Cooperative Systems Stakeholder Analysis

Berichte der
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Haftungsausschluss

Die Arbeit der EasyWay Cooperative Systems Task Force basiert auf Beiträgen und Meinungen der Interessensgruppen und Partner, die bei EasyWay mitwirken.
Die Ergebnisse der Task Force werden einen Freigabeprozess im EasyWAy Lenkungsausschuss durchlaufen. Alle Ergebnisse der einzelnen Arbeitspakete sind daher als vorläufige Beiträge zum Endergebnis der Task Force zu verstehen und sollten nur unter Berücksichtigung der oben genannten Rahmenbedingungen genutzt werden.

Abstract – Kurzfassung

Cooperative Systems Stakeholder Analysis

This report presents the results of a stakeholder analysis which has been performed by the EasyWay Cooperative Systems Task Force. The stakeholder analysis aims at identifying potential roles of the road operator in the operation process of selected cooperative services and describing expectations and aspirations related to the future roles and responsibilities from a European road operator's point of view.

The following cooperative services have been considered in the stakeholder analysis: Hazardous location notification, Traffic jam ahead warning, Road works warning, Automatic access control and Parking management. The stakeholder analysis used findings from previous projects and performed own studies based on desk research and expert assessments which were carried out by the task partners. The approach includes the development of high-level descriptions showing functional schemes of the operational process chains and potential roles / responsibilities related to the road operator. A deepened analysis was performed by assessing the functional schemes / role profiles and collecting opportunities, concerns, and success factors from a road operator's perspective.

Different options of potential role profiles have been developed for each service. It can be seen that the function scheme used for an option strongly influences the related role profile of the road operator. The involvement of the road operator in the operation process is not only a matter of process organisation, but has also to be considered when deciding on functional concepts.

Cooperative services dealing with traffic information and recommendations on itineraries, especially on a regional and nationwide level, require a stronger active role of the road operator in the operation process than is the case for safety related services. Traffic information and recommended itineraries transmitted to the road users have to match up with the traffic management strategies intended by the road operator. In contrast, many of the safety related cooperative services are time-critical and the processing of these services, including the involvement of the road operator, must be kept to a minimum in order to allow high promptness of the service.

The expert assessment identified expected strengths and weaknesses of the optional function schemes and role profiles from a road operator's view. The assessment was based on a set of criteria in terms of quality of service, organisational aspects of the operation process and financial implications of the service. The overall results do not show a clear preference for a single option. The options per service, which vary in function scheme and role profile, show different strengths and weaknesses over the criteria.

Functional solutions which use both WLAN communication (IEEE 802.11p) and cellular communication (GSM, UMTS, or LTE) seem to provide maximum applicability and availability. If both communication technologies are available on the in-vehicle communication platform, the system is able to flexibly adjust its mode of operation to the requirements of different services, changing traffic situations or national conditions of the road side infrastructure etc. The potential to select the appropriate communication technology on demand may also help to mitigate costs.

Chances and opportunities of cooperative services are mainly expected with regard to road safety and traffic efficiency. The collection and exchange of traffic related data will be improved. The road operator can benefit from receiving data generated by the vehicles.

Major concerns and risks are related to a possible mismatch of traffic information and routing recommendations transmitted to the road users by different service providers and different cooperative services. The effectiveness of the road operator's traffic management strategies may be impaired if traffic information and recommended itineraries transmitted to the road users do not match up with the traffic management strategies intended by the road operator. Other concerns and risks are expected with regard to legal and liability issues, privacy of personal data, costs to the road operator's account etc.

A number of critical success factors have been identified and are expected to be important for a successful operation of cooperative services, e.g. agreements on guidelines and strategies for route guidance, organisational development of public private partnerships, standardisation, clarification of the legal situation in the memberstates where required, compliance with privacy requirements and awareness and acceptance of cooperative services by the target groups.

Stakeholder-Analyse von kooperativen Systemen

Der Bericht gibt die Ergebnisse einer Stakeholder-Analyse wieder, die von der Projektgruppe „Kooperative Systeme“ im Rahmen des EU-Projekts EasyWay durchgeführt wurde. Ziel dieser Stakeholder-Analyse ist es, aus dem Blickwinkel europäischer Straßenbetreiber, mögliche Rollen des Straßenbetreibers im Zusammenhang mit dem Betrieb ausgewählter kooperativer

Dienste zu identifizieren sowie Erwartungen und Standpunkte im Bezug auf die zukünftigen Rollen und Verantwortlichkeiten zu beschreiben.

In der vorliegenden Studie werden folgende kooperativen Dienste betrachtet: Benachrichtigung über lokale Gefahrenstellen, Warnung vor vorausliegendem Stau, Warnung vor vorausliegender Baustelle, automatische Zugangskontrolle, Parkplatzsuche und -reservierung. Die Stakeholder-Analyse nutzt Erkenntnisse aus vorausgegangenen Projekten sowie Ergebnisse aus eigenen Studien, die auf theoretischen Betrachtungen und Expertenbewertungen der beteiligten Projektpartner basieren. In dem hier gewählten methodischen Ansatz werden zunächst schematische Funktionsbeschreibungen erstellt. Diese bilden die betriebsrelevanten Informations-/Kommunikationsprozesse der Dienste modellhaft ab und ordnen mögliche Rollen und Verantwortlichkeiten des Straßenbetreibers den einzelnen Teilprozessen der Prozesskette zu. Es schließt sich eine vertiefende Analyse an, in der die Funktionsschemen und Rollenprofile beurteilt und mögliche Chancen, Risiken und Erfolgsfaktoren aufgezeigt werden.

Für jeden der betrachteten kooperativen Dienste wurden mehrere Lösungsoptionen entwickelt und durch Funktionsschemata und entsprechenden Rollenprofile beschrieben. Es zeigt sich, dass die Wahl des Funktionsschemas einen erheblichen Einfluss auf die möglichen Rollen des Straßenbetreibers ausübt. Daraus lässt sich die Notwendigkeit ableiten, die Einbindung des Straßenbetreibers in die Prozesskette eines kooperativen Dienstes nicht nur als eine Frage der Prozessorganisation zu betrachten, sondern schon bei der Festlegung des funktionellen Konzepts eines Dienstes zu berücksichtigen.

Kooperative Dienste, die Verkehrsinformationen und Routenempfehlungen anbieten, scheinen eine stärkere aktive Rolle des Straßenbetreibers im Betriebsprozess zu erfordern als dies für verkehrssicherheitsbezogene kooperative Dienste der Fall ist. Denn die an die Verkehrsteilnehmer übermittelten Verkehrsinformationen und Routenempfehlungen müssen auf die Verkehrsmanagementstrategien des Straßenbetreibers abgestimmt sein. Bei Anwendungen zur Verkehrssicherheit steht dagegen häufig der Aspekt der Zeitkritikalität im Vordergrund, wie z. B. bei der Benachrichtigung über vorausliegende Gefahrstellen. Die Abwicklung in der Prozesskette muss hier möglichst kurz sein, um eine hohe Schnelligkeit dieser Dienste zu ermöglichen. Die Einbindung von Zwischenstationen in der Prozesskette, einschließlich des Straßenbetreibers, sollte daher auf das erforderliche Minimum beschränkt werden.

Die aus Sicht des Straßenbetreibers durchgeführte Expertenbewertung identifiziert Stärken und Schwächen der optionalen Funktionsschemata und Rollenprofile. Die Bewertung basiert auf Kriterien zu Qualität, Organisation des Betriebsprozesses und Kosten des Dienstes. Im Gesamtergebnis über alle Kriterien zeigt sich keine klare Präferenz für eine der Optionen. Allerdings zeigen die Optionen eines Dienstes unterschiedliche Stärken und Schwächen im Bezug auf die einzelnen Kriterien.

Kommunikationslösungen, die eine Kombination aus den beiden betrachteten Kommunikationstechnologien WLAN (IEEE 802.11p) und zellulärer Mobilfunk (GSM, UMTS, LTE) beinhalten, scheinen ein Maximum an Anwendungsmöglichkeiten und Verfügbarkeit bereitzustellen. Wenn beide Kommunikationstechnologien auf der fahrzeuginternen Kommunikationsplattform zur Verfügung stehen, ist das System in der Lage, seinen Kommunikationsmodus flexibel auf die Anforderungen der verschiedenen Dienste, wechselnden Verkehrssituationen oder nationalen Gegebenheiten der Straßeninfrastruktur etc. anzupassen. Wenn das System in der Lage ist, situationsgerecht die geeignete Kommunikationstechnologie zu wählen, kann dies auch zur Milderung der Kommunikationskosten bei kooperativen Systemen beitragen.

Chancen und Nutzen kooperativer Systeme werden vor allem im Hinblick auf Straßenverkehrssicherheit und Verkehrseffizienz erwartet. Die Erfassung und der Austausch von Verkehrsdaten werden sich damit weiter verbessern lassen. Der Straßenbetreiber kann aus den durch die Fahrzeuge erfassten und an ihn weitergeleiteten Verkehrsdaten profitieren.

Bedenken und erwartete Risiken beziehen sich hauptsächlich auf nicht aufeinander abgestimmte Verkehrsinformationen und Routenempfehlungen, die von einer Vielzahl von Dienstleistern in verschiedenen kooperativen Diensten an die Verkehrsteilnehmer gesendet werden könnten. Falls diese Verkehrsinformationen und Routenempfehlungen nicht auf die Verkehrsmanagementstrategien des Straßenbetreibers abgestimmt sind, werden Effektivitätseinbußen im Verkehrsfluss befürchtet. Weitere Risiken werden im Hinblick auf offene Fragen zum Verkehrsrecht und Haftungsrecht, Schutz persönlicher Daten und Kostenbelastung der Straßenbetreiber vermutet.

Aus Sicht der Straßenbetreiber werden Erfolgsfaktoren aufgezeigt, die für die erfolgreiche Einführung von kooperativen Systemen von Bedeutung sind, z. B. Vereinbarungen zu Richtlinien und Strategien für die Routenführung, organisatorische Weiterentwicklung von PPP (Public Private Partnership), Normung und Standardisierung, Klärung der rechtlichen Situation in den Mitgliedsstaaten soweit erforderlich, Einhaltung der Anforderungen hinsichtlich des Schutzes von persönlichen Daten, Sensibilisierung der Zielgruppen und deren Akzeptanz hinsichtlich kooperativer Systeme.

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1 Introduction

The goal of the EasyWay Cooperative Systems Task Force is to bring the point of view of the road operators and road authorities on how to deploy and use cooperative services in the future to the discussion. A stakeholder analysis is performed by the Task Force in Task 2.2 of work package "Cooperative Services".

1.1 Objectives and scope

The objective of Task 2.2 is to conduct a stakeholder analysis focusing on the road operator which is one of the stakeholder groups relevant for the deployment and operation of cooperative systems. This stakeholder analysis aims at contributing to a common understanding of the

- road operators' potential future roles and responsibilities, related to the operation of selected 1st priority services, and the
- road operators' expectations on strengths / weaknesses and benefits / risks related to their future roles and responsibilities.

Traditionally, a stakeholder analysis is defined as a process of identifying the parties (stakeholders) which are affected by a project or event, and analyzing the aspirations of the stakeholders regarding the incoming changes (COMeSafety Architecture Task Force, 2010). The stakeholder analysis has to be aligned with the project phase where the results of the analysis are to be used. Some examples: It may be performed in a very early project phase in order to define user requirements for the development of a new system. As a preparatory step in the development of system architecture, it may also be used to collect expectations of the stakeholders towards their responsibilities in the future operation process and to provide high-level descriptions of their expected roles. In project phases where the system is already well defined and close to implementation, the stakeholders may express their expectations towards their role in the deployment process.

This stakeholder analysis focuses on the stakeholder group road operator / road network manager and its potential roles in the operation process of cooperative systems. Cooperative systems use intelligent communication technologies based on vehicle-to-vehicle communication (V2V) and vehicle-to-infrastructure communication (V2I), i.e. vehicles and road-side infrastructure will serve both as sources and destinations of information related to road safety, traffic efficiency, environmental issues and mobility. Thus, the road operator will not only be affected by the impacts of cooperative systems but may also play an active part in the operation of cooperative systems because of the involvement of roadside infrastructure.

There is yet another aspect which affected the focus of this stakeholder analysis: Previous projects and studies on cooperative systems showed that there is a wide variety of stakeholders, differing in backgrounds, level of knowledge on cooperative systems and aims and interests (PRE-DRIVE C2X Consortium, 2009; COMeSafety Architecture Task Force, 2010). Most of the experts agree that a discussion of the different point of views of the stakeholders is needed, both on national and European level, in order to reach a consensus on how to use and deploy cooperative systems. These complex discussions between the different stakeholder groups have already been started, e.g. at joint stakeholder workshops of the projects EasyWay and PRE-DRIVE C2X in 2009 and 2010. The workshops will be continued in the future and provide a valuable platform for the stakeholders to exchange their views. As a conclusion of the EasyWay / PRE-DRIVE C2X workshop, it was recommended that each stakeholder group should sharpen his view on his own expectations. It is expected that this will facilitate the future discussions between the stakeholder groups and support the process of reaching a consensus. The EasyWay project can introduce the point of view of the road operators and road authorities, as these are the partners driving the EasyWay project. In this respect, this stakeholder analysis supports the EasyWay partners in describing their point of view on their potential roles for the operation of cooperative systems.

1.2 Interaction with other tasks

This task received input from Task 2.1 which proposed a list of seven EasyWay first priority cooperative services and provided descriptions of the underlying use cases (KULMALA, R. et al., 2010). Task 2.2 could not take all first priority cooperative services into account due to limited resources. The task partners selected the following services from the list and considered them in the stakeholder analysis. Each partner accepted responsibility for one of the considered services:

- Hazardous location notification: BASt
- Traffic jam ahead warning: LISITT
- Road works warning: AustriaTech and ASFINAG
- Automatic access control and parking management: Sweco

The outcome of Task 2.2 will feed into the subsequent tasks of the EasyWay Cooperative Systems Task Force, mainly into Task 3.2 Functional Architecture, Task 4.1 Business Case Development, and Task 4.2 Cost-Benefit Analysis. Finally, the results will flow into the preparation of a shared strategy and road map towards the future implementation of cooperative systems, which will be performed by WP6.

1.3 Participants

The task group consisted of the following EasyWay partners and persons: ASFINAG, AT (Marko Jandrisits), AUSTRIATECH, AT (Wolfgang Kernstock), LISITT, ES (José Fco. García Calderaro), SINA, IT (Fabio Ricci), Sweco, SE (Christian Udin & Pia Larsson). The task leader was Roland Schindhelm from BASt, DE.

2 Approach

This stakeholder analysis uses results from previous projects and performs own studies based on desk research and expert estimations, thus collecting the view of the partners involved in the EasyWay Cooperative Systems Task Force.

In order to identify a stakeholder's expectation towards his or her involvement in the operation of a future service, the stakeholder's prospect as to how the service may work has to be taken into account, i.e. the functional mode and operational process of the service. High-level descriptions have been regarded as being helpful to achieve understanding of and express specific expectations on processes and roles (COMeSafety Architecture Task Force, 2010). This approach uses high-level descriptions in order to receive some insight into both functional schemes of the operational process chains and potential roles / responsibilities related to the road operator. Based on the high-level descriptions a deepened analysis of the expectations is performed. The approach used consists of five steps:

- Review of general characteristics of the road operator
- Compilation of a general operational process chain
- Development of high-level descriptions showing options of potential operational process structures and related role profiles of the selected services
- Deepened analysis of expectations regarding the roles and responsibilities of the road operators
- Validation and refinement

Review of general characteristics of the road operator

Task 2.2 starts with the review of relevant reports of previous projects and other publications in order to collect prominent features characterizing the road operator. The features deal with the activities, responsibilities, underlying goals and categories of road operators.

Compilation of a generalised operational process chain

It was originally intended to identify the specific operational processes of the selected cooperative services from literature. But descriptions of specific operational processes could hardly be found for all considered services, or were not available on the same level of the description of features. It would have been difficult for the Task Force to compare and interpret them. Therefore, a generalised process chain is used in order to display the core operational process of all considered services in a simplified way. The compilation of the generalised process chain is based on examples found in literature (SPENCE, 2006; LOTZ, 2010).

Development of high-level descriptions showing options of potential functional schemes and related role profiles of the selected services

Based on the use cases provided by Task 2.1, the partners of Task 2.2 develop options of potential functional concepts and role profiles, which are described by using schematic diagrams.

The options vary in features of the information flow, such as location of the sensor used for detection of an event (inside vehicle, at the road side), signalisation of the event (event marked/unmarked by a radio signal), communication chain to vehicles nearby (V2V, V2I, V2I+TCC as an intermediary), communication technology (WLAN based communication, cellular communication, digital broadcasting). For each service specific options of functional schemes are derived from and described in terms of the included characteristics of the information flow. Using Floating Car Data (FCD) may lead to specific kinds of options for several services. However, FCD is rather a "meta"-service used to collect raw data from the vehicles than an end-user service focusing on dedicated notification messages. It has been agreed by the EasyWay Cooperative Systems Task Force to prioritise dedicated notification messages.

Then potential role profiles are deduced from the functional schemes by using schematic tables which connect the functional schemes to the generalised process chain. The tables allow for indicating potential roles of the road operator in the process chain.

The chart presented in Figure 1 shows how the main steps of this approach are connected, in order to derive potential roles of the road operator, and how these roles are discussed in the following deepened analysis.

Deepened analysis of expectations towards the roles and responsibilities of the road operators

In this step, the task partners' views are collected in order to show the road operators' expectations towards roles and responsibilities in the operational process chain of the considered services. This step tries to achieve a common view of the task partners, whereas country specific preferences may be pointed out during the validation step described below.

The optional function schemes / role profiles identified in the previous step are assessed by using a set of criteria which are derived from expectation categories in terms of quality of service,

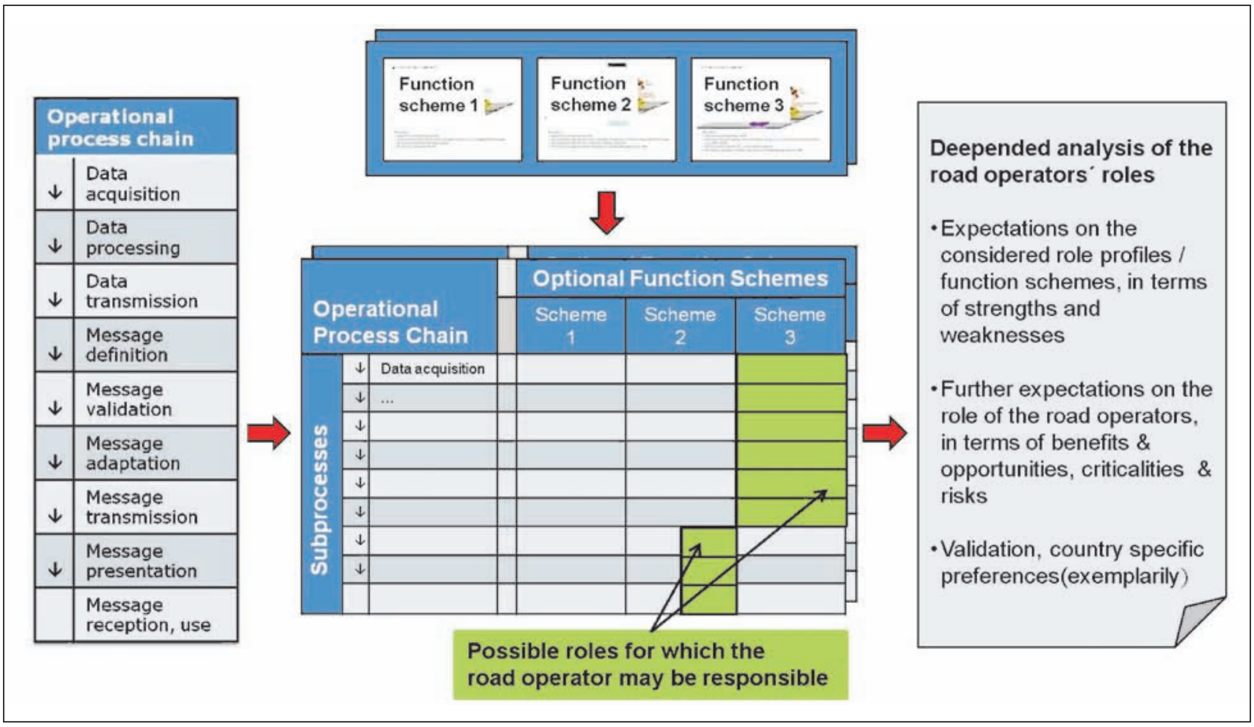

Fig. 1: Structure of the approach used for the stakeholder analysis

organisational aspects of the operation process and financial implications of the service. The assessment focuses on the identification of expected strengths and weaknesses. A two-step approach was used in the assessment in order to support the collection of expectations for each option. In the first step the options are rated by using a 5-point Likert scale. Then the task partners are asked to provide reasons for their judgements, i.e. to describe the expected strengths and weaknesses.

The further analysis of relevant expectations aims at the opportunities/chances and concerns/risks related to the road operators' roles in the operation process of the considered services. A questionnaire is used for the enquiry among the task partners.

Validation and refinement

A first validation loop is carried out by the task partners of T2.2. Furthermore, the report is commented on at EasyWay Task Force level. The Task Force partners are asked to discuss the results with their national road operators and road administrations. It is expected that different views on the stakeholder analysis will be received depending on the existing national situations, e.g. differences in the organisational structure of the road operator, country specific views and preferences on the envisioned roles and responsibilities of the road operator.

