SEAMLESS

Business case for seamless road data dissemination to in-vehicle devices

Report Nr. 2

July 2012

AlbrechtConsult GmbH

Mott MacDonald

Trafficmaster

PTV AG

This project was initiated by ERA-NET ROAD.

Project Nr. 832597

Project acronym: SEAMLESS

Effective distribution of road authority data

Project title: Seamless traffic data dissemination across urban and inter-urban networks

Deliverable Nr 2 – Business case for seamless road data dissemination to in-vehicle devices

Due date of deliverable: 30.04.2012

Actual submission date: 31.07.2012

Start date of project: 01.10.2011 End date of project: 31.10.2012

Author(s) this deliverable:

Michael Ortgiese, PTV, Germany

Jörg Freudenstein, Christoph Kuhlemann, AlbrechtConsult, Germany

Ian Cornwell, Mott MacDonald, UK

Craig Blount, Trafficmaster, UK

Version: 01-00-00

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1 Introduction

This document is the second deliverable of the SEAMLESS project.

The first deliverable detailed the background to the project, introduced the Stakeholders and the two use cases “Traffic Light Phase Assistant” and “Seamless urban and inter-urban roads information for in-vehicle devices”, with journey times as a particular focus. In addition, basic information on the available standards in Europe was documented in order to serve as a reference point for the following work packages. The analysis of existing research projects highlighted the huge number of standardisation projects currently ongoing as public authorities and the European Commission recognise the need for action in the field of cooperative ITS.

This document gives an overview of value and costs of urban traffic data and services; however, given all the existing material on the business case for cooperative systems (e.g. see COBRA 12, section 6.2) this report focuses on the intrinsic value of the data and services, rather than undertaking a detailed cost benefit analysis. This means that aspects of the business case related to the seamless character of urban services especially in relation to legacy systems are analysed, an aspect that does not appear to have received much attention in previous work.

The partner project COBRA of the ERA-NET ROAD II call ("Cooperative Benefits for Road Authorities") is advising/supporting decision makers in the context of Cooperative Systems. The first COBRA deliverable [COBRA 12] clearly shows how other projects like SPITS, EasyWay or SAFESPOT value the benefit of cooperative systems. Nevertheless, one main observation is that the successful implementation of cooperating systems requires a win-win situation for all cooperation partners along the service value chain.

A second conclusion is that such systems require a high level of flexibility to be attractive for the end user. This flexibility is mainly described in terms of characteristics of the end user devices and in-vehicle architecture (e.g. application platforms that are easy to update or even support the replacement of applications vs. former, fixed-function devices that shared the lifecycle of the vehicle). However, rapidly changing applications also mean frequently changing requirements, e.g. different algorithms, different location referencing techniques, different quality requirements or changing requirements regarding latency. Hence, the demand for flexibility is likely to propagate “upstream” through the value chain towards content providers - many of them public authorities – and the associated interfaces to legacy systems.

In addition current deployments are predominantly driven by the private sector with public involvement still being at a very low level. The reason for this is mainly due to the fact that the role and responsibility of the public sector – and its corresponding business model – has not been finally settled. For instance it is not yet clear, how a proper balance between in-vehicle functionality and roadside infrastructure can be found in the future. This and other issues are addressed by other large research projects in form of different scenarios. This deliverable briefly highlights the main issues, whereas the third deliverable of the SEAMLESS project will focus on possible future architectural developments per scenario.

Furthermore, SEAMLESS focuses on urban areas because most interurban road operators have already realised the need for data exchange with service providers and have implemented interfaces for data provision that are suitable to serve seamless services. Motorway-related data like congestion, "level-of-service" and messages related to events (incidents, accidents, weather related, etc.) is already widely disseminated to private service providers.

It is important to note that the number of independent urban authorities exceeds that of interurban operators by an order of magnitude and the complexity of describing an urban traffic situation is also much greater than in the well-controlled trunk road scenario. Therefore, the challenge – but also the benefit – of any major improvements is clearly to be found in urban data and services.

A good example of collaboration between urban and interurban road authorities is the project Düsseldorf in Motion (Dmotion), where strategic traffic management for the metropolitan area Düsseldorf has been established. Its base is a dynamic linking of the urban traffic management (City of Düsseldorf) and the interurban traffic centre (North-Rhine-Westphalia). 400,000 commuters a day benefit from data exchange and dynamic route recommendations when driving from the motorways inside town.

Why road authorities who generate urban data from legacy traffic management systems should seek to make it widely available and how this data can most effectively be disseminated to in-vehicle devices are key questions which will be addressed throughout this deliverable.

Approach

By analysing the business process and the objectives of the stakeholders involved in the value chain, work package 2 provides the following results:

- In chapter 2, the value and cost of urban data and of seamless services are emphasized.

