PROPOSED COOPERATION FRAMEWORK & BOTTLENECKS

SOCRATES 2.0
FAST SAFE GREEN

SOCRATES[2.0] is co-funded by the European Commission

Activity 2 – deliverable
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Contact Person
Dr. Irina Koller-Matschke
Activity 2 leader
irina.koller-matschke@bmw.de

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1. INTRODUCTION

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1.1. Definition and scope

The SOCRATES$^{2.0}$ project paves the way for the next generation of traffic management. Public and private parties cooperate to provide optimal routes and advice (faster, safer, cleaner) for the individual road users, also securing the collective interests via mobile/in-car and roadside services and (in the future) self-driving vehicles.

Road networks, vehicles, road users, telecom networks, roadside systems, mobile and in-car systems, traffic centres and back offices together shape the traffic ecosystem. Improvements are possible both on the short term and the long term, with increasing numbers of connected and automated ITS systems enabling road users and self-driving vehicles to drive as efficiently and safely as possible, with as little damage to the environment as possible.

1.1.1. Traffic Management 2.0

SOCRATES$^{2.0}$ is based on the strategy as developed by the TM2.0 initiative[1]. This platform originated in 2011 and has currently nearly 40 members from all ITS sectors (government, industry, research) focusing on new solutions for advanced active traffic management. It aims to agree on a set of common interfaces, principles and business models to facilitate the exchange of data between vehicles and Traffic Management Centres (TMC). This is crucial for improving the entire value chain for consistent Traffic Management and Mobility services.

Traffic Management 2.0 is a new stage in the development of traffic management. In the past traffic management (TM) was mostly directed one way. A road authority informs road users on its traffic management measures or plans (TMP's) via Variable Message Sign (VMS) or other dynamic signalling. A road authority can also activate TMP's and dose traffic in the network via several (local) traffic control measures. Another stakeholder group in TM is that of traffic information service providers. They inform road users via navigation (embedded in-car or mobile) about the quickest or shortest route to be followed. However, currently:

- Traffic management plans (TMP) are not part of the dynamic traffic information that is delivered via in-car or mobile devices today;
- Individual vehicle behaviour (as available from the route guidance system) is not made available to the traffic management system;
- Today's traffic control strategies do not address individual road users;
- Today's private parties play an important role in collecting and enriching the underlying data;
- Access to in-car and hand-held services (e.g. communication with road users) is the domain of private parties.

[1] http://tm20.org/

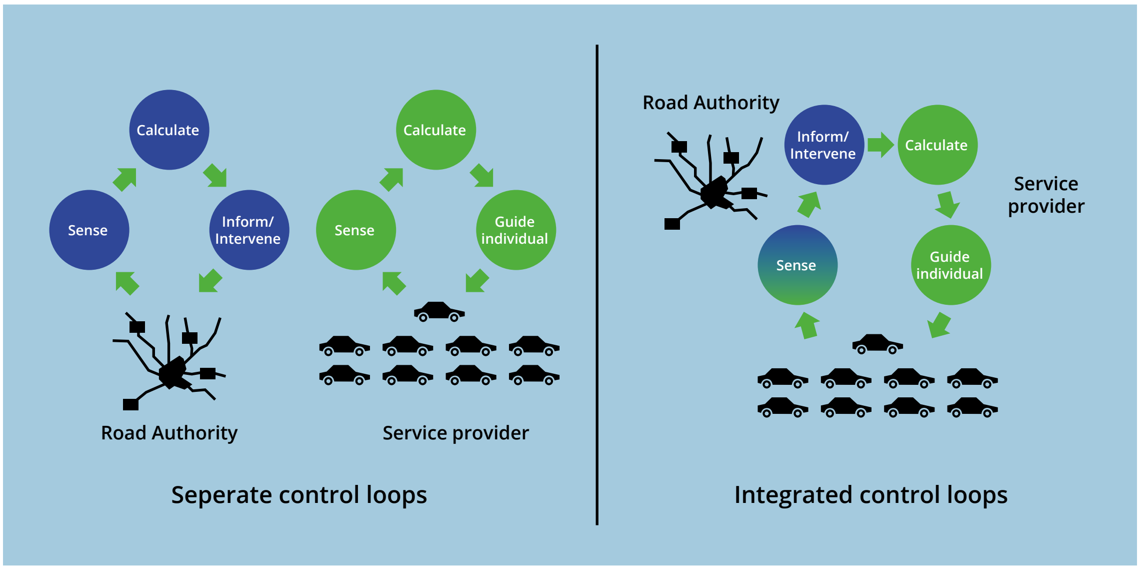

Figure 1: TM2.0 concept

The TM2.0 concept aims to merge the previously divided worlds of centralised traffic management and in-vehicle road user information. For the TM2.0 concept to become operational, a framework of closer cooperation between public and private stakeholders with respect to each other's priorities needs to be defined. The TM2.0 concept is based on achieving a 'win-win' for all stakeholders involved, while implementing Interactive Traffic Management.

The TM2.0 concept is based on the:

- exchange of all available relevant data between stakeholders in the control loops;
- provision of individual communication channels between TMC's and road users/service providers;
- development of a new interface for data exchange between TMC's and service providers, necessary for individual and collective traffic information and signage;
- development of a cooperation framework between public and private stakeholders ;
- development of (new) business models with benefit to all stakeholders.

There is an added value expected for the involved stakeholders:

- Traffic managers can reduce congestion, reduce emissions, improve traffic management with additional data sources and possibility to reach road users directly, and possibly replace existing data collection and collective information (VMS) technologies;
- Road users can avoid congestion, receive more relevant information, have better road safety and get the best route advice;
- Service providers can provide the best route advice well in advance instead of congestion information, and regional information becomes part of an integrated service.

Possible new constellations for such cooperation also raise some items for discussion, for instance: what justification does a road authority have to override an individual's freedom of choice and to regulate service provision in an open market? And why should road authorities make investments which improve the quality of services provided by service providers and therefore increase the latter's revenue? How can service providers provide added value in cooperative ecosystems, while still enabling competing business models? SOCRATES$^{2.0}$ aims to deploy the generic TM2.0 concept by developing a cooperation framework and test the feasibility and advantages of interactive traffic management services in four regions in Europe. SOCRATES$^{2.0}$ and the TM2.0 platform will set up a close collaboration through continuous exchange of findings and results via membership of the TM2.0 Steering Group.

1.1.2. SOCRATES$^{2.0}$ general structure

SOCRATES$^{2.0}$ will build on the strategy of TM2.0, elaborate an approach and test actual services in four regions in Europe. The pilots are located in the regions of Amsterdam, Antwerp, Copenhagen and Munich and include motorways, regional roads, urban-interurban interfaces and urban roads. It is expected to lead to more business opportunities for the private partners, a more cost-effective traffic management for the public authorities and better service for the road users.

The elaborated concept of Interactive Traffic Management needs to be tested in reality before it can be widely deployed. Open questions on such deployment, for instance regarding optimal way of cooperation, business models, legal framework and scalability of the concept, will be explored during the various phases of SOCRATES$^{2.0}$.
The SOCRATES$^{2.0}$ project consists of 9 activities. As shown in the diagram in figure 2 , the project follows a V-model approach. In brief: a common framework is defined (Activity 2) and then specified for the four pilots (Activity 3). This is validated in the pilots (Activity 4-7), evaluated (Activity 8) and the results used to update the framework (Activity 9).

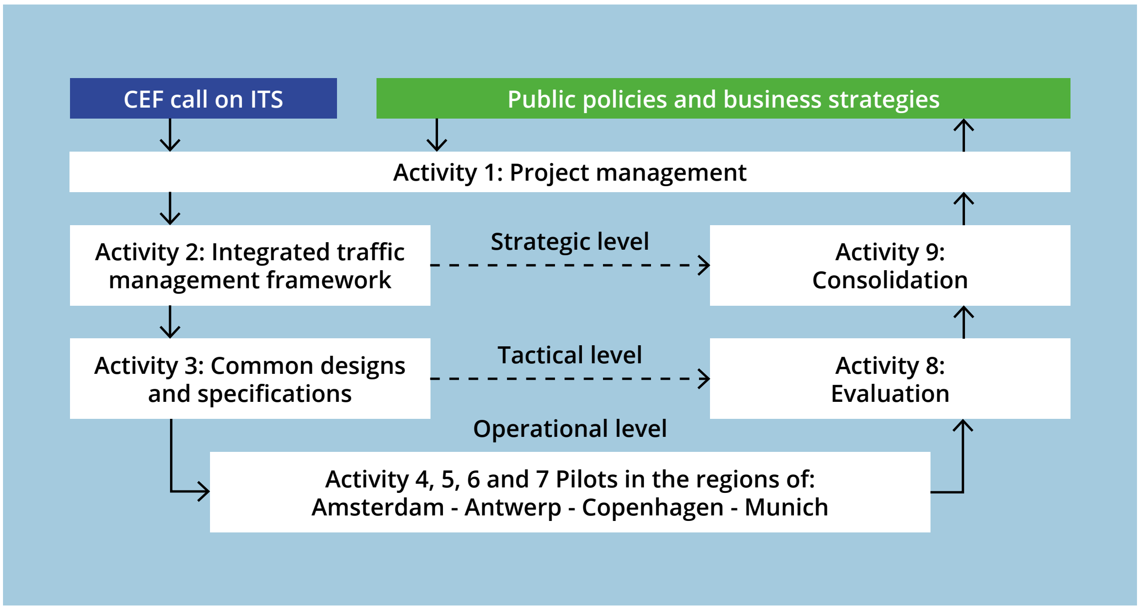

Figure 2: V-model approach

This report describes the results of Activity 2. The goal of Activity 2 is to develop an optimal framework for cooperation between the public and private partners, as a basis for a European deployment of Interactive Traffic Management. Activity 2 scopes the strategic level of such cooperation, while the subsequent activities also cover the tactical and operational levels.

Activity 2 objectives:

- to achieve a shared vision between the partners about Interactive Traffic Management;
- to commonly define a framework for Interactive Traffic Management and to identify and analyse potential bottlenecks.

1.2. Key problem / challenge

The transport of people and goods via the road is by far the largest part of the mobility system in Europe. Road traffic enables human and goods transport; for instance commuting between home and work, travel for leisure, distributing materials and products between factories and retailers.
Many jobs are directly involved in developing, building, operating and maintaining the road transport system. But many more jobs depend on a good accessibility by road to these destinations and thus depend on efficient and safe road traffic.

The European road transport system and road traffic contribute significantly to the quality of life of the European citizens and to the European economy and jobs. But this comes with a huge cost in Europe each year: In 2015, more than 26,000 people died and more than 1,000,000 people were injured on the roads of the European Union[2]; direct costs due to delays amount to more than 20 billion euro's; cities fully blocked; reduced accessibility to industrial areas etcetera. Forecasts show a significant further increase of these problems in the years to come.

So the challenge for SOCRATES$^{2.0}$ is to work on traffic management that improves traffic flow and reduces traffic problems with:

- a safer, cleaner and more efficient traffic flow and optimum use of the road capacity;
- better services to the road users and better quality of life for citizens;
- a more cost-effective traffic management by optimising the use of existing road capacity;
- economic growth and more jobs by reducing traffic problems and by creating new business opportunities.

[2] https://ec.europa.eu/transport/road_safety/specialist/statistics_en

The needs and interests of stakeholders are different and it may be a challenge to find a model that is attractive for all. The SOCRATES$^{2.0}$ partners want to establish something new and not just improving an existing concept. To do so, they recognised that the idea of influencing traffic has to be transformed into supporting people travelling from A to B. As a result, SOCRATES$^{2.0}$ focuses not just on technology or the traffic management process but also on the customer itself as a stakeholder in the loop. People are connected with others continuously, have huge amounts of data available to make any decision at any time they want, share their experiences with others (via social media platforms) and thus are expecting high degrees of freedom in decision making, including those related to travelling from A to B. SOCRATES$^{2.0}$ wants to utilise these opportunities to face the challenges identified.
Interactive Traffic Management, based on the TM2.0 vision, has the potential to solve the problems by improved cooperation, making full use of each other's data sources and technology with valid business models.

1.3. Approach Activity 2

The SOCRATES$^{2.0}$ project consists of 9 activities. A common framework is defined in Activity 2 and then specified for the four pilots in Activity 3. This is validated in the pilots itself (Activity 4-7).

The work in Activity 2 is based on the knowledge and experiences of the SOCRATES$^{2.0}$ partners. All SOCRATES$^{2.0}$ partners provided their input to all tasks in this Activity. Since many partners with different backgrounds and also different liaisons with other projects, such as TM2.0 and C-Roads, have been involved, a wide spread of views and opinions is covered.

To find a consensus between the SOCRATES$^{2.0}$ partners several participation formats were used:

Detailed work within 4 Focus Groups, meetings every 2-3 weeks

- A Focus Group was a temporary 'pressure cooker' workgroup consisting of partner representatives with particular interest or expertise. A specific topic was discussed and elaborated in detail;
- The links to the tactical and operational levels, addressed in the following activities were specified in the Focus Groups;
- The following Focus Groups (FG) were established:
  - FG1 – Vision
  - FG2 – Intermediary and Data fusion
  - FG3 – Strategy and Coordination
  - FG4 – Use cases and Data exchange

  These groups worked mostly in parallel, but the logical order is shown in figure 3.

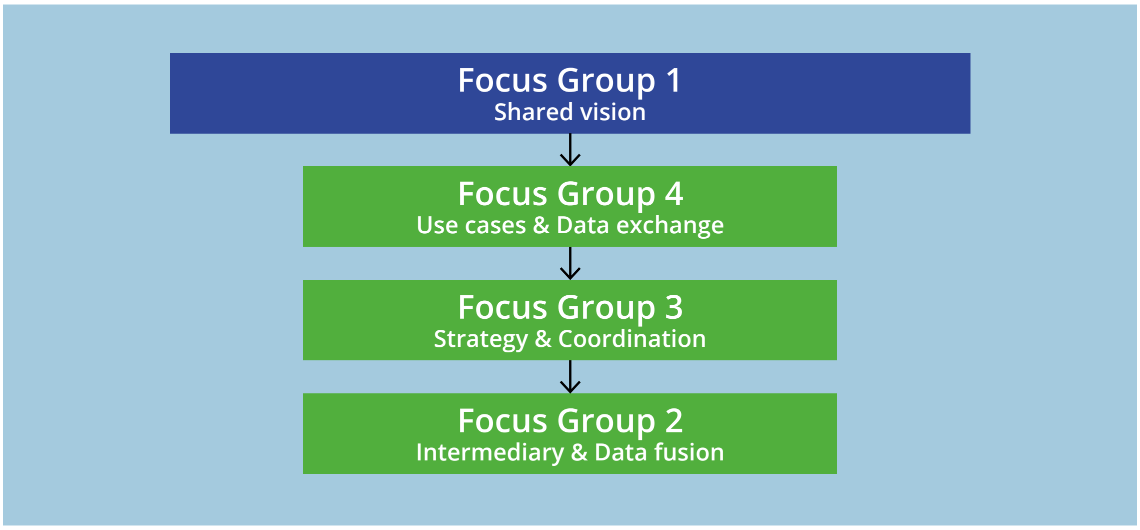

Figure 3: Focus groups

This is also the order in which the results are presented in this report. It starts with an elaboration of the vision which is the basis for further work. Since the road user is a central element in the vision, specifying use cases is next. These include a list of steps defining the interactions between actors and systems to achieve the goals. Then, it is important to assess how the stakeholders can cooperate to be able to take these steps. And finally, the concept of the intermediary is explored, based on the use cases and cooperation models. An intermediary could have a role in data exchange coordination, aggregation, fusion, quality control and common picture creation.

2-day workshops every 2 months with participation of all partners

- Each partner provided its understanding on expectation and vision on Interactive Traffic Management (urban and national road authorities, intermediaries, service providers and the car industry);
- On top of that, the project used a design thinking approach, to come up with joint ideas of solutions to development and test within the project;
- Agreements on clustering the topics, general architecture and relations to the other activities were defined;
- The details elaborated in 4 Focus Groups were presented and discussed with all partners to ensure common understanding and level of knowledge.

Desk research to include as much relevant aspects as possible

- Input through liaisons with projects and initiatives like EU-EIP, DATEX II, CEDR; ERTICO; TEAM, Lena4ITS etcetera. Specifically, the SOCRATES$^{2.0}$ project is building on the foundations that are established by the C-ITS deployment platform[3], the C-Roads platform[4] and the TM2.0 platform.
  - The C-ITS platform delivered their phase 2 final report in September 2017. One of the annexes to this report is the final report of the working group on Enhanced

[3] https://ec.europa.eu/transport/themes/its/c-its_en
[4] https://www.c-roads.eu/platform.html

Traffic Management. Both documents are very relevant to the work of SOCRATES$^{2.0}$ and information is included in this deliverable. SOCRATES$^{2.0}$ is very much in line with long term vision of the platform: 'A Connected traffic system in which all elements act collaboratively, providing the best achievable balance between the individual's needs and the collective's best interest, as for safety, flow efficiency and emission reduction.'
Specifically, the project takes into account the following requirements mentioned by the platform:
  - 'to ensure continuity and interoperability, the Cooperative Traffic Management Services will not be limited to any borders.'
  - 'to ensure flexibility, the tools to develop the Cooperative Traffic Management Services shall be modular, scalable, replicable and compliant with standards.'
  - 'the tools to develop the Cooperative Traffic Management Services shall promote joint cooperation.'
- A further platform requirement is: 'the tools to develop the Cooperative Traffic Management Services will take stock of [...] the deployment of the C-ITS Pilots of C-Roads.' The C-Roads platform published a template for use case descriptions. This template is used for the SOCRATES$^{2.0}$ work. Furthermore, the contents of the C-Roads use case specifications was used as input for the project, as were contents from the projects "C-the Difference", "C-ITS Corridor", "InterCor" and "Shockwave traffic jams A58".
- The TM2.0 platform delivered reports on various topics. The most important one for developing the SOCRATES$^{2.0}$ vision is the report on 'Traffic Management 2.0, the Win – Win'[5]. The paper discusses the value proposition of TM2.0 and relevant information was used for the collaboration models. Next the report on 'Contractual agreements and schemes'[6] was used for elaborating ideas on business models (rewarding and incentives). Finally the report on 'Barriers and Enablers'[7] was the basis for Chapter 6 of this report.
- The project set up a stakeholder analysis with relevant organisations, initiatives and projects. This list is used for gathering further content for the work of the project.

The SOCRATES$^{2.0}$ Cooperation Framework consists of a set of options for cooperation and implementation of services. At this stage no definite choices are made for deployment in de pilots. Choices between these options are made in Activity 3 and will be described in the relevant deliverables.

[5] Rehrl, K., Salanova, J., Laborda, J., Tzanidaki, J., van Waes, F., 2016. Traffic Management 2.0 – The Win-Win. 11th ITS European Congress, June 2016, Paper no. EU-SP0162.
[6] Vlemmings, T., Vroom. O., Tzanidaki, J., Vreeswijk, J., Hofman, P., Spoelstra, J., Rodrigues, N., 2017. Contractual Agreements in Interactive 7 Traffic Management – looking for the optimal cooperation of stakeholders within the TM 2.0 concept. 12th ITS European Congress, June 2017, Paper no. ITS-TP0785.
[7] Traffic Management 2.0 (TM2.0), 2014. Report of the Task Force 2 on Enablers and barriers, January 2015.

1.4. Structure of this report

This Chapter 1 introduces the project, the concepts behind it and explains the process. Chapter 2 describes relevant developments for the projects in the field of mobility and society as a whole. Chapter 3 is about stakeholder needs; what is driving the organisations to be part of this strategic alliance between private and public organisations?
Chapter 4 presents the results of Focus Group 1: Vision. What is the overarching philosophy of SOCRATES$^{2.0}$? It gives guidance to the themes elaborated by the other Focus Groups and provides the overall learning objectives for the project.
The vision is translated into use cases in Chapter 5 (work of Focus Group 4).
Chapter 6 & 7 contains the work of Focus Groups 3 and 2 respectively. What are the strategy & coordination options for the cooperation between stakeholders, and what are the options for intermediary & data fusion?
Chapter 8 is about bottlenecks for Interactive Traffic Management. The report concludes with Chapter 9 – conclusion and an appendix with the detailed use case descriptions.

1.5. Management summary

The SOCRATES$^{2.0}$ project paves the way for the next generation of traffic management. Public and private parties cooperate to provide optimal routes (faster, safer, cleaner) for the individual road users, also securing the collective interests via mobile/in-car and road-side services and (in the future) self-driving vehicles.

SOCRATES$^{2.0}$ partners believe that deployment of the SOCRATES$^{2.0}$ vision will lead to a WIN-WIN-WIN situation for all actors in the Traffic Management eco-system:

- WIN for the road user:
  - they receive the best route options based on interactive traffic management principles
  - they receive aligned traffic information provided on-trip to road users, eliminating confusion on todays conflicting road-side and in-car information
  - they will be able to provide feedback on current traffic situation to the Traffic Management operators
  - will feel as real customers of traffic infrastructure providers
- WIN for public Traffic Management Centres:
  - will be able to substantially optimise Traffic Management operations
  - will become part of a holistic Traffic Management ecosystem, considering the expertise and assets of different parties and market players
- WIN for private Service Providers:
  - will expand their services to seamless door-to-door traveller assistance
  - will serve innovative use cases
  - will take on active responsibility to improve traffic efficiency and safety
  - will keep the competitive freedom how to set-up services towards the travellers

To reach the mentioned WIN-WIN-WIN situation, SOCRATES$^{2.0}$ aims to agree on a set of common interfaces, principles and business models to facilitate the exchange of data between vehicles and TMC's. This is crucial for improving the entire value chain for consistent Traffic Management and Mobility services.

SOCRATES$^{2.0}$ will test actual services in four regions in Europe. The elaborated concept of Interactive Traffic Management needs to be tested in reality before it can be widely deployed. Open questions will be discussed, for instance regarding optimal ways of cooperation, business models and legal framework.

This report describes the results of SOCRATES$^{2.0}$ Activity 2. The goal of Activity 2 is to develop an optimal framework for cooperation between the public and private partners, as a basis for a European deployment of Interactive Traffic Management. Activity 2 scopes the strategic level of such cooperation, while the subsequent activities also cover the tactical and operational levels.

The partners wanted to establish something new and not just improve an existing concept of cooperation. To do so, they recognised that a paradigm shift should be made from 'managing and influencing traffic' to 'supporting people on their travel from A to B'. Goal is to create synergies between actions of the individual road users with the collective mobility objectives, to bridge the innovative developments in the vehicle and in the traffic management, while giving value to the legacy and creating new business opportunities. This goal is summarized in the following statements:

- Customer: "CEO of my own journey!"
- Community: "Choosing our Mobility habits"
- Cooperation: "Joint effort, shared benefit"
- Technology: "Facilitating the journey, unperceived"

Specifying use cases is the next step and this was done around three themes:

1. Smart routing
2. Actual speed and lane advices
3. Local information and hazardous warnings

These include a list of steps defining the interactions between actors and systems to achieve the goals.

Then, it is important to assess how the stakeholders can cooperate to be able to take these steps. For that a theoretical framework describing options for cooperation was created, and a first inventory of preferred options was made.

Finally, the concept of the intermediary was explored, based on the use cases and cooperation models. An intermediary could have a role in data exchange coordination, aggregation, fusion, quality control and common picture. The group came up with a number of typical options for the intermediary role, to be selected and elaborated in the next activities of the project.

This Activity 2 report presents a list of options for cooperation and implementation of services, no definite choices are made. However, a first selection of options to consider in the follow up of the project is done. Variations to these options are possible. Some options are not included in this report because they are not in line with the projects goals, not innovative or not realistic. Choices between these options will need to be made in the next phases of the project. Different options may be tested in the respective pilots areas, or they could be tested in parallel within a test site.

Now the common framework is defined in Activity 2, the approach will subsequently be specified for the four pilots in Activity 3. The plans are then validated in the actual pilots (Activity 4-7), and evaluated in Activity 8. The results will be used to update the framework (Activity 9). Information on the results of these activities will be published in future deliverables.

2. DEVELOPMENTS

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Many developments in mobility have an impact on the work of SOCRATES$^{2.0}$. This chapter describes the developments in automotive industry, traffic management & information, and other areas that are considered to be relevant for SOCRATES$^{2.0}$. The project partners are able, to some extent, to influence and steer developments, while other trends, though relevant, are outside the scope of influence. However, the reason why people travel and the role of city planning in this is outside the SOCRATES$^{2.0}$ scope. This overview can be seen as the context for the SOCRATES$^{2.0}$ vision developed in Activity 2 and that is described in Chapter 4.