3 Results

The following subchapters show the results of the analysis according to the main steps of the approach described in chapter 2. Chapter 3.1 gives a short introduction of the stakeholder group "road operator" with regard to overall goals, activities and general types of road operators. Chapter 3.2 presents, for each service, developed options of potential function schemes and related role profiles of the road operator in the operational process of selected cooperative services. The options of each service have been named as option 1, option 2, option 3 etc. Options showing the same name are not necessarily equal among the services. Chapter 3.3 reports the results gained from the assessment of the functional schemes / role profiles. The results provide expected strengths and weaknesses from a road operator's view. Chapter 3.4 shows the task partners' views towards a) opportunities/chances, b) concerns/risks, and c) critical success factors related to the road operators' involvement in the operation and use of cooperative services.

3.1 General types and characteristics of the road operator

A general description of the stakeholder "Road Operator" is given by the COMeSafety Architecture Task Force (2010):

"This actor represents an organisation that is responsible for maintaining a road network and managing the traffic on it. It can be a private company or an organisation belonging to central government or a local authority."

The term "Road Operator" involves the "Road Network Operator" which is a human entity that uses the facilities of a traffic control centre (TCC) to actively manage the traffic flows in the road network.

A more specific picture of the current role of the road operators can be achieved when looking at overall goals, activities and main types of road operators. These characteristics do not present a complete picture of the current situation, but help to understand the views and expectations of the road operators towards the future operation of cooperative services collected later on in this study.

Overall goals of the road operator

- Optimum use of the existing road net resources by the road users
- Optimum safety level for the road users
- Minimum negative environmental impact
- High cost-efficiency of the service

Activities of the road operator

- Management of traffic data: To collect, administer, validate, simulate, forecast traffic data etc.
- Control and inducement of traffic: To harmonize traffic flow, optimize the distribution of traffic in the road net; to adjust the road capacity dynamically to the traffic situation; to provide information to the road users regarding traffic situation, local hazards etc.

- Management of strategies: To develop strategies for control and the inducement of traffic and the synchronisation of relevant information; to develop strategies for certain incidents / events / situations etc.
- Management of the road infrastructure and road side infrastructure: Monitoring and maintenance of the road condition, winter service etc.
- Management of the communication system, IT-system: Monitoring and maintenance of the IT-related equipment etc.

Main types of road operators on an institutional level

The types are described in terms of public private partnership, i.e. the types consider the apportionment of activities between public and private bodies involved in road operation. The EC member states differ in their organisational structure of highway road operation and the existing type of road operator on an institutional level. In some member states several types of road operators exist.

- The road operator is a public authority. Most of the activities of road operation are conducted by the public road operator himself. A few activities are contracted out to private service providers. Examples: Germany, The Netherlands
- The road operator is a public authority. The public road operator predominantly acts as a supervisor of a considerable number of private contractors which take over specific activities in the process chain of road operation. Examples: Finland, Sweden
- The road operator is a private service provider responsible to a public road authority. The road operator competes with other providers. Examples: Austria, France, Italy

3.2 Potential roles of the road operator in the operational process of selected first priority services

The potential roles described in this chapter can be taken by a public or a private road operator or a joint venture of both. We decided not to differentiate between public and private road operators, but to look at the potential roles of the road operator more generally. A differentiation between public and private road operators would have made the description of role profiles much more complicated and would have resulted in an increasing number of options, e.g. by taking potential business cases into account. The development of potential business cases, however, was beyond the scope of this task.

3.2.1 Core process chain and related generalised roles

The generalised process chain used in order to describe the core operational process of the considered services has been compiled from process chains found in literature (SPENCE, 2006, LOTZ, 2010). The generalised process chain starts with data acquisition of the event (situation, sign) for which the service aims to provide information to the user (see Figure 2).

Two types of events (situations, signs) are considered: The event has to be detected, if it is not marked by a radio signal, e.g. hazardous location on the road surface. In case of events marked by a radio signal, the signal is expected to include relevant information on the event, e.g. mobile work zone which carries a mobile RSU sending the signal. After the raw data are processed, a number of sub-processes are needed in order to prepare the message. Finally, the message is transmitted to the user.

Responsibility for the sub-processes can be expressed by generalized roles. Figure 3 shows a selection of different sets of generalised roles, which have been introduced in former studies dealing with organisational architectures of cooperative systems.

The potential responsibilities of the road operator, which are presented in the following chapters, are described by using the generalised roles “owner” (e.g. owner of the road side equipment responsible for procurement, purchasing maintenance services from contractors etc.), “content provider” (responsible for data generation, data acquisition and processing), “service provider” (responsible for message definition and processing) and “user” (e.g. making use of the information received from a cooperative service and feeding it in other services via traditional media such as Variable Message Signs (VMS), radio etc.).

The road operator is one of the possible actors who may take one or several roles in the operation process of cooperative systems. Other actors are involved in the operation of the cooperative service as well, but are not considered in this study, e.g. vehicle manufacturers, communication network providers and operators, service companies, road authorities and end users.

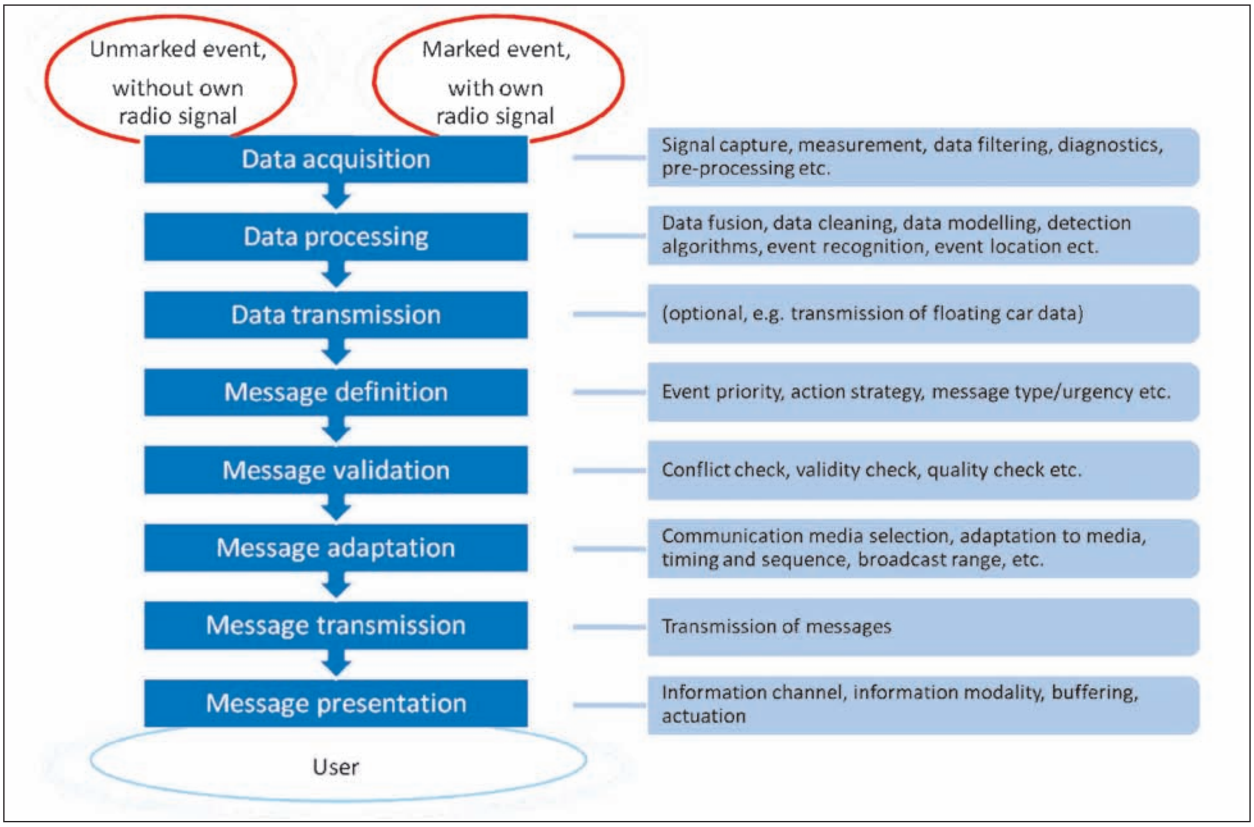

Fig. 2: Core process chain (on the basis of SPENCE, 2006, LOTZ, 2010)

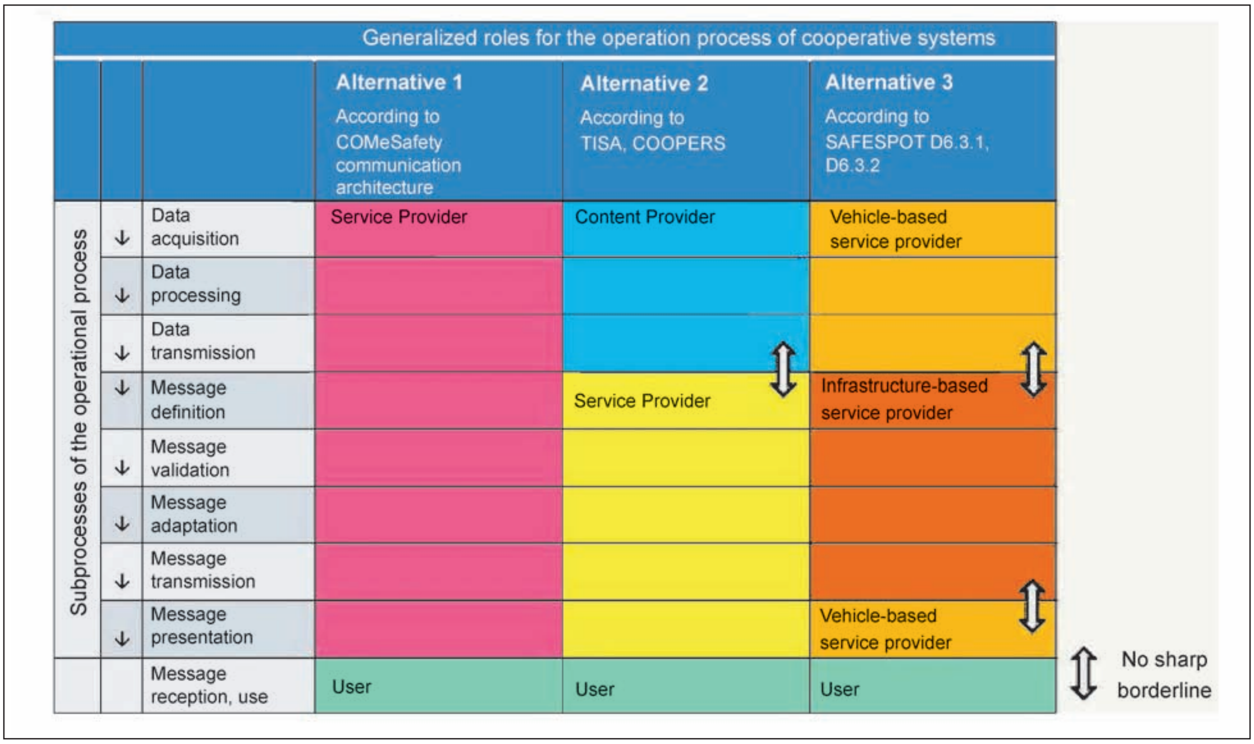

Fig. 3: Generalised roles

3.2.2 Service “Hazardous location notification”

This chapter shows options of potential functional schemes and role profiles developed for the service “Hazardous location notification”.

3.2.2.1 Option 1

Option 1 of the service “Hazardous Location Notification” is based on the function scheme shown in Figure 4. The information flow related to this function scheme has been projected on the operational process chain (Figure 5). The resulting table allows for identifying potential roles of the road operator relating to option 1.

Characteristics of the function scheme (see Figure 4)

- Detection by vehicle-based sensor
- Communication with vehicles in the immediate vicinity via V2V using WLAN-technology
- No communication with the infrastructure
- No communication with the TCC

Potential roles of the road operator (see Figure 5)

- There are no responsibilities in the operation process which are assigned to the road operator.
- The road operator is not an actor in the operation process.

Subprocesses of the operational process chain		Option 1
↓ Data acquisition	Content Provider	Vehicle
↓ Data processing		Vehicle
↓ Data transmission		Inside vehicle
↓ Message definition	Service Provider	Vehicle
↓ Message validation		Vehicle
↓ Message adaptation		Vehicle
↓ Message transmission		V2V WLAN
↓ Message presentation		Vehicle
	User	Driver

Fig. 5: Information flow of option 1 projected on the operational process chain (service “Hazardous Location Notification”)

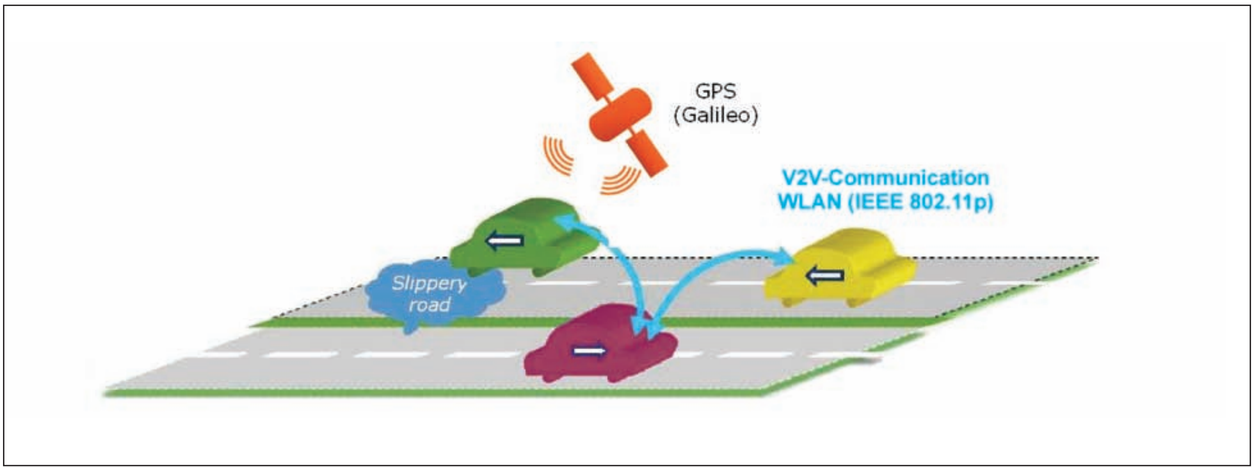

Fig. 4: Function scheme of option 1 (service “Hazardous Location Notification”)

3.2.2.2 Option 2

Option 2 of the service “Hazardous Location Notification” is based on the function scheme shown in Figure 6. The information flow related to this function scheme has been projected on the operational process chain (Figure 7). Based on the responsibilities indicated in Figure 7, potential roles of the road operator relating to option 2 have been identified.

Characteristics of the function scheme (see Figure 6)

- Detection by vehicle-based sensor
- Communication with vehicles in the immediate vicinity via V2V and V2I using WLAN-technology; Traffic Control Centre (TCC) is not an intermediary for the communication with nearby vehicles
- Communication of the RSU with the TCC (I2TCC) via cellular network or proprietary net (wired, wireless)
- TCC initiates messages to road users located further away via other media, e.g. via Variable Message Signs (VMS) or Digital Audio Broadcast (DAB)

Potential roles of the road operator (see Figure 7)

- Owner of the infrastructure equipment for communication via V2I-WLAN
- Service provider of the infrastructure-based service which includes receiving messages from and transmitting messages to vehicles via V2I-WLAN
- Owner of the infrastructure equipment for the proprietary net used for communication between RSUs and TCC (I2TCC communication)
- Service provider of the infrastructure-based service for I2TCC communication using the proprietary net
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

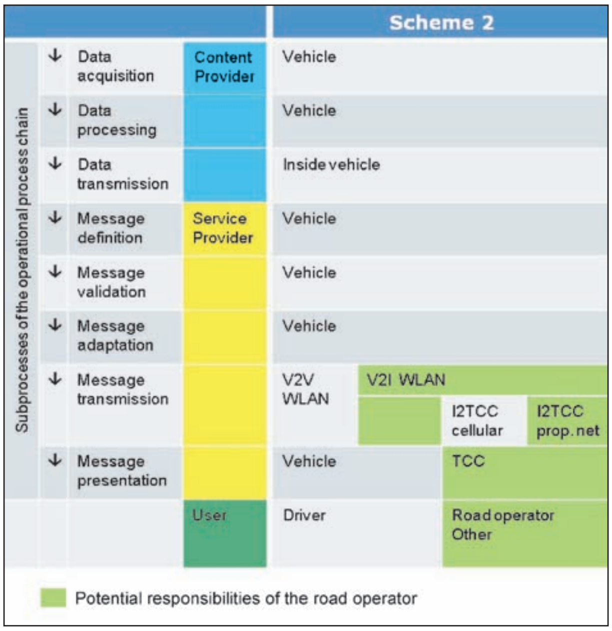

Fig. 7: Information flow of option 2 projected on the operational process chain (service “Hazardous Location Notification”)

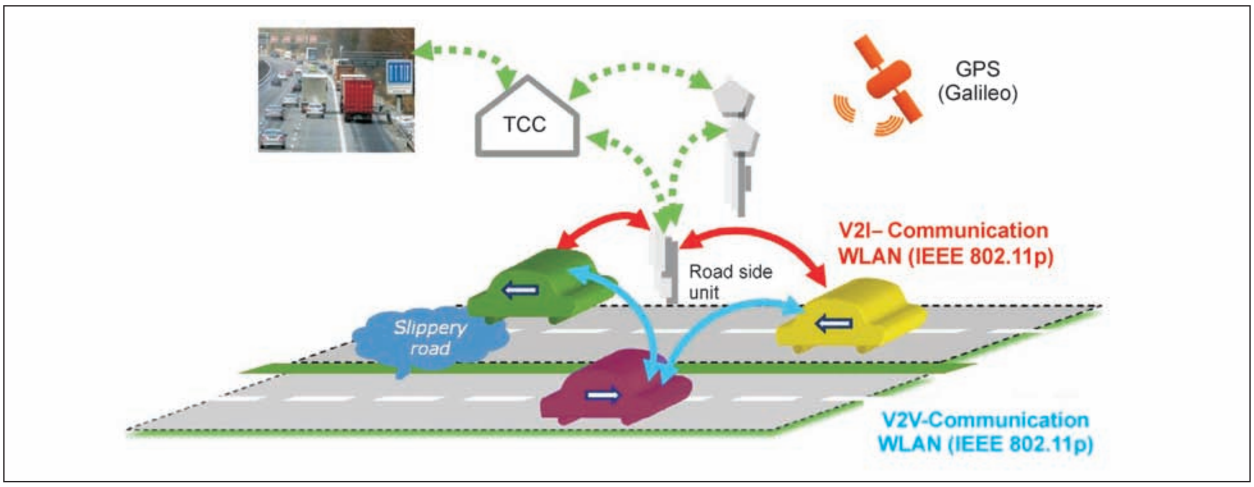

Fig. 6: Function scheme of option 2 (service “Hazardous Location Notification”)

3.2.2.3 Option 3

Option 3 of the service “Hazardous Location Notification” is based on the function scheme shown in Figure 8. The information flow related to this function scheme has been projected on the operational process chain (Figure 9). Based on the responsibilities indicated in Figure 9, potential roles of the road operator relating to option 3 have been identified.

Characteristics of the function scheme (see Figure 8)

- Detection by infrastructure-based sensor
- Communication of the RSU with vehicles in the immediate vicinity via V2I using cellular communication (e.g. GPRS, UMTS, LTE); Traffic Control Centre (TCC) is not an intermediary for the communication with nearby vehicles
- Communication of the RSU with the TCC via cellular network or proprietary net (wired, wireless)
- TCC initiates messages to road users located further away via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 9)

- Owner of the infrastructure equipment for data acquisition and V2I-communication
- Content provider responsible for data acquisition and processing including verification
- Service provider of the infrastructure-based service which includes message definition, validity check, adaptation etc., and handover to the cellular network (not responsible for routing within the cellular net)
- Owner of the infrastructure equipment for the proprietary net used for communication between RSUs and TCC (I2TCC communication)
- Service provider of the infrastructure-based service for I2TCC communication using the proprietary net
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

Subprocesses of the operational process chain		Option 3		
Data acquisition	Content Provider	Road infrastructure		
Data processing		Road infrastructure		
Data transmission		Inside road infrastructure		
Message definition	Service Provider	Road infrastructure.		
Message validation		Road infrastructure.		
Message adaptation		Road infrastructure		
Message transmission		V2I cellular	I2TCC cellular	I2TCC prop. net
Message presentation		Vehicle	TCC	
	User	Driver	Road operator, Other	

Potential responsibilities of the road operator

Fig. 9: Information flow of option 3 projected on the operational process chain (service “Hazardous Location Notification”)

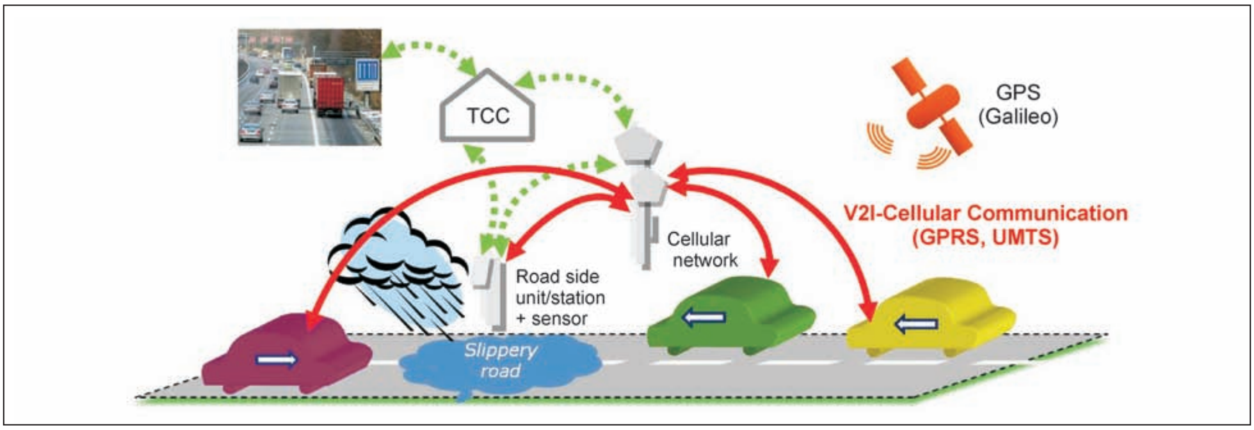

Fig. 8: Function scheme of option 3 (service “Hazardous Location Notification”)

3.2.2.4 Option 4

Option 4 of the service "Hazardous Location Notification" is based on the function scheme shown in Figure 10. The information flow related to this function scheme has been projected on the operational process chain (Figure 11). Based on the responsibilities indicated in Figure 11, potential roles of the road operator relating to option 4 have been identified.

