own Outright
5C	33	High Density Households	1.82	Urban	Mixed	Average	Own Outright/Mortgaged
5D	34	Settled City Dwellers	1.83	Urban	Single Dwelling Building	Average	Own Outright/Mortgaged
5E	33	Middle Income Melting Pot	2.47	Urban	Mixed	Small	Own Outright/Rented
5F	35	Retiring to the suburbs	4.81	Mixed	Single Dwelling Building	Average	Own Outright/Mortgaged
6		Middle Income Households	15.13				
6A	32	Young Family Start-ups	3.92	Mixed	Single Dwelling Building	Average	Own Outright/Mortgaged
6B	32	Diverse Neighbourhoods	1.96	Urban	Mixed	Small	Own Outright/Mortgaged
6C	33	Media España	4.74	Mixed	Single Dwelling Building	Average	Own Outright/Mortgaged
6D	35	Ageing Rural Communities	4.51	Rural	Single Dwelling Building	Large	Own Outright/Inherited
7		Provincial Communities	10.44				
7A	42	Rural Working Families	3.58	Rural	Single Dwelling Building	Average	Own Outright/Mortgaged
7B	43	Small Town Skilled Workers	4.30	Urban	Mixed	Average	Own Outright/Mortgaged
7C	45	Educated Elders	2.56	Urban	Mixed	Average	Own Outright/Mortgaged
8		Modest Means	9.69				
8A	41	Multicultural Singles and Couples	0.67	Rural	Single Dwelling Building	Small	Own Outright/Rented
8B	42	Established Village Communities	4.72	Mixed	Single Dwelling Building	Average	Own Outright/Mortgaged
8C	43	Blue Collar Urban Families	2.15	Urban	Single Dwelling Building	Average	Own Outright/Mortgaged
8D	45	Rural Retirees	2.15	Rural	Single Dwelling Building	Large	Own Outright/Inherited
9		Stretched Families	10.05				
9A	52	Cramped Young Families	0.97	Mixed	Single Dwelling Building	Small	Own Outright/Rented
9B	53	Tourist Town Workers	3.45	Mixed	Single Dwelling Building	Average	Own Outright/Mortgaged
9C	53	Lower Income Environs	2.03	Rural	Single Dwelling Building	Average	Own Outright/Inherited
9D	44	Rural Fringe	2.51	Rural	Single Dwelling Building	Average	Own Outright/Inherited
9E	54	Employment Endeavours	1.09	Urban	Mixed	Small	Own Outright/Mortgaged
10		Struggling Society	5.38				
10A	53	Stretched Service Sector Families	2.40	Urban	Single Dwelling Building	Average	Own Outright/Mortgaged
10B	54	Struggling Urban Households	1.23	Urban	Single Dwelling Building	Average	Own Outright/Mortgaged
10C	55	Low Income Rural Communities	0.85	Rural	Single Dwelling Building	Average	Own Outright/Inherited
10D	55	Agricultural Adversity	0.76	Rural	Single Dwelling Building	Average	Own Outright/Inherited
10E	55	Remote retired couples	0.13	Rural	Single Dwelling Building	Average	Own Outright/Inherited
XX		Unclassified / No data	0.00				

CAMEO Code	CAMEO Int'l Code	CAMEO Spain Category	Household %	Education and Employment												
				Educational Attainment			Unemployment Index	Occupation (Ticked = Index >=120)							Household Income Index (100 = Average Income)
				Primer Grado	Segundo Grado	Tercer Grado		Management	Technical / Professional	Admin / Office Work	Hospitality / Sales	Agriculture	Construction / Manufacturing / Assembly	Elementery / Unskilled	
1		Wealthy Society	9.15												
1A	12	High Flying Families	1.95				83		✓	✓					123
1B	13	Big City Slickers	2.71				81			✓					130
1C	13	Suburban High Life	2.40				75	✓	✓						131
1D	14	Wealthy Established Professionals	2.10				73	✓	✓						133
2		Urban Affluence	12.03												
2A	11	Affluent City Singles	2.06				81	✓	✓						126
2B	13	Educated Urbanites	3.59				70			✓					128
2C	14	Professional Suburbia	2.80				80	✓	✓						124
2D	15	Mature Money	3.57				89					✓	✓		121
3		Well-Off Communities	9.19												
3A	22	Flourishing Family Suburbs	0.69				91		✓						115
3B	23	Cosmopolitan Neighbourhoods	2.00				91	✓	✓						117
3C	23	White Collar Families	3.02				79			✓					118
3D	24	Rural Retreats	3.47				78	✓		✓			✓		117
4		Comfortable Families	4.13												
4A	22	Pre-school Professional Broods	1.36				93		✓						113
4B	23	School Run Households	1.19				90		✓	✓					115
4C	24	Mature Commuter Families	1.58				84		✓						111
5		Dynamic Neighbourhoods	14.82												
5A	32	Comfortable Commuter Families	1.71				89		✓						105
5B	33	Big Family Barrios	2.18				93		✓						109
5C	33	High Density Households	1.82				95	✓							108
5D	34	Settled City Dwellers	1.83				96		✓						108
5E	33	Middle Income Melting Pot	2.47				88			✓					105
5F	35	Retiring to the suburbs	4.81				93					✓			105
6		Middle Income Households	15.13												
6A	32	Young Family Start-ups	3.92				98					✓			98
6B	32	Diverse Neighbourhoods	1.96				94			✓					101
6C	33	Media España	4.74				92					✓	✓		109
6D	35	Ageing Rural Communities	4.51				92					✓	✓		101
7		Provincial Communities	10.44												
7A	42	Rural Working Families	3.58				96					✓	✓		99
7B	43	Small Town Skilled Workers	4.30				97					✓	✓		97
7C	45	Educated Elders	2.56				97	✓				✓			99
8		Modest Means	9.69												
8A	41	Multicultural Singles and Couples	0.67				104				✓			✓	93
8B	42	Established Village Communities	4.72				103					✓		✓	89
8C	43	Blue Collar Urban Families	2.15				103					✓		✓	91
8D	45	Rural Retirees	2.15				90	✓				✓			92
9		Stretched Families	10.05												
9A	52	Cramped Young Families	0.97				120				✓			✓	80
9B	53	Tourist Town Workers	3.43				115				✓				83
9C	53	Lower Income Environs	2.03				110				✓	✓		✓	84
9D	44	Rural Fringe	2.51				103					✓		✓	89
9E	54	Employment Endeavours	1.09				151	✓	✓						57
10		Struggling Society	5.38												
10A	53	Stretched Service Sector Families	2.40				121				✓				72
10B	54	Struggling Urban Households	1.23				153	✓				✓			50
10C	55	Low Income Rural Communities	0.83				127	✓				✓			77
10D	55	Agricultural Adversity	0.76				154	✓	✓			✓			50
10E	55	Remote retired couples	0.13				192	✓				✓	✓		29