2.1. Developments in automotive industry

2.1.1. Connected and automated cars

A major development is that cars are becoming increasingly automated. One could say that this already started with the introduction of the cruise control service, and gradually many more services are being deployed on the way to (possibly) full automation. There are many new entrants to this market (non-traditional car manufacturers).
In this field, six levels of automation are distinguished, with level 0 being 'no automation' and level 5 being 'full automation'. Some companies already offer level 2 automation. An opinion often heard is that automation on highways is less complicated while city centres with many pedestrians and cyclists are very complicated areas for (fully) automated cars.

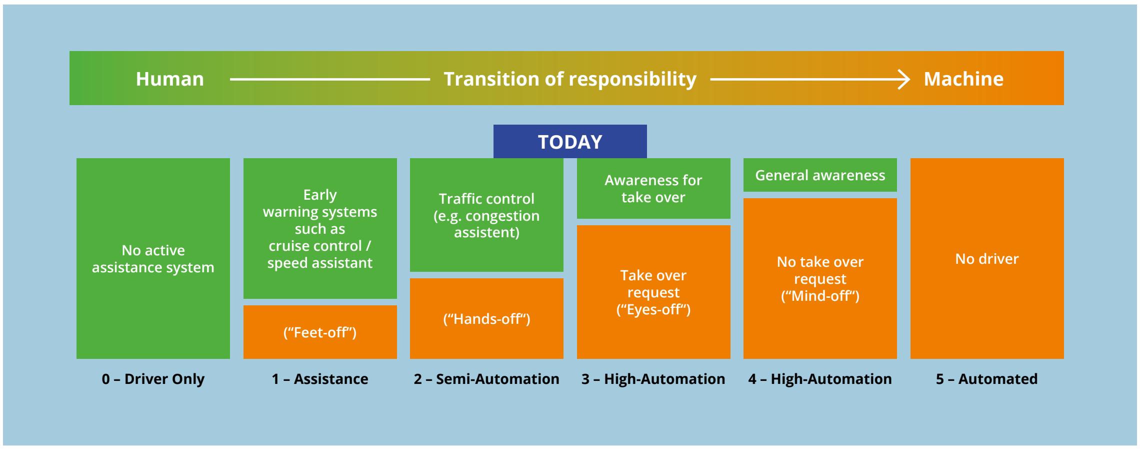

Figure 4: Automation levels

Another distinction is 'connected automation' versus 'standalone automation'. Some manufacturers are developing an autonomous car that drives based on sensors that just look to the outside world, while others are aiming to be connected to the outside world (other vehicles and roadside equipment) and use the information received as additional source.
Being connected is often described as V2V (Vehicle to Vehicle communication) and V2I (Vehicle to Infrastructure or roadside communication). Communication technologies like 'ITS G5' (also called wifi-p) and cellular (mobile phone network) enable cooperative/connected cars. Cellular communication is currently developing towards the fifth generation (5G) promising better performance (e.g. on latency).

Connected cars have the benefit that they can act as sensor: various types of data could be made available for traffic management purposes – not just vehicle positions but also data like slippery road and pot hole detection.
Furthermore, it is a question how private ownership of cars will develop. If most or all cars can be used by everyone, for individual or shared rides, the amount of cars and travel demand could decrease. And this would create a different kind of market situation for traffic management/information service providers.
Apart from private vehicles, automation is also being developed for buses and trucks (especially platooning).
There are many contradicting opinions regarding the speed of developments, ranging from 2025 to 2070 for full automation, while others think it will never become a reality in city centres. A variety of open issues exist, including liability, legislation, privacy, security, standardisation etc.
An important question is what impact automation will have on infrastructure and traffic management. Authorities have relatively long planning cycles, and they would like to know how the roads and roadside systems should be adapted and what opportunities it brings. For what kind of vehicles should traffic management be prepared? With upcoming automation of vehicles, traffic management should not just focus on the driver as end user but also the vehicle algorithms, which is another kind of challenge. How the deal with a mix of human and automated decision making?

2.1.2. Electrification of vehicles

Another major development in the automotive industry is electrification of vehicles. In the discussions around climate change, many are calling to decrease the use of fossil fuels. Air pollution is a problem, mostly in cities, and electric vehicles are far less polluting.
The growing number of charging points as well as improvements in batteries to enlarge the trip range make electric vehicles more and more attractive. The average trip range of most car drivers within one day is around 40 km, meaning that the actual cars on the market are sufficient for the biggest part of mobility habits so far. The main challenge is to take note of doubts from the users, and make them familiar and feeling comfortable with electric cars. This is a common task for politics, society and industry. Some governments have been backing the developments e.g. by tax incentives, open question is how this will work on the long term. Ongoing electrification of the vehicle fleet is often assumed, and that would have an impact on pollution strategies – also in traffic management.
So far, electric cars are mostly private vehicles although there are many initiatives around trucks as well, and electric buses are quite common already. A market share for new electrically chargeable vehicles is to be assumed in the range of 2 to 8% by 2020 to 2025, based on today's market[8].

[8] Website European Automobile Manufacturers Association http://www.acea.be/industry-topics/tag/category/electric-vehicles

2.1.3. New business models

Automation will bring many opportunities for car sharing, private ownership of cars may not be necessary anymore. The development of 'Mobility as a Service' has a link with this; consumers can use the mode of transport they like with one subscription. For each trip they can choose an (automated) car, bike or public transport e.g. depending on cost, time of day and personal preferences. Existing and new mobility stakeholders are starting to offer the MaaS concept. These organisations, some of which also own a fleet of vehicles, can have a large influence on management of the transport system.

The goal is to raise quality of life as well as quality of mobility at the same time, especially in the cities. There are two key action points: more customer focus and utilisation of efficiency potentials. There are already existing evolutions that are the base for the paradigm change: changing mobility preferences and new technical possibilities due to emission free power units, digitalisation and autonomous driving.

2.2. Developments in traffic management & information

2.2.1. Data (detection, fusion and completion)

Traditionally, only road authorities and operators gathered data. Over the last 20 years, more and more data sources have emerged, from the likes of car manufacturers, navigation system suppliers, telecom operators and specialised service providers. It is expected that the amount of data will increase massively with connected and automated vehicles.
To have the full benefits of these data sources, data would need to be combined. So exchange of data between organisations (both public and private) has started and is growing fast. This means that there is an increasing need for data management, quality checks, aggregation, big data analytics, and fuzzy logic. Some of these tasks can be done by the organisations themselves, while for others specialised organisations are better equipped to fulfil the tasks (intermediary organisations).

Ongoing debates are:

- The openness of data (what data is accessible to whom and under what conditions – financial, privacy etcetera)
- Can existing (more expensive) data collection techniques disappear and be replaced by new technologies?

One of the main forums for this discussion is the 'Data Task Force'. The Declaration of Amsterdam on "Cooperation in the field of connected and automated driving" was signed in April 2016 by the EU transport ministers, European Commission and ACEA (European Automobile Manufacturers Association). As a follow up, high level meetings are held and a few member states have started to work on data sharing with OEMs. ACEA stated[9] that they want to find a solution for secure and safe access to vehicle data to interested market participants. The idea is that this statement is a good start for improving road safety through data sharing by OEMs. The task force should focus on creating the necessary high-level agreements for doing this.

2.2.2. Control (decision support, evaluation, presentation & control)

Traditionally, only road authorities and operators sent messages to road users, based on legislation (traffic regulations, e.g. closed lanes, traffic signals) and calculation of collective optimum (traffic management, routes advice on variable message signs).
More and more, service providers are now advising users, with a focus on an individual optimum. New technologies like smart phones bring new opportunities to influence travel behaviour. Stakeholders should cooperate to have the best outcome for all. For a service like smart routing, the goal would be to reach a balance between an individual and collective optimum. For other services like 'slippery road warning' there is a shared interest anyway. Data is often available in real-time which enables better traffic management. And algorithms are becoming available that predict the traffic situation enabling proactive traffic management (e.g. preventing congestion).

2.2.3. Services to consumer

Innovative services to consumers are emerging, making full use of new technologies. Many stakeholders and projects are working on these services. These are often referred to as 'Day 1', 'Day 1.5' , 'Day 2' use cases to indicate envisaged chronological order of implementation.
The C-Roads Platform[10] is a joint initiative of European member states and road authorities for testing and implementing C-ITS services in light of cross-border harmonisation and interoperability. Many countries and projects are active within this platform. InterCor is one of these projects. The platform is co-financed by the European Commission.
At an earlier stage, the 'Amsterdam Group[11]' and 'C-ITS deployment platform'[12] (specifically the Enhanced traffic management working group) discussed lists of services. Another example of an ongoing project is 'Concorda[13]' (Connected Corridor for Driving Automation). These initiatives and projects are working in cooperation to ensure harmonised implementation and to test C-ITS implementations all over Europe. Questions for all of these projects are: what are user needs and how can we ensure sufficient compliance by the road users? Information services to users have varying requirements in terms of latency of information. For safety functions, near real time information may be required while routing advice is mostly less time critical. This means something for the requirements on the communication technology.
In SOCRATES[2.0] Activity 2, three types of use cases are developed, each with a set of sub-use cases. These are described in Chapter 5.

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[9] http://www.acea.be/press-releases/article/automotive-industry-joins-forces-on-access-to-vehicle-data
[10] https://www.c-roads.eu/platform.html
[11] http://www.amsterdamgroup.eu/
[12] https://ec.europa.eu/transport/themes/its/c-its_en
[13] https://connectedautomateddriving.eu/project/concorda/

2.2.4. New frameworks (new actors, changing roles, new business models, public-private TM, ...)

There is an obvious need in the traffic management world to collaborate to take services for road users to the next level. The end of business models is in sight due to wide availability of (free) traffic information services while new (in) car technologies make innovative services possible. So traffic management will become more of a collaboration between public and private stakeholders:

- What will this shift mean for public organisations? Will their only task be to set the framework conditions and make legislation? Or will they have a more active role?
- What will this shift mean for private organisations? What will be the business model? Are there new entrants? Will it be global players or regionally/locally organised businesses?

The SOCRATES$^{2.0}$ project will explore various options for new forms of collaboration.

In general, developments on traffic management and information are captured within the 'transitions' of the Connecting Mobility initiative in the Netherlands. This long-term road map distinguishes six routes[14]:

A. from non-personalised services to personalised services
B. from separate and partially competing to a collaborative mixture of collective individual services
C. from communication via roadside equipment to interaction between roadside and vehicles
D. from specific solutions to (nationally) agreed standards
E. from contractor to entrepreneur and public-private collaboration
F. from closed to easily exchangeable data

2.3. Other relevant developments

2.3.1. Organisational developments (public-private cooperation)

Since the concept of 'government' exists, there is an ongoing debate on what tasks the government has, what tasks is does not, and what government responsibilities can be transferred to private organisations (and under what conditions).
Important discussion items are accountability, efficiency, innovation, market failure, etcetera. Almost everyone agrees that governments should make legislation and that companies are better at some tasks than governments and the other way around.
One could say that there is a constant shift of tasks between public and private organisations, for each policy area including transport and mobility. An example of this is the 'Delft deal' in the Netherlands, where public and private partners came to an

[14] https://connectingmobility.nl/en+home/en+smart+mobility+overview/Transition+routes+and+transition+plateaus/default.aspx

agreement on collection and distribution of traffic information. For both sides there is a paradigm shift, towards the perspective of road users and consumers.
Another current general trend is the fear that big global companies will dominate markets; local players do not have any opportunities and national governments find it hard to have an influence.

2.3.2. Environmental developments (green, sustainability, ...)

Climate change is one of the biggest topics in the world at the moment. Almost every country signed the 'Paris Agreement' setting the world on course to keep global surface temperatures from rising 1,5 degrees Celsius above where they were before the Industrial Revolution.
Road transport is one of the major areas on which this has impact. Electrification, promoting clean transport modes and influencing demand are part of governments' strategies. It is not just about less greenhouse gases, but also about pollution with negative health effects.
In practice, governments are trying to balance between these goals and economic development goals. Ideally, these goals can be combined.

2.3.3. Political developments

Notable political developments are the increased attention for:

- Safety and security: protection of society against terrorism;
- Safeguarding privacy in the context of many new technologies;
- The benefits of automation versus job losses/skills needed from workers, and the distribution of wealth. Who profits from new technologies?
- Safeguarding national (economic) interests versus the benefits of international cooperation;
- Open data policy.

2.3.4. Legal developments (privacy and security)

Specific current legal developments are:

- Stricter privacy rules; from May 2018 the EC will enforce the General Data Protection Regulation (GDPR);
- Recent open data legal framework;
- Legislation on smart mobility; based on the C-ITS deployment platform documents, the EC is discussing the introduction of legislation ('delegated act') with stakeholders. This could have an impact on data provision by public and private organisations.
  The Declaration of Amsterdam and its Data Task Force are already working on this;
- Further legislative discussions are ongoing (see political developments above).

3. STAKEHOLDER NEEDS AND INTERESTS

SOCRATES 2.0
FAST SAFE GREEN

3.1. Introduction

Before determining a vision on Interactive Traffic Management, it is necessary to have a good overview of the needs of the involved stakeholders. In this chapter, the needs and interests are listed based on literature, reports from other projects and input from the consortium partners[15]. This overview can be seen as the context for the SOCRATES$^{2.0}$ vision developed in Activity 2 and that is described in Chapter 4.

3.2. Road users

In recent years several projects have been researching, testing and developing several day-one C-ITS services (C-ITS Corridor, C-Mobile, Compass4D, C-The difference, CODECS, InterCor, etcetera). Within each project several user orientated services have been developed.

Desk research has been carried out within SOCRATES$^{2.0}$ to determine what user needs have been resolved within the services of the mentioned projects. From the projects limited information is found about road user needs; for instance the Amsterdam Practical Trial showed that road users are interested in pre-trip information. Actually, SOCRATES$^{2.0}$ still is one of the first projects of this kind where the user is explicitly in scope.

A way to resolve this missing insight could be to interpret the available evaluation data. This will only give a selected view on the topic however, as the test user only gave feedback on the supplied solution and has not been asked, regardless of any solution or desired development, what he thinks is needed.

The image below illustrates this issue[16]. The image depicts in green the overlap between road user needs and technical feasibility.

Within the SOCRATES$^{2.0}$ project it would therefore be advisable to try and create this much needed insight in user needs per service or use case. Knowing what the user wants and expects will help in developing a service from which all stakeholders (Service Provider, Road Authority and Road User) will benefit and will use for a longer period.

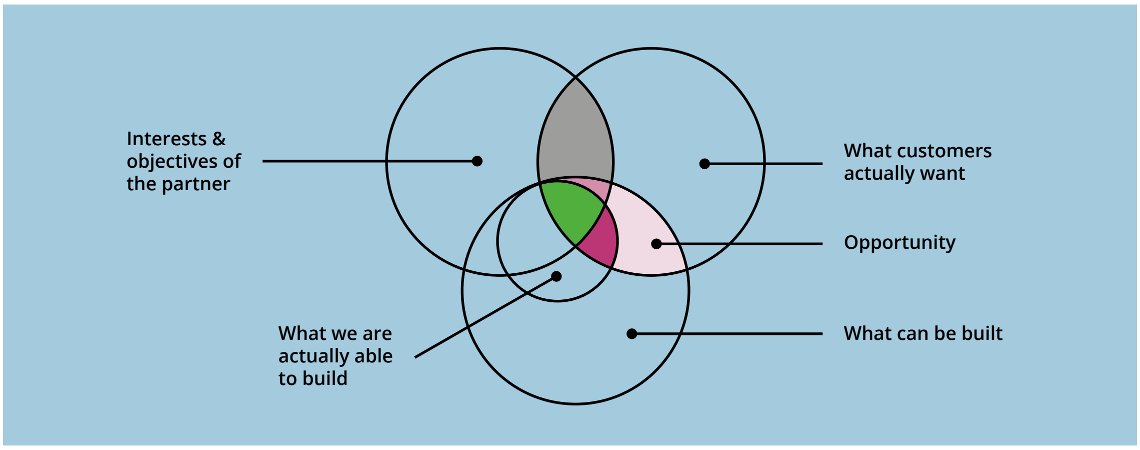


Figure 5: User needs

[15] During the kick off meeting of the project, each stakeholder presented its needs and the summary is included here.
[16] Source: http://blog.strategyzer.com/posts/2018/2/27/do-you-understand-what-customers-want-and-can-you-build-it

3.3. Public Road Authorities

The needs of road authorities can summarised as follows:

Meeting policy objectives, such as:

- High availability of roads
- Optimising use of existing roads
- Safe roads
- Low environmental impact (noise and air pollution reduction)
- Fair access to road infra
- Thriving economy
- Reach organisational goals in an efficient way
- Insight on how to meet policy targets in this transition from ‘being the traffic manager’ to the ‘collaborative arena’
- Competition among private stakeholders delivering services in traffic management chain
- Viable business models for the private stakeholders

Amongst other things this requires:

- The right tools to meet the legal responsibilities of road authorities
- Multimodal information
- Reliable, high-quality data

3.4. Public Traffic Management Centres

The needs of Public Traffic Management Centres can be summarised as follows:

- Meeting operational policy objectives and contribute to the policy objectives mentioned above (such as: road safety, noise and air pollution reduction, fair access to road infra, optimal use of road capacity, thriving economy)
- Being able to proactively manage traffic on its roads
- Being able to reactively manage traffic in case of congestion, events or accidents
- Having access to all existing channels to road users (roadside and in-car)
- Having access to sufficient data, actuators and/or other stakeholders’ channels to manage traffic. Better insight on what is happening and will be happening on the roads
- Provision of relevant, accurate, consistent information to road users, always
- Reliable, high-quality data
- High impact of advice to road users

3.5. Data Providers

The needs of data providers can be summarised as follows:

- Being able to run the business, building a business case. 'Data receivers' provide data, money or other assets in return
- Consent from owners/producers of data to process and use data

3.6. Service providers

The needs of service providers can be summarised as follows (this includes private organisations providing of services to road users and intermediary services):

- Being able to run the business, building a business case. Having enough customers (B2C, B2B or B2G)
- Permission to run a service (where applicable)
- Legislation enabling innovation
- Level playing field
- Sufficient data to roll out their service
- Sufficient intelligence to run a successful service
- Assessment of data quality (certification)
- Automation of data chain
- Standardisation of data exchange
- Shared services on data exchange
- Decision support systems
- Scalable solutions (can be used in other geographic areas)
- Focus on road user
- Continuous development/improvement, being future-proof

3.7. Automotive Industry

The needs of the automotive industry can be summarised as follows:

- Being able to run the business, building a business case. Having enough customers (B2C, B2B or B2G)
- Permission to sell their product (certification)
- Legislation enabling innovation
- Level playing field
- Focus on road user
- Scalable solutions (can be used in other geographic areas)
- Being able to make products that optimise the added value automated and self-driving cars can bring to the road users and to society
- Continuous development/improvement, being future-proof

3.8. Conclusion

It is necessary to have a good overview of the needs of involved stakeholders, as context for developing a vision. This Chapter shows that the needs and interests of stakeholders are in some extent overlapping but are different on other aspects, and it may be a challenge to find a model that is attractive for all. Interactive Traffic Management as being developed in SOCRATES$^{2.0}$ has the potential to solve the problems by improved cooperation making use of each other's data sources and technology with valid business models.

4. SHARED VISION

SOCRATES 2.0
FAST SAFE GREEN

4.1. General

The goal of SOCRATES$^{2.0}$ is to develop and test an optimal framework of cooperation between the public and private partners, as a basis for European deployment of Interactive Traffic Management. The first period of the project scopes the strategic level of such a cooperation (Activity 2), while the subsequent activities of the project cover the tactical and operational levels (Activity 3-7). Activity 2 gives the guideline for the subsequent activities by describing the key questions that should be solved and to ensure that the different stakeholders and target groups are addressed in the inventions.

In Activity 2, the partners of SOCRATES$^{2.0}$ assembled a shared vision on Interactive Traffic Management. Elaborating on the principles of TM2.0, this shared vision identifies the individual and joint motivations, interests and expectations regarding:

- participating in SOCRATES$^{2.0}$;
- the road users (the end users);
- developments in technology, in particular data, roadside systems and in-car services;
- the organisations involved (road authorities, intermediaries, service providers and car industries);
- relationships between the organisations and conditions for optimal cooperation.

The partners wanted to establish something new and not just improve an existing concept of cooperation. To do so, they recognised that a paradigm shift should be made from 'managing and influencing traffic' to 'supporting people on their travel from A to B'. Goal is to create synergies between actions of the individual road users with the collective mobility objectives, to bridge the innovative developments in the vehicle and in the traffic management, while giving value to the legacy and creating new business opportunities.

As main learning objectives the following aspects have been defined:

- To explore what use cases of Interactive Traffic Management can be successful in a collaborative public-private context:
  - demonstrate the impact of private services on public objectives
  - how can public assets and operations add value to private services?
- To explore what business models for Interactive Traffic Management are feasible in a collaborative public-private context:
  - how can the road users be served in the best way?
  - how can private organisations be rewarded for positive impact on collective goals? (impact = functionality x number of users)
  - search for 'impact driven' business model for private parties with in-car traffic management

- To explore how to organise the public-private collaboration:
  - making 1 + 1 = 3 > road user win + public win + private win. How can the road users be served in the best way while also pursuing societal goals?
  - what are the key elements determining scalability and success of the use cases?

  scalability = technological, data quantity/quality, commercial including sustainable business models and organisational
- To explore how roles and responsibilities will change within the public-private collaboration:
  - from ‘managing traffic and roads’ towards ‘supporting individual road users’
  - dealing with the transition from ‘compliance/collective’ driven model(s) towards ‘user driven/centric’ model(s)
  - determining the optimal arrangement of roles for both public and private entities

As a result, the vision does not just focus on technology or the traffic management process but is elaborated along four elements:

- **CUSTOMER**
  Making the customer an active part of the Interactive Traffic Management: let him or her provide feedback and consider it. But also to provide specific information, guidelines and motivation regarding common traffic strategies concerning his journey. The customer should be convinced to recognise the benefit of the offered service; customers will however not actively be involved in the development itself; this will be achieved via the service providers.
- **COMMUNITY**
  People can, as a group, have a certain impact on society/city with their travelling behaviour; by supporting these communities during their journeys, the alliance has an influence on the impact of the mobility of these people.
- **TECHNOLOGY**
  Technology serves as a means to support the individual user, society/communities and the alliance; the project aims to combine technologies in a smart, user-centred way (balanced route optimisation, gamification, predictions).
- **COOPERATION**
  Make the cooperation fit to impact driven business models. A key aspect is to define collaboration KPI’s: how can be measured who contributed what to the common goals?

4.2. The four elements of SOCRATES$^{2.0}$

The partners started with a kind of a 'golden circle' approach. Each elements was elaborated separately by addressing the following points:

- For each element it was made explicit why the partners support joint objectives.
- For each element the key questions to be answered by the pilots were identified.
- And for each element the main ideas (what) and underlying leading principles (how) were determined.
- The essence of each element is captured into four 'slogans', especially summarising what is new behind this concept, compared to contemporary traffic management.