Characteristics of the function scheme (see Figure 10)

- Detection by vehicle-based sensor
- Communication with vehicles in the immediate vicinity via V2I using cellular communication (e.g. GPRS, UMTS, LTE); Traffic Control Centre (TCC) is not an intermediary for the communication with nearby vehicles
- Communication with the TCC via the cellular network
- TCC initiates messages to road users located further away via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 11)

- Service provider of the internal service for presentation of the messages in the TCC; (not responsible for the transmission of the messages, as the messages are transmitted to the TCC by a cellular communication provider)
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

Subprocesses of the operational process chain		Option 4	
Data acquisition	Content Provider	Vehicle	
Data processing		Vehicle	
Data transmission		Inside vehicle	
Message definition	Service Provider	Vehicle	
Message validation		Vehicle	
Message adaptation		Vehicle	
Message transmission		V2I cellular	
Message presentation		Vehicle	TCC
	User	Driver	Road operator, Other

Potential responsibilities of the road operator

Fig. 11: Information flow of option 4 projected on the operational process chain (service "Hazardous Location Notification")

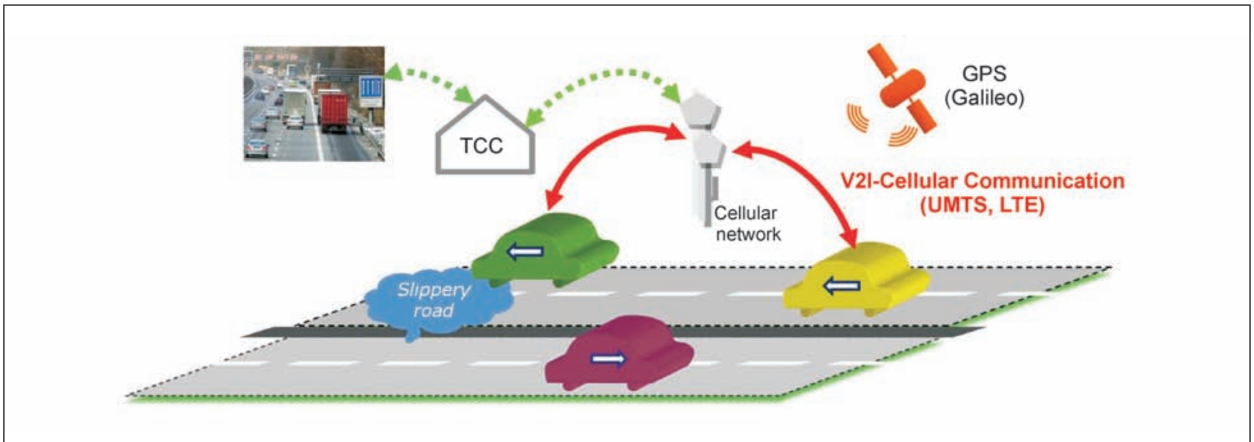

Fig. 10: Function scheme of option 4 (service "Hazardous Location Notification")

3.2.2.5 Option 5

Option 5 of the service “Hazardous Location Notification” is based on the function scheme shown in Figure 12. The information flow related to this function scheme has been projected on the operational process chain (Figure 13). Based on the responsibilities indicated in Figure 13, potential roles of the road operator relating to option 5 have been identified.

Characteristics of the function scheme (see Figure 12)

- Detection by vehicle-based sensor
- In-vehicle system contains two communication devices, one for WLAN-communication, the other for cellular communication; the in-vehicle system automatically selects the appropriate communication technology:
    - o Communication via V2V using low-cost WLAN-technology in case traffic intensity is high enough, or in case of poor coverage of the cellular net
    - o Communication via V2I using cellular communication technology in case traffic intensity is too low for WLAN-communication
- Traffic Control Centre (TCC) is not an intermediary for the communication with nearby vehicles
- Communication with the TCC via the cellular network
- TCC initiates messages to road users located further away via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 13)

- Service provider of the internal service for presentation of the message in the TCC (not responsible for the transmission of the messages, as the messages are transmitted to the TCC by a cellular communication provider)
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

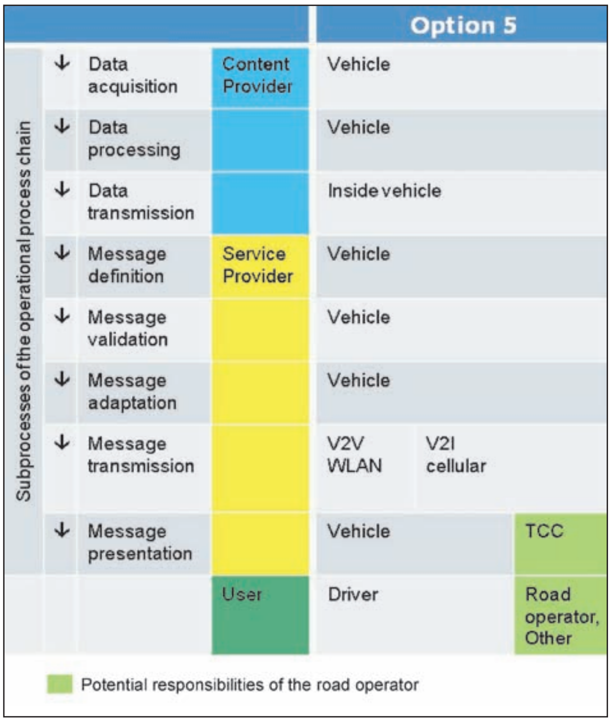

Fig. 13: Information flow of option 5 projected on the operational process chain (service “Hazardous Location Notification”)

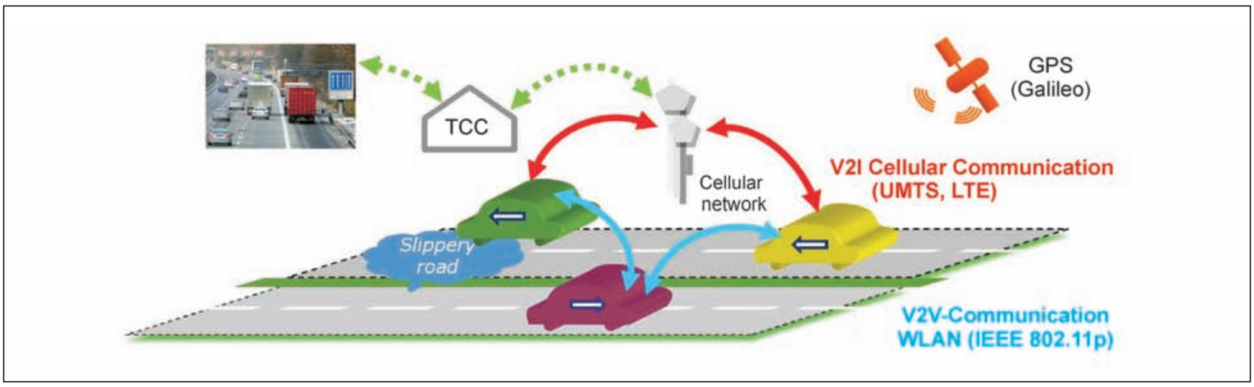

Fig. 12: Function scheme of option 5 (service “Hazardous Location Notification”)

3.2.2.6 Option 6

Option 6 of the service “Hazardous Location Notification” is based on the function scheme shown in Figure 14. The information flow related to this function scheme has been projected on the operational process chain (Figure 15). Based on the responsibilities indicated in Figure 15, potential roles of the road operator relating to option 6 have been identified.

Characteristics of the function scheme (see Figure 14)

- Detection by infrastructure-based sensor
- No direct communication of the RSU with vehicles in the immediate vicinity; Traffic Control Centre (TCC) is always an intermediary for the communication with nearby vehicles
- Communication of the RSU with the TCC via cellular network or proprietary net (wired, wireless)
- Communication of the TCC with vehicles in the immediate vicinity via V2I using cellular communication
- TCC initiates messages to road users located further away, via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 15)

- Owner of the infrastructure equipment for data acquisition and V2I-communication
- Owner of the infrastructure equipment for the proprietary net used for communication between RSUs and TCC (I2TCC prop. net)
- Content provider responsible for data acquisition and processing including verification; handover to the cellular network in case of data transmission to the TCC via the cellular net (not responsible for routing of the messages to the TCC within the cellular net)
- Service provider of the infrastructure-based service which consists of data transmission to the TCC via the proprietary net
- Service provider of the TCC-based service which includes message definition, validity

Subprocesses of the operational process chain		Option 6	
Data acquisition	Content Provider	Road infrastructure	
Data processing		Road infrastructure	
Data transmission		I2TCC cellular	I2TCC prop. net
Message definition	Service Provider	TCC	
Message validation		TCC	
Message adaptation		TCC	
Message transmission		V2I cellular	Inside TCC
Message presentation		Vehicle	TCC
	User	Driver	Road operator, Other

Potential responsibilities of the road operator

Fig. 15: Information flow of option 6 projected on the operational process chain (service “Hazardous Location Notification”)

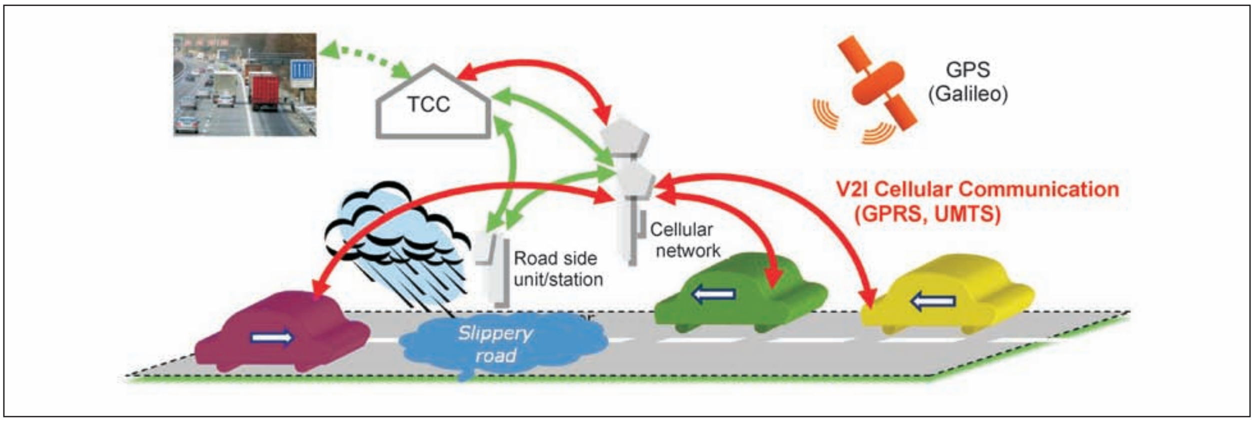

Fig. 14: Function scheme of option 6 (service “Hazardous Location Notification”)

check, adaptation and handover to the cellular network for message transmission to the vehicles (not responsible for routing of the messages to the vehicles within the cellular net)

- Service provider of the internal service for I2TCC communication using the proprietary net
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

3.2.3 Service "Traffic jam ahead warning"

This chapter shows options of potential functional schemes and role profiles developed for the service "Traffic jam ahead warning".

3.2.3.1 Option 1

Option 1 of the service "Traffic Jam Ahead Warning" is based on the function scheme shown in Figure 16. The information flow related to this function scheme has been projected on the operational process chain (Figure 17). Based on the responsibilities indicated in Figure 17, potential roles of the road operator relating to option 1 have been identified.

Characteristics of the function scheme (see Figure 16)

- Detection by vehicle-based sensor & messages from other vehicles
- Communication with vehicles in the immediate vicinity via V2V using WLAN-technology
- No communication with the infrastructure
- No communication with the TCC

Potential roles of the road operator (see Figure 17)

- There are no responsibilities in the operation process which are assigned to the road operator
- The road operator is not an actor in the operation process

Subprocesses of the operational process chain		Option 1
Data acquisition	Content Provider	Vehicle
Data processing		Vehicle
Data transmission		Inside vehicle & V2V
Message definition	Service Provider	Vehicle
Message validation		Vehicle
Message adaptation		Vehicle
Message transmission		V2V WLAN
Message presentation		Vehicle
	User	Driver

Fig. 17: Information flow of option 1 projected on the operational process chain (service "Traffic Jam Ahead Warning")

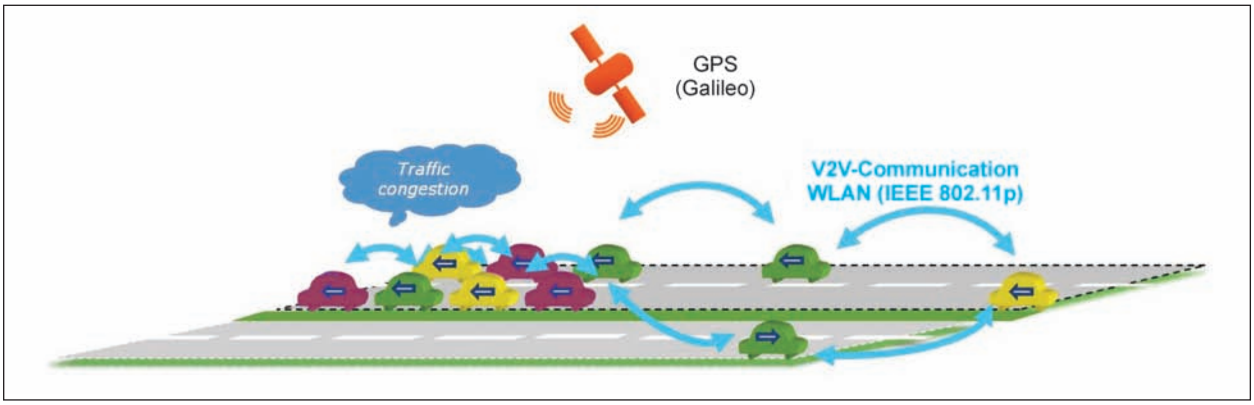

Fig. 16: Function scheme of option 1 (service "Traffic Jam Ahead Warning")

3.2.3.2 Option 2

Option 2 of the service "Traffic Jam Ahead Warning" is based on the function scheme shown in Figure 18. The information flow related to this function scheme has been projected on the operational process chain (Figure 19). Based on the responsibilities indicated in Figure 19, potential roles of the road operator relating to option 2 have been identified.

Characteristics of the function scheme (see Figure 18)

- Detection by
  a) vehicle-based sensor & messages from other vehicles, and/or
  b) RSU using (raw) data sent by the vehicles (Floating Car Data); RSU contains a logical device to validate the raw data received and generate messages
- Communication with vehicles in the immediate vicinity via V2V and V2I using WLAN-technology; TCC not an intermediary for communication with nearby vehicles
- Communication of the RSU with the TCC via proprietary net (wired, wireless etc.)
- TCC initiates messages to road users located further away via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 19)

- Owner of the infrastructure equipment for communication via V2I-WLAN
- Service provider of the infrastructure-based service which includes receiving messages and raw data from vehicles, validating, and transmitting messages to vehicles via V2I-WLAN
- Owner of the infrastructure equipment for the proprietary net used for communication between RSUs and TCC (I2TCC communication)
- Service provider of the infrastructure-based service for I2TCC communication using the proprietary net
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

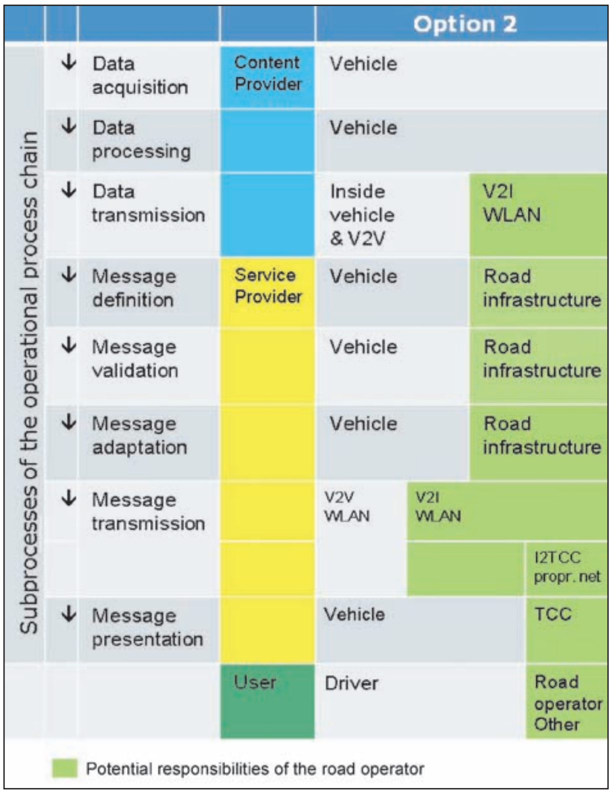

Fig. 19: Information flow of option 2 projected on the operational process chain (service "Traffic Jam Ahead Warning")

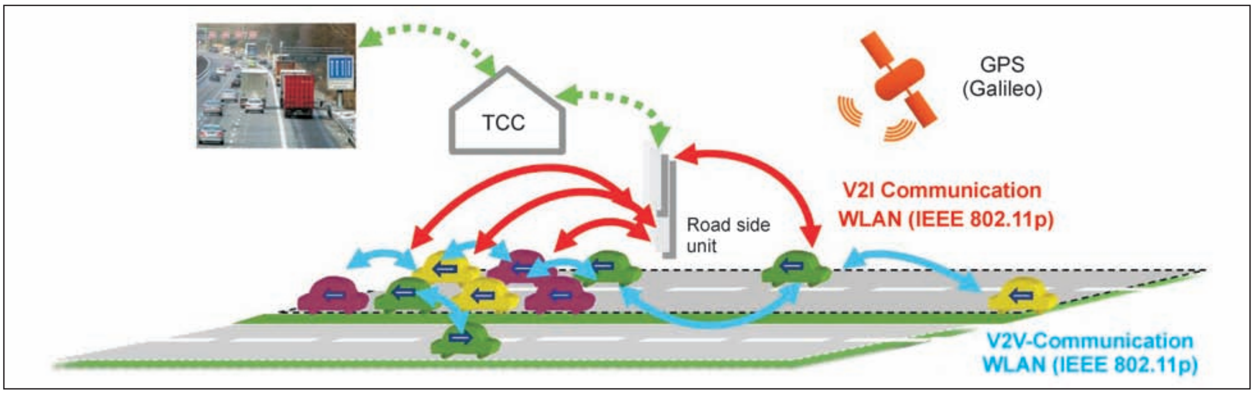

Fig. 18: Function scheme of option 2 (service "Traffic Jam Ahead Warning")

3.2.3.3 Option 3

Option 3 of the service “Traffic Jam Ahead Warning” is based on the function scheme shown in Figure 20. The information flow related to this function scheme has been projected on the operational process chain (Figure 21). Based on the responsibilities indicated in Figure 21, potential roles of the road operator relating to option 3 have been identified.

Characteristics of the function scheme (see Figure 20)

- Detection by infrastructure-based sensor
- Communication with vehicles in the immediate vicinity via V2I using cellular communication (e.g. GPRS, UMTS); TCC not an intermediary for communication with nearby vehicles
- Communication of the RSU with the TCC via the cellular network or proprietary net
- TCC initiates messages to road users located further away via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 21)

- Owner of the infrastructure equipment for data acquisition and V2I-communication
- Content provider responsible for data acquisition and processing including verification
- Service provider of the infrastructure-based service which includes message definition, validity check, adaptation etc., and handover to the cellular network (not responsible for routing within the cellular net)
- Owner of the infrastructure equipment for the proprietary net used for communication between RSUs and TCC (I2TCC communication)
- Service provider of the infrastructure-based service for I2TCC communication using the proprietary net
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

Subprocesses of the operational process chain		Option 3		
Data acquisition	Content Provider	Road infrastructure		
Data processing		Road infrastructure		
Data transmission		Inside road infrastructure		
Message definition	Service Provider	Road infrastructure.		
Message validation		Road infrastructure.		
Message adaptation		Road infrastructure		
Message transmission		V2I cellular	I2TCC cellular	I2TCC prop. net
Message presentation		Vehicle	TCC	
	User	Driver	Road operator, Other	

Potential responsibilities of the road operator

Fig. 21: Information flow of option 3 projected on the operational process chain (service “Traffic Jam Ahead Warning”)

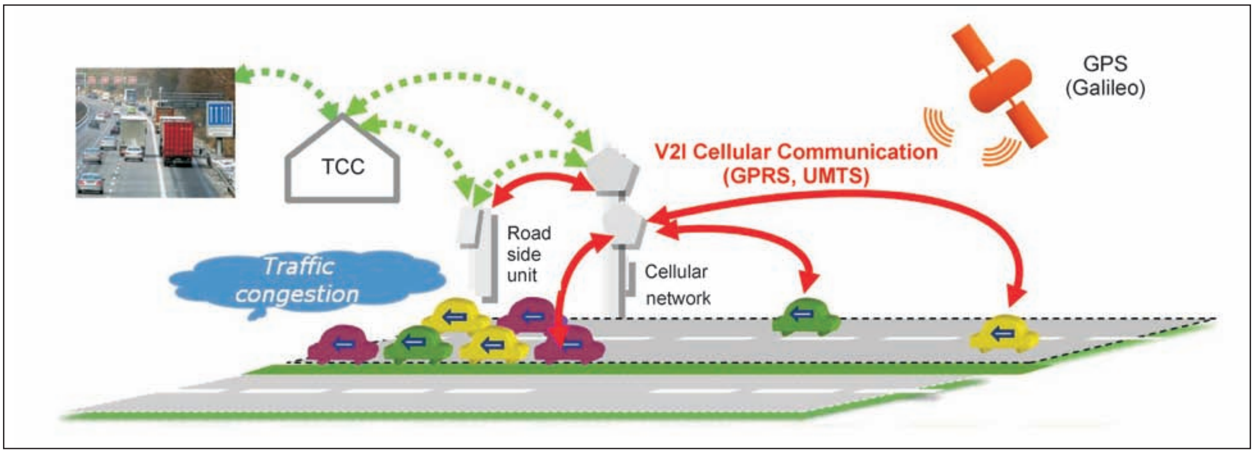

Fig. 20: Function scheme of option 3 (service “Traffic Jam Ahead Warning”)

3.2.3.4 Option 4

Option 4 of the service “Traffic Jam Ahead Warning” is based on the function scheme shown in Figure 22. The information flow related to this function scheme has been projected on the operational process chain (Figure 23). Based on the responsibilities indicated in Figure 23, potential roles of the road operator relating to option 4 have been identified.