  Chapter 3 covers the exchange of data along the value chain. Three "Cooperation Cases" are reviewed: (1) The detection and provision of content. (2) The exchange of processed data, e.g. Level of Services or Speed on Link. (3) The presentation of Information to the end user/driver. The section covers requirements for the technical aspects of stakeholder cooperation. The results of this are the requirements for architecture and interface design to be undertaken in work packages 3 & 4.

- Chapter 4 describes the business models which are currently in place and gives recommendations with respect to the two SEAMLESS use cases.

2 Value of Data and Services

2.1 The Value of Urban Data

Research projects and Field Operational Tests (FOTs) give a clear picture of the state of the art in the cooperation process of public bodies and private stakeholders. The private sector has established excellent traffic information services in areas where required input data was easily accessible. This is mainly traffic condition information via fixed infrastructure, floating car and mobile phone data and also extends to incident detection at the inter-urban level. This data is frequently used to deliver adaptive navigation services on the roads for which such information is available.

However, at an urban level private service providers currently fail to provide more advanced services, largely due to the required information from urban operators being unavailable in an easily assessable manner, making the delivery and realisation of services like the traffic phase assistant, or navigation services aligned with urban traffic management measures, impossible on a national basis. Public road authorities' willingness and ability to cooperate on providing data for these services are not yet clear. Nevertheless, the missing data for such services cannot be readily substituted by private stakeholders. Private information providers and the automotive sector have therefore realised the need for improved cooperation between the (urban) public authorities and industry. Numerous research projects have been and still are being carried out to identify suitable business models for both public bodies as well as private sector services. Typical examples are:

- The project Dmotion tackles the issue of traffic information, dynamic routing and event handling by an active cooperation between the city of Düsseldorf and private (information) operators. Traffic flow information is provided from the private stakeholders to the city, leading to traffic signal programs in Düsseldorf being adapted dynamically according to the real-time situation on the whole network (including motorways). The city disseminates the information on traffic management measures taken (e.g. improved capacity due to adapted traffic signal plans) and preferred routes to private navigation services, ensuring that route guidance is delivered which is consistent with the best routing strategy under the current traffic conditions. Mutual benefit results in the best possible traffic condition on the road. Field tests have empirically proven the positive benefit of the system [DiM 10].

Figure 1 - Rerouting in Dmotion [DiM 10]

- The FOTs sim^{TD} and Score@F make use of urban data for communicating it into vehicles via infrastructure-to-vehicle communication. The traffic phase assistant (sim^{TD}) and “Stop-Start at Traffic Light“ (Score@F) applications transmit the traffic signal timing data directly to vehicles in the vicinity of a traffic signalled junction, enabling safer and more efficient driving in urban environments. This data is normally generated within the signal controller which is under the responsibility of a public authority; the private stakeholder has no other opportunity to access this data than to establish cooperation. The projects are working on practical solutions to make this data available for vehicles. Results regarding the benefit have not been published yet. Statistical observation of traffic signal patterns (black box observation) is currently considered as a substitute to direct communication with the traffic signal controllers in other projects, but since these algorithms are adaptive to traffic their behaviour is impossible to predict and the quality of prediction that can be expected from external observation is unknown. The fact that serious research on this is carried out with the single purpose of avoiding the need to connect into a legacy system like the signal controller is a strong indicator for the challenges of trying to connect new applications to existing infrastructure.
- The project “Aktiv” has tested the “cooperative traffic signal” in Hattersheim, Germany via bidirectional information exchange between the vehicles and the traffic signal controller. The project was able to prove a significant reduction of stops at stop lines in some scenarios. A smoother driver experience resulted in addition to a more efficient traffic flow. Again, data exclusively available from public sources had been fused with private data to give a benefit to the road user and the traffic situation as a whole. The practical use and benefit of the cooperation has been demonstrated with this project [Aktiv 10].

The Value of Urban Data to the Commercial Information Provider

The discussion about value has to consider that public road operators are interested in financial aspects as well as establishing a sound traffic management programme for cities and motorways. So the cooperation model has to consider both the commercial and social objectives.

Commercial information providers generally produce their own traffic data from probes or their own fixed infrastructure. However, the desire to deliver the highest possible quality content with the widest geographical coverage means that accurate and reliable content from third party sources is always attractive to commercial information providers if it can be cost effectively integrated in to their national and global product offers.

The above said, the commercial providers have traditionally faced serious challenges in unlocking the value within such urban/public data sources. This is because such data sources are generally under the control of local, rather than national, authorities which frequently results in there being variations in:

- the level of implementation of the underlying data collection technology between different local authority areas
- the use of different hardware and software suppliers with different approaches to data collection and data management
- wide variations in the underlying data structures of any information that is generated.