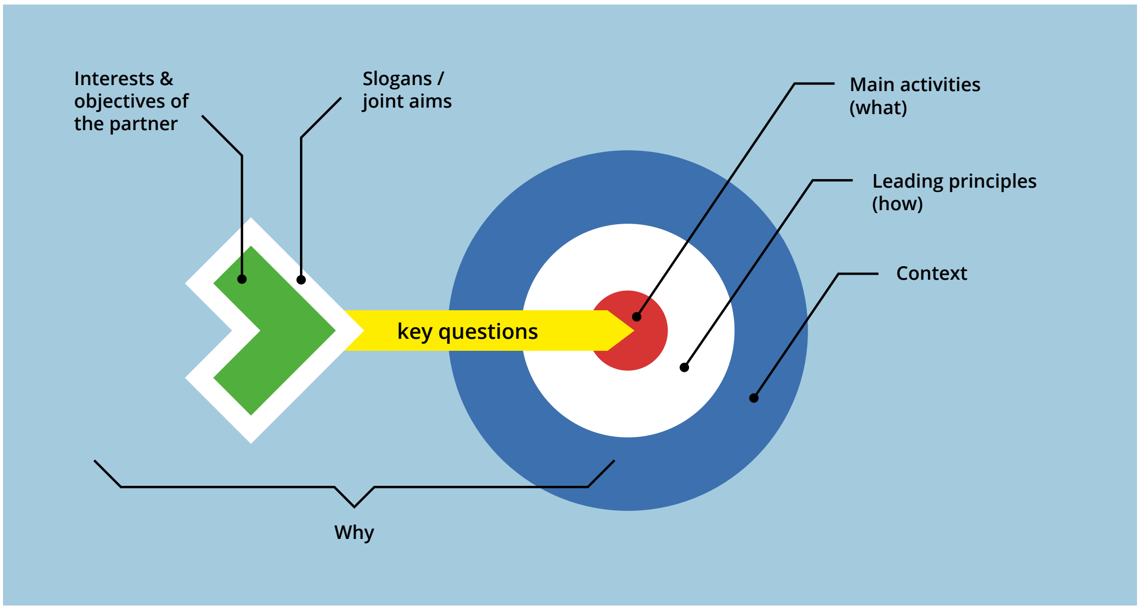


Figure 6: The framework of the shared vision of SOCRATES$^{2.0}$

4.2.1. Customer

The focus of SOCRATES$^{2.0}$ is on road-related users, but not incorporation of all modes like public transport in use caseuse cases or pilots. The addressed road user in SOCRATES$^{2.0}$ is limited to those users who can be reached by the communication channels and the specific use cases that are part of the pilots (e.g. partners' app users, specific use case situation). The common picture of the customer is a road user who makes decisions based on his personal experiences and individual habits. The function of Traffic Management is to provide him or her with information and guidelines concerning his journey, but at the end the user is the one who makes decisions within the legal rules and is offered infrastructure and services. Thus, wanting him or her to behave according to traffic management goals (e.g. load balanced, safety and environmental aspects), he or she has to be informed about the what AND the why, to be motivated and to collect AND to consider his or her feedback. Note that this might change when automated driving really takes off. When level 4 and level 5 automation are introduced on a large scale the needs of the customer can undergo dramatic changes. The relevance of information directly targeted at human beings, might diminish. Instead of that automated messages that can be incorporated in the vehicles algorithms gain importance.
The 'language' that is used by service providers to communicate with individual road users is expected to lead to improved understanding and adoption. As a result, people are more capable to decide for themselves (CEO!) while their decisions become more predictable. The consortium partners are combining a variety of communication channels: navigation systems, apps on smartphones, in-car equipment, social media platforms and roadside equipment. As a result, we are capable of reaching and supporting a much broader range of road users, and at different stages of the journey: pre-trip, on-trip and post-trip. This combination makes the influence on individual decision making more effective than today's service provision. At the same time, it provides a better insight in what choices road users are about to do. This will help to predict the impact on traffic, on the network and on society and intervene appropriately. Eventually, this results in a WIN-WIN-WIN situation.

Customer

Slogan: CEO of my own journey

Individual customer can make his own decisions; we provide him tools to support this

Key questions:

- What user groups should we focus on? And how do we maximize compliance by the road user?
- What do customers use (and what not) and why (also related to the network characteristics and ITS smart facilities)?
- To identify key indicators to assess user acceptance, satisfaction and impact on network performance
- On which situations/conditions can specific individual customers or user groups have an (higher) impact?
- How do we ensure clear, consistent and individually relevant distribution of information and advices to users?

Main ideas:

- Find trip advice that suits me most
- Ask me, challenge me, reward me
- Let me provide feedback and share my experiences
- Give me feedback/confirmation that I have made the right decisions
- Show me the impact of my trip
- Let me indicate how detailed I want to be informed

Principles/characteristics:

- Intuitive, effortless, hasslefree travelling for all modes: feels like being lucky & happy during the entire journey
- Meet and manage my road-related journey expectations
- I rely on my own car, personal devices, available transport modes, trusted/reliable information
- I make my choices at start of trip and on-trip
- Stick to road traffic at this stage

4.2.2. Community

As a community a group of users is meant that have something in common and at the same time – as a group – have impact on society with their behaviour. A user can be part of different and also changing communities e.g. depending on his travel purpose, motivation of his trip, trip destination etcetera (e.g. commuter, car owner/shared mobility user, attendee of an event). The challenge is to cluster communities in the right way (target group), to find the right composition and to treat them differently. The clustering of communities can be different for each stakeholder. Public authorities may focus on how citizens can be persuaded into behaviour that is beneficial for society while service providers are interested in the motivation of its customers, but also visitors of a specific event to be able to deliver an attractive service. But the addressed community has be part of the collaboration and data exchange to come to a balanced strategy how to treat the different communities. Depending on the characteristic of the community (new) ways to communicate and to interact with them have to be found to reach a higher involvement. Offering feedback in kind describing contribution to social common goals (for instance safety awareness like avoiding schools and "footprint" like shared trips, saved kilometres, saved time, sum of followed recommended routes) could be a way to motivate user groups. For pre-trip choices the awareness of multi-modal information might be of importance to certain communities.

Community

Slogan: Choosing our mobility habits

Seeking for a constant balance between what is good for the individual road user and what is good for society and encouraging individuals to behave responsibly: healthier, wealthier, wiser

Key questions:

- How can road operators utilise the intelligence of service providers to improve system optimisation?
- How can service providers include collective objectives in individual user-oriented optimisation and communication?
- How do we measure the impact of individual decisions on society and provide easy to understand and appealing feedback to customers?
- What changes in travel/driving behavior result from providing this feedback to customers?
- How will service providers deal with/communicate to customers that the service may be suboptimal for the individual?
- How to define the value of driving behavior change for road operators?
- How can we fairly optimise the system while addressing and preserving each community's interests?
- How can we fairly optimise the system while addressing and preserving each private business' interests?

Main ideas:

- Activate green awareness by providing a mobility footprint
- Introduce positive incentives and pricing to change behavior
- Find balance between efficiency and comfort/users and environment

Principles/characteristics:

- Not just one community, composition changes all the time
- Groups to be treated differently: explain people what's behind it
- We all want to keep people/travelers safe
- We want to experiment with new ways to communicate with citizens and to involve them

4.2.3. Technology

The principle of SOCRATES$^{2.0}$ is to use technology (= hardware, software and orgware) that is already available, but may not yet be used in the context of traffic management (e.g. social media). The SOCRATES$^{2.0}$ partners bring in various technology expertise, e.g. in data exchange platforms, communication technologies, collaboration between roadside systems and in-car/on–person communication and social media communication. New in SOCRATES$^{2.0}$ is to test new ways of collaboration which also implies the use of the existing technologies in new fields and combinations.

Technology

Slogan: Facilitating the journey, unperceived

Putting hardware, software and orgware in place to support customers optimally and reliably, as if it was always there

Key questions:

- What data chains are to be established to deliver interactive traffic management? Examples for other domains?
- Who has access to what data, for what purposes/circumstances and under what conditions?
- How will the required data flow change the internal working process of road operators?
- Interface to the customer: how to ensure that it is aligned?
- How do we take care of privacy and security in the data chains arising?
- What maintenance conditions are imposed on the road network and roadside equipment?
- How to ensure that this platform for data exchange is open to organisations that want to join?
- Consolidation: how and who to bring the data chains (not just the interfaces) to the market? How to reach scale?
- Technology develops faster than SOCRATES$^{2.0}$: how to become flexible?

Main ideas:

- Standardised interfaces, open platforms
- Adopt technology that enables individuals to meet expectations, while fitting in services managed for groups within the community
- KPIs for network performance & customer satisfaction

Principles/characteristics:

- Substantial improvement by using new data sources thanks to new technologies
- Try to be hardware agnostic: goal = optimal cooperation
- Intelligent use of what is already available: modular approach, e.g. set up data chain per use case instead of everything at once
- Public data open to all service providers

4.2.4. Cooperation

The SOCRATES$^{2.0}$ project partners are motivated to collaborate. Not because it is inevitable, but really motivated to work together and to bridge the gap between the dimensions and create something new. The goal is to make the cooperation fit to impact driven business models: organisations have an interest to contribute to common goals because that is where there are rewarded for. A key aspect therefor is to define collaboration KPI's: how can be measured who contributed what to the common goals?

However, we must be aware that different partners in SOCRATES have different goals. Serving the collective interest might be a common tool but the goals for the governments differ from the goals of the private partners involved. This poses a challenge on the collaboration: how can we make sure that the collaboration is in the interest of any party involved. Can the common good be served while in the mean time market differentiation allows different private partners to meet their business cases? This is one of the main challenges SOCRATES$^{2.0}$ faces.

Cooperation

Slogan: Joint effort, shared benefit

Everyone is rewarded for contributing to improved societal impact

Key questions:

- What is the societal and commercial value of what we develop together? Are the assumptions valid?
- Customer in the loop: how to arrange this within the alliance?
- What are the key factors determining success and scalability (technologically, commercially, organisationally)?
- How does the alliance perform on these key factors?
- How do we cooperate with other, nearby and similar projects (to prevent reinventing the wheel)?
- How do we determine and create 'impact' and how is it rewarded?

Main ideas:

- Making the alliance durably successful (collab. KPIs)
- Impact driven solutions
- Cooperation utilising each other's strengths to the full (equal partners)
- Think big, act small (scrum)
- Levels of transparency
- Exportable to future, other players and other areas

Principles/characteristics:

- Desire to collaborate
- Reciprocity with respect to data and information exchange
- Making cooperation fit to impact driven business models
- Customers and community in the loop: feedback from users on various topics, not just about the services

4.3. Conclusion

The shared vision provides the main objectives, key research questions and leading principles on a strategic level. The vision is ambitious and gives guidance to define use cases and the scope of tests to be performed at the various pilot sites. The paradigm shift is needed to achieve real and successful interaction between customers (road users), private and public organisations in mobility. As such it really paves the way to future Interactive Traffic Management.

The vision describes the desired future state, but the intermediate steps to get there are yet to be defined. To bring the vision to the pilots in the ongoing deployment work, it is productive to have the slogans as the agreed base:

- Active involvement of the customer (road user) and the communities (pre-trip, on-trip and post-trip)!
- Move from managing traffic to supporting individuals!

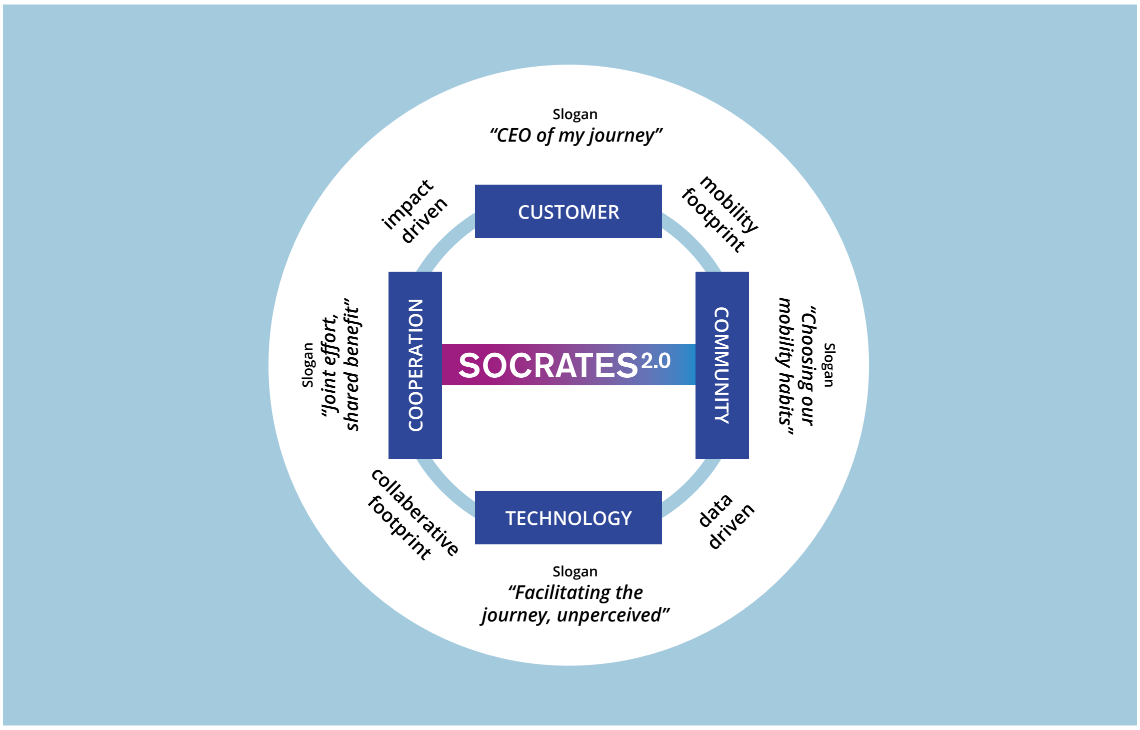


Figure 7: The four elements of SOCRATES2.0 and their slogans

5. USE CASES

SOCRATES 2.0
FAST SAFE GREEN

5.1. Introduction

The vision, as described in Chapter 4, sets the scene for the project. One the elements of the vision is that the road user should be in the centre of attention. This means that 'use cases' are a logical next step in the process. A use case can be described as 'a list of actions or event steps typically defining the interactions between an actor and a system to achieve a goal. The actor can be a human or other external system.'[17]

The following requirements needs to be fulfilled to create a valid use case:

1. A use case must describe the relevant stakeholder
2. A use case must provide value to a stakeholder > Goal orientation
3. A use case must be a complete narrative describing the story of how the value is provided > Must have main and alternative flows
4. A use case must stand alone > No sequencing of use cases
5. A use case must not describe system design > Describe "what" instead of "how"

The project selected the following use cases in the proposal phase:

- Smart routing
- Actual speed and lane advices
- Local information and hazardous warnings
- Improved roadside traffic management measures

A common feature of these four use cases is that they require the collaboration between traffic centres and (service provider) back offices based on an interactive use and dissemination of information and data. This leads to an approach in which traffic centres actually can influence, warn and advise road users (via the service providers) or self-driving vehicles (via the car industries) and the services delivered to end users are of improved quality (accurate, timely, rich individual and context-aware content), meaning: serves better their individual needs.

SOCRATES$^{2.0}$ cooperates among others with the C-Roads Platform, the European ITS Platform (EIP), the Traffic Management 2.0 platform and DATEX II community, especially on the functional design of the SOCRATES$^{2.0}$ services. All four use cases of SOCRATES$^{2.0}$ are described as so-called "Day 1" or "Day 1.5" services.
In this phase (Activity 2), a first elaboration of the use cases is done. Further specification will be done in subsequent phases. During Activity 2, it turned out that it made more sense to integrate the fourth use case (improved roadside traffic management measures) into the other three use cases. This proved to be an enabler for the other use cases. So this use case is not explicitly specified.
This chapter includes a short summary of the use cases so far. In the appendix to this report, the complete use case can be read.

[17] https://en.wikipedia.org/wiki/Use_case

5.2. Smart routing

Summary

Cooperation between road authorities and navigation service providers on the generation and transmission of ‘smart routes’ to improve traffic flow and efficiency and to provide more reliable navigation solutions for the road user.

Background

Conventionally, a route for a road user is determined by individually optimising the user’s preferences; e.g. travel time/travelled distance. This information can be enriched with information such as real-time traffic information in order to determine estimated time of arrival more accurately. The information generation and route calculation is usually done by private companies.

Road authorities would like to influence the use of certain routes by individual road users in order to reduce traffic congestion and emissions and increase traffic safety. Moreover, they have exclusive access to traffic information relevant for the route generation[18].

A framework for better cooperation between public and private stakeholders to align on each other’s priorities and needs is seen as beneficial for all stakeholders.

Objective

Bring together the road authorities’ needs and the navigation service providers’ tasks to provide ‘smart routes’ for road users to:

- provide road users an enhanced travelling comfort and higher satisfaction;
- offer fleet authorities /managers that apply a ‘smart route’ to a controlled vehicle a reliable travel time;
- make sure roadside and in-car systems do not give conflicting advice to road users establish collaboration between public and private for future projects. However, this may not be a problem as long as the road user does not get confused by the information provided. For this, we need to understand what road users really need or use in given situations;
- support road authorities to have a better outreach to road users and communities/ target groups;
- use of the service providers knowledge on the needs and characteristics of their specific clients, communities/target groups in order to be able apply this to “optimal/smart routes” from the public perspective;
- support road authorities to better monitor travel patterns and the acceptance of routing advices;

[18] In the Netherlands a lot of information is not exclusive to the road authority, but also provided as open data. However, the level of detail might be insufficient, the specific data might not be open and outside of the Netherlands this data might not be open.

- provide service providers with information on routing strategies within different road conditions and traffic situations and this way improve / expand service offer of service provider;
- support road authorities to spread traffic through the network according to current or expected traffic and road conditions and route strategies.

Expected benefits

- Road users receive more and consistent information (what you see in the car is what you see on the road sign) to take informed decisions;
- Road users arrive at their destination more satisfied, e.g. due to shorter travel times, higher comfort, lower costs etcetera;
- Road authorities can better monitor travel patterns and acceptance of routing advices which helps to improve the effectiveness of the system;
- Service providers benefit from satisfied customers (cities/and/or road users) due to better services compared to competitors;
- Fleet managers improve their results;
- Optimised traffic demand distribution leading to better traffic flow, less congestion and emissions and increase in quality of life.

Sub use cases

The following use cases within this category have been identified so far:

1. **Optimising network traffic flow**
2. **Individual routing towards public event locations**

5.3. Actual speed and lane advices

Summary

The service provides speed and lane advice to road users in order to improve traffic safety and traffic flow efficiency and to reduce traffic emissions. Speed and lane advices could be mandatory.

Background

On roads that are equipped with a lane control system (LCS), road users are provided with actual speed and lane advices by dynamic traffic signs. This information could also be provided to the road user via an In-Vehicle Signage (IVS) service.
On roads that are not equipped with a physical lane control system (LCS), a virtual LCS could be installed, providing the same type of information to road users via an In-Vehicle Signage (IVS) service. This IVS service is generated by service providers and should be aligned with speed and lane advices that are provided by road authorities.

Objective

- Aligning speed & lane advices provided by service providers with the ones provided by road authorities;
- Reinforcing the messages shown at the roadside by providing them in-car as well;
- Expanding the reach of speed & lane advices towards places without roadside equipment;
- Monitoring the follow-up behaviour of road users; ●... Facilitating the driving task of road users by providing them with up-to-date in-vehicle information;
- Minimising doubts regarding actual speed limits and lane situations (e.g. availability of hard shoulder running).

Expected benefits

- Improved traffic safety;
- More attentive driving;
- Increased driving comfort;
- Preventing or reducing traffic accidents (i.e. rear-end collisions).Preventing or reducing congestion on roads;
- Improved traffic flow;
- Decreased traffic emissions;
- Higher reach of road users;
- Better insight in follow-up behaviour of road users.

Sub use cases

The following use cases within this category have been identified so far:

1. **Maximum allowed speed**
2. **Speed advice “Congestion ahead”**
3. **Speed advice “Head of congestion”**
4. **Speed advice at traffic lights**
5. **Speed advice at shockwaves**
6. **Lane information**
7. **Lane advice at short on- and off-ramps**
8. **Lane advice at traffic lights**

5.4. Local information and hazardous warnings

Summary

Local information and hazardous warnings' aim is to inform and warn vehicles on local situations and receiving feedback on the information from road users based on the current real world situation.

Background

This service has an informative and safety-related nature and also a user feedback response.

Objective

Warn and inform on upcoming road situations and mirror road signage and receive feedback on the provided data from road users.

Expected benefits

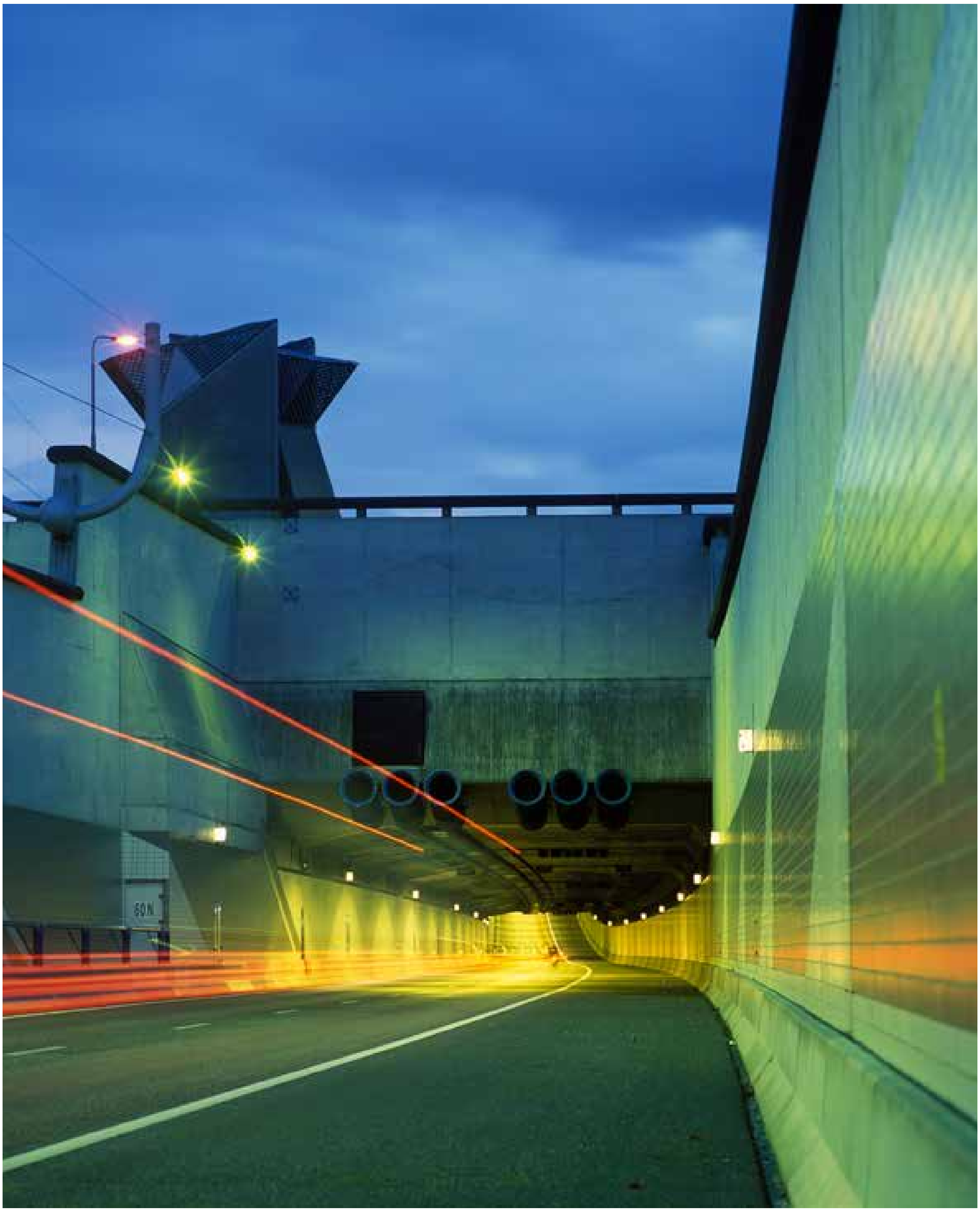
Reduction of avoidable incidents and generation of a higher level of detail within the available data set.

Sub use cases

The following use cases within this category have been identified so far:

1. **Road works warning**
2. **Road condition warning**
3. **Emergency service protection**
4. **Environmental/Areal information and constraints**

6. STRATEGY & COORDINATION



6.1. Background

In SOCRATES2.0, we want to discuss and describe future Traffic Management concepts, including cooperation between different road authorities and service providers / OEMs. Cooperation in this context is understood as the agreement on, and exchange of Traffic Management strategies. The strategy includes the vision that we are moving the perspective from managing traffic to supporting the decision making of individual drivers, and putting the end-user in the loop.

As explained before in this report, future concepts for cooperation in the field of Traffic Management have been already discussed within other platforms.
The working group "Enhanced Traffic Management" of the C-ITS Platform[19] envisions that traffic operations can be heavily optimised with the potential of increasing connectivity and automation. For this, "Pan-European Cooperative Traffic Management Services" need to be deployed.
The working group has also investigated how such Cooperative Traffic Management may be put into operation, looking at an example of incident management.

In the current situation (left figure below), a service provider would recommend the alternative route "B" when an accident happens, as it is the shortest and fastest path, resulting in travel patterns through non-desirable road network elements (urban neighbourhood).
In an ideal situation (right figure below), the road authority and service provider coordinate their activities to achieve an overall higher network performance with increased safety and reduced congestion time.