Characteristics of the function scheme (see Figure 22)

- Detection by the TCC using data sent by the vehicles (FCD)
- No direct communication between the vehicles in the immediate vicinity; TCC is always the intermediary. Data transmission from the vehicles to the TCC via V2I using cellular communication (e.g. GPRS, UMTS, and LTE)
- Communication of the TCC with vehicles in the immediate vicinity via V2I using cellular communication (e.g. GPRS, UMTS, LTE)
- TCC initiates messages to road users located further away via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 23)

- Service provider of the TCC-based service, which includes message definition from raw data received from vehicles via cellular network, validity check and handover to the cellular network (not responsible for routing within the cellular net); incl. presentation of the messages in the TCC
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

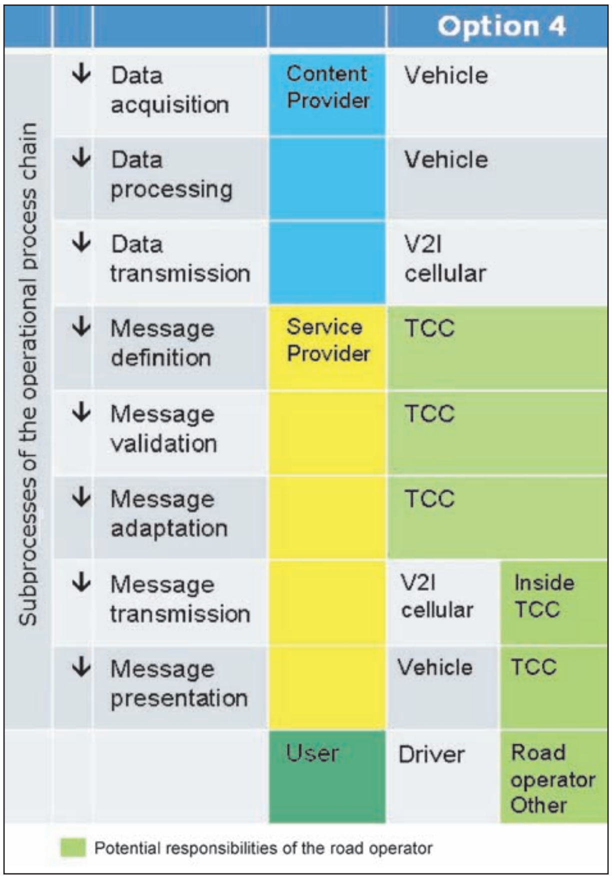

Fig. 23: Information flow of option 4 projected on the operational process chain (service “Traffic Jam Ahead Warning”)

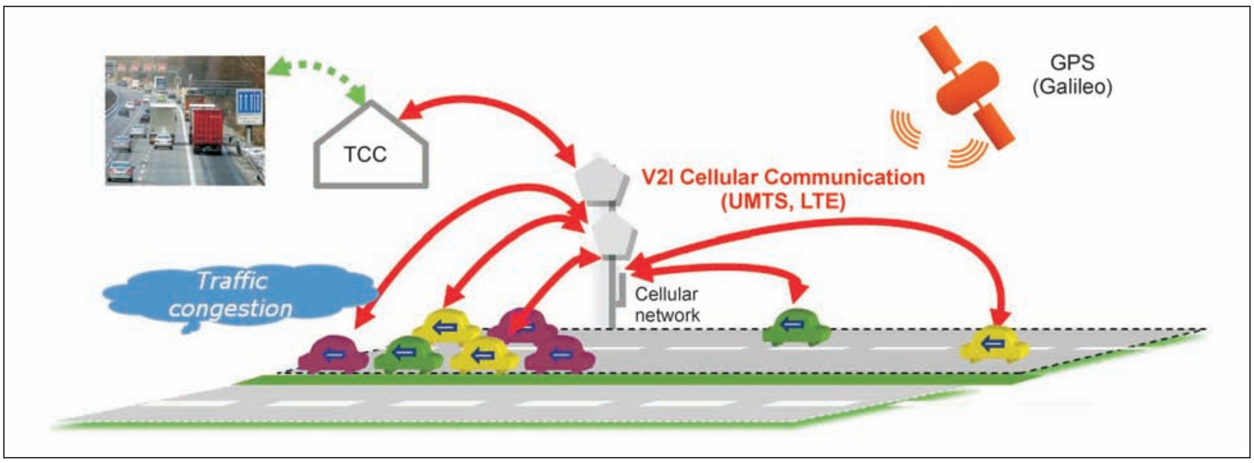

Fig. 22: Function scheme of option 4 (service “Traffic Jam Ahead Warning”)

3.2.3.5 Option 5

Option 5 of the service "Traffic Jam Ahead Warning" is based on the function scheme shown in Figure 24. The information flow related to this function scheme has been projected on the operational process chain (Figure 25). Based on the responsibilities indicated in Figure 25, potential roles of the road operator relating to option 5 have been identified.

Characteristics of the function scheme (see Figure 24)

- Detection by vehicle-based sensor and other vehicle messages
- In-vehicle system contains two communication devices, one for WLAN-communication, the other for cellular communication; the in-vehicle system automatically selects the appropriate communication technology:
    - o Communication via V2V using low-cost WLAN-technology, in case traffic intensity is high enough, or in case of poor coverage of the cellular net
    - o Communication via V2I using cellular communication technology in case traffic intensity is too low for WLAN-communication
- Traffic Control Centre (TCC) is not an intermediary for the communication with nearby vehicles
- Communication with the TCC via the cellular net
- TCC initiates messages to road users located further away via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 25)

- Service provider of the internal service for presentation of the message in the TCC (not responsible for the transmission of the messages, as the messages are transmitted to the TCC by a cellular communication provider)
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

Subprocesses of the operational process chain		Option 5		
Data acquisition	Content Provider	Vehicle		
Data processing		Vehicle		
Data transmission		Inside vehicle		
Message definition	Service Provider	Vehicle		
Message validation		Vehicle		
Message adaptation		Vehicle		
Message transmission		V2V WLAN	V2I cellular	
Message presentation		Vehicle		TCC
	User	Driver		Road operator Other

Potential responsibilities of the road operator

Fig. 25: Information flow of option 5 projected on the operational process chain (service "Traffic Jam Ahead Warning")

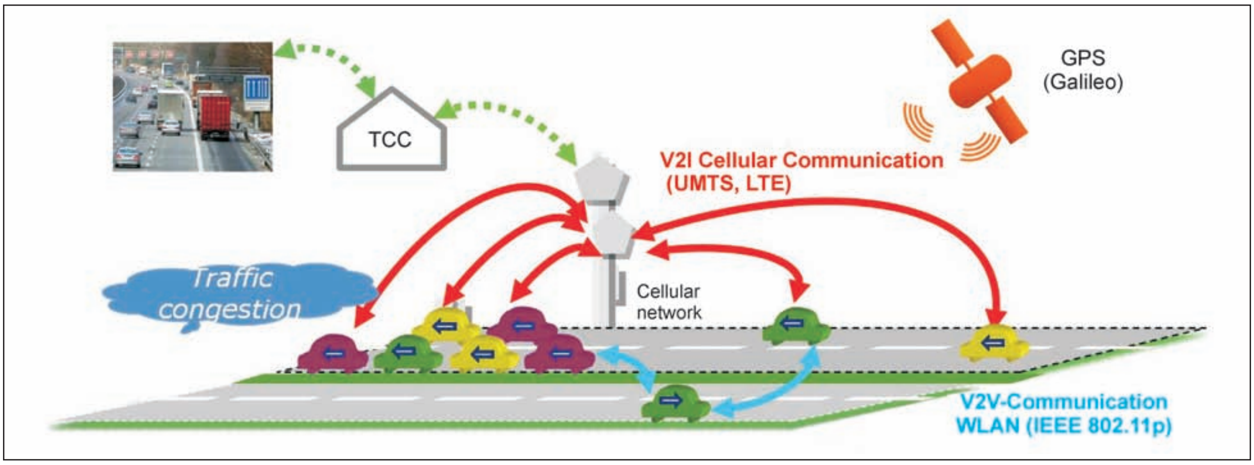

Fig. 24: Function scheme of option 5 (service "Traffic Jam Ahead Warning")

3.2.3.6 Option 6

Option 6 of the service "Traffic Jam Ahead Warning" is based on the function scheme shown in Figure 26. The information flow related to this function scheme has been projected on the operational process chain (Figure 27). Based on the responsibilities indicated in Figure 27, potential roles of the road operator relating to option 6 have been identified.

Characteristics of the function scheme (see Figure 26)

- Detection by vehicle-based sensor & messages from other vehicles
- Communication with vehicles in the immediate vicinity via V2V and V2I using WLAN-technology. RSU transmits the messages or raw data received from the vehicles, but contains no logical device to validate raw data (in contrast to scheme 2); TCC not an intermediary for communication with nearby vehicles.
- Communication of the RSU with the TCC via proprietary net (wired, wireless etc.)
- TCC initiates messages to road users located further away via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 27)

- Owner of the infrastructure equipment for communication via V2I-WLAN
- Service provider of the infrastructure-based service which includes receiving messages from and transmitting messages to vehicles via V2I-WLAN
- Owner of the infrastructure equipment for the proprietary net used for communication between RSUs and TCC (I2TCC communication)
- Service provider of the infrastructure-based service for I2TCC communication using the proprietary net
- User of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media

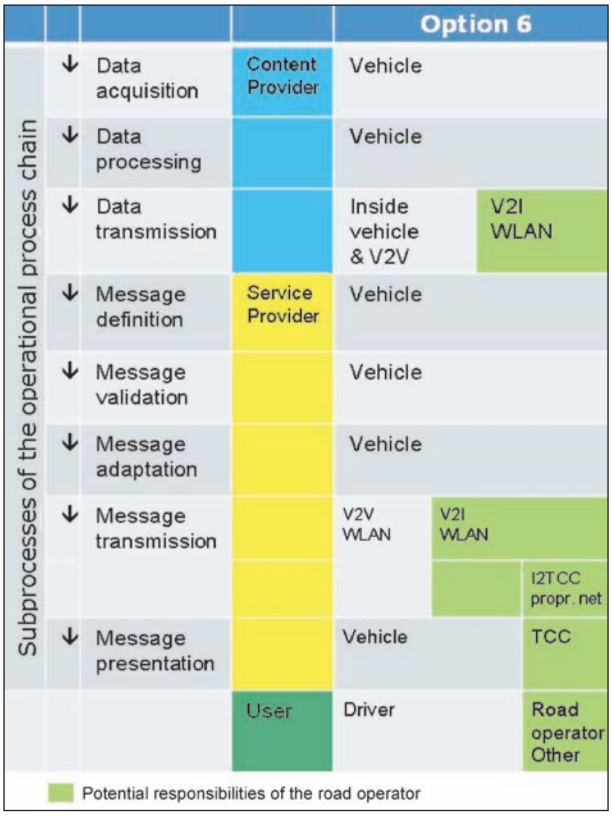

Fig. 27: Information flow of option 6 projected on the operational process chain (service "Traffic Jam Ahead Warning")

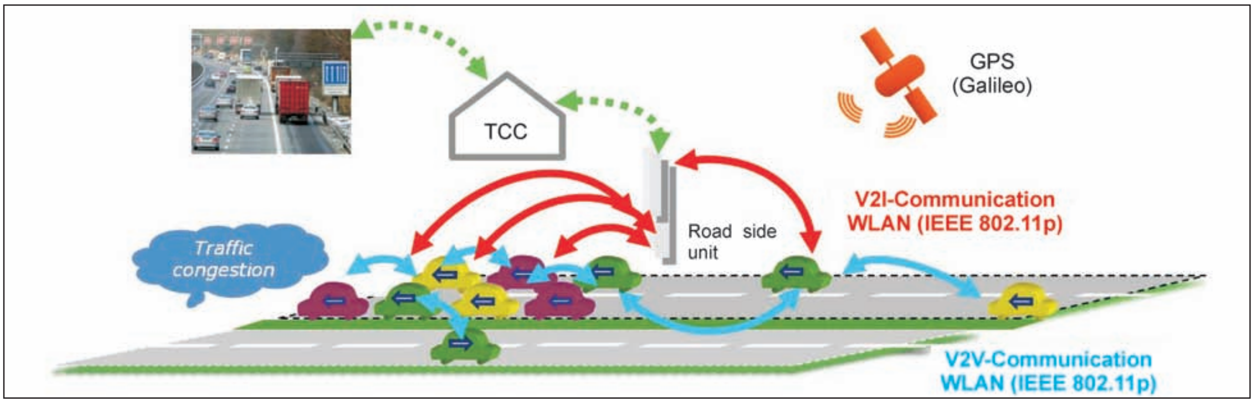

Fig. 26: Function scheme of option 6 (service "Traffic Jam Ahead Warning")

3.2.4 Service "Road works warning"

This chapter shows options of potential functional schemes and role profiles developed for the service "Road works warning".

3.2.4.1 Option 1

Option 1 of the service "Road Works Warning" is based on the function scheme shown in Figure 28. The information flow related to this function scheme has been projected on the operational process chain (Figure 29). Based on the responsibilities indicated in Figure 29, potential roles of the road operator relating to option 1 have been identified.

Characteristics of the function scheme (see Figure 28)

- TCC / road operator knows the existence and location of the road works
- Communication of the TCC with approaching vehicles via V2I using cellular communication (downlink only), i.e. the TCC periodically sends a message which is displayed inside the vehicle and may include a warning as well as further information, e.g. beginning of the construction site, length, recommended speed etc.
- TCC initiates messages to road users located further away, via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 29)

- Content provider responsible for providing the data of the construction site (e.g. location, number of lanes, speed limit)
- Service provider of the TCC-based service which includes message definition, validity check, adaptation etc., and handover to the cellular network (not responsible for routing of the messages to the vehicles within the cellular net)
- User of the messages when executing other tasks for which the road operator is responsible, e.g. providing messages to road users located further away or other service suppliers via other media

Subprocesses of the operational process chain		Option 1	
↓ Data acquisition	Content Provider	TCC	
↓ Data processing		TCC	
↓ Data transmission		Inside TCC	
↓ Message definition	Service Provider	TCC	
↓ Message validation		TCC	
↓ Message adaptation		TCC	
↓ Message transmission		V2I cellular	Inside TCC
↓ Message presentation		Vehicle	TCC
	User	Driver	Road operator, Other

Potential responsibilities of the road operator

Fig. 29: Information flow of option 1 projected on the operational process chain (service "Road Works Warning")

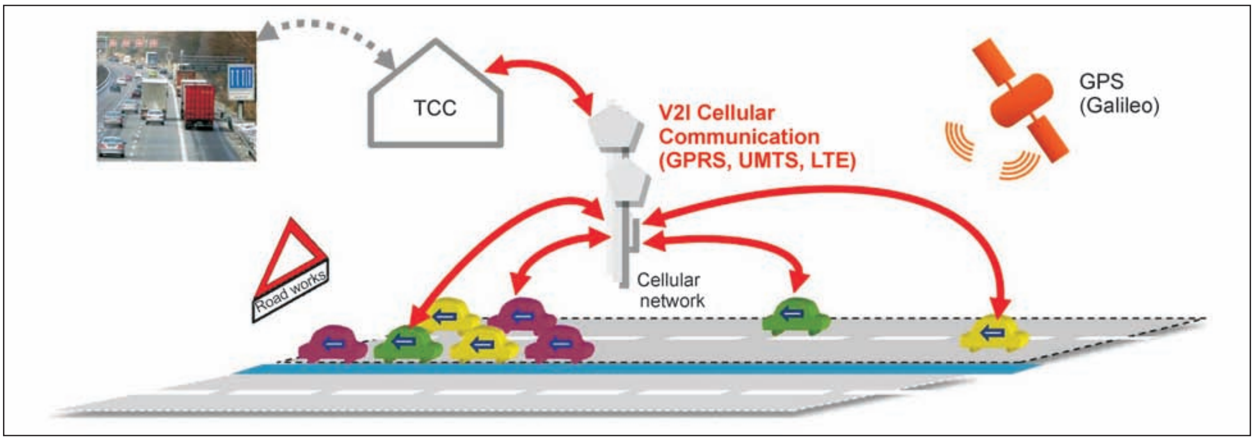

Fig. 28: Function scheme of option 1 (service "Road Works Warning")

3.2.4.2 Option 2

Option 2 of the service "Road Works Warning" is based on the function scheme shown in Figure 30. The information flow related to this function scheme has been projected on the operational process chain (Figure 31). Based on the responsibilities indicated in Figure 31, potential roles of the road operator relating to option 2 have been identified.

Characteristics of the function scheme (see Figure 30)

- Road works carries mobile RSU or site vehicle which periodically sends messages to approaching vehicles in the immediate vicinity, via V2I or V2V using WLAN-technology (downlink only); the message may include warning, beginning and end of the construction site, recommended speed etc.
- Communication between the vehicles via V2V using WLAN-technology
- Communication of the mobile RSU / site vehicle with the TCC via cellular network or proprietary net (wireless)
- TCC initiates messages to road users located further away, via other media, e.g. via VMS or DAB

Potential roles of the road operator (see Figure 31)

- Owner of the mobile RSUs which is equipped with a sender providing information on the road works via V2I-WLAN and can be positioned near the construction site
- Content provider responsible for providing the data / parameters needed for setting the mobile RSU (e.g. data on the progress of the construction work)
- Service provider of the infrastructure-based service, i. e. responsible for running the mobile RSU, processing the data in the mobile RSU and transmitting messages to vehicles via V2I-WLAN
- Owner of the infrastructure equipment for the proprietary net used for communication between mobile RSUs and TCC (I2TCC communication)
- Service provider of the infrastructure-based service for I2TCC communication using the proprietary net

Subprocesses of the operational process chain		Option 2			
Data acquisition	Content Provider	Mobile road side unit/ Site vehicle			
Data processing		Mobile road side unit/ Site vehicle			
Data transmission		Inside mobile road side unit/ Inside site vehicle			
Message definition	Service Provider	Mobile road side unit/ Site vehicle			
Message validation		Mobile road side unit/ Site vehicle			
Message adaptation		Mobile road side unit/ Site vehicle			
Message transmission		V2V WLAN	V2I WLAN	I2TCC cellular	I2TCC prop. net
Message presentation		Vehicle		TCC	
	User	Driver		Road operator Other	

Potential responsibilities of the road operator

Fig. 31: Information flow of option 2 projected on the operational process chain (service "Road Works Warning")

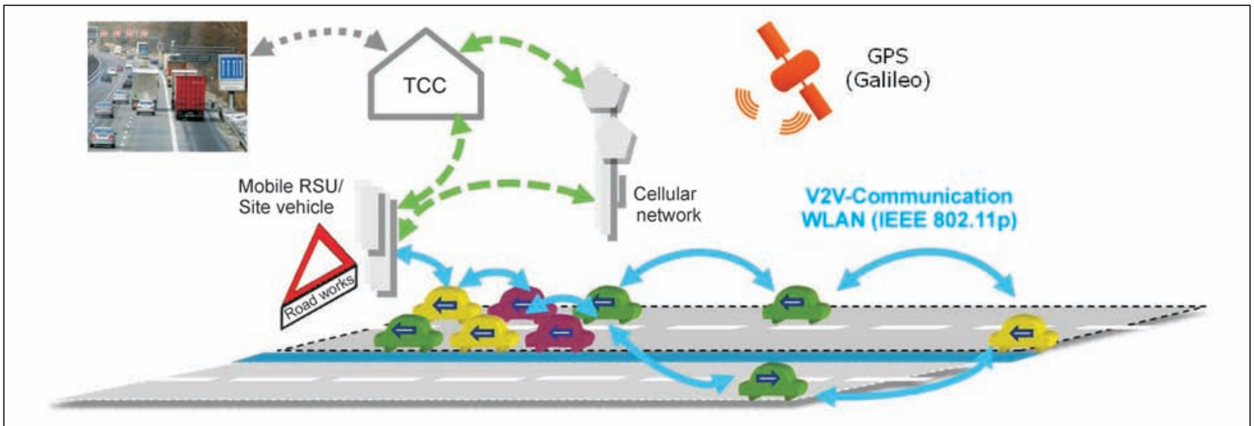

Fig. 30: Function scheme of option 2 (service "Road Works Warning")

- User of the messages when executing other tasks for which the road operator is responsible, e.g. providing messages to road users located further away or other service suppliers via other media (especially in those cases where mobile work zones determine by themselves changes at the site, such as precise location, available lanes, recommended speed)

3.2.5 Service "Automatic access control"

This chapter shows options of potential functional schemes and role profiles developed for the service "Automatic access control".