Commercial information providers have therefore had to deal with each urban data source on a unique case by case basis - meaning that only the very largest and strategically significant data sources – the most valuable - ever become ‘unlocked’ and integrated in to the data sets of the commercial information providers. In short the commercial information providers have to date struggled to justify the business case for the bespoke integration of less significant urban data sources covering smaller geographical areas.

Within the UK many local authorities would challenge this observation, and claim to have overcome this lack of consistency by utilising UTMC-based ITS systems, which in theory offer the prospect of inter-operability between various ITS investments through the use of a defined set of standards. UTMC has significantly reduced the cost of integration of urban data sources. However, in reality, because of the degree of flexibility within the UTMC standards, a UTMC data feed from one local authority can be different to that of another authority, therefore failing to completely eliminate the requirement for bespoke integration work on the part of a commercial provider for each data feed.

Furthermore, there is also a lack of consistency in the policy for making such data available to commercial providers, with some authorities happy to facilitate the ‘unlocking’ of the value within their data by releasing it ‘free of charge’, whilst others are reluctant to release data on such an open basis. This approach further dilutes the attraction of such data to the commercial provider.

An example of these challenges can be seen from the limited level of integration of public authority data feeds within the current commercial product offer of Trafficmaster, where the integrated data feeds from public authorities are limited to a Highways Agency national data feed, and data generated from Transport for London’s congestion charge monitoring cameras. The former provides an additional free of charge source of data covering the motorways and major trunk roads of England, and the latter provides an additional source of data covering many major roads within the UK’s most significant and congested city.

Whilst many other ‘urban’ data sources are available within the UK, the business case to integrate these sources and ‘unlock’ their value is not justified in terms of the value that the content adds to Trafficmaster’s overall commercial proposition versus the cost of the bespoke integration work required to utilise the data and/or lack of clarity regarding the on-going commercial terms for use of the data.

From a commercial provider perspective the key to ‘unlocking’ the value of urban data is therefore:

- Data is released to the commercial providers ‘free of charge’ using a simple model contract with few if any restrictions on data re-use
- Data should be available from all sources in one (or a minimum set of) agreed common formats.

A promising development is the emergence of DATEX II services attached to UTMC systems in the UK. These services address the desirable characteristics in the following ways:

1. DATEX II is a CEN specification with support across Europe
2. DATEX II was designed for information dissemination rather than urban traffic management integration, and standardises implementations more than the UTMC specifications do.
3. DATEX II uses mainstream web services technology.
4. DATEX II outputs may be easily validated against the DATEX II schema. As noted in point 2 above, there may be a need for more restrictive profiles, in which case there would need to be validation against those profiles.

There is also a UTMC XML specification and at least one implementation, which share some of the noted benefits of the DATEX II services.

However, implementations may still not be sufficiently standardised to make integrations economic for service providers. For each kind of data, the services from a single product vendor should be consistent, but there still may be some variation across vendors. This is an area for further investigation in this project. Also the kinds of available data will vary as shown in Table 1 (see page 15). There may be a need for more restrictive profiles to refine the DATEX II schemas e.g. a profile to describe a minimum set of safety-related information, and a profile describing a set of travel information that is useful for service providers and that is provided by a substantial proportion of authorities.

However there is no well-used directory of services to inform service providers about available local authority data. The TIH Catalogue of Services aims to provide such a directory in the UK, but is not currently well used. The DATEX II website www.datex2.eu contains a "nodes directory" which lists DATEX II services, but it currently lists mainly national services, a small number of regional services and no urban services. Awareness of this directory outside the EasyWay project participants is probably very limited. In Germany, the MDM will provide a directory, and with richer features such as filtered queries and geographic searching.

In the UK at least, with extensive deployment of UTMC traffic management systems, increasing deployment of DATEX II or UTMC XML services should be inexpensive for local authorities because there are established products which provide these services, so the effort needed to deploy a service for local authority with a UTMC system consists largely of configuration.

2.2 The Value and Costs of ‘seamless’ services

The previous chapter focussed on the value and costs of urban data. For the analysis of the value and costs of seamless services, we first need to define what seamless services are.

The notion of ‘seamless service’ in the technical communication domain often refers to a proper handover of an on-going communication between two or more different networks, e.g.

some mobile devices are able to seamlessly switch from a wireless LAN to a mobile WAN (e.g. UMTS) when the coverage area of the WLAN is left without losing connection on higher level, e.g. a phone call or a data download are continued without interruption.

For the SEAMLESS project, the scope of this concept shall be extended beyond the mere technical point of view, covering also the organisational framework required. From the users' (drivers') perspective a seamless service is characterised by the provision of an ITS service across geographical, technical and jurisdictional boundaries, providing a constant level of information provision and route guidance throughout an end user's journey. The user of a particular service should not recognise a transition (with respect to the seamless service) from one network/city/provider to another.