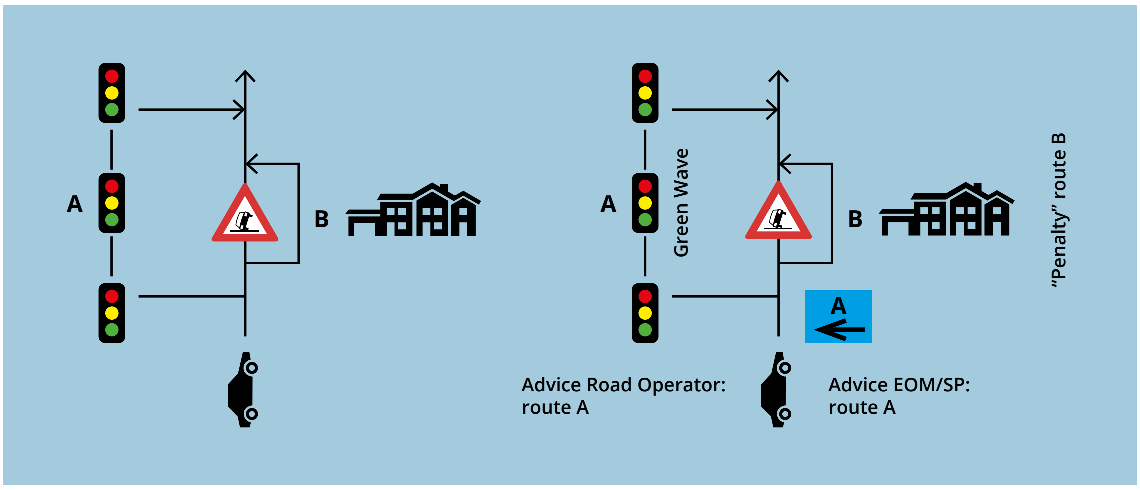


Figure 8: Re-routing with Cooperative Traffic Management (left: current situation; right: ideal situation)
Source: C-ITS Platform, 2017. Draft Final report Phase II

[19] C-ITS Platform, 2017. Draft Final report Phase II.

In this example, both stakeholders take actions which complement each other, leading to a win-win situation for everyone. This example also shows the cooperation efforts by both actors, i.e. the definition and alignment of complementary measures, and the consistent communication towards the road user.
In this context, the working group has emphasized the need for the collaboration and dialogue between stakeholders[20]. It has identified three key topics for such a dialogue:

1. The data categories and the exchange requirements for establishing the dialogue;
2. The governance model in which the dialogue can be established;
3. The means for establishing the dialogue.

Further perspectives on these matters have been elaborated by the TM2.0 platform, particularly its taskforce on Traffic Management Plan (TMP) Exchange[21],[22].
TM2.0 sees mutual benefits for both road authorities and service providers when TMP's are exchanged. TM2.0 also aims to overcome current difficulties due to heterogeneous data availability and quality across Europe, and to utilise new possibilities due to increased connectivity, use of in-car services and improvements in Traffic Management infrastructure.
The TM2.0 taskforce has developed a concept of TMP's (including decisions, procedures and strategies) and ideas how to exchange them in practice. This concept is mainly referring to Smart Routing, with the idea that individual route advice may be optimised by cross-checking and cross-fertilising with TMP's, eventually creating better advice to road users and enabling user feedback to TMC's. In addition, TM2.0 has formulated applicable use cases, recommendations and guidelines for involved stakeholders, with the goal of a "European TM2.0 Ecosystem".
One essential recommendation is that the two main groups of stakeholders (road authorities and service providers) have to understand and respect each other's interests and translate Traffic Management Strategies into measures taken by both.

To discuss and identify suitable cooperation frameworks for future traffic management, with a particular focus for SOCRATES$^{2.0}$, a dedicated Focus Group "Strategies and Cooperation" was set up within Activity 2 (FG3). The key questions of this group were:

- What is a strategy at all?
- How to ensure continuity from policy to operational level?
- How to develop & decide on optimal and common strategies?
- How to combine/prioritise (conflicting) strategies?
- How to experiment with different roles / to play with responsibilities?
- How to address both public and private needs, including competition of service providers?

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[20] C-ITS Platform, 2017. Draft Final report Phase II.
[21] Spoelstra, J., van Waes, F., Mann, M., Kontantinopoulou, L., Dr. Tzanidaki, J., 2017. Exchanging Traffic Management Plans data between Traffic Management Centres and Service Providers in Traffic Management 2.0. 12th ITS European Congress, June 2017, Paper no. TP0809.
[22] Rodrigues, N., Spoelstra, J., Sykora, R., van Waes, F., Dirnwoeber, M., Kontantinopoulou, L., Dr. Tzanidaki, J., 2016. The exchange of traffic management plans in TM2.0. 11th ITS European Congress, June 2016, Paper no. ITS-EUTP0199.

The lower set of these key questions can be summarised into this fundamental question: *"How do we want to organise cooperation between each other?"* The Focus Group elaborated these questions based on internal and external expert knowledge as well as intense discussions among project partners.

6.2. Definitions

As a first approach towards the topic, different perspectives on the term "Traffic Management strategy" were discussed. The following figure shows, how one may look at strategy.

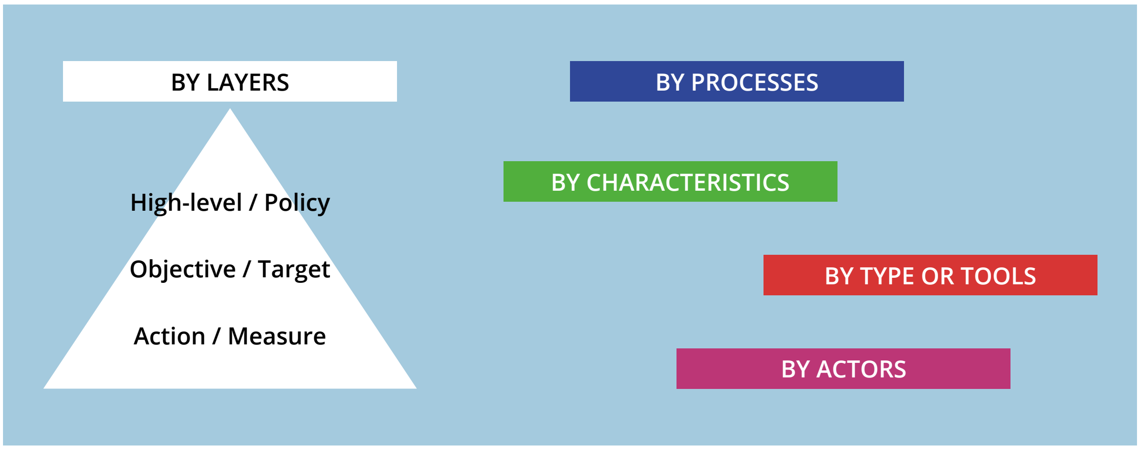


Figure 9: Different ways to look at Traffic Management Strategy

The most important parameters were identified in the "Layers" definition, with three layers of Traffic Management from policy to operational level. A detailed definition on these three layers can be found at TM2.0[23]:

- On a **strategic layer**, policies are decided e.g. regarding the priority of traffic flow in the network.
- On a **tactical layer**, the situation in the network is described, bottlenecks are analysed and measures are identified to resolve the bottlenecks. A Traffic Management Plan is a set of measures, such as traffic flow control, rerouting etc.
- On the **operational layer**, Traffic Management Plans are executed by sending out messages/instructions to road users, either via roadside equipment or via in-car or via personal communication devices.

The Focus Group concluded that the idea of a Traffic Management strategy not only applies to an operational TM measure, but also includes higher-level and tactical levels. Thus, any strategy and coordination concept within SOCRATES$^{2.0}$ has to consider those multiple dimensions, in order to ensure continuity of Traffic Management throughout the layers.

[23] Spoelstra, J., van Waes, F., Mann, M., Kontantinopoulou, L., Dr. Tzanidaki, J., 2017. Exchanging Traffic Management Plans data between Traffic Management Centres and Service Providers in Traffic Management 2.0. 12th ITS European Congress, June 2017, Paper no. TP0809.

Besides the definition of a Traffic Management strategy, further definitions are necessary to describe related stakeholders, roles, actors, processes and actions.

Relevant stakeholders already have been identified and assessed under the “Stakeholder needs” (see Chapter 3). Another definition on stakeholders, with a special focus on Cooperative Traffic Management, has been made by TM2.0:

- Road Infrastructure Owners
- Roadside Service Providers
- Content Service Providers
- In-car Service Providers
- Service Consumers

For the matter of Cooperative Traffic Management, it is also necessary to differentiate between roles and actors, which can be defined with a role-model approach as follows[24]:

- Actor: an organisational entity / institution that is capable of performing behaviour;
- Role: responsibility for performing specific behaviour, to which an actor can be assigned. It can be considered as a set of actions. The bundling of actions to a role is determined by a given objective;
- Action/process: defined as a behaviour element that groups behaviour, based on an ordering of activities. It is intended to produce a defined set of products or business services.

While actors may be identically defined as in the definitions before, roles are not bound to a specific institution/organisation. Roles in this context may be service provision, traffic light control, technology provision, intermediary, service usage etcetera. Roles may be assigned differently depending on the cooperation concept and the specific deployment. The actions/processes, as introduced in the role-model approach above, will also depend on the individual cooperation concept and deployment, so no comprehensive definition can be made here.
However, a generic categorisation of related processes has been made by TM2.0, described as three phases for the collaboration between stakeholders:

- TMP elaboration phase: management tasks of involved stakeholders; preparation and combination of services, agreement upon a common understanding between stakeholders;
- TMP operation phase: execution of a Traffic Management Plan;
- TMP evaluation phase: recurrent analyses of impacts and, if necessary, revisions of measures; eventually improving the original Traffic Management Plan.

[24] The Open Group, 2012-2013. ArchiMate® 2.1 Specification.

6.3. Cooperation Models

In order to answer the above-mentioned question “How do we want to organise cooperation between each other?”, a higher-level debate was led by the Focus Group, looking at the goals of future Traffic Management in general, as well as at the requirements and assets of individual partners.
To structure this debate, different Cooperation Models were introduced and discussed. These Cooperation Models were defined in the form of a matrix, looking at two dimensions regarding the exchange of Traffic Management strategies:

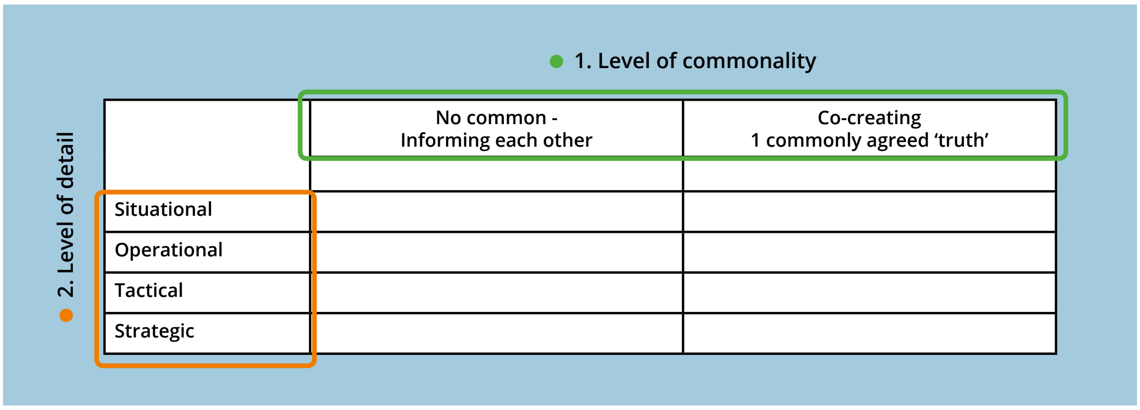


Figure 10: Cooperation Model Matrix

The two dimensions of this matrix are explained as follows:

1. **Level of commonality**
   Question: Is there a commonly agreed plan/basis?
   Options:
   1. ‘Informing each other’ means exchanging information to allow organisations to enrich their own information with the information of others, *enabling the possibility to anticipate on each other’s actions and decisions*, without the existence of a commonly agreed plan.
      > I know what others do/want and can anticipate on it, but we do not have a common basis/plan that I follow with my actions.
   2. ‘Co-creating a commonly agreed truth’ means exchanging information to *co-create one commonly agreed basis* that is the basis for individual actions/decisions.
      > We have a common and agreed basis/plan, that I follow with my actions.

2. **Level of detail**
   Question: At what level of detail do we exchange?
   Options[25]:
   a) Situational – exchanging / agreeing on the status/situation of the network
   For example: sensors (FCD, air quality, sound levels, traffic volumes, etcetera), actuators (VMS text, active signs, traffic lights, warnings etcetera)

[25] The four options correspond to the three “layers” of Traffic Management, as described above, plus the “situational” layer with a pure focus on information handling

b) Operational – exchange / agreeing on the measures/actions of actors
For example: Changed rules in traffic lights, activated triggers, TM scenarios in place
c) Tactical – exchange / agreeing on the targeted service levels (& motivation) behind measures
For example: Upgraded / downgraded in-flow or out-flow (as basis for changed rules in traffic lights), motivation behind TM scenario / VMS text
d) Strategic – exchange / agreeing on goals/objectives, boundaries, and priorities, behind service levels
For example: KPI on high level network performance, priorities between KPI's (policy goals), minimum performances (limits)

The matrix could be expanded to a third dimension, talking about the level of commitment of the individual actors.

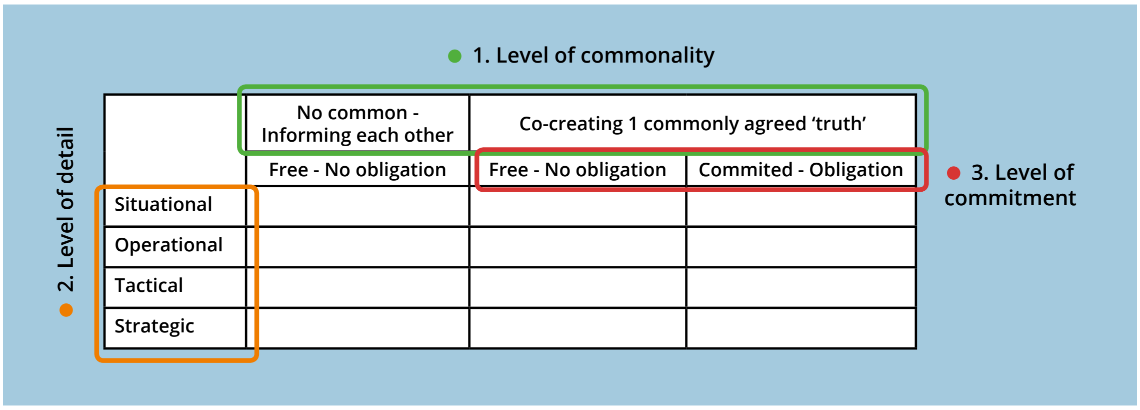


Figure 11: Expanded Cooperation Model matrix

3. **Level of commitment**
Question: Are actors free to use the agreed plan/basis?
Options:
a) Free/No obligation – Actors are free to use/ignore the common information as a basis for their measures.
For example: A suggested route advice that is shared, but there is no obligation to show it to road user. There might be KPI's indicating a contribution of measures to policy goals, but one is not obliged to use it in calculating route advice. Further, incentives can be organised to encourage the use of (common) information.
b) Committed / obligation – The commonly agreed plan/picture has to be used as a basis for individual measures.
For example: common (predicted) situational picture of traffic demand that have to be used in calculating routing advice, or KPI limits (representing for example policy objective) that have to be used in calculating routing advice, or a route advice or hazard warning that has to be given when certain conditions are met.
Legislation can be implemented to enforce the use of (common) information.

The different options on the vertical side of the matrix may be visually explained as follows:

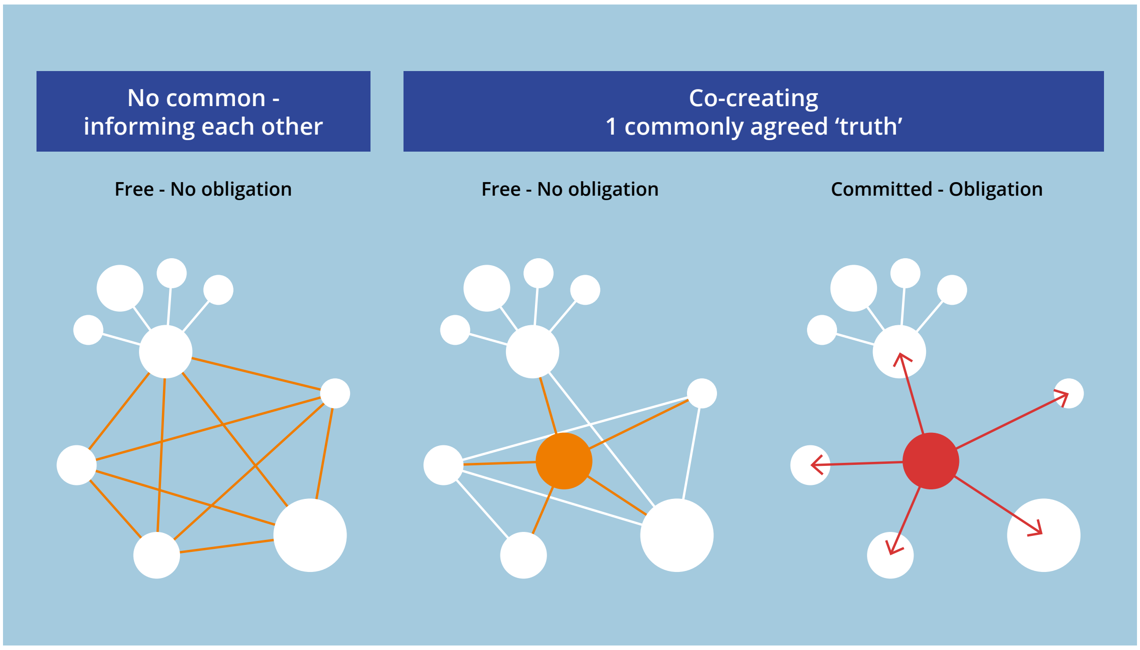


Figure 12: Visual explanation of Cooperation Models

First discussions within the Focus Group on the interpretation and a potential preference of the many options made obvious that there will be no "one size fits all" Cooperation Model. In contrast, it is expected the selection of a "right" Cooperation Model depends on individual criteria, such as the applied use case, technical and economic feasibilities, existing governance rules, geographic characteristics etc.

Further, it is expected that different models will require different data sets to be exchanged, different intermediary services, different agreements and possibly different business models etcetera.

However, the concept of Cooperation Models, as introduced above, should give partners some orientation on the many options and their implications, helping them find the "right" Cooperation Models when specifying individual deployments. It is also recommended, that the upcoming SOCRATES$^{2.0}$ pilots experiment with different Cooperation Models, so we get more experiences and lessons learned.

To identify some first preferences on the Cooperation Models, the concept above was presented to all SOCRATES$^{2.0}$ partners, asking for feedback on the following questions:

- On what level does your organisation require/prefer to coordinate with others?
- To coordinate on this level/these levels: what needs to be commonly agreed, and what can be done by informing?
- What level of freedom/commitment/obligation do you require/prefer?

Referring to the use case “Smart Routing”, SOCRATES$^{2.0}$ partners were asked to:

- describe pros/cons, expected benefits/concerns and questions on each of the Cooperation Models;
- identify the most interesting scenario to be tested for use case Smart Routing;
- share considerations on the level of freedom, and;
- identify research questions for the preferred scenario.

Feedback was received from eight partners. Based on analyses of this feedback, individual perspectives on the Cooperation Models show some commonalities, as summarised below. (The comments with + show expected pro’s/expected benefits. The comments with - show cons/expected concerns).

<table>
<tr><th></th><th>Informing each other</th><th>Co-creating 1 common ‘truth’</th></tr>
<tr><td>Situational</td><td>+ Transparent and factual
+ Better situational picture
- No intelligence used form other actors
- Redundant data handling at each actor
- How to access (sensitive) SP information?
- Not suitable for ‘advanced’ Use Cases</td><td>- Who defines and handles the common ‘truth’
- difficult data fusion
- universal commitments may impede individual business models</td></tr>
<tr><td>Operational</td><td>- possible contradictory measures by different actors
- not sure which information to communicate from SPs to TMCs</td><td>+ perfect alignment of TMCs and SPs
+ all ‘channels’ to travelers used
- difficult to find consensus
- take away freedom of actors</td></tr>
<tr><td>Tactical</td><td rowspan="2">+ improve user acceptance when tactical or strategic information is communicated
- Not sure which information to communicate from SPs to TMCs</td><td rowspan="2">+ common commitment on higher-level
+ higher impact with common targets or KPIs
+ flexibility and competition for actors
- no guarantee that compatible measures are followed by all actors
- difficult to describe commonly accepted targets, KPIs and methods
- difficult scaling (e.g. for different government levels)</td></tr>
<tr><td>Strategic</td></tr>
</table>

Figure 13: Commonalities from partner feedback on Cooperation Models

There is also a first consensus towards a set of preferred Cooperation Models (see below) as a scoring of individual preferences (each number represents how often a Cooperation Model was selected for a preferred scenario; a selection of multiple models was allowed).

	Informing each other	Co-creating 1 common ‘truth’
Situational	5	1
Operational	4	1
Tactical	3	5
Strategic	2	7

Figure 14: Scoring of preferred Cooperation Models, referring to the use case “Smart Routing”, based on partner feedback (numbers represent how often a Cooperation Model was selected; selection of multiple models was allowed)

As a tendency, the “Informing each other” concept is preferred for the situational and the operational levels. The “Co-creating 1 common ‘truth’” concept is preferred for the tactical and strategic levels.

While a “common ‘truth’” approach could be a threat to the business model of partners at the situational and operational levels, clear benefits are seen at the tactic and strategic levels, when targets and KPI’s are shared and aligned with each other. This is seen as a clearly innovative concept to be tested in SOCRATES$^{2.0}$. The stakeholders could discuss if it is necessary and possible to co-create on an operational and situational level as well as a result of collaboration on the strategic and tactical levels.

However, procedure and services need to be designed to enable such a target/KPI exchange and alignment. This has a relevance to the set-up of the SOCRATES$^{2.0}$ pilot sites, particularly of the potential intermediaries.

6.4. Conclusions

The Focus Group has consolidated some important conclusions, especially to be considered in the upcoming SOCRATES$^{2.0}$ activities, such as the design and planning of the pilots:

- When defining strategies and how to exchange them, all levels of Traffic Management (strategic, tactical, operational) have to be considered, to ensure continuity from policy to operational level.
- Actors, roles and processes need to be clearly defined for all involved parties in Traffic Management. However, roles and actors may change among different (pilot) deployments.
- For Cooperation Models, there is no “one size fits all”. In contrast, individual characteristics of a deployment have to be considered. Some preferences towards Cooperation Models could be identified, which should be tested at the SOCRATES$^{2.0}$.

Research questions, as identified during the Cooperation Model discussion, have to be considered and evaluated at the upcoming pilots.

7. INTERMEDIARY AND DATA FUSION

SOCRATES 2.0
FAST SAFE GREEN

7.1. Introduction

The various use cases and coordination models described in the previous chapters each ask for certain roles to be fulfilled by stakeholders. In this chapter, we explore the options for an 'intermediary'. This role has been initially described as a facilitator for the interaction between public traffic centres and private back-offices.

The Focus Group 2 presents a number of intermediary options in this chapter, for further discussion in the continuation of the project. For instance, the pros and cons of each option should be explored in the context of the applied cooperation model and use case. These options were chosen because they are clearly different in nature and show the width of options. Options chosen to be deployed in the pilot sites could still be variations on these options.

In the options, a number of governments and their Traffic Management Centres (TMC) are present, as well as a couple of service providers (SP). Each TMC and SP has their own communication channels (measure actuation) towards the road users.

For each option, roles like legal/privacy, business/contracting, standardisation and organisation are also necessary but are left out of the pictures to keep it a bit simpler.

7.2. Different levels of complexity

While describing the expected interaction between several public TMC and several private service providers the following levels of complexity were identified.

1. Data exchange
   a. Provide data – receive data between public-public, public-private and private-private
   b. Use and handling of public and private owned data while assuring all parties interests
2. KPI Monitoring
   a. Understand government goals and strategies vs. user needs served by private services
   b. Transparency on impact of private services towards public goals and vice versa
3. Identification of win-win-win value case
   a. Insight into business and societal value
   b. New business cases development
   c. Quantification of win – win – win (Public – Private – Road user)
   d. Alignment between services and needs
4. Orchestration of cooperation
   a. Development of common optimum as information (or mandatory)
   b. Publishing win – win – win value case
   c. Orchestrate measures and coordination between involved organizations; Commitment and engagement of public and private parties

5. Settlement of cooperation/interaction
    a. Liability, administration, clearing, settlement/integrity
    b. Demonstrate and validate value

An intermediary (or a group of) can support or deliver a solution for overcoming these initially identified complexities and challenges for each type of cooperation model.