3.2.5.1 Option 1

Option 1 of the service "Automatic Access Control" is based on the function scheme shown in Figure 32. The information flow related to this function scheme has been projected on the operational process chain (Figure 33). Based on the responsibilities indicated in Figure 33, potential roles of the road operator relating to option 1 have been identified.

Characteristics of the function scheme (see Figure 32)

- Detection of vehicle by infrastructure-based sensor
- RSU processes, whether vehicle has access; no communication of the RSU with the back office/TCC for check of authorisation; fully automatic access control by the RSU
- Communication of the RSU with the vehicle via V2I using short range communication (DSRC, WLAN, or other short range communication techniques)
- Direct communication between driver and back office, only if necessary (e.g. information about access conditions, pre-booking, enquiry call of the back office) via V2I cellular communication or cellular communication using a personal nomadic device
- Communication of the RSU with the TCC via cellular network or proprietary net
- TCC forwards messages from the RSU to road users located further away via other media if access to the restricted access area is temporarily denied

Subprocesses of the operational process chain		Option 1		
Data acquisition	Content Provider	Road Infrastructure		
Data processing		Road Infrastructure		
Data transmission		Inside road infrastructure		
Message definition	Service Provider	Road Infrastructure		
Message verification		Road Infrastructure		
Message adaptation		Road Infrastructure		
Message transmission		V2I DSRC / WLAN	I2TCC cellular	I2TCC propr. net
Message presentation		Vehicle	Back office / TCC (+comm. with driver via cellular net, if necessary)	
	User	Driver (+comm. with back office via cellular net, if necessary)	Road operator, Other	

Potential responsibilities of the road operator

Fig. 33: Information flow of option 1 projected on the operational process chain (service "Automatic Access Control")

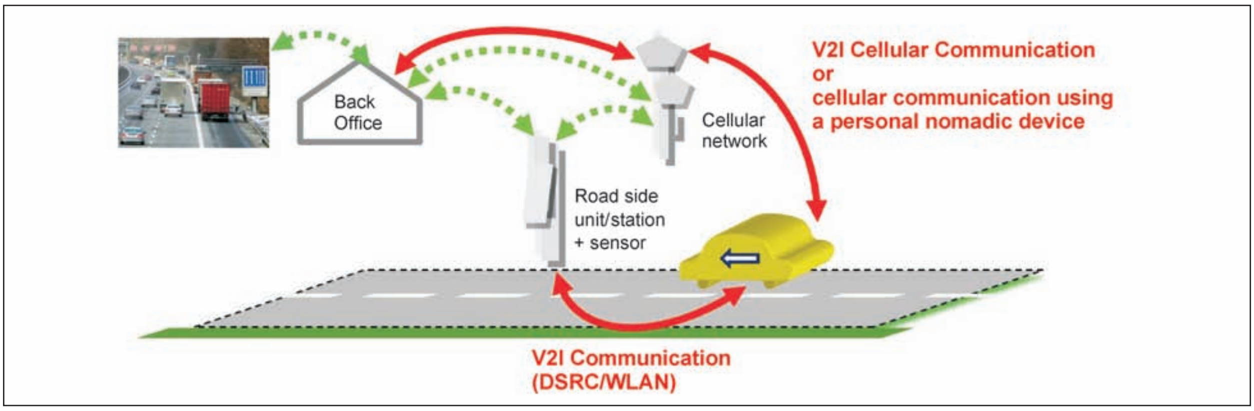

Fig. 32: Function scheme of option 1 (service "Automatic Access Control")

Potential roles of the road operator (see Figure 33)

- Owner of the infrastructure equipment for data acquisition and V2I-communication
- Content provider responsible for data acquisition and processing including verification
- Service provider of the infrastructure-based service which includes message definition, validity check, adaptation and transmission except direct communication between vehicle and TCC
- User of the messages when forwarding the messages from RSU to other communication channels, e.g. VMS and DAB

3.2.5.2 Option 2

Option 2 of the service "Automatic Access Control" is based on the function scheme shown in Figure 34. The information flow related to this function scheme has been projected on the operational process chain (Figure 35). Based on the responsibilities indicated in Figure 35, potential roles of the road operator relating to option 2 have been identified.

Characteristics of the function scheme (see Figure 34)

- Detection of the vehicle by infrastructure-based sensor
- Authorisation of the vehicle is always checked and entitled by the back office/TCC
- Communication between vehicle and RSU (e.g. vehicle sends data for identification, RSU transmits message from TCC granting / denying access to the vehicle) via V2I using short range communication (e.g. DSRC, WLAN)
- Communication between RSU and the back-office via cellular network or proprietary net (wired, wireless etc.)
- Direct communication between driver and back office, only if necessary (e.g. enquiry about access conditions, pre-booking, call back of the back office) via V2I cellular communication or cellular communication using a personal nomadic device
- TCC forwards messages from the RSU to road users located further away via other media, if access to the restricted access area is temporarily denied

Potential roles of the road operator (see Figure 35)

- Owner of the road side equipment for data acquisition and V2I-communication
- Owner of the infrastructure equipment for the proprietary net used for communication between RSU and the back office/TCC (I2TCC prop. net)
- Content provider responsible for acquisition (V2I), processing and verification of data in the RSU; handover of the data to the proprietary net or the cellular net for data transmission to the back office
- Service provider of the infrastructure-based service which consists of data routing between the RSU and the back office via the proprietary net; not responsible for routing within the cellular net
- Service provider of the service in the back office including authorisation of the vehicle, validity

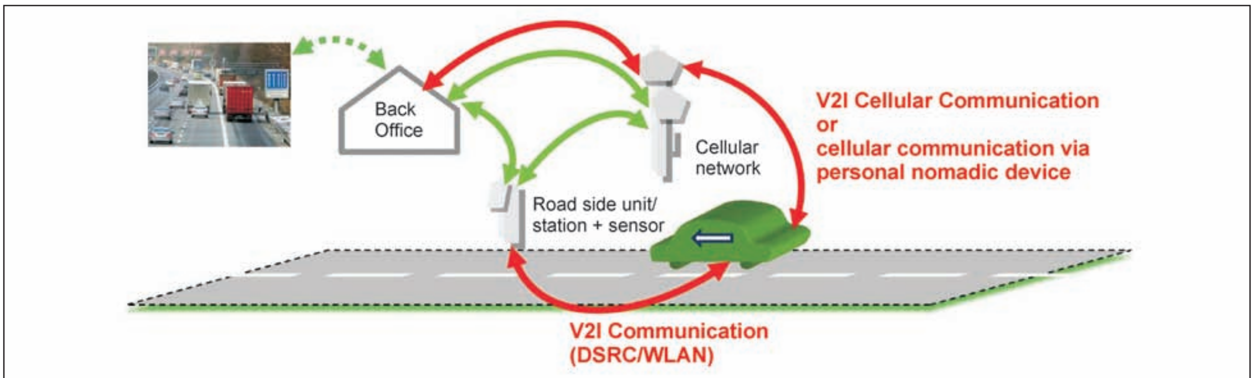

Fig. 34: Function scheme of option 2 (service "Automatic Access Control")

check and definition of the messages which approve / disapprove access; handover of the messages to the proprietary net or the cellular net for message transmission to the RSU and/or to the vehicle; direct communication with the driver via cellular net, if necessary

- Service provider of the infrastructure-based service which includes transmitting messages to the vehicles via V2I-WLAN (may be the same entity as the content provider, see above)
- User of the messages when forwarding the messages from RSU to other communication channels, e.g. VMS and DAB

Subprocesses of the operational process chain		Option 2		
Data acquisition	Content Provider	Road Infrastructure		
Data processing		Road Infrastructure		
Data transmission		I2TCC cellular	I2TCC propr. net	
Message definition	Service Provider	Back office (public, or private subcontractor)		
Message verification		Back office (public, or private subcontractor)		
Message adaptation		Back office (public, or private subcontractor)		
Message transmission		V2I cellular or ND	I2TCC cellular / V2I DSRC / WLAN	I2TCC propr. net
Message presentation		Vehicle		
	User	Driver		
		Back office, TCC		

Potential responsibilities of the road operator

Fig. 35: Information flow of option 2 projected on the operational process chain (service “Automatic Access Control”)

3.2.6 Service “Parking management”

The function scheme developed for the service “Parking Management” is shown in Figure 36. The information flow related to this function scheme has been projected on the operational process chain (Figure 37). Based on the responsibilities indicated in Figure 37, potential roles of the road operator relating to the service “Parking Management” have been identified. The service “Parking Management” is closely connected to option 2 of the service “Automatic Access Control”.

Characteristics of the function scheme (see Figure 36)

- RSU detects vehicle which occupies a parking place or enters a parking area (or vehicle sends booking request to the RSU at on-site parking)
- Communication between vehicle and RSU (e.g. vehicle sends data for identification, RSU transmits message which approves booking) via V2I using e.g. DSRC/WLAN
- Communication between the RSU and the Back office / TCC via cellular network or proprietary net (wired, wireless etc.)
- Back office approves the booking
- Direct communication between driver and back office, only if necessary (e.g. information about access conditions, pre-booking, enquiry call of the back office), via cellular network
- TCC initiates messages to road users located further away via other media, e.g. on availability of free parking lots

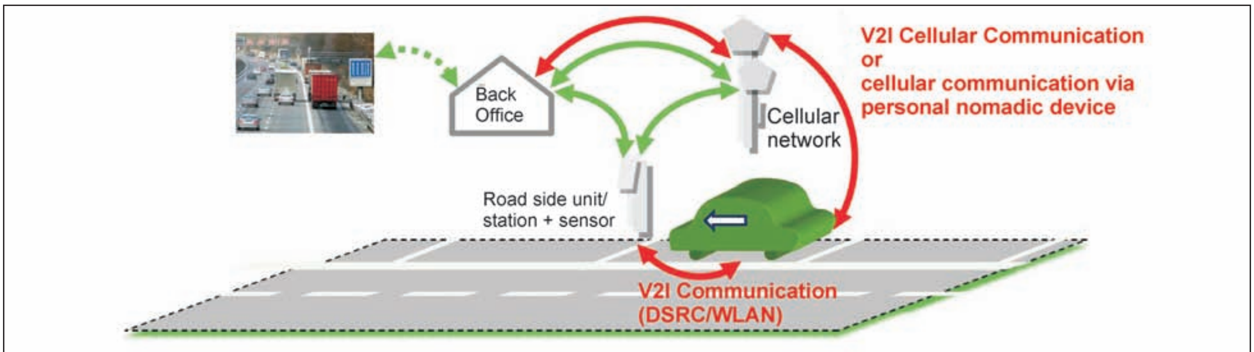

Fig. 36: Function scheme of service “Parking management”

Potential roles of the road operator (see Figure 37)

- Owner of the road side equipment for data acquisition and V2I-communication
- Owner of the infrastructure equipment for the proprietary net used for communication between RSUs and TCC (I2TCC prop. net)
- Content provider responsible for acquisition (V2I), processing and verification of data in the RSU; handover of the data to the proprietary net or the cellular net for data transmission to the back office
- Service provider of the infrastructure-based service which consists of data routing between the RSU and the back office via the proprietary net; not responsible for routing within the cellular net
- Service provider of the service in the back office including authorisation of the vehicle and definition of the messages which approve / disapprove the booking of the parking place; handover of the messages to the proprietary net or the cellular net for message transmission to the RSU and/or to the vehicle; direct communication with the driver via cellular net, if necessary.

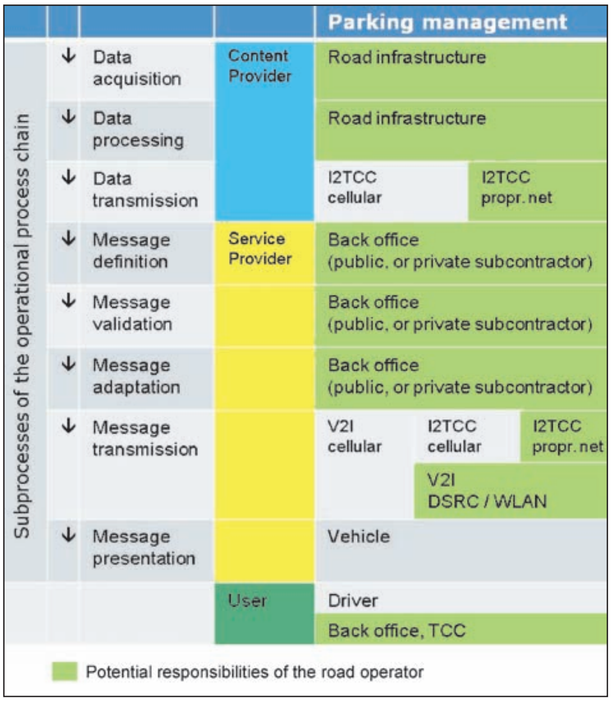

Fig. 37: Information flow of service "Parking management" projected on the operational process chain

- Service provider of the infrastructure-based service which includes transmitting messages to the vehicles via V2I-WLAN (may be the same entity as the content provider, see above)
- User of the messages when forwarding the messages from RSU to other communication channels, e.g. VMS and DAB

3.3 Expected strengths and weaknesses of the considered functional schemes and role profiles

This chapter shows the results of the qualitative assessment which aimed at identifying expected strengths / weaknesses of the function schemes and role profiles introduced in chapter 3.2. The assessment was based on the criteria described in chapter 3.3.1. Each option of a service has been assessed by the responsible task partners from a road operator's view. In a first step, the options were rated regarding their suitability for satisfying the requirements related to the criteria. Thereafter, the task partners were asked to provide reasons for their judgements and describe their expectations on relevant strengths and weaknesses.

3.3.1 Categories of expectations and criteria used for the assessment of strengths and weaknesses

The assessment of the developed functional schemes / role profiles has been based on a set of criteria. The criteria are related to different categories of expectations, i.e. different fields of requirements from a road operator's view. This study uses criteria from the following categories of expectations:

- Expectations regarding the quality of the service
- Expectations regarding organisational aspects and quality of the operation process
- Expectations regarding financial impacts of the service

The expectation categories and the related criteria are by no means exhaustive. The selection of criteria has to take account of the objects and the level of detail showing the characteristics of the objects, i.e. the options and the available features which are to be assessed by using the criteria. In this study, only a small number of characteristics of the options are available and can be considered during the assessment. The following tables provide descriptions of the criteria used in the assessment.

Expectation category 1: Quality of the service

The criteria of this expectation category apply to the quality of the service delivered to the user (= traffic related information). The quality of the service has an impact on the expected benefits regarding road safety, traffic efficiency and environmental acceptability.

ID	Criteria
1.1	Availability of the service to the user (Independency of time and place)
1.1.1	The service should be available to the user at any place where it is needed. Additional aspects included: The availability of the service should preferably be independent of the number of specific road side units nearby the location of the user (i.e. independency from the infrastructure equipment at a certain location).
1.1.2	The service should be available to the user at any time when it is needed. Additional aspects included: The availability of the service should be independent of time of day and season. The availability of the service should preferably be independent of the number of other equipped vehicles which – subject to time of day or season – are nearby the location of the user (i.e. independency from traffic volume and fleet penetration rate at a certain time).

Tab. 1: Criteria related to “Availability of the service to the user”

ID	Criteria
1.2	Promptness of the service (Throughput time of the information, up-to-dateness of the message, ...)
1.2.1	Throughput time of the information should be minimum (time from data acquisition to data presentation to the user) Further included aspects: The throughput time of the information should be preferably independent of location, time and traffic volume. The throughput time of the information should be preferably independent of the load of the communication net Messages sent to the user should be up-to-date.

Tab. 2: Expectation category “Promptness of the service” and related criterion

ID	Criteria
1.3	Accuracy of the service (Accuracy of situation/event, hazard category, location ...)
1.3.1	Accuracy of the indicated situation (or event, sign) should be high. Additional aspects included: The accuracy of the detected type of situation / event / sign should preferably be independent of location, time and traffic volume. The accuracy of the detected degree of risk of the situation / event should be as high as possible and advisable. Excluded aspects: Verification and validation are processes which can be used to increase accuracy. These processes are considered by separate criteria (see below).
1.3.2	Accuracy of the indicated location of the situation (or location of the event or sign) should be high. Additional aspects included: The accuracy of the indicated location of situation / event / sign should be as independent of location, time and traffic volume as possible.

Tab. 3: Expectation category “Accuracy of the service” and related criteria

Expectation category 2: Organisational aspects of the operation process

The criteria of this expectation category apply to organisational aspects of the operation process which may have a direct effect on the work of the road operator.

ID	Criteria
2.1	Dependability (Dependability of the process in order to ensure resilience, integrity, low susceptibility to manipulation, e-security)
2.1.1	The process should be resilient (low fault liability). Additional aspects included: The fault liability of the communication technology should be low. The number of intermediary transmitters involved in the information flow should be low, as fault liability may increase with the number of interfaces which are passed by the information.
2.1.2	The process should be secure against unauthorised interventions. Additional aspects included: The process should avoid possible toeholds for unauthorised intervention or manipulation of the information flow. The effort of a violator to intervene or manipulate the information flow should be high. To ensure mutual trust the process should include authentication of the entities, e.g. by exchanging electronic signatures or electronic certificates. If necessary, the road operator / TCC or his subcontractor should be involved in the process in such a way that he is able to authenticate data / messages and their sources.

Tab. 4: Expectation category “Dependability of the process” and related criteria

ID	Criteria
2.2	Controllability (Controllability of the process in order to enable quality control of the information flow, data or messages)
2.2.1	Data / messages should be verifiable. Additional aspects included: Here, verification means a process of quality control which aims to provide evidence of correctness and reliability. The detection of a situation / event should be repeatable several times, and the derived interpretation of the detected event as well as the messages should be reproducible. If necessary, the road operator / TCC or his subcontractor should be involved in the verification process of the data / messages.
2.2.2	It should be possible to validate data / messages. Additional aspects included: Here, validation means a process of quality control and quality intensification. The validation process aims to check how well the provided data / intended messages meet the given demands of the intended purpose. The validation process may use additional data from other sources in order to increase accuracy. The validation process allows for adjusting the intended messages, if necessary. If necessary, the road operator / TCC or his subcontractor should be involved in the validation process of the data / messages.

Tab. 5: Expectation category “Controllability of the process” and related criteria

ID	Criteria
2.3	Compatibility (Compatibility with other tasks and responsibilities of the road operator)
2.3.1	The road operator / TCC should be involved in the information flow of the process in such a way that he receives data / information which supports him in the execution of other tasks for which he is responsible. Additional aspects included: Other task can be e.g. • notification of road users located further away via other media, e.g. via VMS or DAB • maintenance / repair of the road surface, bridges, tunnels • removal of dangerous obstacles from the road surface • winter services

Tab. 6: Expectation category “Compatibility of the process” and related criterion

Expectation category 3: Financial impacts of the service

This expectation category contains relevant factors which describe the financial expenditures for providing the service. They have an impact on the costs for which the road operator and/or the end users are billed.

ID	Criteria
3.1	Expenditures for investment
3.1.1	The necessary investment costs to the road operators' account should be limited. Additional aspects included: Investment costs to the road operators' account are affected by e.g. • volume, spatial distribution of RSU • unit costs per RSU (with/without sensors, cellular communication / WLAN communication radio module) • charges for necessary upgrading of the cellular communication network by the cellular network provider

Tab. 7: Expectation category "Expenditures for investment" and related criterion

ID	Criteria
3.2	Expenditures for operation
3.2.1	The necessary operation costs to the road operators' account should be limited. Additional aspects included: Operation costs to the road operators' account are affected by e.g. • personnel costs of the staff needed for operation • connection costs for communication

Tab. 8: Expectation category "Expenditures for operation" and related criterion

ID	Criteria
3.3	Expenditures for maintenance
3.3.1	The necessary operation costs to the road operators' account should be limited. Additional aspects included: Operation costs to the road operators' account are affected by e.g. • personnel costs of the staff needed for maintenance, • connection costs for communication

Tab. 9: Expectation category "Expenditures for maintenance" and related criterion

ID	Criteria
3.4	Reimbursement to the road operator
3.4.1	The costs to the road operators' account should pay off. Additional aspects included: Pay off is affected by the willingness of the users to pay for the service.

Tab. 10: Expectation category "Reimbursement to the road operator" and related criterion

3.3.2 Service "Hazardous location notification"

Figure 38 gives an overview of the results obtained from the rating of the options of service "Hazardous location notification". The chapter then provides a description of the results by comparing the options per assessment criterion.