The current situation is not seamless. Information provision is mainly restricted to interurban areas, whereas on local roads service coverage is rare and unpredictable. In order to establish a seamless service, three issues need to be addressed:

1. Interface must be harmonised
2. Business / organisational processes must be connected
3. Data quality and consistency must be assured

The following figure depicts possible interconnections between relevant stakeholders:

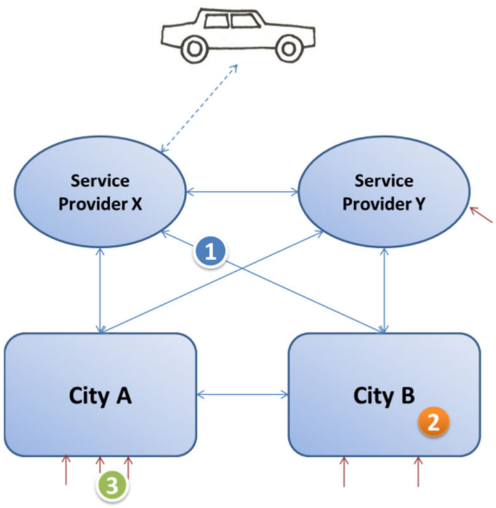

Figure 2 – Interconnection between relevant stakeholders for seamless services

Interface (1) may be the most critical for seamless services. Standards play a great role here. As outlined in SEAMLESS Deliverable One, there are already some standards existing and many more under development. Formal standards – or sometimes even well-established proprietary interfaces, often referred to as "industry standards" – ensure interoperability that is a basic requirement for information exchange between stakeholders.

Furthermore, the organisational processes inside the stakeholders' organisations (2) need to be able to support the exchange of information on a sufficient service level. An interface itself is not sufficient, if system operation does not provide sufficient service availability.

Finally, the data itself needs to be of sufficient quality to ensure the success of the information exchange. If data quality is not satisfying the requirements of the end user service, all action taken on the previously described steps remain useless. Assuring, monitoring and describing ITS data quality is the focus of a whole set of dedicated R&D projects.

Looking at data flowing along the described value chain of public authorities and private sector service providers, seamless services appear technically feasible today. However, few are actually fully in place and close to none appear to provide the desired level of quality. The discrepancy between the presentation of public and private data is only one area of lacking performance (which has been identified as a highly rated safety risk by Safespot [Safespot 07]) and will be discussed later in this chapter. Given that current Local Authority traffic management operations collect a massive amount of data electronically (loops, CCTV, databases for scheduled events, etc.), only very little of this data is made available to external services. The problem appears to lie within the local authorities themselves and their inability to effectively take on the role of being a content provider within a multi-organisational service chain. What makes that so challenging?

Looking into the projects, we find the expected multitude of databases holding traffic monitoring data, traffic signal data, operational data like current and scheduled roadworks and road closures or details of public events relevant to traffic, etc. The problem is the disparate handling of that data throughout authorities due to datasets being heterogeneous and scattered over different responsibilities and organisations. In order to enable the provision of an ITS service, certain requirements regarding data quality, continuity or timeliness have to be met, which usually were not part of the original design specifications for these systems. Authorities fear unpredictable investments being imposed on their extremely stretched budgets. Concerns regarding the impact of such activities on staff and ICT operations often exceed concerns regarding the system upgrade costs. It appears that a successful approach towards seamless services and cooperative systems will require a new definition of roles and responsibilities in (urban) traffic management.

This concern is also reflected in Safespot with a reference to new and enhanced risks to the public: “The public sector involvement in providing sensors etc., to emit or confirm data, engages the public authorities and their franchised operators in new legal exposures; they might also face liability if they licensed or continued to approve actors who were not complying with the agreed standards, particularly as to safety, as well as ensuring a reasonable program of maintenance and checking that the sensors were actually working.” [Safespot 06]

Nevertheless, since all this public equipment (and therefore the resulting data) has ultimately been paid for by the tax payer, it appears that recent major policy changes towards open data are putting pressure on road authorities to work towards making this data available as widely as possible. Furthermore, the dissemination of such urban data for the provision of high quality ITS service would often result in a secondary or tertiary benefits such as strengthening the competitiveness of the ITS industry or the economic area covered by these services.