7.3. Functions

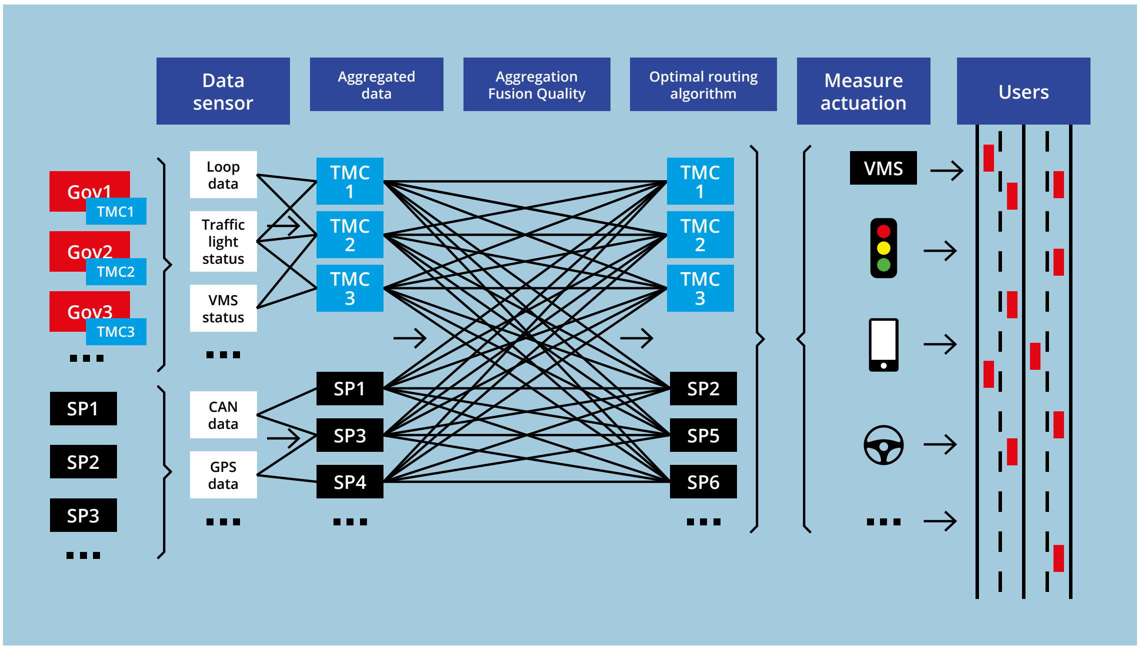
We distinguish the following (possible) functions that an intermediary could provide. By analysing National Access Points some functions (listed below) were identified and can be used as indications.

Function / service	**Possible sub functions**
Data sensor (Raw data)	Collection
	Distribution
	Aggregation
Aggregated (Processed) data	Completion / imputation
	Fusion
	Analytics (historic)
Quality	Assessment
	Control / audit
Optimal routing (Traffic management)	Common Situational Picture - State of network
	Common Predicted Situational Picture - Future state of network
	Common KPI picture - Calculation KPI on policy goals on vital elements
	Common Desirable Picture - Optimisation /negotiation/balancing/ validation
	Common DELTA picture - Difference CDP and CPSP
	Translation to measures - for Navigation routing and RS measures
Actuation/Measures	Routing services operation: navigation and roadside
	Feedback loop - Measures to CPS
Organisational / Exchange	Access to data (exchange)
	Access to services
	Interfacing back ends
Business / Contracting	Service value case developme
	Marketplace for impact driven services
	Reward/billing
	Coordination
	SLA management
Legal	Privacy
	Security
	Terms and conditions
	Consent management
Standardisation	

7.4. Intermediary Options

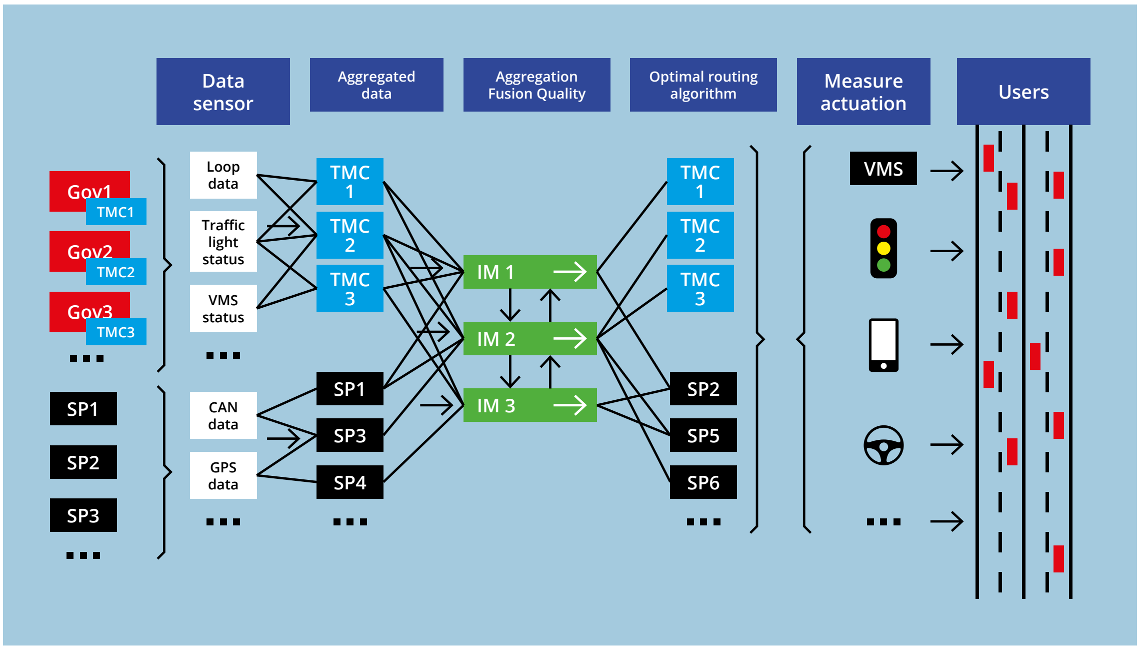
The following options for an intermediary role related to a Smart routing use case were studied at this stage of the project.
Depending on the different use cases and stakeholders, combinations of intermediary options presented below may be relevant. The discussion of advantages and disadvantages per option will be done in Activity 3. This will cover the specific situations in the pilot sites including regional boundary constraints, options and use case specific requirements.

No intermediary



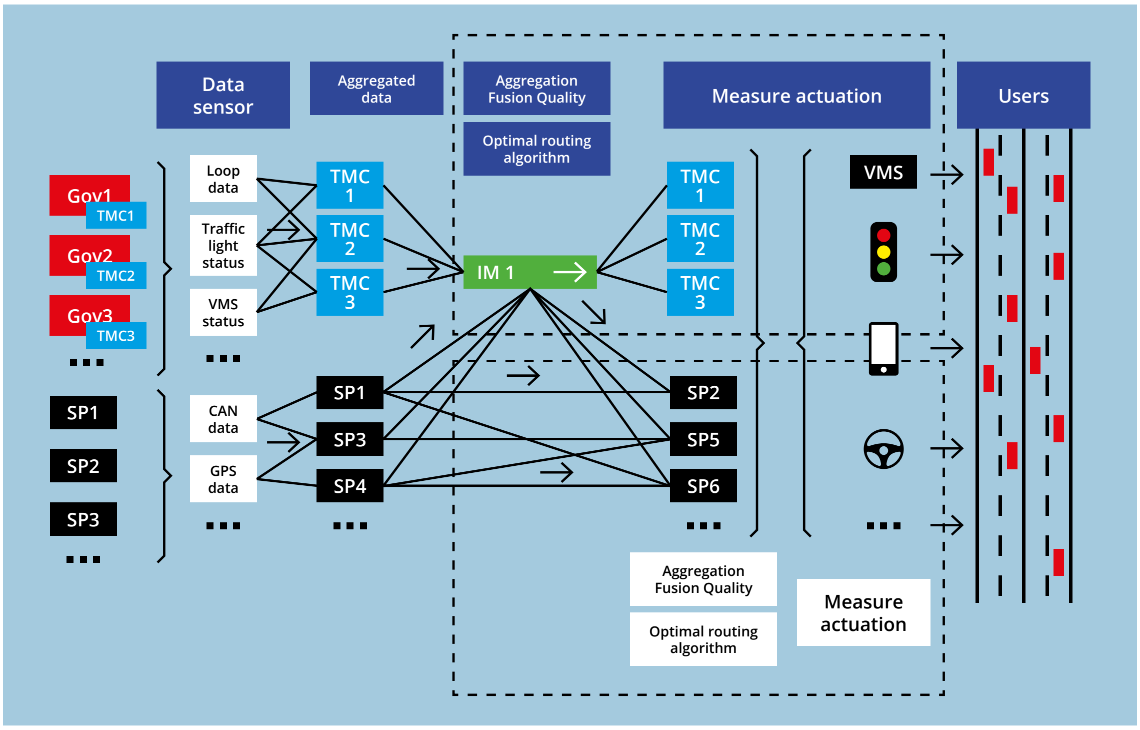
In this option, no intermediary is established. Each Traffic Management Centre and Service Provider arranges their own connection to the others. Each TMC and SP determines its own service optimum considering the given traffic situation. There is no common and agreed truth.

Multiple intermediaries for data aggregation - Informing each other



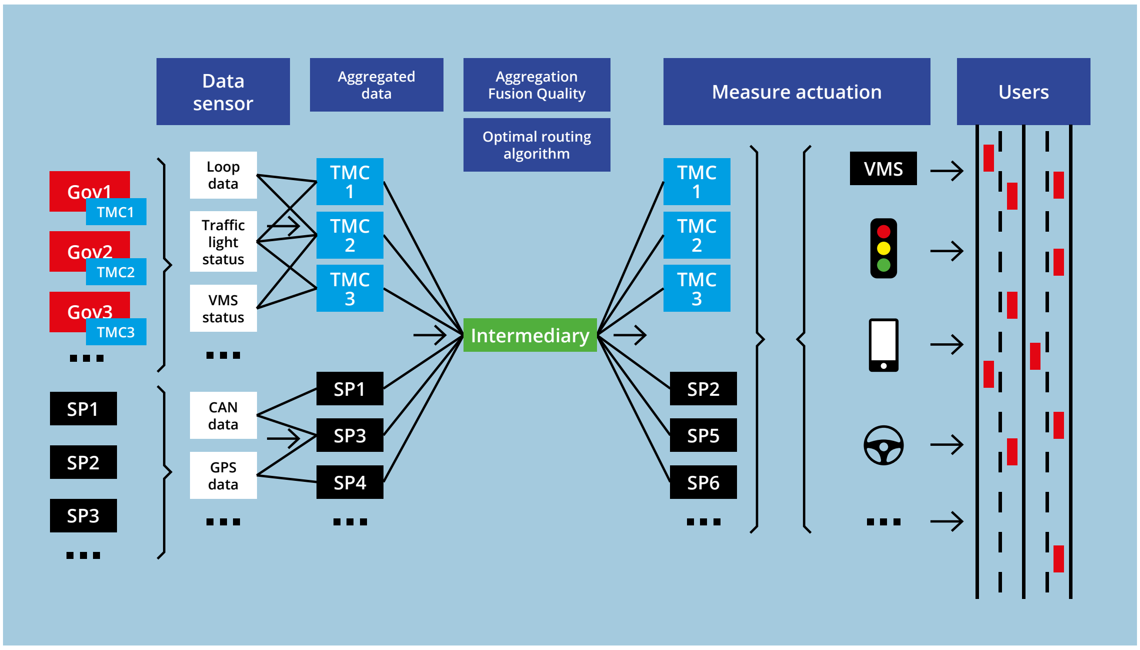
In this option, multiple intermediaries offering data aggregation services are present, there is competition. Each Traffic Management Centre and Service Provider can decide which intermediary service it wishes to subscribe to. Each TMC and SP determines its own optimal routing for the users. The intermediaries may be 1 public organisation and multiple private organisations.

1 intermediary for governments for aggregation & coordination - No intermediary for service providers



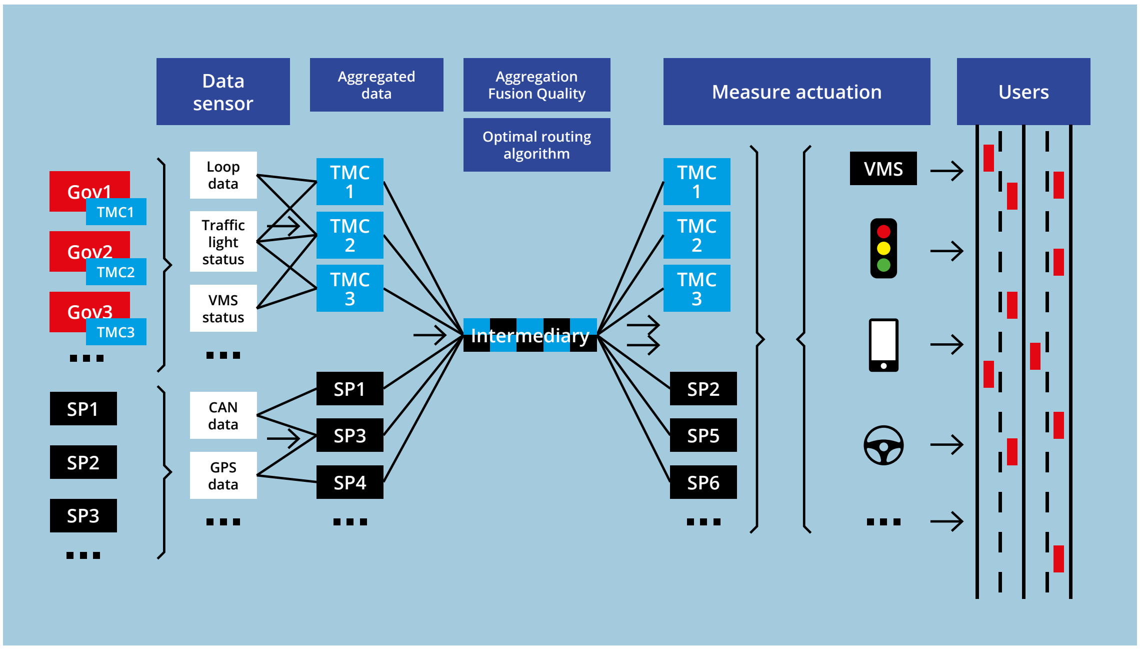
In this option, 1 intermediary is established for governments while the Service Providers do not have a dedicated intermediary, although data is shared back and forth. The government Traffic Management Centres use the intermediary to align on Traffic Management Plans and actuation of Traffic Management measures. The Service Providers do operate independently from each other.

1 distributed intermediary for aggregation and coordination; - 'Common truth', 'Trusted Entity'



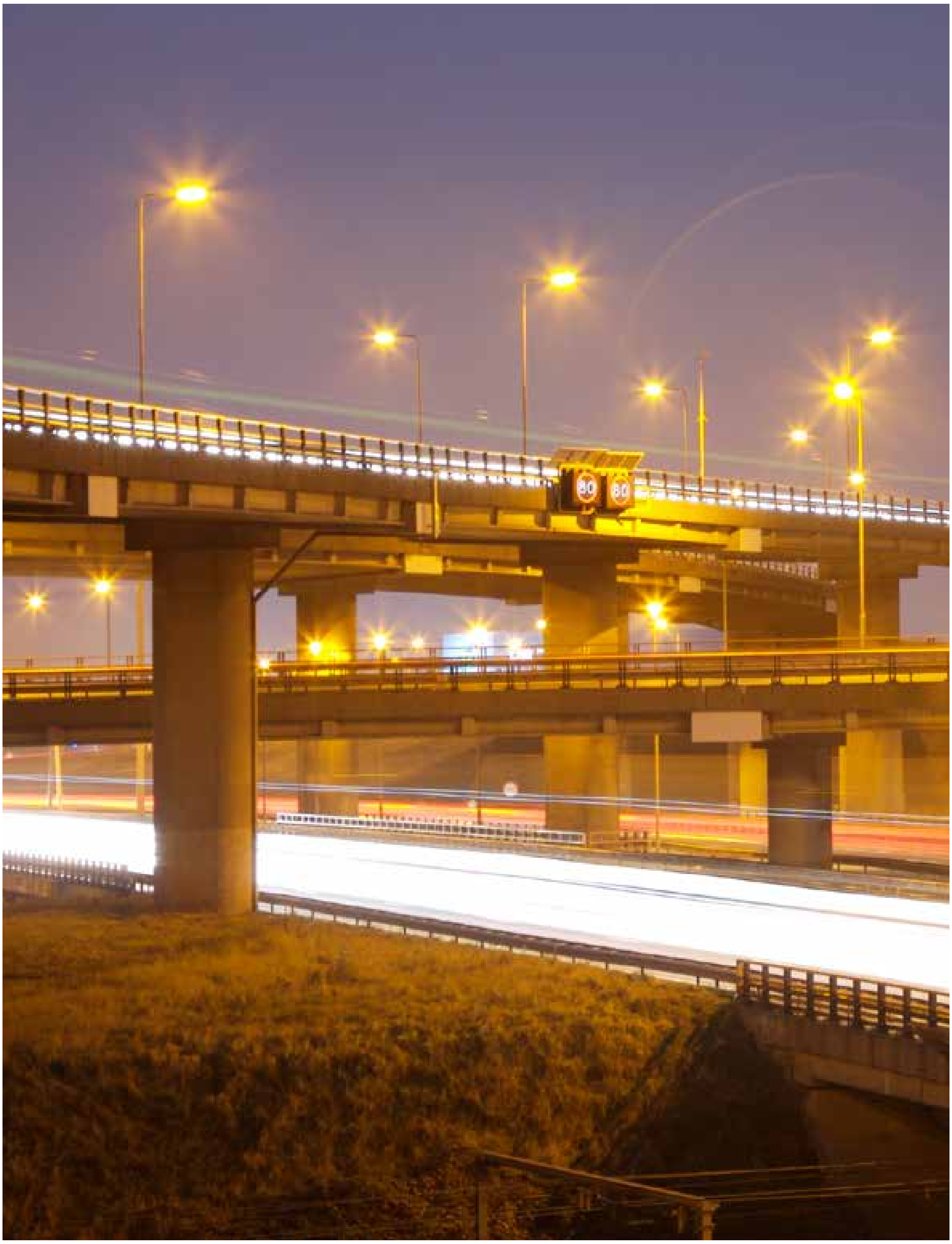
In this option an intermediary framework is established that allows the trustful cooperation between stakeholders. The tasks of the intermediary can be fulfilled by several stakeholders. Introducing the concept of a trusted entity will allow even cooperation between competing parties aiming for a common truth and agreed system behaviour. Each Traffic Management Centre and Service Provider will act as an integrated part of the intermediary.

1 single intermediary for aggregation & coordination - 'Orchestration', 'Centralised System'



In this option only one intermediary is established. Each Traffic Management Centre and Service Provider is connected to the intermediary. The task of the intermediary is to generate common truth and provide instructions to all parties for their system behaviour.

8. BOTTLENECKS



SOCRATES 2.0
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SOCRATES$^{2.0}$ paves the way for the next generation of traffic management. On this way, there are several challenges, impediments, or generally speaking, bottlenecks. Bottlenecks may slow down or even hinder some of the envisioned goals. They may affect any Traffic Management solutions during their preparations or during their deployment, either in pilot sites or in a European roll-out. Bottlenecks may also differ depending on the type of use case or local conditions.

Some bottlenecks have been already addressed in other projects. Some other bottlenecks have been specifically identified within SOCRATES$^{2.0}$. The following chapter aims to give an overview on relevant bottlenecks and their relevance to the topic "Interactive Traffic Management", generally, or to SOCRATES$^{2.0}$, specifically.

Regarding possible solutions, there is no explicit aim to solve all the bottlenecks - that is far beyond its scope - but SOCRATES$^{2.0}$ will identify possible approaches for occurring bottlenecks during deployment of the concept in the four pilot sites. The project may also identify needed higher-level actions outside of the scope of this project, for instance on legislation or standardisation, and motivate related institutions to work out suitable solutions.

One of the main sources for this chapter is the TM2.0 report on enablers and barriers[26]. The bottlenecks have been clustered into the following categories. This is again based on TM2.0. However, a "data" category has been added, as many bottlenecks are related to this.

- Data bottlenecks
- Technical bottlenecks
- Organisational bottlenecks
- Business-related bottlenecks
- Legal bottlenecks
- Conceptual bottlenecks

The bottlenecks are described in the form of structured templates, including the following entries:

- Name
- Description
- Source
- Effect on (e.g. which element of SOCRATES$^{2.0}$?)
- Risks when not solved
- Responsible stakeholder (which body should take care of this?)
- Already addressed (e.g. other projects)
- Possible solutions

[26] Traffic Management 2.0 (TM2.0), 2015. Report of the Task Force 2 on Enablers and barriers, January 2015.

Based on current analyses, there are 17 bottlenecks in total. Some of them have a current relevance for SOCRATES$^{2.0}$, i.e. they have been explicitly discussed in the SOCRATES$^{2.0}$ project so far. However, it is expected that the other listed bottlenecks will be also relevant during later stages of the project. It is also possible that further bottlenecks will be added later.

It is suggested that the following elaboration is considered a “living document”, to be completed or amended during the project runtime.

8.1. Data bottlenecks

1: Lack of accessibility to data **[Description]** Many use cases of Interactive Traffic Management rely on data sources that are in the domain of various stakeholders. It is important to raise awareness to stakeholders to open up their data sources to external partners as much as possible, respecting everyone’s business-models, assets and privacy. **[Source]** FG4 (see Chapter 6) **[Effect on]** Interoperable utilisation of any data within Interactive Traffic Management **[Danger when not solved]** Domain-based data cannot be communicated between stakeholders. Basic goals of Interactive Traffic Management are not met. **[Concerned stakeholder]** Developers of Interactive Traffic Management **[Already addressed]** On-going high-level discussions on openness of data, e.g. the ‘Data Task Force’ with governments and car manufacturers aiming to reach agreements. Regarding specific data requirements, a “data landscape” for potential use cases was elaborated in FG4. Further, the upcoming designs of SOCRATES$^{2.0}$ pilots will specify data provision from individual partners. **[Possible solutions]** Proven data-sharing models from previous projects. Point of attention is that necessary agreements on data provision between stakeholders in the traffic management chain may not comply with the legal framework for open data.
2: Lack of standardisation for Traffic Management Plan data **[Description]** Traffic Management Plans (TMP’s) have to be exchangeable between different actors. TMP’s may be very different from case to case, and include complex contents. Only limited standards for interoperable data models and interfaces for TMP’s exist. **[Source]** FG3; TM2.0 **[Effect on]** Interoperable utilisation of TMP data within Interactive Traffic Management **[Danger when not solved]** TMP’s cannot be communicated between stakeholders. Basic goals of Interactive Traffic Management are not met. **[Concerned stakeholder]** Standardisation bodies; traffic information service providers **[Already addressed]** A DATEX II extension was developed for the use case “strategic routing” in the project LENA4ITS[27]. **[Possible solutions]** Further standardisation of TMP data models and interfaces. A specific interface will be realised in SOCRATES$^{2.0}$ (“TMex”).