Appendix 4 CS4 notes and datasets

Notes on Great Britain characteristics of the infrastructure of the rail network

Prior to 2004-05 route length data and electrification data was collected using various systems and collected on a semi-annual basis. These systems, whilst often the most accurate measures available at the time would not have provided as accurate a measure as the GEOGIS system and there is therefore a break in the time series between 2003-04 and 2004-05.

There is a break in the time series between 2006-07 and 2007-08 due to a new methodology where the route classification reference data was revamped. There is also a break in series between 1993-94 and 1994-95 for passenger stations data only. More details on methodology can be found in the quality report relating to this dataset: http://orr.gov.uk/statistics/published-stats/statistical-releases

The quality report pulls together the key qualitative information on relevance, accuracy and reliability, timeliness and punctuality, accessibility and clarity and coherence and comparability. It also includes information on some additional quality principles on user needs and perceptions, confidentiality, transparency and security of data.

This dataset is used in the rail infrastructure, assets, and environment statistical release. To view or download the statistical release: http://orr.gov.uk/statistics/published-stats/statistical-releases

Revisions:

The route open for freight traffic only has been revised for 2014-15. The data has changed from 1,256KM to 1,254KM. This is due to a calculation error from Network Rail in 2014-15. The route open for passenger and freight traffic has been updated to reflect this change (from 1,504KM in 2014-15 to 1,506KM in 2015-16).

Data can be subject to revisions indicated by (R). For the latest information on data revisions, please see the revisions log: http://orr.gov.uk/statistics/code-of-practice/revisions-log

Other datasets:

For further information on network infrastructure in Great Britain Network Rail publishes an Annual Return. To view or download the latest data: http://www.networkrail.co.uk/Publications/Annual-return/

Notes on table: Number of franchised passenger kilometres travelled (billions) Great Britain

Data does not include Heathrow Express, Eurostar or light rail (inc. underground) services. More details on methodology can be found in the quality report relating to this dataset: http://orr.gov.uk/statistics/published-stats/statistical-releases

This dataset is used in the passenger rail usage statistical release. To view or download the statistical release: http://orr.gov.uk/statistics/published-stats/statistical-releases

Revisions:

For the latest information on data revisions, please see the revisions log http://orr.gov.uk/statistics/code-of-practice/revisions-log

Other datasets:

DfT publish annual light rail and tram usage statistics https://www.gov.uk/government/collections/light-rail-and-tram-statistics#history

Transport Scotland publish data on rail usage in their annual Scottish Transport Statistics publication http://www.transport.gov.scot/statistics/scottish-transport-statistics-all-editions

Data comparing the UK with other European countries is available from Eurostat http://ec.europa.eu/eurostat/web/transport/data/database

Notes on table: Number of actual freight train kilometres on Network Rail infrastructure (million kms) in Great Britain

More details on methodology can be found in the quality report relating to this dataset: http://www.orr.gov.uk/statistics/published-stats/statistical-releases

This dataset is used in the freight rail usage statistical release. To view or download the statistical release: http://www.orr.gov.uk/statistics/published-stats/statistical-releases

Revisions:

For the latest information on data revisions, please see the revisions log: http://www.orr.gov.uk/statistics/code-of-practice/revisions-log

Other datasets:

Eurostat publishes data on freight transport statistics including an annual breakdown of rail freight by commodity. Eurostat uses the standard goods classification, NST (2007), which differ from those used in the table above. To access the latest Eurostat freight statistics: http://ec.europa.eu/eurostat/web/transport/data/database and to find more information on NST (2007): http://www.unece.org/fileadmin/DAM/trans/doc/2008/wp6/ECE-TRANS-WP6-2008-INF02e.pdf