3 Cooperation Cases along the value chain

The definition of suitable business cases is based on the value chain defined by TISA and introduced in Deliverable One. It shows the following chain-segments:

- Collection of raw data
- Processing of raw data under consideration of service requirements
- Information service generation under the responsibility of service providers or road operators
- Information service presentation by end-user devices or road side infrastructure

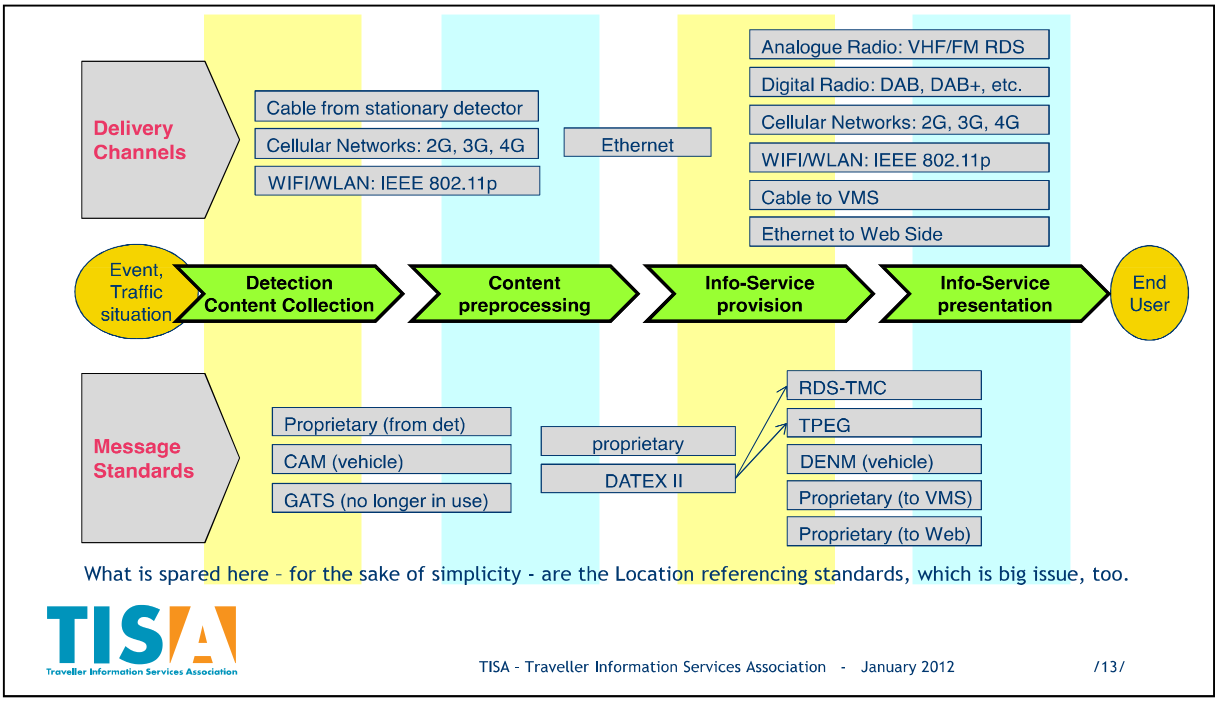

Figure 3 – TISA's value chain

Each element of the chain gives the opportunity for cooperation between stakeholders. With respect to the objectives of the SEAMLESS project the cooperation between public and private stakeholders is the most important type of interaction.

3.1 Cooperation Cases

The following figure shows the resulting three "Cooperation Cases":