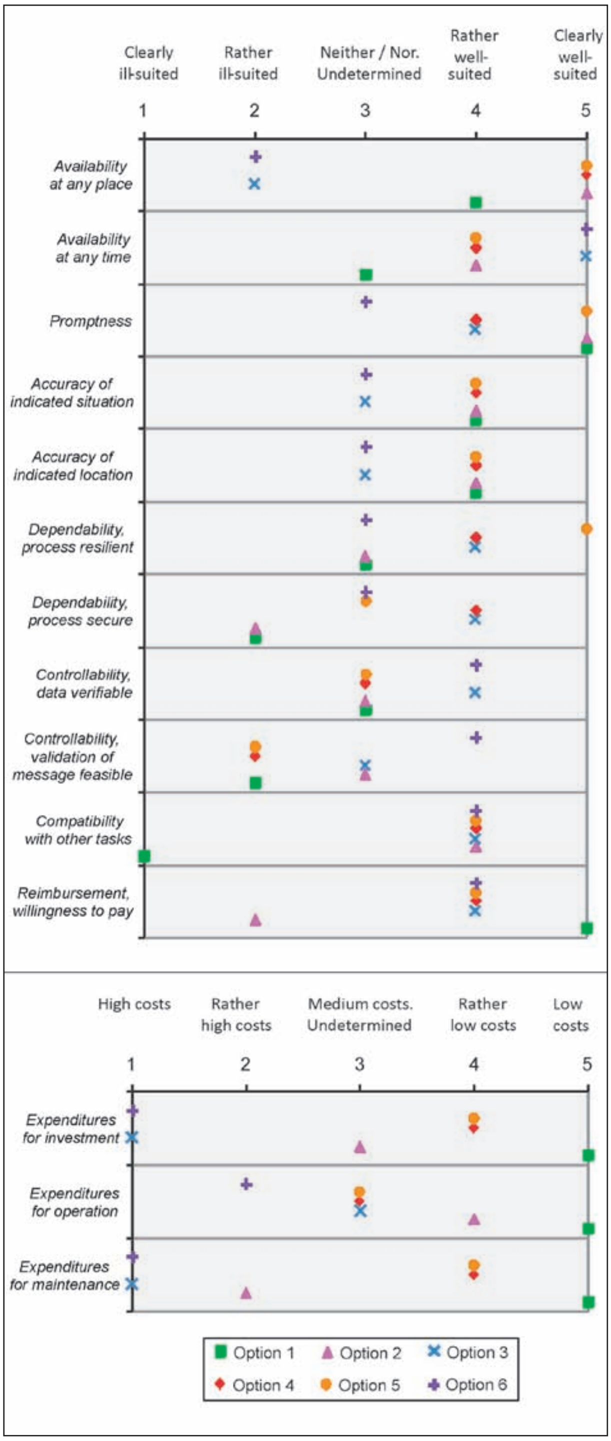

Fig. 38: Overview of strengths and weaknesses of the options for service "Hazardous Location Notification": Results of the rating

Availability of the service to the user

The expectation category "Availability of the service to the user" contains two criteria:

- The service should be available to the user at any place where it is needed.
- The service should be available to the user at any time when it is needed.

Options 4 and 5 are expected to satisfy the requirements of the first criterion (Availability at any place) best (Figure 38). It seems that options which are based on the functional characteristics "Detection by vehicle-based sensor" and "Communication with vehicles in the immediate vicinity via V2I using cellular communication" are advantageous. In case of sufficient traffic density these options are not directly dependent of the location, the road type and the presence of road side units. Moreover, the messages transmitted to approaching vehicles cover a large area. Though on some rural roads the coverage by the cellular net may be poor, the message can be transmitted to the subsequent vehicles as soon as a connection to the cellular net is possible. Given that road side units are available, option 2 is also well-suited. In areas of low traffic density the hazard detection and the exchange of data may be poor for option 1. Therefore, option 1 has been downgraded compared to options 2, 4 and 5. Options 3 and 6 have been rated as being rather ill-suited. They depend on "Detection by infrastructure-based sensor".

These results are different to those gained for the second criterion (Availability at any time): Here, options based on "Detection by infrastructure-based sensor" show the best suitability (options 3 and 6). However, none of the other options seem to be ill-suited.

Promptness of the service

Apart from option 6 for which the rating score is undetermined (neither/nor), all options are expected to meet the requirements of low throughput time. Options 1, 2 and 5 are clearly well-suited, i.e. function schemes based on V2V communication using WLAN seem to be advantageous.

Accuracy of the service

This expectation category contains two criteria:

- Accuracy of the indicated situation / event / sign should be high.
- Accuracy of the indicated location of the situation / event / sign should be high.

Options 1, 2, 4 and 5 are expected to be rather well-suited for both criteria. These options are based on “Detection by vehicle sensors”. Accuracy is expected to be slightly lower for options which are based on “Detection by infrastructure-based sensors” (options 3 and 6).

Dependability of the operational process

The following criteria were involved in this expectation category:

- The process should be resilient (low fault liability).
- The process should be secure against unauthorised interventions.

Option 5 is expected to be clearly well-suited related to the first criterion (resilient process). The reasons given for the judgement show that low fault liability is expected, as only a low number of intermediary transmitters are involved in the information flow. Furthermore, communication is based on cellular communication technology which seems to be less susceptible to faults than WLAN technology. Additionally, option 5 shows a high safeguard against system black-out, as two independent communication technologies are available. Options 3 and 4 are rather well-suited. They show similar strengths to option 5, but lack the high safeguard based on two independent communication technologies. The rating scores for options 1, 2 and 6 are undetermined (Neither/nor).

As for the second criterion (secure process), options 3 and 4 seem to be rather well-suited. Option 3 allows for authenticating all messages by the road operator, as the road operator / TCC holds control of the RSU which is the source of the messages sent to the vehicles. Furthermore, hacking into the cellular communication net is expected to be more difficult than hacking into a WLAN based net. In the case of option 4, authentication of messages is not possible, but considerable effort is needed in order to manipulate a large number of vehicles and thus substantially manipulate the data sources. Option 1 and 2 (only WLAN based communication) are expected to be rather ill-suited. It is expected that hacking into the WLAN based net is easier than hacking into a cellular communication net. Once a violator has hacked into the WLAN based net, only moderate effort is needed in order to substantially manipulate the information flow by using a computer worm. Authentication of messages is not possible (option 1) or is only available for part of the information flow (option 2).

Controllability of the operational process

The expectation category “Controllability of the operational process” contains two criteria:

- Data should be verifiable.
- It should be possible to validate data / messages.

In relation to the first criterion (data verifiable) the options 3 and 6 are expected to be rather well-suited, whereas the other options are expected to be neither ill-suited nor well-suited. Both option 3 and option 6 allow for verification through repeated detections and messages sent by the RSU. The time needed for verification does not depend on traffic density. The verification process can be controlled and supported by the road operator. In case of the options 1, 2, 4 and 5 verification is possible through repeated detection and messages sent by different vehicles passing the hazardous location. This seems acceptable, but verification may take some time in case of low traffic density.

In relation to the second criterion (validation of data / messages feasible), option 6 is expected to be the option which best meets the requirements. All messages can directly be validated by the road operator / TCC who is directly involved in the information flow between the vehicles. Thus the validation process allows for increasing the accuracy on the indicated situation and adaptation of the message, as the TCC can use additional data available from other sources, e.g. from meteorological services. Option 2 and 3 are expected to be neither ill-suited nor well-suited. These options enable the road operator to indirectly validate the data / messages through appropriate validation logic installed in the control unit of the RSUs. In case of the options 1, 4, and 5, the road operator / TCC has no access to the information flow between the vehicles, i.e. the data / messages cannot be validated by the road operator / TCC.

Compatibility of the operational process

Apart from option 1, which seems to be clearly ill-suited in relation to this criterion, all options are expected to be rather well-suited in order to meet the requirements. The options 2, 3, 4, 5 and 6 enable the road operator / TCC to receive data from the process of the service. This data can be supportive of the road operator / TCC executing other tasks for which he is responsible, e.g. in order to remove dangerous obstacles, to send messages to road users located further away via other media.

Reimbursement to the road operator

Some aspects which are expected to affect the willingness of the users to pay for the service were considered for the assessment. Option 1 received the best rating scores. There is no effort needed on the part of the road operator in order to charge the end user, as option 1 is based on V2V communication only. The options 3, 4, 5, and 6 which are based on cellular communication seem to be rather well-suited. It is expected that the end user is rather be willing to pay for extra cellular communication costs than to be charged by the road operator. Therefore, these options allow for business models where fees demanded by the road operator can be collected in connection with the fees for cellular communication. Option 2 uses V2V and V2I communication via WLAN technology. If the road operator has to collect a fee from the user of the road side equipment, it seems to be difficult to raise the end users' acceptance.

Expenditures for investment

No investment costs for infrastructure system arise with option 1, as only in-vehicle systems are needed due to V2V communication using WLAN. Therefore, from a road operator's view, this option meets the requirement of limited investment costs to the road operator's account in an optimal way (Figure 38, lower part). Rather low investment costs are expected for option 4 and 5, because these options also do not require investments for the road infrastructure, but increased investment costs for the necessary extension of the cellular communication network will occur and may result in increased charges to the road operator's and the end user's account. Medium costs are expected for option 2, as roadside infrastructure has to be equipped. On the other hand, option 2 seems to require both only moderate investment costs per RSU and a moderate equipment rate of the road net. High investment costs are expected for option 3 and 6. In comparison to option 2, additional investment costs arise with option 3 and 6, because they need RSUs which have to be equipped with sensors and with radio modules for cellular communication.

Expenditures for operation

Option 1 is based on V2V communication only, thus no operation costs to the road operators' account are expected for option 1. Rather low operation costs seem to arise for option 2. Connection costs of the communication between RSU and TCC are expected to be low, as part of the communication will occur in the proprietary net of the road operator. Only moderate operation costs arise at the TCC, as the TCC is not directly involved in the information flow. In comparison to option 2, higher operation costs will arise for option 3, 4, and 5 because of connection costs for using the cellular net. Rather high operation costs are expected for option 6 because of high operation costs at the TCC which is involved in the information flow between the RSUs and the vehicles.

Expenditures for maintenance

As with the investment costs and operation costs, no maintenance costs to the road operator's account arise with option 1. Low maintenance costs are expected for option 4 and 5, as these options also do not require any devices at the road side. However, increased maintenance costs may arise with the cellular communication network and result in increased charges to the road operator's and the end user's account. For option 2, rather high maintenance costs are expected in the case of high road net coverage. Maintenance costs for options 3 and 6 seem to be even higher than those of option 2. Increased costs for the maintenance of the cellular communication network will presumably result in increased connection costs to the road operator's account.

3.3.3 Service "Traffic jam ahead warning"

Six options providing alternative function schemes and role profiles of the service "Traffic jam ahead warning" have been assessed. Figure 39 shows an overview of the results obtained from the rating. In the subsequent descriptions the results are compared per criterion used in the assessment.

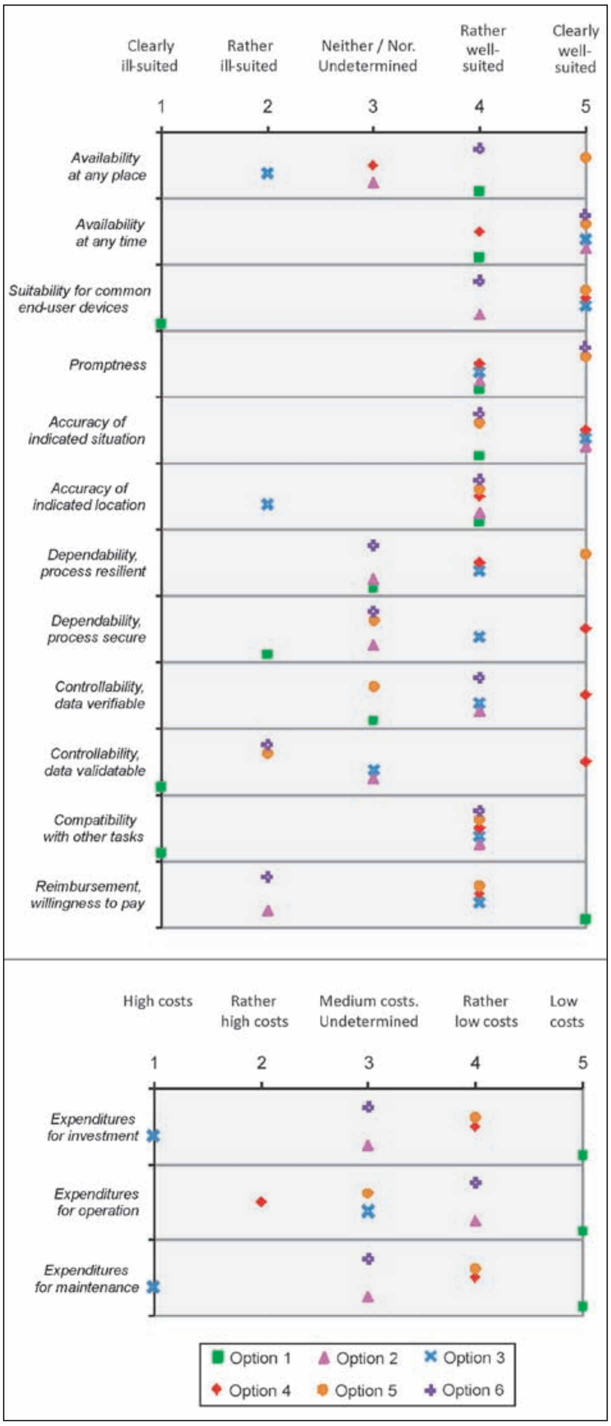

Fig. 39: Overview of strengths and weaknesses of the options for service "Traffic jam ahead warning": Results of the rating

Availability of the service to the user

Options 1, 5 and 6 seem to meet the requirements of the criterion "Availability at any place" well (Figure 38). These options are based on the functional characteristic "Detection by vehicle-based sensor" and use V2V communication via WLAN. They are not directly dependent of the location, the road type and the presence of road side units. Additional benefit can be achieved if both communication technologies, WLAN and cellular communication, are available due to the extended range of transmission (Option 5). However, the exchange of data may be poor in areas of low coverage of the cellular net, if an option features V2I communication via WLAN or cellular communication only. This is the reason why option 2 and 4 seem to be weaker than the options mentioned before. Option 3 has been rated as being rather ill-suited due to "Detection by infrastructure-based sensor".

All options seem to meet the requirements of the criterion "Availability at any time". Option 3 is clearly well-suited, as it seems to be independent of time. The RSU detects the traffic jam independently of fleet penetration rate, buffers the message in case of low traffic density and will be able to send repeated messages to approaching vehicles using the cellular net. Option 1 received a lower score because of strong dependency on fleet penetration rate and traffic density. Option 2 and option 6 have been rated better than option 1, since the RSU can help to transmit the messages in case of low traffic density. Option 5 uses cellular communication in case WLAN is not available and is therefore as similarly suited as option 2 and 6 are. Option 4 has been rated equivalent to option 1, since cellular communication may sometimes not be available. In contrast to option 3, option 4 has no RSU available which may buffer the message.

The results for the criterion "Suitability for common end-user devices" show clear preference for options with cellular communication (options 3, 4 and 5), as the messages are also available on common nomadic devices. Options based on WLAN communication (IEEE 802.11 p) are expected to require devices with specific equipment. However, option 2 and option 6 are rated as being rather-well suited, as road users located further away may receive messages initiated by the TCC. Option 1 is clearly ill-suited, as only equipped vehicles will be able to receive messages.

Promptness of the service

All options are expected to be suitable in order to meet the requirements of low throughput time. Options 5 and 6 are clearly well-suited. They seem to be slightly stronger than the other options because of low latencies at both short and long transmission distances. Option 5 uses V2V-WLAN and cellular communication for the transmission of messages. Option 6 uses V2I and V2V communication via WLAN.

Accuracy of the service

All options are expected to be suitable in order to meet the requirement "Accuracy of the indicated situation". However, options 2, 3 and 4 received higher scores than options 1, 5 and 6. If the detection of a traffic jam is based on in-vehicle sensors (options 1, 5 and 6), the accuracy of the indicated situation is affected by the number of equipped vehicles which are in a traffic jam. In contrast, accuracy of the indicated situation may not be dependent on fleet penetration rate if the traffic jam is detected by an infrastructure based sensor (option 3). Detection by infrastructure using floating car data also seems to be hardly dependent on fleet penetration rate, given that most new vehicles are able to send FCD data (option 2 and 4).

As for the criterion "Accuracy of the indicated location", it is expected that road infrastructure devices will not be able to precisely detect the tail end of a traffic jam, unless the coverage of road side detectors is high. Therefore, option 3 does not seem to be as well suited as the other options which include vehicle-based detection.

Dependability of the operational process

Two criteria have been involved in this expectation category:

- The process should be resilient (low fault liability).
- The process should be secure against unauthorised interventions.

As for the first criterion, option 5 seems to show the lowest fault liability, as only few intermediary transmitters are involved in the information flow. Option 5 uses cellular communication technology which seems to be less susceptible to faults than WLAN technology. Additionally, option 5 shows a high safeguard against system black-out, as two independent communication technologies are available. Options 3 and 4 are rather well-suited. They show strengths which are similar to option 5, but lack the high safeguard based on two independent communication technologies. The rating scores for options 1, 2, and 6 are undetermined (Neither/nor).

The requirements of the second criterion (secure process) are best met by option 4. Option 4 allows authentication of all messages by the road operator, because the road operator / TCC is the entity which receives FCD data, detects the traffic jam from the FCD data and sends messages to the vehicles. Option 3 seems to be rather well-suited. It allows indirect authentication of the messages by the road operator, because the RSUs are the sources of the messages sent to the vehicles. Additionally, cellular communication is expected to be more secure against violators than the WLAN based net. Options 2, 5, and 6 are neither well-suited nor ill-suited. Options 2 and 6 offer vehicle based detection. Therefore, considerable effort is needed to manipulate a large number of vehicles. Furthermore, both options allow indirect authentication of the messages by the road operator, as the RSUs are the sources of the messages sent to the vehicles. However, the messages are sent via WLAN based net which does not seem to be as secure as the cellular net. Option 5 uses vehicle based detection and sends messages partly via cellular communication and partly via V2V-WLAN. Option 1, which is based on WLAN based communication only, is expected to be rather ill-suited. Authentication of messages by the road operator is not possible with this option.

Controllability of the operational process

The expectation category "Controllability of the operational process" contains two criteria:

- Data should be verifiable.
- It should be possible to validate data / messages.

Option 4 is well-suited in relation to the first criterion (data verifiable), since the TCC is enabled to verify the traffic jam by receiving messages (FCD) from different vehicles which detected the traffic jam. Options 2, 3 and 6 are rather well-suited. Option 2 and option 6 also allow for repeated detections by the vehicle, whereas option 3 offers repeated detection by the RSU. Control units inside the RSU may be used by the road operator in order to indirectly support the verification process. Though repeated detection by the vehicles is also possible with options1 and 5, support of the verification process by the roadside infrastructure is not available.

In relation to the second criterion (validation of data / messages feasible), option 4 is expected to be well suited. All messages can directly be validated by the road operator / TCC who is involved in the information flow between the vehicles. Option 2 and option 3 are expected to be neither ill-suited nor well-suited. These options enable the road operator to indirectly validate the data / messages through appropriate validation logic installed in the control unit of the RSUs. Options 5 and 6 do not allow for validation of the messages sent to the vehicles. However, the TCC receives the message as a user and thus may be able to send additional information via other media, e.g. VMS or DAB. Option 1 does not allow for validation by the road operator, as the road operator / TCC has no access to the information flow between the vehicles, nor receives the message as a user.

Compatibility of the operational process

Options 2, 3, 4, 5 and 6 enable the road operator / TCC to receive data from the process of the service. These options are rated as being rather well-suited. The data can be supportive of the road operator / TCC when executing other tasks for which he is responsible, e.g. to send messages to road users located further away via other media. Option 1 is ill-suited, as the road operator does not receive data from the information flow.

Reimbursement to the road operator

Regarding the reimbursement to the road operator, option 1 seems to be well-suited. The road operator does not need to charge the end user, as option 1 is based on V2V communication only. It is expected that the end user will rather be willing to pay for extra cellular communication costs than to be charged by the road operator separately. Therefore, options 3, 4 and 5, which are based on cellular communication, allow for business models where fees demanded by the road operator can be collected in conjunction with the fees for cellular communication. Options 2 and 6 are based on V2V and V2I communication via WLAN technology. In the case of option 2 and 6 the road operator may have to collect a separate fee for the use of the road side equipment, which would encounter low acceptance by the end users. The end users may question whether the improvement of functionality related to the inclusion of the roadside devices justifies an extra fee.

Expenditures for investment

Option 1 does not require any investment costs for roadside devices, as only in-vehicle systems are needed due to V2V communication using WLAN (see Figure 39, lower part). Option 4 and option 5 use cellular communication only. They do not require investments for roadside devices. However, increased investment costs for the necessary extension of the cellular communication network will occur and may result in increased charges to the road operator's and the end user's account. Medium costs are expected for option 2 and option 6 which use both communication via V2V-WLAN and V2I-WLAN. Though roadside infrastructure has to be equipped, option 2 and 6 seem to require only moderate investment costs per RSU and a moderate equipment rate of the road net. High costs are expected for option 3 in case of high road net coverage.

Expenditures for operation

No operation costs to the road operators' account will appear for option 1, as it is based on V2V communication only. Rather low operation costs to the road operator's account seem to arise for option 2 and option 6. Connection costs of the communication between RSU and TCC are expected to be low, as part of the communication will occur in the proprietary net of the road operator. Only moderate operation costs arise at the TCC, as the TCC is not directly involved in the information flow between the vehicles. For option 5 the operation costs are higher than those of option 2 or option 6, as connection costs of the cellular communication between RSU and TCC are expected to be higher than communication via the proprietary net. Option 3 uses only cellular communication for the messages sent from the RSU (detector) to the vehicles. The operation costs to the road operator's account may be moderate (similar to those of option 2 and option 6), in case the end user pays for these costs. However, it is possible that the road operator has to bear part of the connection costs. Rather high operation costs are expected for option 4. Connection costs will be rather high, as the TCC is involved in the information flow between the RSUs and the vehicles and messages are sent via the cellular net only.

Expenditures for maintenance

No maintenance costs to the road operators' account will arise with option 1.

Rather low maintenance costs are expected for option 4 and 5, as these options also do not require any devices at the road side. However, increased maintenance costs arise at the cellular communication network and may result in increased charges to both the road operator's and the end user's account. Medium maintenance costs to the road operator's account appear for option 2 and option 6 in case of a moderate road net coverage of the RSU. Maintenance costs seem to be higher for option 3, as high road net coverage is expected and increased costs for the maintenance of the cellular communication network will presumably result in increased connection costs to the road operator's account.