[27] bast.opus.hbz-nrw.de/volltexte/2015/1625/pdf/F108_barrierefreies_Internet_PDF.pdf

3: Lack of standardisation for vehicle probe data **[Description]** Standards for vehicle probe data are not finalised, or are not consistent to each other. **[Source]** TM2.0 **[Effect on]** Interoperable utilisation of vehicle probe data within Interactive Traffic Management **[Danger when not solved]** Vehicle probe data cannot be communicated between stakeholders. Basic goals of Interactive Traffic Management are not met. **[Concerned stakeholder]** Standardisation bodies; OEM industry **[Already addressed]** On-going standardisation activities, e.g. at ETSI[28] **[Possible solutions]** Further standardisation of vehicle probe data
4: Lack of interoperable maps and georeferencing methods **[Description]** Existing maps and georeferencing methods differ among different stakeholders and among use cases. **[Source]** TM2.0 **[Effect on]** Interoperable utilisation of any spatial data within Interactive Traffic Management **[Danger when not solved]** Spatial data cannot be communicated between stakeholders. Basic goals of Interactive Traffic Management are not met. **[Concerned stakeholder]** Standardisation bodies; traffic information service providers **[Already addressed]** On-going guidance, specification and standardisation activities at TN-ITS[29] **[Possible solutions]** Increased use of state-of-the-art georeferencing methods enabling data exchange and cross-referencing between stakeholders, e.g. OpenLR[30]
5: Lack of security infrastructure for Cooperative Vehicle Data **[Description]** A security infrastructure, assuring integrity and privacy of vehicle data, has been proposed by C-ITS stakeholders, but is not in place yet. **[Source]** TM2.0 **[Effect on]** Interoperable utilisation of Cooperative Vehicle Data within Interactive Traffic Management **[Danger when not solved]** Security threats resulting in malfunctions or lowered user acceptance **[Concerned stakeholder]** C-ITS stakeholders, e.g. at the Amsterdam Group[31] **[Already addressed]** On-going deployment activities for C-ITS, e.g. at C-ROADS[32] **[Possible solutions]** Proposal for a "Public Key Infrastructure"

[28] www.etsi.org/technologies-clusters/technologies/automotive-intelligent-transport
[29] http://tn-its.eu/
[30] http://www.openlr.org/
[31] amsterdamgroup.mett.nl/default.aspx
[32] www.c-roads.eu/platform/activities/wg-technical-aspects.html

6: Lack of common data formats for intermodal traffic information **[Description]** Intermodality will be part of many use cases of Interactive Traffic Management. However, there are only limited common data formats and interfaces for intermodal traffic information, crossing different modes, countries and operators. **[Source]** TM2.0 **[Effect on]** Deployment of services including intermodal traffic information **[Danger when not solved]** Lacking information to road users on all available traffic modes **[Concerned stakeholder]** Stakeholders of intermodal traffic information **[Already addressed]** On-going efforts to establish National Access Points for intermodal traffic information, in accordance to Commission Delegated Regulation (EU) 2017/1926[33] **[Possible solutions]** Data hubs for the integration of regional public transport information, e.g. DELFI[34]
7: Insufficient or unclear quality of exchanged data **[Description]** When acquiring data from external parties, it is not always clear if the data meet the requirements of the data user. Quality of data is rarely systematically assessed and transparently documented. **[Source]** TM2.0 **[Effect on]** Reliability and safety of related services of Interactive Traffic Management **[Danger when not solved]** System malfunctions; erroneous information to the road user; lowered user acceptance **[Concerned stakeholder]** Data providers **[Already addressed]** Quality assessment concepts in the field of traffic information, e.g. the QKZ-method[35]; Quality frameworks for various ITS data types on EU level, e.g. in EU EIP[36] **[Possible solutions]** Proven quality assessment procedures from previous projects

[33] eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017R1926
[34] www.delfi.de/
[35] https://doi.org/10.1016/j.sbspro.2012.09.809
[36] eip.its-platform.eu/activities/sa-41-determining-quality-european-its-sevices

8.2. Technical bottlenecks

8: Lack of compatibility with TMC legacy systems **[Description]** Existing TMC's need to be enhanced regarding communication, interfaces, data/ information processing etcetera in correlation with external actors. However, older systems do not always allow such scalability / interoperability. **[Source]** TM2.0 **[Effect on]** Europe-wide roll-out of Interactive Traffic Management. (For pilot projects, such as SOCRATES$^{2.0}$, this may not be a problem, as solutions are usually worked out within the project frame.) **[Danger when not solved]** When working with existing systems: functionalities of Interactive Traffic Management are limited; when building new systems: possible redundancies (parallel "old" and "new" systems) **[Concerned stakeholder]** TMC operators; financing bodies behind TMC's **[Already addressed]** Pilot projects with an operational trial, e.g. NAVIGAR[37] **[Possible solutions]** Provide technical and financial support to upgrade/redesign/migrate existing TMC's.
9: Insufficient penetration of vehicles and compatible TMC's **[Description]** Long transition periods towards a critical mass of integrated vehicles and TMC's **[Source]** TM2.0 **[Effect on]** Measurable, large-scale benefits of Interactive Traffic Management **[Danger when not solved]** Effects of Interactive Traffic Management will be only on limited number of road users. **[Concerned stakeholder]** Governments and industry **[Already addressed]** SOCRATES$^{2.0}$ pilot sites will have a significant number of participating road users. **[Possible solutions]** Roll-out on a large scale; promotion of products on the vendor-side; investments into TMC upgrades (see Bottleneck no.1)
10: Insufficient cellular communication networks **[Description]** Services based on cellular communication require full availability and quality of the network coverage. **[Source]** TM2.0 **[Effect on]** Functionality of services based on cellular communication **[Danger when not solved]** Services are spatially/temporarily not available. **[Concerned stakeholder]** Telecommunication industry, governments **[Already addressed]** several initiatives by telecommunication industry, governments **[Possible solutions]** Improvements towards availability and quality of the network coverage.

[37] www.its-bw.de/navigar

11: Lack of advanced Traffic Management algorithms

[Description] Existing TMC's are mainly isolated systems, including proprietary sensors and actuators, and (automated) algorithms triggering Traffic Management measures. For Interactive Traffic Management, with many more sensors and actuators, these algorithms have to be re-designed and re-validated.

[Source] BASt

[Effect on] Efficiency of measures in Interactive Traffic Management

[Danger when not solved] Envisioned goals (e.g. for traffic flow) cannot be met.

[Concerned stakeholder] TMC operators, research organisations

[Already addressed] On-going research project at BASt

[Possible solutions] Re-design of existing algorithms

8.3. Organisational bottlenecks

12: Non consensus on cooperation models

[Description] A viable cooperation model has to be clearly defined and accepted among partners for each deployment of Interactive Traffic Management. During first discussions in FG3, it became clear that it is not ease to find a "right" cooperation model.

[Source] FG3

[Effect on] Deployment of Interactive Traffic Management with added value for each partner

[Danger when not solved] No sustainability of deployment (e.g. partners may leave the project)

[Concerned stakeholder] Developers of Interactive Traffic Management

[Already addressed] Different cooperation models have been discussed in FG3, including what models may be preferred. The upcoming SOCRATES$^{2.0}$ pilots will test different cooperation models, which then will be evaluated. Further conclusion will be given at the end of the project.

[Possible solutions] Proven cooperation models from previous projects

8.4. Business-related bottlenecks

13: No clear return of investment for actors

[Description] Any investments in technical infrastructure (e.g. upgrades of TMC's) and provision of data and/or information (e.g. traffic flow data from service providers) need an economic justification. This has not been proven on a large scale.

[Source] FG3; TM2.0

[Effect on] Technical infrastructure; provision of data flows between actors

[Danger when not solved] Traffic Management data cannot be communicated between stakeholders. Basic goals of Interactive Traffic Management are not met.

[Concerned stakeholder] Developers of Interactive Traffic Management

[Already addressed] Discussion of "impact-driven business models" as part of the cooperation models. The upcoming design of SOCRATES$^{2.0}$ pilots will include decisions on cooperation models and if any financial transactions (or other arrangements) are involved.

[Possible solutions] Proven business models from previous projects. Nationwide fiscal incentives could be considered. Assess possible investments in TMC's not just in the light of its own operational objectives, but take the wider policy goals in account as well (with financial support from the policy makers if possible).

8.5. Legal bottlenecks

14: Unsolved privacy concerns **[Description]** Services involving sensitive personal data (e.g. origin/destination information) need to comply with privacy legislations. Such data is subject to EU national laws, specifically laws transposing EU Directives. **[Source]** TM2.0 **[Effect on]** Deployment of services involving personal data **[Danger when not solved]** No approval of deployment due to privacy legislations; lowered user acceptance **[Concerned stakeholder]** Developers of Interactive Traffic Management **[Already addressed]** Various academic approaches looking at the user side of C-ITS **[Possible solutions]** Applications which explicitly ask for user's consent before personal data is sent out, e.g. in PRICON project[38]
15: Unclear liability in case of malfunctions or erroneous data **[Description]** System malfunctions or erroneous data may have legal and liability implications for actors. This is especially important for use cases that go beyond the "recommendation character", e.g. displaying legally-binding traffic rules via in-vehicle devices. **[Source]** TM2.0 **[Effect on]** Legally accepted concepts of Interactive Traffic Management **[Danger when not solved]** Impediment of viable business models; in case of concrete damages: complicated legal trials and possible high costs. **[Concerned stakeholder]** Developers of Interactive Traffic Management **[Already addressed]** On-going high-level discussions on "ethics" in context of Automated Driving, e.g. led by the German Ministry for Transport[39] **[Possible solutions]** Proven liability models from previous projects
16: Unspecified ownership of data **[Description]** Data ecosystems in Interactive Traffic Management may become quite complex, including various sources and processing steps. Eventually it is not clear who owns the (processed) data. **[Source]** TM2.0 **[Effect on]** Legally accepted concepts of Interactive Traffic Management **[Danger when not solved]** Impediment of viable business models **[Concerned stakeholder]** Developers of Interactive Traffic Management **[Already addressed]** On-going higher-level discussions on "ownership of mobility data", e.g. led by the German Ministry for Transport[40] **[Possible solutions]** Proven data ownership models from previous projects

[38] www.researchgate.net/profile/Thilo_Von_Pape/publication/321133930_A_Privacy-aware_Data_Access_System_for_Automotive_Applications/links/5a0ed8baa6fdccd95db719cb/A-Privacy-aware-Data-Access-System-for-Automotive-Applications.pdf
[39] www.bmvi.de/SharedDocs/DE/Publikationen/G/bericht-der-ethik-kommission.html?nn=12830
[40] www.bmvi.de/SharedDocs/DE/Publikationen/DG/eigentumsordnung-mobilitaetsdaten.html?nn=12830

8.6. Conceptual bottlenecks

17: Lack of political/societal acceptability

[Description] Introduction of Interactive Traffic Management on a large scale will have implications to the current actors (e.g. changing their responsibilities) as well as to the society (influencing an individual's travel behaviour). Clear policies about the goals and approaches are required to reach a high level of acceptance among actors and users of such systems. To enable international roll out, the various national policies need to find a common ground.

[Source] TM2.0

[Effect on] Societally accepted concepts of Interactive Traffic Management

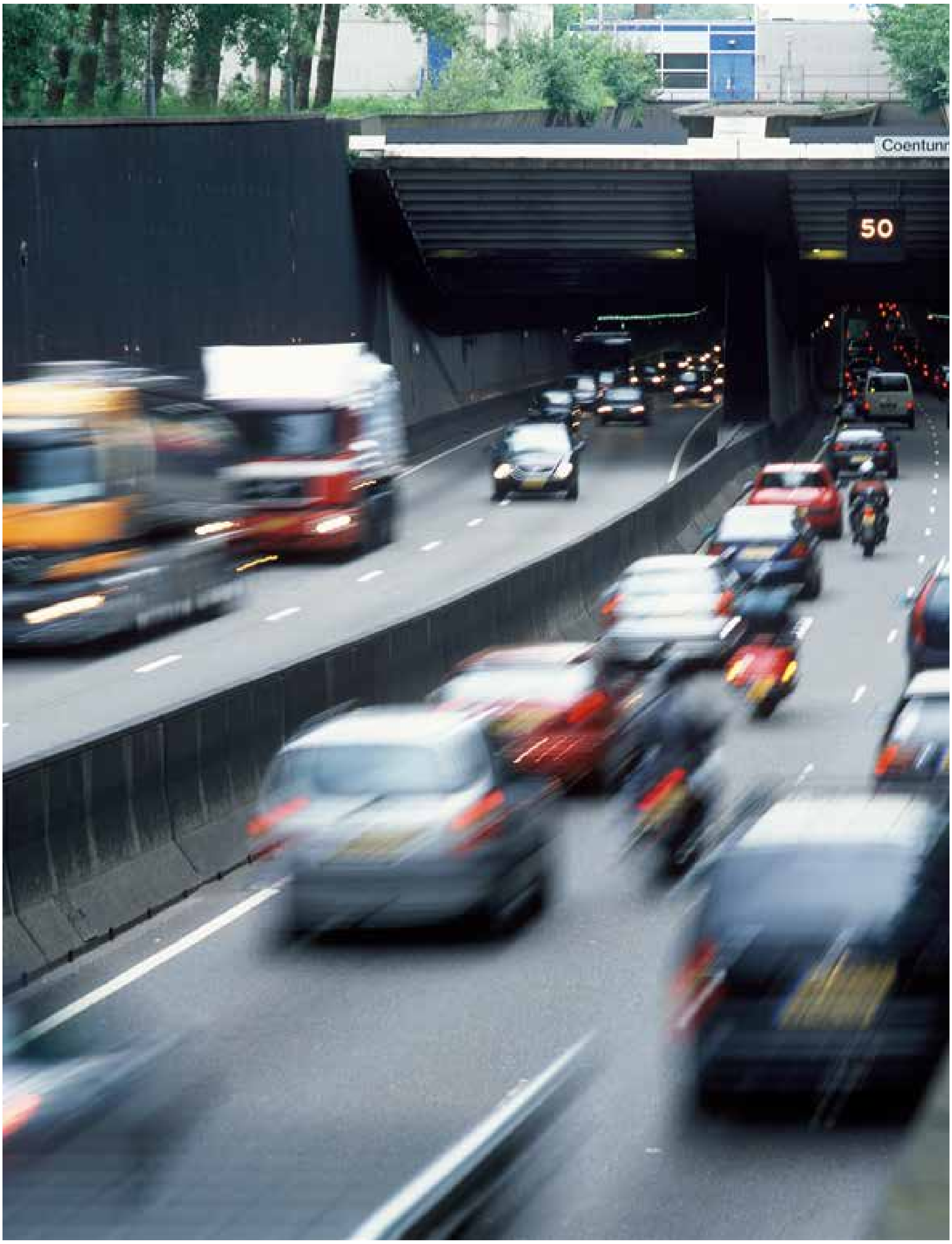
[Danger when not solved] Lower actor motivation; lowered user acceptance

[Concerned stakeholder] Policy makers

[Already addressed] A commonly accepted "Shared Vision" has been elaborated in SOCRATES$^{2.0}$, which may be used as a base for policy.

[Possible solutions] Proven participation and communication concepts from previous projects

9. CONCLUSION



SOCRATES 2.0
FAST SAFE GREEN

The SOCRATES$^{2.0}$ project paves the way for the next generation of Traffic Management. Public and private parties cooperate to provide optimal routes (faster, safer, cleaner) for the individual road users, also securing the collective interests via mobile/in-car and roadside services and (in the future) self-driving vehicles.

SOCRATES$^{2.0}$ is based on the strategy developed by the TM2.0 initiative[41]. It aims to agree on a set of common interfaces, principles and business models to facilitate the exchange of data between vehicles and TMC's. This is crucial for improving the entire value chain for consistent Traffic Management and mobility services.

SOCRATES$^{2.0}$ will build on this strategy, elaborate an approach and test actual services in four regions in Europe. The elaborated concept of Interactive Traffic Management should be tested in reality before it can be widely deployed. Open questions will be discussed, for instance regarding optimal ways of cooperation, business models and legal framework. Further initiatives which SOCRATES$^{2.0}$ builds on are (among others) the C-ITS deployment platform and C-Roads.

The vision of the SOCRATES$^{2.0}$ partners is that it will lead to a win-win-win situation for all actors in the Traffic Management eco-system:

- Win for the road user:
  Effective Traffic Management depends on the acceptance by an individual traveller. However, a traveller a will only follow certain traffic management rules, when those rules are well-aligned between the various parties setting up the rules, and also efficiently communicated towards him. In this ideal case, the traveller will get a "one-stop-shop" of traffic information, based on coordinated Traffic Management strategies and algorithms. Also the traveller will be able to communicate back to the Traffic Management operators, giving feedback on current traffic flows and the efficiency of services. This way, each traveller will be respected as real customers of traffic infrastructure providers.
- Win for public Traffic Management Centres:
  Traffic Management Centres will be able to substantially optimise Traffic Management operations. They will be able to address a wide range of road users with tailor-made, precise information, and will also take advantage of new communication channels and sensor/feedback techniques. Eventually, they will leave their current silo approach, trying to influence traffic operations by their own means. Instead, they become part of a holistic Traffic Management ecosystem, considering the expertise and assets of different parties and market players in the field of data detection, processing and communication.

[41] http://tm20.org/

- Win for private Service Providers:
  Similarly, service providers will leave their current roles as pure navigation service providers for the individual traveller, based on own routing algorithms and barely considering collective information. Their information services will expand to seamless door-to-door traveller assistance. They will serve innovative use cases beyond navigation, such as showing available travel mode options, or giving lane-specific driving advice. All these new elements will be aligned with public, collective Traffic Management strategies, being part of sustainable cooperation models developed in SOCRATES$^{2.0}$. This way, they will take on active responsibility to improve efficiency and safety of our traffic systems. However, the specific set-up of services towards the travellers (being their costumers) will remain in the service provider's freedom, promoting the best solutions in a competitive market.

To reach the mentioned win-win-win situation, some base concepts and common agreements need to be elaborated among the mentioned actors. This elaboration is mainly covered in SOCRATES$^{2.0}$ Activity 2.

The goal of Activity 2 is to develop an optimal framework for cooperation between the public and private partners, as a basis for a European deployment of Interactive Traffic Management. Activity 2 scopes the strategic level of such a cooperation, while the subsequent activities also cover the tactical and operational levels.

The partners wanted to establish something new and not just improve an existing concept of cooperation. To do so, they recognised that a paradigm shift should be made from 'managing and influencing traffic' to 'supporting people on their travel from A to B'. Goal is to create synergies between actions of the individual road users with the collective mobility objectives, to bridge the innovative developments in the vehicle and in traffic management, while giving value to the legacy and creating new business opportunities.
This goal is summarized in the following statements:

- Customer: CEO of my own journey!
- Community: Choosing our mobility habits
- Cooperation: Joint effort, shared benefit
- Technology: Facilitating the journey, unperceived

Since the road user is a central element in the vision, specifying use cases is crucial to establish the link between road authorities, private service providers and road users. This was done around three themes:

1. Smart routing
2. Actual speed and lane advices
3. Local information and hazardous warnings

Then, it is important to assess how the stakeholders can cooperate to be able to take these steps. For this a theoretical framework was created, describing options for cooperation. Finally, the concept of the intermediary was explored, based on the use cases and cooperation models. An intermediary is expected to have a role in data exchange coordination, aggregation, fusion, quality control and common picture. A set of typical options for the intermediary role has been defined and described.

Now the common framework is defined in Activity 2, the approach will subsequently be specified for the four pilots in Activity 3. The plans are then validated in the actual pilots (Activity 4-7), and evaluated in Activity 8. The results will be used to update the framework (Activity 9). Information on the results of these activities will be published in future deliverables.

In short:

- There is a common ground for cooperation;
- Some promising cooperation models are already identified;
- The challenge for the next activities will be to keep a balance between the interests of each stakeholder (public and private goals);
- Testing the various cooperation options in several use cases and on several locations will provide valuable insights.

GLOSSARY

Interactive Traffic Management
Traffic Management based on the interaction between the traveler, the vehicle and traffic management systems, with the objective of supporting end users in their individual travel and driving choices while being aware of the collective traffic management context.

Interactive Traffic Management services
Services based on usage and benefiting from the interaction between the traveler, the vehicle and traffic management systems. Typical interactive traffic management services are:

- Advanced navigation services: individual turn by turn navigation taking into account road and traffic conditions predictions, also based on traffic management plans
- Adaptive and dynamic traffic control: traffic management and control services with adaptive and dynamic decision making processes based on real time and historical traffic data
- Traffic status and event detection: traffic state information service including real time event detection

These services provide a basis for the identification of involved actors, data and value exchange, which can lead to identification of supporting business models.

C-ITS	Cooperative Intelligent Transport Service
CAM	Cooperative Awareness Message
DENM	Decentralised Environmental Notification Message
EC	European Commission
ETA	Estimated Time of Arrival
ETSI	European Telecommunications Standards Institute European Union
FCD	Floating Car Data
FG	Focus Group
HSR	Hard Shoulder Running
IVI	In-Vehicle Information
IVS	In-Vehicle Signage
KPI	Key Performance Indicator
LCS	Lane Control System
OEM	Original Equipment Manufacturer (in this report referring to car industry)
SP	Service Provider
RA	Road Authority
RTTI	Real Time Traffic Information
TM	Traffic Management
TMC	Traffic Management Centre
TMP	Traffic Management Plan
VMS	Variable Message Sign

APPENDIX: USE CASES

Chapter 4 gives a short overview of the essence of the cases (high level descriptions). This appendix describes the use cases in detail.

SMART ROUTING

Service introduction	
Summary	Cooperation between road authorities and navigation service providers on the generation and transmission of 'smart routes' to improve traffic flow and efficiency and to provide more reliable navigation solutions for the road user.
Use cases	The following requirements needs to be fulfilled to create a valid use case: 1. A use case must describe the relevant stakeholders. 2. A use case must provide value to a stakeholder. > Goal orientation 3. A use case must be a complete narrative describing the story of how the value is provided. > Must have main and alternative flows 4. A use case must stand alone. > No sequencing of use cases 5. A use case must not describe system design. > Describe "What" instead "how" The following use cases may be implemented under consideration of these common design options: • The use case may include services for specific vehicle type. Another approach is using vehicle type as a distinguishing feature to base actions upon. • Synchronisation with roadside units for less confusion and better alignment with strategy accounts for both use cases. One caveat should be mentioned: it might not be possible to completely align VMS texts and navigation advice to road users when different road users get a different advice in the same geographic location. This would mean a VMS would have to display two or more texts to accommodate all the road users (or: 'check your in car device'). Two or more texts on VMS's are undesirable. • Require a good information strategy to the road users. • May be implemented on different levels of detail and cooperation (see FG3). • May or may not use an intermediary to reach the goals. The following use cases have been identified so far: UC_SR_01: Optimising network traffic flow UC_SR_02: Individual routing towards public event locations The following actors have been identified: • Road users • Vehicle driver • Service provider • Road authority • Road operator • Traffic centre • Intermediary • Fleet operator • Public transport operator Optional actors: • Police • Fire department • Hospitals

Use case functional description - Optimising network traffic flow

Use case: function of the system, the desired behaviour (of the system and actors), specification of system boundaries and definition of one or more usage scenarios.

Optimising network traffic flow	
Use case introduction	
Summary	Road users are advised routes that are optimal for the overall network performance and societal goals.
Background	Today, individual routing advice provided by service providers does not account for the network optimum and for higher-level policies of road authorities. This eventually results in conflicting route advices (from road authorities vs. service providers), and in decreasing efficiency of public traffic management measures. Also, the routes that service providers advise to the road users might be undermined by traffic management measures. Furthermore, service providers cannot accurately predict if congestion will occur on the advised route.
Objective	By optimising the network usage and adhering to policy, optimised routing advice provided by service providers will help achieve societal goals, like increasing network efficiency, reducing emissions and improving traffic safety.

Desired behaviour	The system will calculate the optimal route for individual road users based on collective road usage and network compatibility considerations. This should be related to the capacity of the road and higher-level network strategies. Also, the system will enable road authorities to request the service providers to specifically prefer or avoid specific network elements, with inclusion of an explanation (environmental, safety (e.g. school or retirement home), location quality, primary road for another modality (bike, public transport, pedestrians)). This measure can be also be addressed to specific road users (vehicle type, resident vs. non-resident etc.) or circumstances (time of day etc.). For a further optimal effect, current and planned travel patterns of road users will be analysed to determine the actual travel demand in a high-resolution picture regarding time and location. Road users will optimally comply and drive using the optimised navigation advice. This is accompanied by a concise (visual/textual) description of features of possible route options, including any advantages and hazards. The road user will still have the freedom to choose his favourite route. However, by being well-informed about the route options, it is most likely that he will follow the recommended “smart route”. This information can be produced pre-trip and on-trip. Design options: • Inclusion of multiple routes, including reasons why some routes are less attractive. When this is chosen there should be a discussion about the “default” route of “first” advice a service provider provides to the road users. • Inclusion of incentives for road users accepting an optimal route for the network/societal goals (being a suboptimal route for the individual). The incentives might include: monetary reward , collecting virtual points, following a “social” route (and feeling good about that) and having a higher priority at traffic lights. Be aware that a monetary incentive might lead to undesirable situations (e.g. virtual sessions using GPS spoofing). • Inclusion of incentives for fleet operators to route vehicles according to the road authorities’ goals (e.g. avoidance of certain network regions) • Inclusion and information of dynamic tolls for specific road parts (e.g. the Liefkenshoektunnel). If the toll is lifted, this might entice certain road users to use the tunnel more often. • Inclusion of multimodal navigation in order to reduce the overall traffic demand on the road network. The modes may be conventional public transport or private ride sharing services. • Integration of a feedback loop for road authorities, who will receive information via the service providers, if a “smart route” is accepted and followed by a road user. This may help road authorities to evaluate and optimise their traffic management rules.
Expected benefits	Better network performance, better road usage (with respects to priorities, safety and environment), better navigation experience for road users (better ETA’s, better RTTI).