- Data provision
- Data exchange
- Service

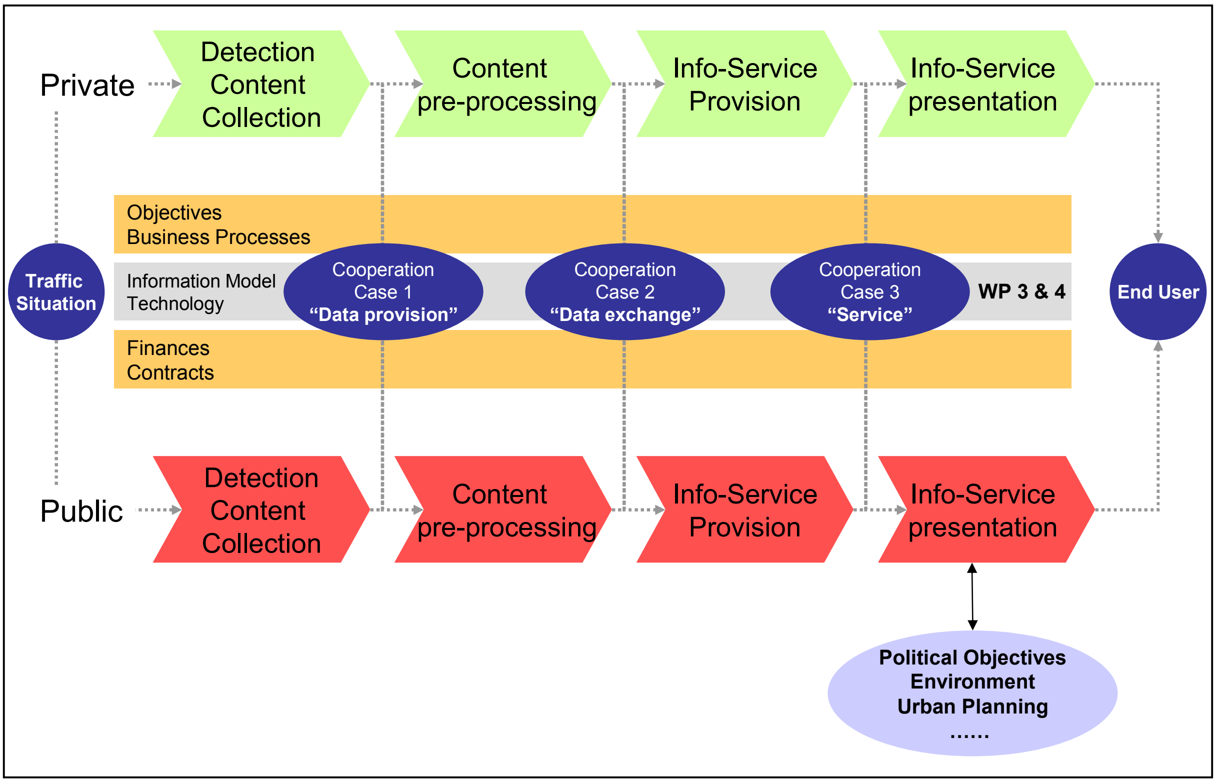

Figure 4 – Cooperation cases

The Cooperation Cases are explained in detail in the following sections.

3.1.1 Data provision

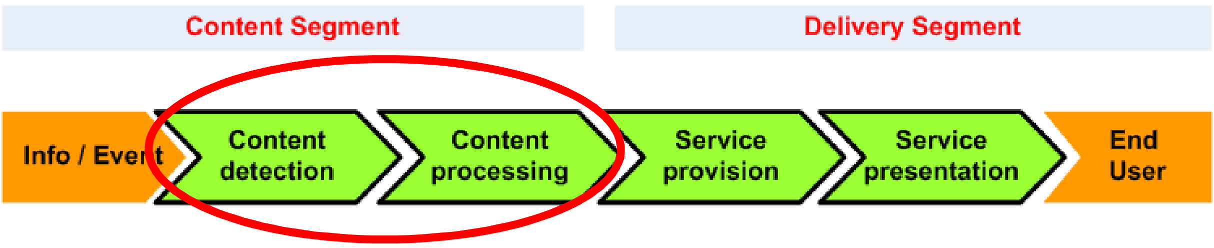

Figure 5 – Cooperation Case 1

The road operators are gathering and managing a huge amount of data which is required for the day-to-day operation as well as for planning and maintaining the infrastructure systems.

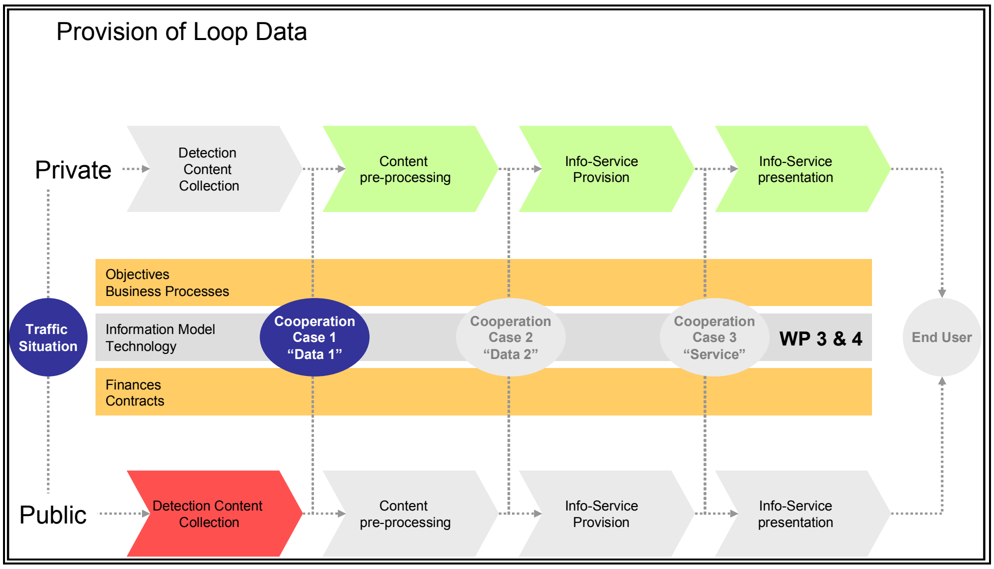

Figure 6 – Example Provision of Loop Data

With respect to the use cases addressed in the SEAMLESS project the following static and dynamic types of data have to be distinguished:

- Real time data generated by local detectors and cameras. The detection infrastructure is usually linked to dedicated traffic systems, e.g. traffic lights or variable messages signs, implying certain data characteristics that can limit the value for other applications, particularly traffic systems. For instance stop-line detectors have a very limited value for the network-wide traffic state calculation (Level Of Service).
- Level Of Service: Few cities and motorway operators make processed traffic flow data (LOS) available.
- Incident messages: In cooperation with police many road operators publish incident messages geo-referenced on the TMC network. The messages cover both safety critical warnings as well as information about the general traffic situation (e.g. jam). The publication of such incident messages is a worthwhile contribution to traffic management measures.
- A special topic is the distribution of dedicated safety critical messages. They are clearly focussed on driver warnings and are one of the priorities of the ITS directive of the European commission.
- Road construction information – current and scheduled – including the duration of the work as well as impact on capacity and driver experience.
- Route recommendations: The current discussions show that the exchange and publication of route recommendation (in accordance with the current set of traffic management measures) is one of the road operator's key topics in the discussion about public-private data exchange.
- Static speed limits
- Dynamic VMS (e.g. speed limits) in order to increase traffic safety
- Signal phase: The latest developments in the field of cooperative systems for urban areas are pushing the discussion about the exchange of signal phase information. Form a technical viewpoint two solutions are conceivable: (1) local data exchange

based on short range communication or (2) data offering via a centre-based service using cellular communication.

UK example

In a sample of 12 UK local highways authorities, the following data provision capabilities have been implemented in their UTMC systems. (Note: Absence of a data type from the UTMC system does not mean that the local authority does not have that data, just that it is not currently integrated and available).

Data provision	Number of systems (of 12)
Traffic events	12
Car park information	11
Equipment faults	11
Strategies (i.e. interventions)	12
Journey times	11
VMS settings	10
Traffic control	10
Queue detectors	4
Traffic counters	3
Air quality	2
Integrated CCTV	3
Ice / Wind	4
Real-time passenger information	4
Bus journey time	2

Table 1 – availability of data in a sample of urban traffic management systems

Many authorities are actively considering expansion of their urban data sets, but they have differing priorities often depending upon the availability of the data sources (e.g. weather), which may have been established for other services delivered by the authority. As the traffic managers need only need to integrate these existing data sources into their UTMC systems these sources are pursued as priorities.

Data purchasing

Besides providing data road operators are also interested in buying data from commercial providers in order to increase the percentage of the road network for which information is available. Further intentions are reducing costs or closing the information gap in time-limited situations, e.g. road constructions.

Data offered to road operators must meet the requirements of the applications road operators are responsible for. Data services which are currently on the market today are primarily focussing on the needs of traffic and traveller information services, so today's commercial data services are not completely in line with the requirements of traffic control applications.

3.1.2 Data exchange technology - impact on business case

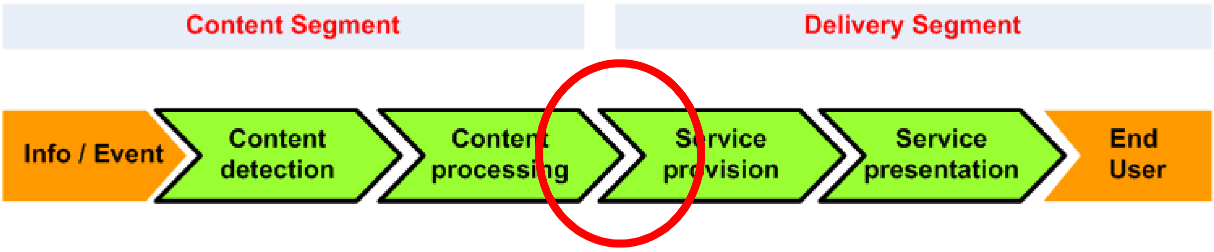

Figure 7 – Cooperation Case 2

As mentioned above road operators are currently looking for a bidirectional data and information exchange with private service providers.

In order to support such cooperation data exchange platforms are under development or rather in the final stage of construction in a number of European counties. In the Netherlands the **NDW** (National Data Warehouse) has been in place for around two years, whilst in Germany the operation of the **MDM** (Mobility Data Marketplace) commenced at the beginning of 2012.

NDW operates a database containing traffic data, as a result of a collaborative venture between various authorities. These authorities have combined forces to collect traffic data and utilise it to the full. This collaboration makes it possible to tackle short-term traffic congestion at national level. The national approach has clear added value. The NDW implementing body is at the heart of the network of local authorities and private parties concerned.