3.3.4 Service "Road works warning"

Figure 40 shows an overview of the results obtained from the rating of the two options of service "Road works warning". The results are described in the subsequent part of this chapter by comparing the options per criterion.

Availability of the service to the user

The expectation category "Availability of the service to the user" contains the following criteria:

- The service should be available to the user at any place where it is needed.
- The service should be available to the user at any time when it is needed.
- The service should be available for a broad range of end user devices (specific device, unspecific device , e.g. radio, mobile phone)

Both options meet the requirements of the criterion "Availability at any place" (Figure 40). However, option 1 transmits the messages by cellular communication and covers a larger area than option 2, which uses WLAN communication (V2I, V2V). In case of poor cellular net coverage in the vicinity of the construction site, the routing of

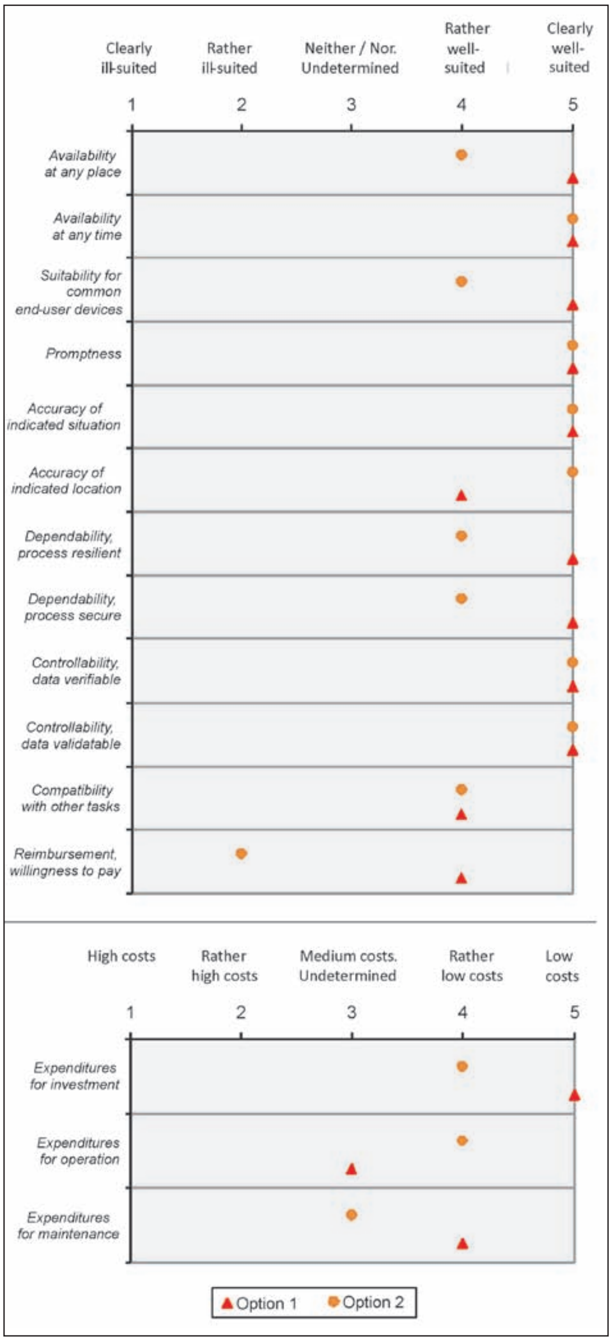

Fig. 40: Overview of strengths and weaknesses of the options for service "Road works warning": Results of the rating

messages to the vehicle can be adjusted. For option 2 the range may be limited in case of low traffic density.

As for the criterion “Availability at any time”, both options are clearly well-suited. The availability is not dependent of time, as the driver will be warned continuously as soon as the road work starts on the network.

The results relating to the criterion “Suitability for common end-user devices” are similar to the results obtained for the options of service “Traffic jam ahead warning” (see above). There is a preference for option 1, as the messages may also be available on common nomadic devices due to cellular communication. Option 2, which is based on WLAN communication (IEEE 802.11 p) is expected to require devices with specific equipment. However, both options enable the road operator / TCC to notify road users located further away via other communication channels, e.g. variable message signs or DAB.

Promptness of the service

Both options are expected to show low throughput time, as normally the information on road works is given to the driver a short time before site start in order to make the driver aware of upcoming road works.

Accuracy of the service

This expectation category contains two criteria:

- Accuracy of the indicated situation / event / sign should be high.
- Accuracy of the indicated location of the situation / event / sign should be high.

Both options are clearly well-suited to meet the requirements of the criterion “Accuracy of the indicated situation”.

“Accuracy of the indicated location” seems to be higher for option 2 because of higher accuracy of the mobile RSU which is located in the construction site. In the case of mobile road works the accuracy of option 2 also seems to be higher than the accuracy of option 1, as the mobile RSU travels with the road works.

Dependability of the operational process

Two criteria have been involved in this expectation category:

- The process should be resilient (low fault liability).
- The process should be secure against unauthorised interventions.

As for the first criterion, option 1 is clearly well-suited, as cellular communication seems to be less susceptible to faults than communication by WLAN technology. The mobile RSU used for option 2 is exposed to some hazards which may appear on the construction site, e.g. weather, dust, mechanical damage.

Both options are rather well-suited when taking the second criterion (secure process) into account. The options allow authentication of the messages by the TCC or the contractor which operates the construction site. Additionally, the messages can be sent via downlink, i.e. there is no uplink stream which may be used for intrusion of the data source by a potential violator. Considerable effort seems to be necessary in order to manipulate a large number of vehicles.

Controllability of the operational process

The expectation category “Controllability of the operational process” contains two criteria:

- Data should be verifiable.
- It should be possible to validate data / messages.

Both options are clearly well-suited. There is no detection of the road works by a sensor, which would need repeated measurement in order to verify the outcome of the detection process. The messages to be transmitted are provided by the TCC or pre-set by an authorised person at the construction site and can be validated and readjusted by these entities from time to time.

Compatibility of the operational process

Both options are rated as being rather well-suited, as they enable the road operator / TCC to receive data from the operation process of the service. The data can be supportive of the road operator / TCC when executing other tasks for which he is responsible, e.g. to generate messages to road users located further away via other media.

Reimbursement to the road operator

Option 1 is based on cellular communication. The score is higher for option 1 than for option 2, as option 1 allows for business models where fees demanded by the road operator can be collected in conjunction with the fees for cellular communication. In the case of option 2, it seems to be difficult to raise the end users' acceptance for being charged with an extra fee which is collected by the road operator.

Expenditures for investment

Both options do not require investments in stationary roadside devices. The investment costs of option 2 are expected to be higher than that of option 1, as a number of mobile RSUs are needed in order to equip the working zones. For option 1 some investment costs will occur for equipping the TCC with an appropriate communication system. The extension of the cellular communication network necessary for option 1 may result in increased charges to the account of the road operator and the end users.

Expenditures for operation

Rather low operation costs to the road operator's account seem to occur for option 2. The connection costs for the communication between the mobile RSUs and the vehicles are expected to be low, as communication is based on WLAN technology. The operation costs for option 1 will be higher than those of option 2, as option 1 uses the cellular net for communication between the TCC and the vehicles.

Expenditures for maintenance

Maintenance costs seem to be higher for option 2 than for option 1 because of the mobile RSUs needed for option 2. Increased costs for the maintenance of the cellular communication network will occur with option 1 and will presumably result in increased connection costs to the road operator's account.

3.3.5 Service "Automatic access control"

An overview of the results obtained from the rating of the two options of service "Automatic access control" is shown in Figure 41. The results are described in the subsequent part of this chapter.

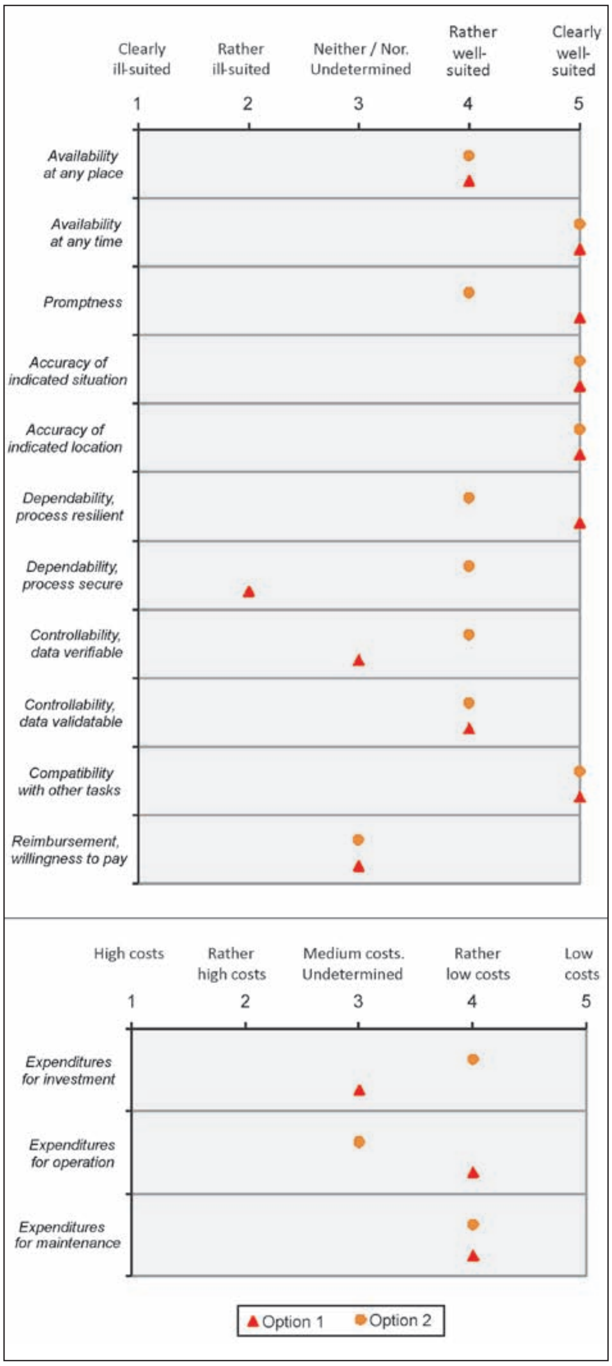

Fig. 41: Overview of strengths and weaknesses of the options for service "Automatic access control": Results of the rating

Availability of the service to the user

Communication with a RSU is expected to be a prerequisite for this service, though a solution based on cellular communication between the vehicle and the back office without RSU is conceivable. However, such a solution will show relevant drawbacks, e.g. regarding privacy (tracking of the vehicle) and high load of the cellular network. Furthermore, access control could be connected to the presence of a gate or a bar, which requires the installation of some infrastructure equipment. Therefore, only options communicating via a road side unit have been considered.

Both options are expected to meet the requirements of the criteria “Availability at any place” and “Availability at any time (Figure 38).

Promptness of the service

Option 1 shows a RSU with automatic handling of the process. In contrast, option 2 always requires authorisation and confirmation by the back office. Therefore, the option 1 process is expected to be faster than the process of option 2.

Accuracy of the service

The information exchanged between the vehicle and the RSU is simple and static. The position of the RSU to which the vehicle communicates is given. No differences can be shown between the options. Both options are well-suited.

Dependability of the operational process

This expectation category consists of two criteria:

- The process should be resilient (low fault liability).
- The process should be secure against unauthorised interventions.

Fault liability seems to be lower with option 1 than with option 2, as the number of interfaces involved in the information flow of the main process is lower for option 1 (no communication of the RSU with the back office for check of authorisation needed).

As for security of the process, option 2 is expected to be better suited than option 1. The authentication and confirmation process of option 2 is always handled by the back office. In contrast, manipulation of the process of option 1 seems to be easier, as the violator only needs to hack into the RSU.

Controllability of the operational process

The requirements of verification are met by both options. The verification process of option 2 seems to be slightly stronger, as it contains two sub-processes for the access control, one sub-process performed by the RSU and the other sub-process performed by the back office.

Both options allow for a validation process, i.e. direct communication between the driver and the back office.

Compatibility of the operational process

Both options are clearly well-suited, since the back office receives data from the process of the service and can forward them to the road operator / TCC, if necessary.

Reimbursement to the road operator

The service is often initiated by an authority or an institution which will pay for the service and contract it to a private service provider other than the road operator. Usually, the road operator does not expect revenues from the service. If a toll has to be connected to the access, payment may be easily enclosed in the operation process of both options.

Expenditures for investment

Option 1 does require RSUs which contain extra electronic equipment in order to handle the process automatically. The investment costs of option 1 seem to be higher than that of option 2.

Expenditures for operation

The connection costs for the communication between the RSU and the back office are expected to be higher for option 2 than for option 1

Expenditures for maintenance

Both options are expected to need rather low costs for maintenance.

3.3.6 Service “Parking management”

An overview of the results obtained from the assessment of the option of service “Parking management” is given in Figure 42. The results per criterion are described in the subsequent part of this chapter.

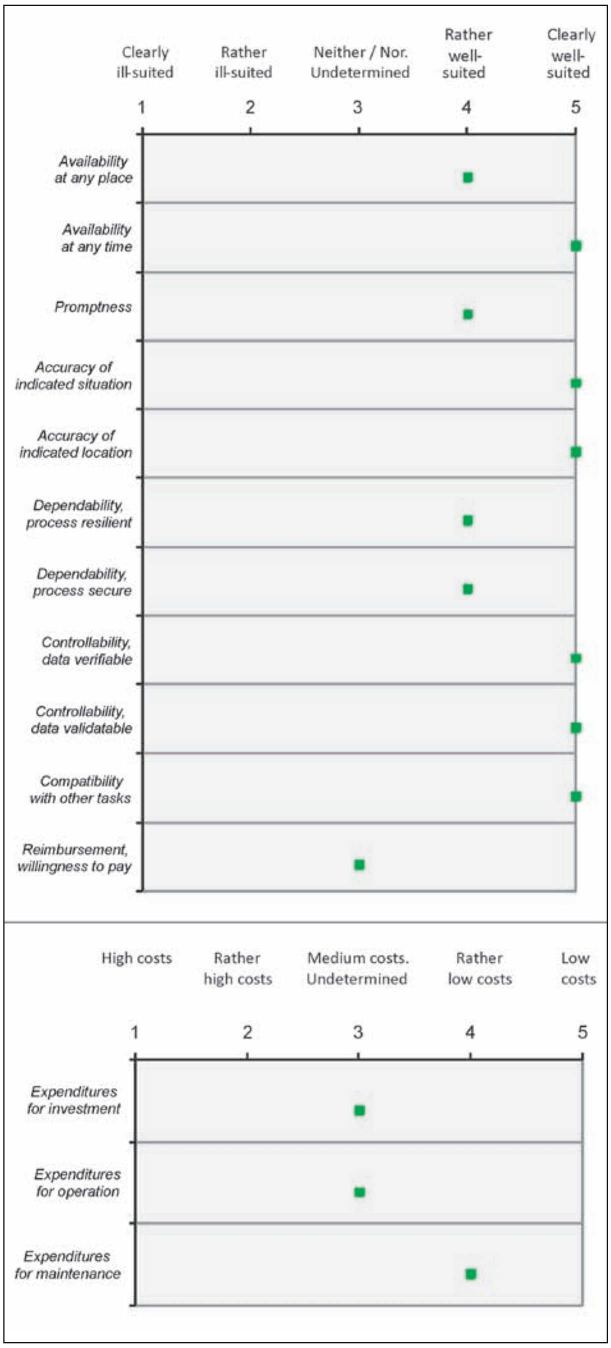

Fig. 42: Overview of strengths and weaknesses of the options for service “Parking management”: Results of the rating

Availability of the service to the user

Similar to the service “Automatic access control”, communication with a RSU is expected to be a prerequisite for the service “Parking management” as well. The considered option fulfils this prerequisite and meets the requirements relating to the criteria “Availability at any place” and “Availability at any time” (Figure 42).

Promptness of the service

The option always requires authorisation and confirmation by the back office. Though the process may not be as fast as an automatic process, the option is expected to be rather well-suited with regard to promptness.

Accuracy of the service

The presence of a RSU allows for high accuracy of the indicated situation and the indicated location. The position of the RSU and therefore the position of the connected parking place are well defined. The RSU detects whether a parking place is empty or occupied, will send requested information on the status of the parking place to the vehicle, and may support the communication between the vehicle and the back office. So, the option is clearly well-suited.

Dependability of the operational process

As for the two criteria included in this expectation category (fault liability and security of the process), the considered option of the service “Parking management” is comparable to option 2 of the service “Automatic access control”. Fault liability is expected to be low, as only a low number of interfaces is involved in the information flow of the main process. Security seems to be high, as the authentication and confirmation process is always handled by the back office, which makes it difficult to violate the process.

Controllability of the operational process

The requirements of verification and validation are met by the option. The option allows for repeated measuring and enables the back office to validate the data and the messages to the vehicle.

Compatibility of the operational process

The option is clearly well-suited regarding this criterion, since the back office receives data from the process of the service and can forward them to the road operator / TCC, if necessary.

Reimbursement to the road operator

The driver is used to being charged at parking places in urban areas or at specific truck parking zones which include security services. In case of public parking areas on public motorways, the driver will show little willingness to pay for the service. The driver may expect that the use of public parking space is free, as the road users already paid for it through taxes. In case of private parking areas, the willingness to pay will be higher. The private operator may offer additional information on the services available at the parking area in order to raise the acceptance of the road user. The costs for communication between the driver and the back office via the cellular net may be directly charged to the driver's account or included in the parking fee.

Expenditures for investment

Investment costs are expected to be moderate. Only a low number of RSU may be necessary in order to serve a high number of parking places per parking area. Connecting the RSUs with the backbone system will require the main part of the investment costs.

Expenditures for operation

The operation costs to the road operator's account seem to be moderate. The costs for WLAN communication between the RSUs and the vehicles will be low. The handling of the service in the back office will constitute the main part of the operation cost, including part of the connection costs for cellular communication between the back office and the driver.

Expenditures for maintenance

The option seems to need rather low costs for maintenance because of the low number of RSUs per parking area.

3.4 Expected opportunities, concerns and critical success factors related to the roles and responsibilities of the road operator

Besides the assessment which focused on indicating the strengths and weaknesses expected for the selected priority services (see chapter 3.3), the task partners' view towards opportunities / chances, concerns / risks and critical success factors have been collected. The task partners responded to the following questions:

- What opportunities and chances are expected, from a road operator's view, in relation to the road operator's role in the operation process of the first priority services?
- What concerns / risks / threats are expected, from a road operator's view, in relation to the road operator's role in the operation process of the first priority services?
- What are the expected critical factors, from the road operator's view, for a successful operation of the considered V2X services?

The respondents have also been asked to specify the type of road operator whose point of view they take for answering the questions. The feedback showed that different types of road operator have been involved (public road operator; public road operator as a supervisor contracting a considerable number of providers; private road operator). However, the aspects addressed by the respondents did not show big differences between the different types of road operators. In fact, differences may exist. However, it seems that they did not appear due to the small number of participants.

The results are described in the following sub-chapters. They have been merged according to their relation to the services. Some comments apply to the considered services in general, while others are related to a specific service.

3.4.1 Opportunities and chances

Expected opportunities applying to cooperative services in general

- Cooperative services have the potential to increase the effectiveness of the road transport system. It is expected that they can make substantial contributions to the overall goals of road transport:

- o More efficient use of the road net, e.g. by reducing or avoiding congestions, empty trips, search runs.
- o ncrease of road safety, e.g. by avoiding serious accidents, reducing the call-out time of the emergency services.
- o Better connection of road transport to the other modes of transport (railway, air, water carriage).
- o Reduction of negative environmental impacts, especially of CO2 emissions.

- Cooperative systems can improve the collection of traffic related information and thus support traffic management. The road operator / TCC will be able to quickly receive up-to-date data / messages generated by the vehicles. These data / messages enable the road operator / TCC to timely detect and validate local traffic situations as well as conditions of the road. It is expected that both urgent measures and the development of strategies for traffic control and influence can benefit from the information received by cooperative systems.
- Road operators own specific traffic related and road related data. Private service providers may be interested in this data in order to improve their services. Cooperative systems will enable the road operator to play an active role on the data market.
- Further substantial improvements of traffic safety and traffic efficiency, by means of investing in the road side in a traditional way, will be expensive and difficult to achieve. Instead, investing in cooperative services might have the potential of achieving a better benefit-cost rate.

Expected opportunities applying to the service "Hazardous location notification"

- This cooperative service will help to improve road safety by providing warnings on local hazards. Detection by vehicle-based sensors facilitates precisely localising the hazardous spot, identifying the type of hazard and estimating the degree of risk. Detection by several vehicles improves verification of the hazard.
- The road operator might not be involved in the information flow of the warning sent to approaching vehicles, but may also receive the message as an "expert user". The service will thus provide data which contribute to improving the quality of traffic information. If hazards bear a risk for specific vehicles, e.g. for trucks, the warning can be sent to the appropriate drivers in the vicinity of the hazard.

Expected opportunities applying to the service "Traffic jam ahead warning"

- This cooperative service will help to improve road safety by reducing the number of rear end collisions at tail ends of unexpected traffic jams, e.g. traffic jams behind curves. The warning sent to the approaching vehicle is of high accuracy regarding the location of the beginning and the end of the traffic jam and can be transmitted without delay.
- The road operator might not be involved in the information flow of the warning sent to approaching vehicles, but may also receive the message as an "expert user". The service will thus provide data which contribute to improve the quality of traffic information on congestions and of traffic management, e.g. localization and length of a traffic jam, notice on dissipated traffic jams.