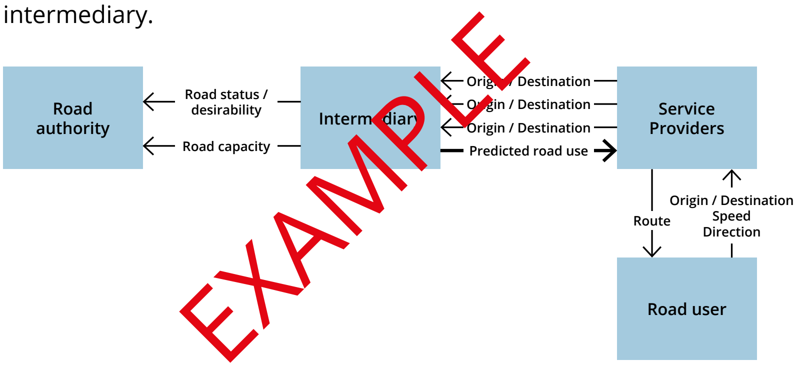
<table>
<tr><th colspan="2">Use case description</th></tr>
<tr><td>Situation</td><td>A service provider, road authority or intermediary has determined through algorithms that several road users will use a road that will probably (predictive) be congested.
The prediction among others depends on the information about current traffic-related events such as hazards or road works, which are made available to the service providers and road authority (see use cases “Hazard Information”).
Some or all of the users will receive a “smart route” navigation advice that will support the flow of the network. Depending on options that were chosen these users will get a choice of a different first or default route.
The operator receives general information on the collective acceptance of the “smart route”.</td></tr>
<tr><td>Actors and relations</td><td>Exemplary implementation:

Road user: Enters a destination (and origin if applicable) and receives optimised navigation advice.

Road authority: sends data (probably through the intermediary) about the current and future road status, including specific network elements that have to be preferred or avoided (called “road desirability” below).

Intermediary: The intermediary consolidates and validates information from multiple sources, relays relevant information and ensures there are no privacy concerns. This will mean that certain information flows will have to be aggregated, combined and/or stripped of information that can be used to tie the data to a specific person .

Service provider: The service provider receives information from the road authorities (probably through the intermediary) and delivers information to road users. Also it delivers relevant information to the intermediary.


</td></tr>
</table>

Scenario	Example: An event takes places which will cause high traffic demand on the roads in its proximity. There are road users who do not like to visit the event but whose shortest route towards a destination would share network elements with visitors of the event. Based on service provider's algorithms and the road authority expertise, potential capacity bottlenecks along the network are identified. Also, the road authority has deemed certain roads less desirable, since there is a pollution problem on certain parts of the route. The intermediary exchanges information about traffic demand (from service providers) and network supply (from road authorities). The service providers can query the intermediary for relevant information in order to enhance individual route advices in form of a "smart route".
Display / alert principle	Pre-trip: When the road user starts his individual navigation service, "smart route" options are displayed, based on the data exchange described above. On trip: In case traffic conditions change, the "smart route" options are immediately updated, including an explanation for the change.
Functional Constraints / dependencies	• For many data types required for the concept above, data formats and data communication techniques need to be agreed on: - Geo-description of network elements and/or areas which are to be preferred or avoided ("road desirability") - Travel demand information - Generic description of road user type (e.g. vehicle type, emission class, resident vs. non-resident) - Information on features (e.g. reason and significance) of specific "smart routes" (e.g. eco-friendly route or social route) • Road authorities will have to be able to automatically communicate information about the road status, road desirability and road capacities, in an interoperable, up-to-date and complete manner. • Service providers will have to be able to automatically communicate travel demand information, in an interoperable, up-to-date and complete manner. • In this context, travel demand information will have to go from one service provider to another. This might impact business opportunities. There is probably a solution using an intermediary. • Further, travel demand information should be handled very carefully. This will have a privacy implication. • Travel demand information can be derived from service providers, which gather any destination requests from road users. Since most service providers will be reluctant to share this information with competitors, the central intermediary may play a crucial role here. Since this party will receive all the information from all parties, this should be an impartial (with no ties to certain service providers) party.

Use case functional description - Individual routing towards public event locations

Individual routing towards public event locations	
Use case introduction	
Summary	Provide smart routes (guidance) for certain destinations (e.g. events)
Background	Some events are visited by a huge number of people. Usually a significant part of these people intend to travel to the event in private vehicles. This stresses the overall infrastructure and likely causes congestion and high delays. Furthermore, the road user usually needs to find a parking lot where he leaves the 'driving' mode and switches to another mode (such as walking or public transport) in order to reach the final destination. This problem is usually addressed by local traffic managers, who try to optimise incoming traffic by dynamic parking information systems, advices to use P&R facilities, dynamic lane assignment etc. However, that kind of local traffic management is rarely communicated via navigation systems, resulting in decreased efficiency of local traffic management and inconvenience and confusion for the road user.
Objective	Road users that request a route to such a destination shall be supported by a route guidance that incorporates the traffic management measures of the organisation's strategies. For instance, road users can be guided to less occupied parking lots close to a festival. When approaching a certain destination, road users are guided until they reach their parking spot. This requires that information along the road (via VMS etc.) and in-car (via navigation devices) is up-to-date, consistent and comprehensive to the road users. It is also recommended to "dynamise" the destination information for the individual road user. Instead of routing to a fixed address/ coordinate, a most-suitable driving destination (e.g. a parking lot) will be decided by the system on-route, based on current traffic conditions. Design Options • Inclusion of multimodal navigation in order to reduce the overall traffic demand on the road network. The modes may be conventional public transport or private sharing services • It is possible that a predicted state of the network and a predicted state of the event location (for instance, amount of free parking spaces) are needed for an optimal travel experience.
Desired behaviour	Road users will adapt their driving behaviour, route choice and potentially mode choice based on local traffic management rules.
Expected benefits	Avoidance of negative traffic impacts in the context of events etc., increased comfort for road users, better navigation experience for road users.

Required data	• Road users current position and destination • Depending of local traffic management: especially availability of free parking lots, availability of alternative travel modes, information on temporary lane closures/openings, routing strategy, etc. • The event organiser will also have information that is relevant to the traffic flow: the time the event will start and end, the estimated amount of visitors and sometimes also the location the road users will most likely come from (origin). For SOCRATES the road authority may deliver this data. • In order to calculate whether certain parking locations will end up full, when the road user will arrive at the event location, the amount of public transport data might also give an insight into the predicted traffic flow. Weather information might also be a good predictor on the amount of event attendees that will use the car as a mode of transport. • "Dynamic" destination information for the individual road user (instead of a fixed address/coordinate, the navigation systems should be able to enter an event (e.g. "concert") or a general area e.g. ("city centre"), and then determine the most-suitable driving destination during the trip, maybe including some options.)

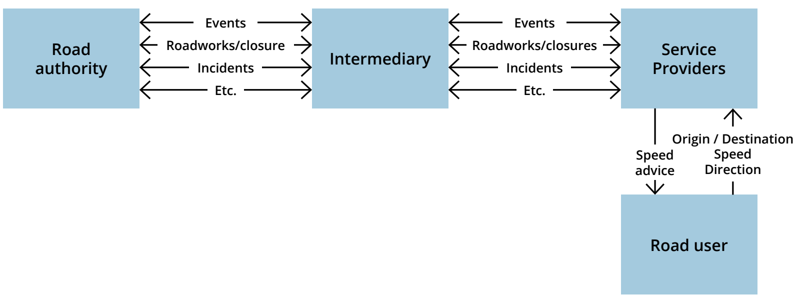
Use case description	
Situation	The service providers system will be able to recognise a destination as an “event destination”. It will then offer a route to the road user that will minimise search traffic.
Actors and relations	Exemplary implementation: Road user: Enters a destination (and origin if applicable) and receives optimised navigation advice. Road authority: sends data (probably through the intermediary) about the current and future road status, including specific network elements that have to be preferred or avoided (called “road desirability” see previous use case). The road authority will also share the amount of free parking spaces, start/end time of the event, the predicted amount of visitors and public transport data. Service provider: The service provider receives information from the road authorities (probably through the intermediary). The service provider will route the road user to the optimal parking location. Optional intermediary: The intermediary consolidates and validates information from multiple sources, relays relevant information and ensures there are no privacy concerns. This will mean that certain information flows will have to aggregated, combined and/or stripped of information that can be used to tie the data to a specific person.
Scenario	Example: Several road users want to go to the Amsterdam ArenA. Therefore several road users will input the same destination. Also there is another event going on somewhat near the events in Amsterdam. Based on service provider’s algorithms, shared data (visitors, parking information, etc) the road users receive a route to the most optimal parking location. The intermediary exchanges information. The service providers can query the intermediary for relevant information in order to enhance individual route advices in form of a “smart route”.
Display / alert principle	Pre-trip: When the road user starts his individual navigation service, the road user is informed that he/she will drive to an event location. The system will ask if the road user wants to be directed toward a parking space. On trip: Road users must be informed of status changes in relation to the destination (e.g. parking lot is full, you will be rerouted).
Functional Constraints / dependencies	• Road authorities will have to be able to automatically communicate information about the parking spaces and event data, in an interoperable, up-to-date and complete manner. • Service providers will have to be able to detect an event destination from user input. • Service providers will have to be able to automatically update the destination of the road user, using the data that was mentioned in the use case.

ACTUAL SPEED AND LANE ADVICE

Service introduction	
Summary	The service provides speed and lane advice to road users in order to improve traffic safety and traffic flow efficiency and to reduce traffic emissions. The use case also includes dynamic maximum speeds and red crosses, which are mandatory.
Use cases	• UC_SLA_01: Maximum allowed speed • UC_SLA_02: Speed advice “Congestion ahead” • UC_SLA_03: Speed advice “Head of Congestion” • UC_SLA_04: Speed advice at Traffic Lights • UC_SLA_05: Speed advice at shockwaves • UC_SLA_06: Lane information • UC_SLA_07: Lane advice at short on- and off-ramps • UC_SLA_08: Lane advice at Traffic Lights

Use case functional description – Maximum allowed speed

Maximum allowed speed	
Use case introduction	
Summary	Maximum allowed speeds can be displayed to road users in the car. Multiple parameters are taken into account: • the static speed signs • the dynamic speed limits via matrix signs • temporary speed limits, for example at road works • time-dependent rules, for example during the day / night / specific hours • weather-dependent rules, for example during heavy rain, smog-alerts • vehicle-specific characteristics, for example trucks or caravans
Background	In case of temporary speed limits: In order to protect sites with incidents or road works, speed limits are advised or imposed.
Objective	Safety & Comfort. This should minimise any doubts on what the maximum allowed speed would be for any road user. In case of temporary speed limits: The aim is to alert the road user about the speed limit so that he can adapt his speed. Road users are given a speed advice when approaching road works, incidents or similar situations. Service providers will receive government data through the intermediary to reach this goal. Service providers will also have their own data.
Desired behaviour	In case of temporary speed limits: the road user adapts his driving behaviour complying to the applicable driving speed limit.
Expected benefits	In case of temporary speed limits: • Road authority: safer road use, less incidents. • Road user: improved safety and better informed. • Service provider: happier users, better service.

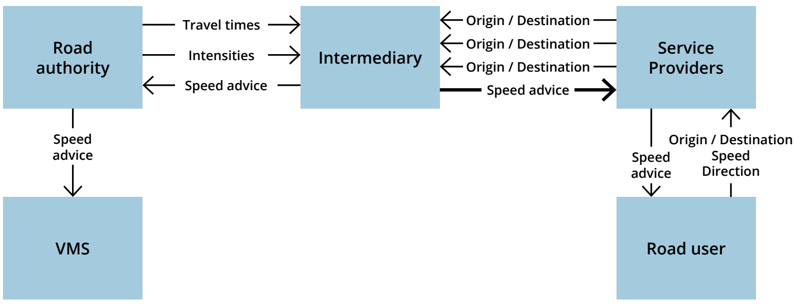
Use case description	
Situation	In case of temporary speed limits (when road users are approaching road works, incidents, lost cargo, overcrowded streets (demonstrations/ manifestations) or chaotic situations (like taxi's unloading or taking up passengers)): the traffic centre uses the lane control system (LCS) to display to the road speed limits. The same information could be displayed on an In-Vehicle Signage (IVS) service. On motorways that are not equipped with a physical lane control system (LCS): a virtual LCS could be used, providing the same information to the IVS service. IVS does not have the same legal stature as law or legal regulations, nor can provide the same legal authority and proof, so this would remain purely informational. it has to be clarified how legal binding can be also reached for virtual LCS. Remark: the road user should get a speed advice and explanation for the advice.
Actors and relations	In case of temporary speed limits: depending on the cooperation model, the actors could be: • Road user: Receive speed advice and change speed accordingly. • Road authority: deliver relevant data to the intermediary. This should at least include known incidents, planned and actual road works (with the addition of the type and amount of hindrance), planned and actual demonstrations, planned and actual chaotic situations. • Intermediary: receive and send data between road authorities and service providers. • Service providers: receive, use, validate and combine data. Send speed advices to road users, including the reason for the speed advice. * Perhaps the intermediary also validates and combines data if this helps with the use case. This should be further investigated.
Scenario	In case of temporary speed limits: Depending on the cooperation model, the scenario could be: • The Traffic Centre takes the decision to install speed limits. • The vehicle receives information about speed limits. • The road user adapts his driving behaviour (speed). • Road authority is sending all known situations to the intermediary. • Intermediary sends information to the service providers. 
Display / alert principle	Display info in-car to road user.

Functional Constraints / dependencies	In case of temporary speed limits: Many Traffic Centres use automated decision algorithms how/when to install speed limits along the road sections. Usually this is based on traffic flow detection at the specific VMS location. In the future (e.g. with a virtual LCS concept), these decision algorithms have to be revised, taking into account the extended possibilities: (a) to detect traffic flow and (b) to inform road user s. As dynamic speed limits and lane closures are legally binding traffic management measures, it has to be clarified how legal binding can be also applied for virtual LCS. Navigation functions and/or destination are needed if the speed advice is given in relation to a certain part of the route. If there is no destination set, the road user might take a different route, where there will be no congestion and the advice has no use. An exception to this rule is a road user driving on a road that will inevitably lead to a congested part. The most important aspect that must be realised in developing this service is avoiding contradictory information on the roadside and in-car. This might happen when the current signalling system stays active while the in-car system doesn't take this into account. A contradictory situation might occur when the current signalling system advises 50 for very close traffic jam, while the in-car system advises 70 for road users approaching road works. This should not occur.
Required data	Static and dynamic speed limits.

Use case functional description – Speed advice “Congestion ahead”

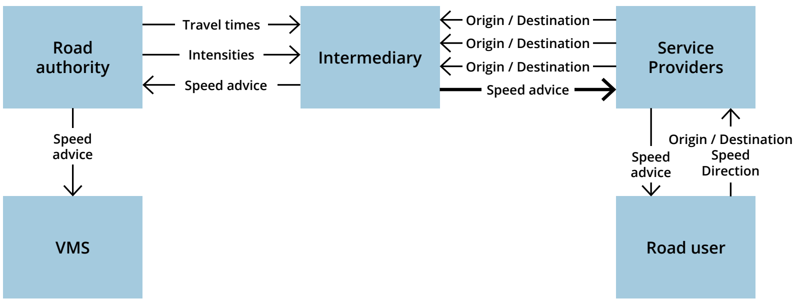
Speed advice “Congestion ahead”	
Use case introduction	
Summary	To anticipate the congestion on a road, the oncoming traffic must receive a lower speed advice. The recommended speed depends on the maximum allowed speed on the road and on the average measured speed in the congestion.
Background	Not only will the lower speed advice aid in countering the development of a (starting) congestion on the road but the warning will also help the road user in anticipating on time to the changing conditions downstream. In this way accidents in the tail of the congestion may be prevented.
Objective	Safety & Comfort. Queue tail protection (this should prevent head-tail accidents). Reducing congestion on the road.
Desired behaviour	The road user is able to anticipate on time, thereby reducing the congestion on a road.
Expected benefits	• Road authority: safer road use, less incidents. • Road user: improved safety and better informed.

Use case description	
Situation	When driving, road users will receive speed advice when there is a congestion ahead. The message might be very specific (for a less congested travel experience a speed of 70 is advised) or less specific (for less congested travel experience we suggest you slow down). However, if a combination with VMS is developed, a specific speed is preferred, which can be aligned with the speed on the VMS. This system will need a process to determine where speed advice will have a positive impact on (predicted) congestion. This means that the system should know the route the road user will take thus the road user is either using navigation or on a road that will inevitably lead to a congested part.
Actors and relations	• Road user: Receive speed advice and change speed accordingly. • Road authority: deliver relevant data to the intermediary. This data will help service providers to determine where congestion might occur and calculate/predict whether speed advice might alleviate the situation. Optionally showing the same speed advice on VMS. • Service provider: receive, use, validate and combine data. And delivering speed advice to the road user. • Intermediary: Receiving and delivering data for the use case.

Scenario	Depending on the cooperation model: scenario could be: Scenario 1: Road user is approaching road works, incident, lost cargo, overcrowded street or chaotic situation. Road authority is sending all known situations to the intermediary. Service provider sends speed advice to road user including reason. Scenario 2: Road user is driving to a destination where congestion is expected on a part of the route. Road authority is sending intensities, travel times, incidents, event information, road closures/road works to the intermediary. The service provider receives the information from the intermediary and adds their own data sources. Either through a service request or their own algorithms, the service provider sends a speed advice to the road user. The service provider informs the intermediary of the speed advice. The road user receives the speed advice and changes speed. The intermediary receives information and turns this into a feed for road authorities. 
Display / alert principle	Display info in-car to road user
Functional Constraints / dependencies	• Quality and availability of congestion data should be high enough. • Warning should reach road user s on time.
Required data	• Location of congestion • Location, heading and speed of incoming traffic participants

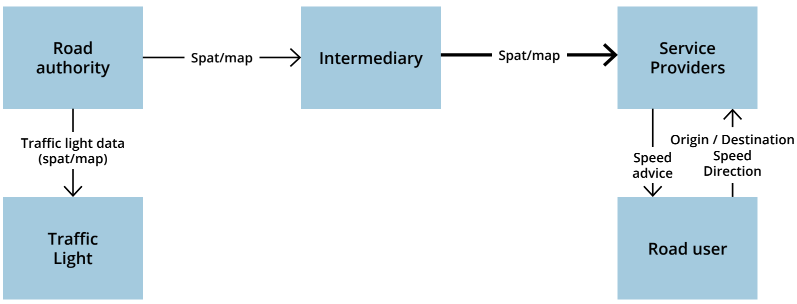
Use case functional description – Speed advice “Head of congestion”

Speed advice “Head of congestion”	
Use case introduction	
Summary	To reduce congestion on a road, road user s at the head of the queue can be advised to speed up. When leaving the queue (transition from congestion to free flow), road user s should keep the gaps with the vehicles in front of them short.
Background	When reaching the end (head) of congestion, road user s should speed up and follow closely to the road user s upfront. Speeding up at the head of the congestion will result in a faster dissolution of the congestion.
Objective	Traffic flow optimisation. Prevention of Capacity drop.
Desired behaviour	Road users change speed to comply with the advice given by service providers.
Expected benefits	Benefit to the road authority: improved traffic flow. Dissolution of traffic congestion.

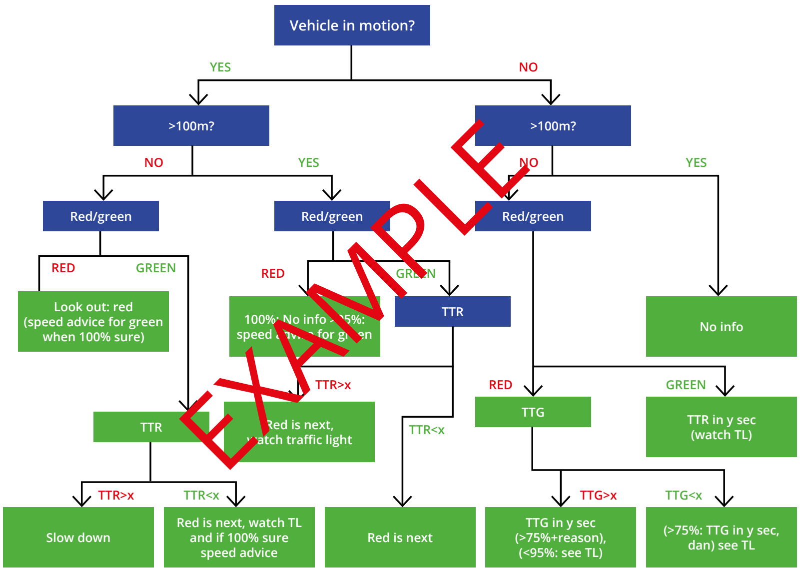
Use case description	
Situation	When reaching the head of the congestion, road user s should be given an in-car speed advice that will help in dissolving the congestion. The speed advice might be very or less specific. However, if a combination with VMS is developed, a specific speed is preferred, which can be aligned with the speed on the VMS.
Actors and relations	• Road user: Receive speed advice and change speed accordingly. • Road authority: deliver relevant data to the intermediary. This data will help service providers to determine where the head of the congestion might occur and calculate/predict whether speed advice might alleviate the situation. Taking speed advice on VMS into account if necessary. • Service provider: receive, use, validate and combine data They will also deliver speed advice to the road user. • Intermediary: Receiving and delivering data for the use case. • Road authority, intermediary or service provider: Determining when and where a speed advice to road users will aid in the dissolution of the congestion.
Scenario	Depending on the cooperation model: scenario could be: Road authority is sending intensities, travel times, incidents, event information, road closures/road works to the intermediary. The service provider receives the information from the intermediary and sends a speed advice to the road user. The service provider informs the intermediary of the speed advice. Road users that are driving in congestion which is expected to end, will receive a message with speed advice. The road user will shortly after receiving the message change speed. The intermediary receives information and turns this into a feed for road authorities. 
Display / alert principle	When arriving at the location where the congestion is ending, the road user can be warned in-car (with an app).
Functional Constraints / dependencies	• Quality and availability of congestion data should be high enough. • Warning should reach road users on time. • Privacy regulation.
Required data	• Location of congestion head • VMS information if available.

Use case functional description – Speed advice at traffic lights

Speed advice at traffic lights	
Use case introduction	
Summary	When a vehicle is driving towards a junction regulated by traffic lights, speed advice could be given to the road user such that he will pass the traffic lights during the green phase (=green wave). Unnecessary accelerating / decelerating can be avoided. Road users approaching traffic lights in cars receive a speed advice. The advice is based upon the predicted state of the traffic light (red/yellow/green) and helps road users determine if they have to decelerate, drive the same speed or accelerate for optimal traffic flow. In the Netherlands, this will build upon the framework delivered by Talking Traffic.
Background	When approaching a traffic light road users driving cars have several options. They can slow down, because there is red or yellow light or they can speed up, since there is a green light. This service will give a speed advice to the road user concerning the traffic light. This means that the road user might no longer have to slow down or brake before a red light, because they know that they will go through a green light, if they change their speed to the advice. Also, road users will know that speeding up to go through a green light might be useless, since there is no way to reach the green light in time. This will reduce some of the guesswork and will lead to better traffic flow, less emissions and a safer driving experience. Safety is an essential goal in relation to this use case. In talking traffic there are many aspects taken into consideration. For instance: how many seconds before green to we let road users know the light will turn green? From what distance to the traffic light should the advice be given? Etc…
Objective	Reduction of traffic emissions. Improved traffic safety. Improved traffic flow.
Desired behaviour	Road users change speed to comply with the advice given by service providers.
Expected benefits	Benefit to the road user: Better informed, safer and lower gas usage, Benefit to the road authority: improved traffic flow and reduced gas emissions (especially for trucks). Benefit to the service provider: this is an additional service to the road users, which might lead certain users to prefer their solution over other solutions.