Expected opportunities applying to the service "Traffic information and recommended itinerary"

- Cooperative systems can improve traffic management by providing the end user with dynamic recommendations on itineraries and re-routing.
- Traffic information transmitted by cellular communication does not depend on the road net coverage with intelligent infrastructure at the road side. Cellular communication will allow for providing precise traffic information on secondary roads as well (e.g. specific information on the intended route of a vehicle).
- Cooperative systems will enable the road operator / TCC to control recommendations for itineraries, in contrast to the current situation, where autonomous navigation systems provide recommendations which cannot be controlled by

the road operator / TCC and thus may be contradictory to those given or intended by the road operator / TCC.

Expected opportunities applying to the service "In-vehicle signage"

- This cooperative service can provide the end user with continuous information about effective speed limits and their contextual or temporary variation along the road, and will warn the driver in the case of exceeding a speed limit. Cooperative systems enable the end user to obtain speed recommendations depending on the traffic situation or sudden events on the road ahead. Thus, this cooperative service will help to reduce the number of speed violations, to reduce the number of accidents caused by speeding and to achieve a harmonised traffic flow.
- When considering the investments on road infrastructure aimed at road safety and traffic control, the cooperative service "In-vehicle signage" might be an alternative solution for some of the traditional road infrastructure measures. For example, variable message signs might be replaceable with the cooperative service "In-vehicle signage" in the future.

Expected opportunities applying to the service "Parking management"

- This cooperative service will support the end user in searching for and navigating to free parking lots located in areas which are not connected to existing vehicle-park routing systems, e.g. parking areas on motorways. Additionally, the service will allow the driver to make reservations from the vehicle. The service can contribute to reducing searches by overtired truck drivers when looking for a free parking place, and avoiding tailbacks at entrances of overcrowded parking areas. This may reduce the number of necessary interventions of the road operator / TCC. It is expected that safety and traffic efficiency will increase.
- From the perspective of a private road operator, this cooperative service allows for the provision of information on the extended range of services offered in "Intelligent Parking Areas" (e.g. showers, rooms, restaurants).

Expected opportunities applying to the service "Road works warning"

- Accuracy and up-to-dateness of road works warnings will increase, as the warnings provided by the cooperative service can be closely connected to the progress of the construction work. Road safety at mobile road works will increase.
- The cooperative service allows for controlling the progress of the construction work without direct monitoring at the construction site.
- If the road works carries a mobile RSU which continuously sends warnings to approaching vehicles, the service does not depend on traffic density or on road net coverage of stationary detectors at the road side. All vehicles equipped with an in-vehicle system will be warned, including the first vehicle arriving at the construction site. Additionally, the mobile RSU allows for sending up-to-date information to the road operator / TCC.

3.4.2 Concerns and risks

Expected concerns applying to cooperative services in general

- Users of cooperative services may receive better and more current information on the traffic situation than the road operator / TCC, in the case where the road operator / TCC (or his contractor) is not included in the cooperative service and thus receives no data from the process. When comparing the information from the cooperative service with the information received from the traditional service of the road operator, the end user may have the impression that the road operator's service is poor. The end users may lose confidence in the original service of the road operator and no longer accept the recommendations of the road operator. This may decrease the effectiveness of the traffic management strategies of the road operator.
- Many end users regard the road operator as being the responsible provider of traffic information. The road operator may be blamed for wrong traffic information in those cases where the road operator is involved in the cooperative service but information flow does not allow him to validate the information transmitted to the end user.

- The investment costs to the road operators' account for deploying cooperative V2I systems based on WLAN communication technology largely depend on the equipment needed for the road side. Although cooperative V2I systems seem to provide benefits in improving road safety and traffic efficiency, large-scale infrastructure equipment on the road side is not expected to be efficient from a socio-economic point of view because of the high costs.
- The road operator, as a strategic actor, needs to specify the requirements of the services so that they are oriented towards the overall goals of the road authorities. The complexity of cooperative services will be the reason that considerable effort is required in order to provide the specifications and control the compliance at the providers and contractors.
- Equipment needed for cooperative systems will be procured on the international market. Experiences with other telematics systems show that the possibility of acquiring equipment in order to test devices under the conditions of a particular country is often low. Thus, devices obtained may not completely fulfil the national standards and the quality level required by a specific road operator. As a result, service quality offered to the end user may be poor (Example: Deployment of RDS-TMC at the beginning).
- In the case of cellular communication, high communication costs for the operation of the services, which have to be borne by the road operator and the end user, are expected.
- Property rights on data collected by the vehicles seem to be unclear as yet. If the road operator wants to make use of the data, he may have to pay for them.

Expected concerns applying to the services "Automatic access control" and "Parking management"

- Vandalism against infrastructure devices is a possible risk, especially in those cases where the service has to reject access or reservation.
- Advance booking of public parking space may be restricted by national law in some countries.
- Compliance with privacy requirements seems to be an important issue with these services, as individual data of the vehicle are transmitted, e.g. for pre-booking, payment, authentication for approval of access.

Expected concerns applying to the services "Traffic information and recommended itinerary" and "In-vehicle signage"

- Liability issues may cause some problems. In the case of traffic violations or accidents, the driver might state that he/she adhered to some information which was displayed on the in-vehicle system, whereas the road operator might state that different/no information had been sent.
- Users may receive information from competing service providers which provide different traffic information and different recommendations on itineraries.

Expected concerns applying to the service "In-vehicle signage"

- Traffic signs displayed inside the vehicle may be contradictory to traffic signs posted at the road side or to information displayed at the VMS. Such situations may confuse the drivers. This may also be the case if the in-vehicle HMI uses pictures which are different to pictures existing on real traffic signs.
- There is some discussion as to which legal status the information displayed inside the vehicle will equal in the future, e.g. information on speed limits, restricted access, closed lanes. For example: If the speed limit displayed inside the vehicle is contradictory to the speed limit signposted on the road side, which information is the mandatory one? Assigning legal priority to the information displayed inside the vehicle would make it difficult for the authorities to control information and would exclude unequipped vehicles.
- It seems unrealistic that the cooperative service "In-vehicle signage" can totally replace the signposting on the road side in the near future. In the case of a breakdown of the in-vehicle display, signposting at the road side will allow for driving in a fallback mode as it provides mandatory information to the driver.

3.4.3 Critical success factors

- Standardised devices with clear specifications must be available both for the equipment of vehicles and road side, thus ensuring interoperability. Data to be exchanged between different systems of different manufacturers have to be compatible.
- A road operator should have the possibility of testing road side devices and services in real traffic situations on his road net and under the specific national conditions.
- Cooperative service providers should exist on the market. In countries where road operators predominantly act as supervisors, the road operators have to contract private service providers who are able to operate the cooperative services.
- Data privacy must be ensured. Confidentiality of messages requires encrypting a message for a specific recipient so that only the dedicated recipient can use it (IEEE 1609.2, 2006). This is highly important, especially for cooperative services which transmit individual data of the vehicle and/or the end-user, e.g. for services such as “Automatic access control” and “Parking management”. Anonymity for end-users is another major requirement which has to be ensured as far as possible. Messages sent from a vehicle of a private end-user should be secure in order to minimize identifiability and traceability by unauthorized recipients.
- High-level security services are needed in order to protect the whole system against intrusion and manipulation by violators and to mitigate the negative effects of attacks, e.g. manipulation of systems to send out incorrect message contents, altering a message in transit, tricking a recipient into accepting incorrect messages.
- It has to be verified, from a socio-economic perspective, that the benefits of cooperative systems exceed the costs (benefit-cost rate > 1). For cooperative services which include V2I communication, it is expected that a major impact on the benefit-cost rate will be caused by the costs of the infrastructure devices, especially in the case of large-scale equipment of infrastructure. Therefore, the costs to the road operator’s account should be limited, i.e. investment costs and maintenance costs of infrastructure devices and infrastructure related costs for operation of the services.
- It is essential that all actors involved in the value chain can profit from a service.
- Acceptance by the end users is one of the important success factors. Real benefits to the end user have to be offered and demonstrated, e.g. benefits on safety, efficiency, comfort, savings in fuel consumption etc. Additionally, the end users’ perception on the benefits of the cooperative services has to be raised, e.g. by campaigns. The costs to the end user’s account are also an important factor for the acceptance by the end user (SAFESPOT SP6, 2010). It is essential for the end user‘s willingness to pay for a cooperative service, that the benefits received from the service exceed the costs to the end user‘s account (costs of the in-vehicle system, fee for the service etc.). Some services, including a set of safety related data, should be provided without charging the end user.
- For the deployment process of cooperative systems which include V2I communication, close coordination between the road operators and the other stakeholders (electronic device manufactures, automobile industry, service providers including net providers etc.) is necessary.
- It is important to create a strong Memorandum of Understanding with the telecom providers regarding the transmission of floating car data via the cellular network and the creation of traffic related services linked to nomadic devices, e.g. PDAs, smart phones.
- There must be clarification of the future legal status of the information displayed inside the vehicles, especially of information related to traffic rules if only displayed inside the vehicle.
- Recommendations on itineraries and rerouting must not be based on economic criteria only. Instead, they should be based on an integrated traffic management strategy, taking into account a comprehensive set of relevant criteria (safety, efficiency, environment, mobility). An integrated traffic management will allow optimising the use of cooperative service providing traffic information and recommending itineraries. Clear strategies will help to maximise the benefit for society and, under certain conditions, to meet the requirements of an individual customer.

4 Conclusions and recommendations

This stakeholder analysis focuses on the stakeholder group “Road operator”. It identifies the road operators’ potential roles for the operation of selected cooperative services and describes their expectations connected to the future roles and responsibilities. The main findings and conclusions of the study are shown in the following summary:

1. A simplified method for identifying potential roles has been developed. The methodology is based on a generalised process chain for the operation of cooperative services and on high-level descriptions of optional function schemes which are characterised by features of the information flow. The core of this methodology is a schematic table which connects the optional function schemes with the sub-processes of the generalised process chain. The schematic table allows for identifying potential roles of the road operator for the operation of cooperative services. Potential roles of the road operator are closely linked to the road operator’s responsibility for road infrastructure.

   The methodology was successfully used in this stakeholder analysis. The experiences show that it provides a quick approach for receiving a first insight into potential role profiles and forthcoming responsibilities. This insight supported the stakeholders involved in this analysis in expressing their opinions and aspirations towards opportunities and concerns of the upcoming changes more explicitly. The approach can be recommended for use as an early analytical step preceding the in-depth procedures which aim at the development of systems architectures.

2. Different options of potential function schemes and related role profiles could be identified for the considered services. The considered services have been selected from the list of first priority services collected in Task 2.1: Hazardous location notification (6 options), Traffic jam ahead warning (6 options), Road works warning (2 options), Automatic access control (2 options) and Parking management (1 option).

   The optional function schemes developed for each service have a strong effect on the related role profiles of the road operator in the operation process. Three main categories of options can be identified, depending on the road operator’s involvement in the operation process of a service:

   - The road operator plays an active role in the operation process of the service, i.e. the road operator is involved in the information flow of the process before the message is presented to the end user.
   - The road operator is not actively involved in the operation process but is connected to the end of the information flow, i.e. this role allows the road operator to only receive messages from the information flow.
   - The road operator is completely excluded from the information flow, i.e. the road operator will not receive any information from the service.

   Active roles of the road operator in the operation process enable the road operator to have some influence on the information flow and the information transmitted to the end user. Active roles seem to be possible with two types of function schemes: a) function schemes where the sub-process of data acquisition / detection is performed by infrastructure-based sensors, or b) function schemes where the data acquisition / detection is carried out by vehicle-based sensors and the transmission of messages to approaching vehicles involves infrastructure. In these cases the road operator can take roles such as

   - owner of the road side systems used for data acquisition and V2I-communication via WLAN,
   - owner of the infrastructure equipment for the proprietary net used for communication between the RSUs and the TCC,
   - content provider responsible for data acquisition using infrastructure-based sensors and sources, as well as processing of data including verification, i.e. sub-processes prior to message definition,
   - service provider of the infrastructure-based service (without or with involvement of the TCC/back office) which may include message definition, validity check or

authorisation, adaptation etc., and hand-over to the WLAN net, the cellular net, or the proprietary net,

- service provider of the infrastructure-based service which includes receiving messages from and transmitting messages to vehicles via V2I-WLAN (not responsible for routing within the cellular net),
- service provider of the infrastructure-based service responsible for transmission of data and messages in the proprietary net (communication between different road side systems, or between road side systems and TCC),
- service provider of the internal service for presentation of the messages in the TCC/back office (messages may be received via the cellular net, the WLAN net or the proprietary net of the road operator), and
- user of the messages when executing other tasks for which the road operator is responsible, e.g. road maintenance, providing messages to road users located further away or other service suppliers via other media.

A specific type of function scheme allows for the road operator's receiving of messages at the end of the information flow only. In this case, the road operator's role is limited to the role of an expert user. This role enables the road operator to use the messages in order to advance quality and processes of other tasks for which the road operator is responsible, e.g. traffic information to road users located further away via other media (VMS, DAB etc.), road maintenance services. However, the road operator is not an actor in the supply chain of the cooperative service and thus has no influence on the messages forwarded during the operation process of the cooperative service. The main characteristics of these function schemes are data acquisition / detection by vehicle-based sensors and transmission of the message via cellular communication (e.g. options 4 and 5 of the service "Hazardous Location Notification", option 5 of the service "Traffic jam ahead warning").

Function schemes based on data acquisition / detection by vehicle-based sensors and using V2V communication via WLAN only show a passive role of the road operator in the operation process and do not allow the road operator to be involved as a user of the messages exchanged between the vehicles, e.g. option 1 of the service "Hazardous Location Notification" (see chapter 3.2.2.1), option 1 of the service "Traffic jam ahead warning" (see chapter 3.2.3.1).

It may be argued, that the effect of function schemes on role profiles is self-evident. However, the discussion shows the importance of the function schemes. If the road operator wants to be involved as an active player in the operation process, the function scheme has to comply with specific requirements. The involvement of the road operator in the operation process is not only a matter of process organisation but has also to be considered when deciding on functional concepts.

3. The expectations on strengths and weaknesses, which have been collected in the assessment of the optional function schemes and role profiles, are specific to option, criterion and service. The overall results on suitability and costs do not show a clear preference of a single option (see Figure 38 to Figure 42).

   The options per service, which vary in function scheme and role profile, show different strengths and weaknesses over the criteria. When comparing the options between the services, some options can be found which have been composed of similar function schemes and role profiles. However, this similarity does not necessarily lead to the same results regarding strengths and weaknesses, e.g. option 3 of service "Hazardous Location Notification" vs. option 3 of the service "Traffic jam ahead warning". A specific function scheme / role profile can show different strengths and weaknesses at different services.

   The results are affected by the underlying conditions and assumptions of the assessment. Especially the functional and organisational characteristics which have been used to describe the options, and the criteria, which cover some selected aspects in terms of quality of service, process organisation and financial impacts of the service, have a major impact on the results. The criteria were derived from requirements defined from a road operator's perspective. They have been adapted to the services and the level of details available for the characterisation of the options. Further criteria and weightings of criteria may be available in future in-depth assessments and will affect the results. The variance of the experts' opinions has some influence on the results and their comparability between the services and the options, too.

4. The results received for the criteria on expenditures allow, for a limited scope of services, a rough differentiation between cost-intensive options and low-cost options from a road operator's perspective:

   - Service "Hazardous location notification"
     Low or rather low costs expected: Option 1, option 4, option 5.
     High or rather high costs expected: Option 6, option 3.

   - Service "Traffic jam ahead warning"
     Low or rather low costs expected: Option 1, option 5.
     High or rather high costs expected: Option 3.

   - Service "Road works warning"
     Low or rather low costs expected: Option 2.
     High or rather high costs expected: Option 1.

   The lowest costs to the road operator's account are clearly expected for option 1 of service "Hazardous location notification" and option 1 of service "Traffic jam ahead warning". Both options are similar in their function schemes. As they are based on detection by in-vehicle sensors and use V2V-WLAN for communication, they do not require roadside equipment (only in-vehicle systems are needed). It is obvious, therefore, that no costs to the road operator's account arise for investment, operation and maintenance. However, the road operator will not be able to receive data from the information flow of these options.

   High costs are expected for V2I-WLAN communication in case of a high road net coverage of road side units which are used for data acquisition / detection and data transmission to the vehicles (e.g. option 3 of service "Hazardous location notification", option 3 of service ""Traffic jam ahead warning", option 1 of service "Road works warning"). These options show high investment costs and high maintenance costs in the case of large scale equipment of the infrastructure.

   If the cellular communication network is used, high operation costs are expected because of the connection costs. Operation cost to the road operators account may even increase if data collected by the RSUs are not directly sent to the vehicles, but have to pass the TCC first, e.g. for validation of data or for message definition by the TCC.

   However, despite of some open questions regarding cellular communication (e.g. high connection costs; buffering of information for a period of time), moderate costs seem to be achievable with options which are based on detection by in-vehicle sensors and V2V communication via the cellular net (e.g. option 4 of service "Hazardous location notification", option 4 of service "Traffic jam ahead warning"). These options do not require an equipping of the road infrastructure with specific road side units. The needed upgrading of the cellular net is expected to create only moderate costs to the account of road operators and end-users.

5. Both WLAN communication (IEEE 802.11p) and cellular communication (GSM, UMTS, LTE) have been considered in the stakeholder analysis. It seems that both communication technologies ought to be available on the in-vehicle communication platform in order to allow the system to flexibly adjust its mode of operation to the requirements of different services, changing traffic situations and national conditions of the road side infrastructure etc.

   Such a solution will provide maximum applicability and availability. It does not only enable the in-vehicle system to be applied for a bundle of services using different communication technologies, but may also allow a single service to use different function schemes on-demand. The potential to select the appropriate communication technology on demand may also help to mitigate costs. Cellular communication can avoid high investment costs which occur in case of a large-scale equipping of road infrastructure with RSU. WLAN communication is expected to show low connection costs. An example of such a combined solution using both communication technologies is shown by option 5 of service

"Hazardous Location Notification" (similar to option 5 of service "Traffic jam ahead warning"): The hazardous spot is detected by vehicle-based sensors. The in-vehicle communication platform automatically selects the appropriate communication technology. The message is transmitted to approaching vehicles via V2V communication using WLAN, if traffic density is high and enough equipped vehicles are in the vicinity. Cellular communication may be selected in times of low traffic density and in the beginning of market introduction when the penetration rate is low. The road operator may receive the message either via cellular communication to the TCC or, if available, via WLAN communication to a RSU in the proprietary net of the road operator.

6. The main opportunities, from a road operator's perspective, are expected with regard to the overall goals of road transport. Cooperative services are expected to allow for substantial improvements of road safety and traffic efficiency. They contribute to a better connection of different modes of transport and the reduction of negative environmental impacts.

   The end-user will benefit from fast and up-to-date traffic information and recommendations which suit the current traffic situation or hidden risks on the road ahead.

   The collection and exchange of traffic related data will be improved. On the one hand, the road operator can benefit from receiving data generated by the vehicles. The data do not only advance the quality of traffic management and traffic information, but also support the road operator in the execution of other tasks for which he is responsible, e.g. road maintenance. On the other hand, cooperative services will have the potential of new and advanced business cases for the road operator. The road operator can play an active role in the operation of services by providing private actors with data.

7. A major part of the concerns and risks deals with the information transmitted to the road users by different service providers and different cooperative services. The effectiveness of the traffic management strategies of the road operator may be impaired if traffic information and recommended itineraries given to the road users are contradictory to the information given by the road operator, or do not match up with the traffic management strategies intended by the road operator. There seem to be many open questions related to this issue, e.g. organisational concepts of cooperative services without involvement of the road operator, lack of agreements on traffic management strategies, legal and liability risks, preference and legal priority of information displayed inside and outside of the vehicle. Other concerns are related to privacy of personal data, as some of the cooperative services need to collect and transmit individual data of the vehicle.

   Costs to the road operator's account seem also to cause a number of concerns, e.g. expenses for the equipment and maintenance of communication systems at the road side, communication costs for the operation of the cooperative services and costs for the use of vehicle-generated data due to property rights. Cooperative V2I systems based on WLAN are expected to be effective in improving road safety and traffic efficiency, but large-scale equipping of the road side with RSUs is not expected to show a high benefit-cost rate. Increased connection costs are expected with cellular communication. It does not seem feasible, at least in the medium term, that cooperative services displaying information inside the vehicle can replace sign-posting at the road side and thus reduce costs.

8. The following aspects summarise the success factors which have been identified by the consulted experts. These factors are expected to be important for a successful operation of cooperative systems:

   - International standardisation and harmonisation, e.g. system architectures, interfaces, data formats
   - Clarification of the legal situation for cooperative services, systems and data, e.g. liability issues (including public bodies), property rights in data, legal status of information displayed in the vehicles
   - Field tests of road side devices and services under national / regional conditions in order to ensure compatibility of technical solutions with the requirements of the road operator

- Organisational development of public private partnerships (PPP), which includes a clear allocation of competences and responsibilities to the actors involved in the operation of the cooperative services

- Role of the road operator in the operation process of cooperative systems has to be adequate with regard to the official duties of the road operator: Cooperative services (on a regional and nationwide level) dealing with traffic information, recommendations on itineraries and rerouting require a stronger active role of the road operator in the operation process than is the case for safety related services. Many of the safety related cooperative services are time-critical and the processing of these services must be kept to a minimum in order to allow high promptness of the service

- Agreement (or outline regulation) on guidelines and strategies for route guidance in order to avoid incompatibilities between the information provided by different service providers and the traffic management strategies of the road operator

- Verification of both acceptable benefit-cost rates from the perspective of society and profitability from the perspective of the involved stakeholders; business models should offer the potential that all stakeholders involved in the value chain can profit from a service

- Resistance to technical breakdown; secure fall-back mode in case of a system breakdown, which takes into account the availability of mandatory traffic information, the driver's capabilities and skills etc.; high security against intrusion of violators

- Compliance with privacy requirements

- Awareness and acceptance of cooperative services by the public; effective procedures to raise awareness of target groups, i.e. end-users and consumer groups, road authorities, road operators, communication net providers and operators etc.

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