Use case description	
Situation	The road user is approaching a traffic light. The road user receives a speed advice from the service provider. This advice might be in the form of a specific speed, but might also be in the form of a more generic advice (speed up, slow down, stay the same speed). The advice is based upon data from the (intelligent) traffic light.
Actors and relations	• Road user: The road user uses a navigation solution while approaching a traffic light. • Road authority: The traffic light sends out information about the most probable time the light turns green/yellow/red. This information is sent to the intermediary. • Intermediary: Receiving and sending of information from road authority to the service providers. • Service provider: Providing a speed advice based upon the data from road authorities.
Scenario	Depending on the cooperation model: scenario could be: • Road user approaches a traffic light. • The traffic light is sending out data to the intermediary. • Based upon the data the road user receives a speed advice.* • The road user changes speed.  * There are many variables to take into account. For example: The distance to the traffic light, whether the vehicle is in motion or not, the state of the traffic light, the next light in the cycle (whether there is a time to green or a time to yellow/red).

<table>
<tr><td>Display / alert principle</td><td>Here we describe triggering conditions and what is displayed to the user when.


</td></tr>
<tr><td>Functional Constraints / dependencies</td><td>For more details information from the talking traffic project should be used.</td></tr>
<tr><td>Required data</td><td>Location and direction of the different traffic lights (= MAP data)
• Time-to-green (= SPAT data)
• Time-to-red (= SPAT data)
• Location, heading and speed of incoming traffic participants, high temporal resolution!
• Number of vehicles waiting at the traffic light</td></tr>
</table>

Use case functional description – Speed advice at shockwaves

<table>
<tr><th colspan="2">Speed advice at shockwaves</th></tr>
<tr><th colspan="2">Use case introduction</th></tr>
<tr><td>Summary</td><td>By lowering traffic speed upstream of a shockwave, it is possible to reduce congestion or even to let a congestion shockwave disappear.

The road user receives speed advice as he drives. The speed advice is given when a system determines that a certain speed will reduce the chance of congestion. Optionally the road authority can display the same advice on their Variable Message Signs (VMS).</td></tr>
<tr><td>Background</td><td>Showing the road user an advice to change speed.</td></tr>
<tr><td>Objective</td><td>Reduction of Congestion, shockwave damping.

By reducing the intensity on certain roads, it is possible to reduce the amount of congestion.

When road users are advised to slow down, they will arrive later at a location where there is a high probability (or actual present at the time) of congestion. This will decrease the amount of vehicles that contribute to the congestion, increasing the likelihood of a smaller amount of congestion and a lower period needed for the congestion to dissolve.

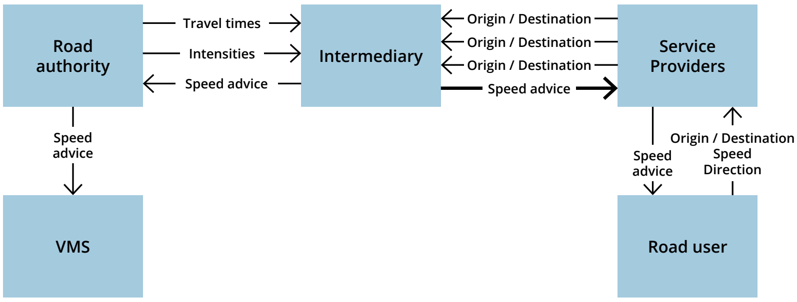
Perhaps it is also possible an advice to speed up (while adhering to the speed limit) might have a positive effect on potential congestion, if keeping the same speed (or lower) will increase the likelihood that the road user will arrive at a certain location along with a large group of other road users. It will have to be determined if this is possible.

There are two ways this system might work. One without additional VMS and one with VMS.
1. Without additional VMS. Based on a predetermined rule based system and data an actor (road authority, intermediary or service provider)* determines when and where a speed advice to road users might help reduce or prevent congestion. Road users receive a speed advice. Information on the amount of informed road users is transmitted to the intermediary. The intermediary turns this into a feed for road authorities. Road authorities receive this information and use this to ensure the systems that trigger on travel times do not mistake slower traffic for congestion (and thus suppress additional action).
2. With additional VMS. Based on a predetermined rule based system and data an actor (road authority, intermediary or service provider)* determines when and where a speed advice to road users might help reduce or prevent congestion. Road users receive a speed advice. Additionally road authorities show the same speed advice on VMS. Since the road authority knows that there is a speed advice in action, systems can suppress additional actions based on slower traffic.

* There is a case to be made to let any of the three involved parties determine when and where speed advice to reduce or prevent congestion. This should be further discussed.</td></tr>
<tr><td>Desired behaviour</td><td>Road users receive speed advice when it is pertinent. Road users change speed according to the speed advice.</td></tr>
</table>

Expected benefits	This will benefit the road authority: less congestion on the network. This will also benefit the road user: a more comfortable and informed driving experience. On the other hand, this might also be a detriment to certain road users: those that prefer less travel time over less time in congestion. This will finally benefit the service provider: this is an additional service to the road users, which might lead certain users to prefer their solution over other solutions.

Use case description	
Situation	When driving, road users will receive speed advice when it is relevant to preventing congestion. The message might be very specific (for a less congested travel experience a speed of 70 is advised) or less specific (for less congested travel experience we suggest you slow down). However, if a combination with VMS is developed, a specific speed is preferred. This speed advice could be part of a TM scenario as well (e.g. involving ramp metering) This system will need a process to determine where speed advice will have a positive impact on (predicted) congestion. This means that the system should know the route the road user will take. This means the road user is either using navigation or the road user is on a road that will inevitably lead to a congested part. Road users will have to receive this message when it is pertinent. Hopefully, a large enough part of the road users adhere to the message.
Actors and relations	• Road user: While driving receiving messages and adhering to these messages. • Road Authority: Delivering data for service providers to the intermediary. This data will help service providers to determine where congestion might occur and calculate/predict whether speed advice might alleviate the situation. Optionally showing the same speed advice on VMS. • Service provider: Delivering speed advice to the road user. • Intermediary: Receiving and delivering data for the use case. • Road authority, intermediary or service provider: Determining when and where a speed advice to road users will reduce or prevent congestion. First thought: Since there are many road authorities and many service providers, it seems like the intermediary might be the best location to determine this.

Scenario	Depending on the cooperation model: scenario could be: Road user is driving to a destination where congestion is expected on a part of the route. Road authority is sending intensities, travel times, incidents, event information, road closures/road works to the intermediary. The service provider receives the information from the intermediary and had their own data sources. Either through a service request or their own algorithms, the service provider sends a speed advice to the road user. The service provider informs the intermediary of the speed advice. The road user receives the speed advice and changes speed. The intermediary receives information and turns this into a feed for road authorities. 
Display / alert principle	When a situation occurs that can benefit from speed advice to road users. This will be based upon data and predictive technology.

Functional Constraints / dependencies	Navigation functions and/or destination are needed if the speed advice is giving in relation to a certain part of the route. If there is no destination set, the road user might take a different route, where there will be no congestion. An exception to this rule is a road user driving on a road that will inevitably lead to a congested part. Safety and advice compliance might be issues: it is unlikely that all (or even the majority of) road users will receive speed advice in relation to the (predicted) congestion. Therefore most surrounding road users will drive at a different speed. This might lead to an unsafe situation when road users comply to the advice. This issue can be mitigated by additionally using the road authorities VMS. This introduces a new issue: road users accustomed to speeds on VMS based upon very immediate congestion. When there is no congestion immediately, road users might lose trust in the signalling. Other road users driving at a different speed will probably impact advice compliance. The most important aspect that must be realised in developing this service is avoiding contradictory information on the roadside and in-car. This might happen when the current signalling system stays active while the new system doesn't take this into account. A contradictory situation might occur when the current signalling system advises 50 for very close traffic jam, while the in-car system advises 70 to reduce congestion further on the road (because this system has determined that the road user is too close to reduce or prevent congestion by lowering the speed). This should not occur. Many details need further inspection: the distance from the congestion where the speed advice is given. The exact speed advice given in relation to the amount of congestion. Will we use VMS or not and if not: will this work with other road users driving at a different speed? Etc...
Required data	• Location, heading and speed of incoming traffic participants, high frequent updates. • Lots of end users! • ...

Use case functional description – Lane information

Lane information	
Use case introduction	
Summary	Provide in-car information on the actual and upcoming lane-situation: • end of lane • open/end of rush hour (or other temporary) lane • open/end of interchangeable lane (lane dedicated to one driving direction depending on traffic) • closed lanes due to incidents / road works. In case of hard shoulder running (HSR): The road user receives information that the hard shoulder is open to traffic and is recommended to use it. In case of closed lanes: the road user receives information about closed lanes due to incidents/road works as he drives. The message subject is the temporary closed lanes given by the Traffic Centre. Lane Closures may be also subject to specific vehicle types (e.g. "no lorries" etc.)
Background	In case of HSR, in general, the hard shoulder is underused. Road users tend to hesitate on using the hard shoulder. Hard shoulders are usually used for broken-down vehicles or for other emergencies. However, this is quite rare, therefore road capacity of hard shoulders is not fully used. In case of closed lanes: in order to protect sites with incidents or road works, lanes are blocked and/or closed.
Objective	Safety & Comfort. This should minimise any doubts on the lane-situation for any road user. In case of HSR: The aim is to urge the road user to use the hard shoulder. In case of closed lanes: The aim is to alert the road user about the closed lanes so that he can move on towards an open lane.
Desired behaviour	In case of HSR: Road users using the hard shoulder more frequently.
Expected benefits	In case of HSR: increased road capacity; reduce congestion upstream; improved traffic safety due to reduced overtaking by the right (on the hard shoulder). In case of closed lanes: leaving blocked/closed lanes more smoothly.

Use case description	
Situation	In case of HSR: The road user receives information about the hard shoulder being open to traffic and is urged to use it as the right lane. In case of closed lanes: In case of an incident or road works, the traffic centre uses the lane control system (LCS) to display to the road user closed lanes (red cross). The same information could be displayed on an In-Vehicle Signage (IVS) service. On motorways that are not equipped with a physical LCS: a virtual LCS could be used, providing the same information to the IVS service.
Actors and relations	In case of HSR: • Traffic centre: takes decision to HSR and sends out the message. • Road user: The end-receiver that should benefit from this information, by receiving information on HSR. • Service provider: disseminates the message to the road user. In case of closed lanes: • Traffic centre: takes decision and sends out the message • Road user: The end-receiver that should benefit from this information, by receiving information on lane closures. • Service provider: disseminates the message to the road user.
Scenario	Depending on the cooperation model, the scenario could be: In case of HSR: • The Traffic Centre takes the decision to HSR • The vehicle receives information about HSR and the advice to use the hard shoulder as the regular right lane • The road user adapts his driving behaviour • The Traffic Centre permanently monitors the conditions on the hard shoulder. In case of detected broken-down vehicles or other emergencies, HSR is instantly out of operation. Vehicles and road users receive this information and are rerouted to regular lanes. In case of closed lanes: • The Traffic Centre takes the decision to close lanes (or gets informed about blocked lanes). • The vehicle receives information about closed lanes. • The road user adapts his driving behaviour (lane choice).
Display / alert principle	In case of HSR: • Display info in-car to road user. • In the future: broken-down vehicles or other emergencies along the hard shoulder will be detected by the vehicle (via its sensors) or by the road users (via apps etc.)
Functional Constraints / dependencies	As lane closures are legally binding traffic management measures, it has to be clarified how a legal binding can be also reached for virtual LCS.
Required data	Static and dynamic info on • end of lane • open/end of rush hour (or other temporary) lane • open/end of interchangeable lane (lane dedicated to one driving direction depending on traffic) • closed lanes due to incidents / road works.

Use case functional description – Lane advice at short on- and off-ramps

Lane advice at short on- and off-ramps	
Use case introduction	
Summary	On-ramp: A road user on the main road can be warned when there is a short on-ramp ahead. Lane advice could be to move to the left, especially when there is heavy traffic. Road users on the on-ramp can also be warned, especially when speed difference between main road and on-ramp is high. Off-ramp: Road users on the main road upstream of an off-ramp can be warned when there is a short off-ramp or when there is congestion on the off-ramp.
Background	Short off- and on-ramps are potentially dangerous situations especially during dense traffic, if the speed difference between the on-/ off-ramps and the main roads is high, or there is no clear line of sight. Providing in-car information about these potentially dangerous situations leads to the road user being able to anticipate to this situation on time.
Objective	Traffic Safety. Improving traffic flow.
Desired behaviour	Road users will be alerted in time when a dangerous situation occurs on short on-or off ramps and will be able to anticipate on time.
Expected benefits	Improved traffic flow and traffic safety.

Use case description	
Situation	When driving on the main road with a short on-ramp ahead, a warning can be given towards the road user on the main road to move to the left lane or to give road users on the ramp space to move in. When arriving on a short on-ramp for merging on the main road a warning (+ speed advice) can be given to alert the road user for the short ramp.
Actors and relations	• Road user: While driving receiving messages and adhering to these messages. • Road Authority: Delivering data for service providers to the intermediary. This data will help service providers to determine where short on-/off-ramps occur. • Service provider: Delivering speed and/or lane advice to the road user. • Intermediary: Receiving and delivering data for the use case. • Intermediary or service provider: Determining when (during dense traffic? Time window?) and where (main road or on short ramp? Both?) a warning (and speed and/or lane advice) to road users will be send.
Scenario	Depending on the cooperation model, the scenario could be: The road authority sends information to the intermediary about lane configuration and all locations of the short ramps. The intermediary receives and delivers all necessary information (lane, configuration, location short ramps, traffic information, speed information nearby the short ramps, ...) for the use case. The service provider will receive the information and transform this into a useful warning (and speed advice) for the road user. The vehicle receives a warning (and speed advice) when arriving at a short on-/off- ramp. The road user adapts his driving behaviour (speed).
Display / alert principle	The road user on the main road receives a warning when approaching a short ramp. This could contain a lane (and speed) advice. A road user who will use the ramp will receive a warning (and speed advice) when arriving on the ramp.
Functional Constraints / dependencies	Data provided by the road authorities should be sufficiently detailed.
Required data	Location of the on-and off-ramps. Lane configuration of the ramps and main roads.

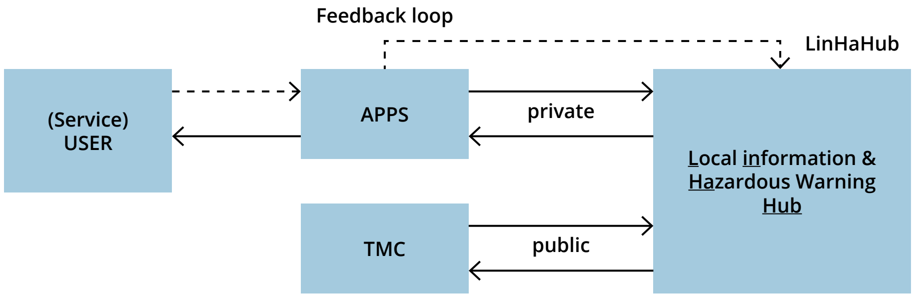
Use case functional description – Lane advice at traffic lights

Lane advice at traffic lights	
Use case introduction	
Summary	Redistribution of traffic over lanes in order to utilise the available capacity better and to optimise traffic throughput.
Background	With good in-car information it has become possible to give customised advice in terms of speed, route, etc. Advising road users with lane information at traffic lights in order to redistribute traffic over available lanes will result in more efficient traffic flows.
Objective	Traffic flow optimisation, reduction of congestion.
Desired behaviour	Road users will be redistributed over the available lanes which will result in more efficient traffic flows.
Expected benefits	Traffic flow optimisation. Reduction of congestion.

Use case description	
Situation	When road users arrive at (unknown) complex crossroads, it can be helpful to receive lane advice upfront. Especially when there is dense traffic and when this traffic is un-equally distributed over the lanes (for example: on one lane there is congestion and the other lane is open and free). A lane advice could distribute road users equally over the available lanes which will result in less congestion and less waiting time. Less (complicated) lane changes will have to be made by people, also reducing congestion.
Actors and relations	• Road user: While driving receiving messages and adhering to these messages. • Road Authority: Delivering data for service providers to the intermediary. • Intermediary: Receiving and delivering data for the use case. • Service provider: Delivering lane advice to the road user.
Scenario	Depending on the cooperation model, the scenario could be: A road user arrives at a traffic light with multiple available lanes. He will receive a message with lane advice from the service provider. The lane advice will be based on the route of the road user and on the information received from the Intermediary. The latter will gather the information from different road authorities. The information requested from the road authorities are lane configuration, traffic information, speed information nearby traffic lights, traffic density of the different lanes, ...
Display / alert principle	A message with lane advice is given when the traffic is not equally distributed over the different lanes.
Functional Constraints / dependencies	Data should be detailed enough to estimate densities on the different lanes.
Required data	Traffic speeds & intensities at different locations upstream of the traffic light (e.g. 20m and 200m upstream of traffic light). Position & speed of individual vehicles approaching the traffic light (high temporal resolution).

LOCAL INFORMATION AND HAZARDOUS WARNINGS

Service introduction	
Summary	Local Information and Hazardous Warning aim is to inform and warn vehicles on local situations and receiving feedback on the information from road users based on the current real world situation.
Use cases	• UC_LIHW_01: Road Works Warning • UC_LIHW_02: Road condition warning • UC_LIHW_03: Emergency Service protection • UC_LIHW_04: Environmental/Areal information and constraints



Use case functional description – Road Works Warning

Road Works Warning	
Use case introduction	
Summary	The road user receives notifications as he/she drives. The message subject are Environmental Notification and Warning Messages.
Background	Alert the user, on upcoming changes to the normal and to be expected driving situation.
Objective	The objective is to warn every passing vehicle and provide all available and relevant information, in a harmonised, timely and non-contradicting way, on the section of road it approaches, to the vehicle. And also to receive input/update information from the road user on new or current road works.
Desired behaviour	The vehicle receives all information and displays the information to the road user or makes it available to the drive system. The road user can give feedback when the current situation is different from the situation described by the data through the services which delivers the info to the user.
Expected benefits	Every road user/vehicle is aware of all current and oncoming road and driving conditions. Every road authority /service provider is aware of the current and updated road and driving conditions.

Use case description	
Situation	A vehicle approaches a section of road on which road works are located. The incident involves an oil leakage and as a consequence a slippery road on lane 2.
Actors and relations	The central system that holds the current information and condition of the road (this can be either put in manually of automatically). Roadside system for message delivery at/around the incident location. Passing traffic (either direction) for receiving the information. An intermediary should/could check and validate all retrieved information.
Scenario	A vehicle approaches and is within distance of a known road works site. It receives a warning message for the location of the road works. The warning message contains information on changed speed limits and lane restriction and layouts related to the road works site. The warning messages are transmitted from a central system. The central system generates a broader/wider/more general warning message to be broadcasted within a larger catchment area. The general warning message is broadcasted by roadside equipment within the relevant catchment area. The warning message is received by on-coming traffic and the vehicle acts accordingly. This can be done directly, by changing to another lane, or indirectly by advising the road user to change to another lane, or no warning is displayed as the vehicle has established that it is driving on a different road within the catchment area and the vehicle will not directly pass the incident location. The road user can give feedback on the reported road works through the services provider (information valid, situation changed, etc) that delivered the information. The road user can also report new road works to the services provider the system did not report on.

Display / alert principle	The vehicle displays/acts on the message when the path of the vehicle is crossing the location of the incident.
Functional Constraints / dependencies	Generating, sending and receiving of DEN-messages must be possible and a central system has to be in place to receive and redistribute the various messages and warnings. On-board vehicle status must be known.

Use case functional description – Road Condition Warning

Road Condition Warning	
Use case introduction	
Summary	The road user receives notifications as he drives. The message subject are Environmental Notification and Warning Messages.
Background	Alert the user, on upcoming changes to the normal and to be expected driving conditions.
Objective	The objective is to warn every passing vehicle and provide all available and relevant information, in a harmonised, timely and non-contradicting way on the section of road the vehicle approaches. And also receive input/update information from the road user on changed road conditions.
Desired behaviour	The vehicle receives all information and displays the information to the road user or makes it available to the drive system. The road user can give feedback when the current situation is different from the situation described by the data.
Expected benefits	Every road user/vehicle is aware of all current and oncoming road and driving conditions. Every road authority /service provider is aware of the current and updated road and driving conditions

Use case description	
Situation	A vehicle approaches a section of road on which the road condition has changed. The incident involves a pothole on lane 2.
Actors and relations	The central system that holds the current information and condition of the road (this can be either put in manually of automatically). Roadside system for message delivery at/around the incident location. Passing traffic (either direction) for receiving the information. An intermediary should/could check and validate all retrieved information.
Scenario	A vehicle detects an abnormity in the road surface. It generates a warning message for the location. The warning messages are relayed to a central system. The central system generates a broader/wider/more general warning message to be broadcasted within a larger catchment area. The general warning message is broadcasted by roadside equipment within the relevant catchment area. The warning message is received by on-coming traffic and the vehicle acts accordingly. This can be done directly, by changing to another lane and/or reduce speed, or indirectly by advising the road user to change to another lane or reduce speed, or no warning is displayed as the vehicle has established that it is driving on a different road within the catchment area and the vehicle will not directly pass the incident location. The road user can give feedback on the reported road condition through the services provider that delivered the information. The road user can also report a new road condition warning to the services provider the system did not report on.
Display / alert principle	The vehicle displays/acts on the message when the path of the vehicle is crossing the location of the incident.
Functional Constraints / dependencies	Generating, sending and receiving of DEN-messages must be possible and a central system has to be in place to receive and redistribute the various messages and warnings.

Use case functional description – Emergency Service protection

Emergency Service protection	
Use case introduction	
Summary	The road user receives notifications as he drives. The message subject are Environmental Notification and Warning Messages
Background	Alert the user, on upcoming emergency services active on driving lanes.
Objective	The objective is to warn every passing vehicle and provide all available and relevant information, in a harmonised, timely and non-contradicting way on the section of road the vehicle approaches.
Desired behaviour	The vehicle receives all information and displays the information to the road user or makes it available to the drive system. The road user can give feedback when the current situation is different from the situation described by the data.
Expected benefits	Every road user/vehicle is aware of all current and oncoming road and driving conditions.

Use case description	
Situation	A Road Marshall is deployed at an incident location. The Road Marshall (or his/her vehicle) sends a warning message indicating where he/she is located and how traffic has to avoid him/her.
Actors and relations	The central system that holds the current information and condition of the road (this can be either put in manually of automatically). Roadside system for message delivery at/around the incident location. Passing traffic (either direction) for receiving the information.
Scenario	A Road Marshall is deployed at an incident location. The Road Marshall (or his vehicle) sends a warning message indicating where he/she is located and how traffic has to avoid him/her. The warning messages are relayed to a central system. The central system generates a broader/wider/more general warning message to be broadcasted within a larger catchment area. The general warning message is broadcasted by roadside equipment within the relevant catchment area. The warning message is received by on-coming traffic and the vehicle acts accordingly. This can be done directly, by changing to another lane, or indirectly by advising the road user to change to another lane, or no warning is displayed as the vehicle has established that it is driving on a different road within the catchment area and the vehicle will not directly pass the incident location.
Display / alert principle	The vehicle displays/acts on the message when the path of the vehicle is crossing the location of the incident.
Functional Constraints / dependencies	Generating, sending and receiving of DEN-messages must be possible and a central system has to be in place to receive and redistribute the various messages and warnings.

Use case functional description – Environmental/Areal information and constraint

Environmental/Areal information and constrain	
Use case introduction	
Summary	The road user receives information as he drives. The message subject are Environmental Notification and Warning Messages.
Background	Alert the user, on upcoming environmental and/or Areal constraints and/or limitations.
Objective	The objective is to inform vehicles on upcoming driving limitations.
Desired behaviour	The vehicle receives all information and displays the information to the road user or makes it available to the drive system. The road user can give feedback when the current situation is different from the situation described by the data.
Expected benefits	Every road user/vehicle is aware of all current and oncoming road and driving constraints.

Use case description	
Situation	A vehicle is approaching an area with access limitations. For instance it is entering a city area.
Actors and relations	The central system transmits the current access limitations for that location to every passing vehicle. The information message is received by a passing vehicle. The vehicle assesses the received information.
Scenario	Access to a city is restricted for vehicles with a high emission value. A vehicle is approaching the city limits. The central system transmits the current access limitations for that location to every passing vehicle. The information message is received by a passing vehicle. The vehicle assesses the received information. The vehicle presents its findings on access limitations to the road user or the vehicle subsystem. If needed the vehicle plans a different route and/or changes its destination to the nearest point of the original destination where driving is allowed.
Display / alert principle	The vehicle displays/acts on the message when the path of the vehicle is crossing an area where the vehicle is not allowed to travel.
Functional Constraints / dependencies	Generating, sending and receiving of DEN-messages must be possible and a central system has to be in place to receive and redistribute the various messages and warnings.

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