The MDM is part of the *High-Tech Strategy for Germany* and the result of preliminary studies which prepared the technology for deployment. In addition to the implementation and operation of the MDM in the current pilot phase, the project focuses on the organizational and legal issues of the future business model for operation of the marketplace. The MDM should support the business processes of its users and facilitate the efficient exchange of data. Innovative mobility services developed by private providers are encouraged, as well as high-level mobility management by the public road operators. The active involvement of all stakeholders in the market is especially important.

Both projects provide the technical infrastructure as well as standardised interfaces for the data exchange to be implemented by local authorities and motorway operators on one hand and private service providers on the other. Furthermore they are contributing to a more standardised business environment in the whole area of Intelligent Transportation Systems.

In the UK road authorities are also exchanging data with one another. The Traffic Management Act (2004) imposed duties on traffic authorities which led to them to begin to provide traffic information to neighbours and national authorities as well as to private service providers [Cor07]. In some cases direct UTMC communications have been used between existing UTMC systems:

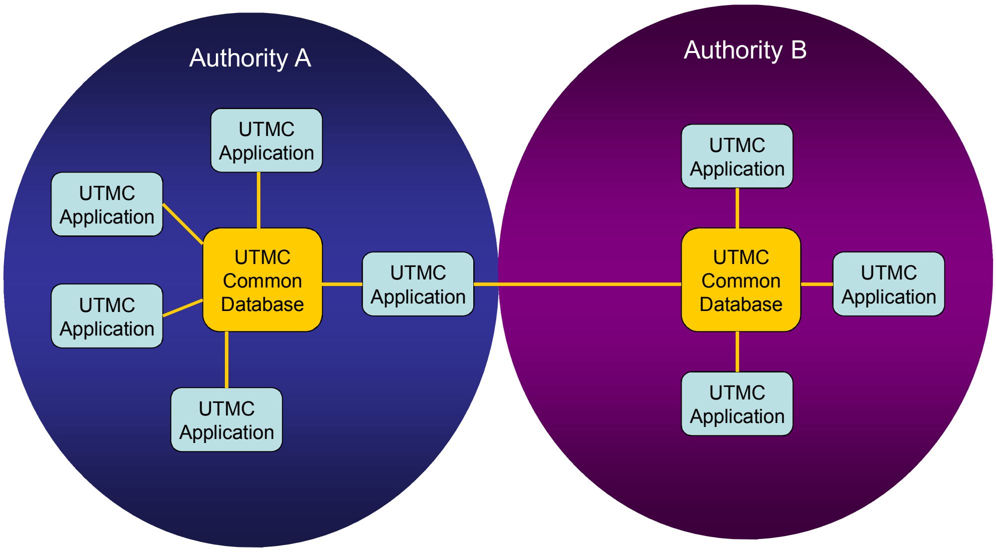

Figure 8 – Sharing information via existing UTMC systems

This pattern of direct UTMC communication has also been used in urban/inter-urban integration.

In other cases the local authority has implemented a data publication service (typically DATEX II) for use by other authorities, service providers and trunk road authorities alike.

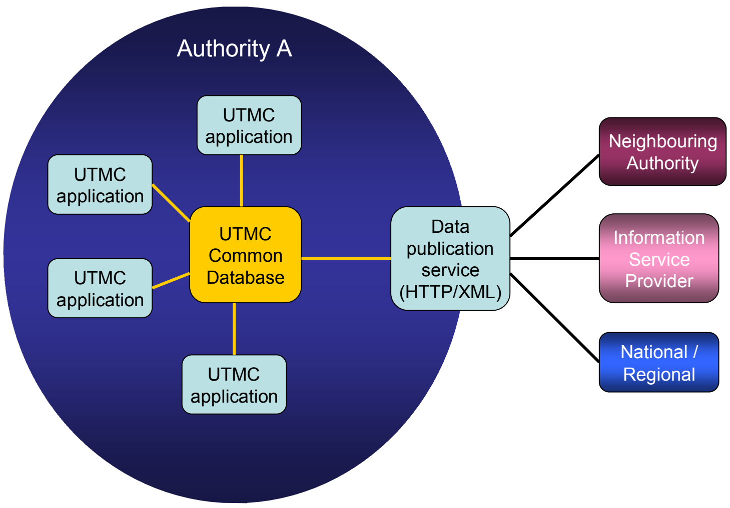

Figure 9 – Data publication services from existing UTMC systems

In a sample of twelve UK local highways authorities with UTMC systems, nine have implemented DATEX II data publication services, another one offers a custom SOAP publication service, and one also offers an SMS service.

The DATEX II services have few users:

- internal consumer for publication on the authority's public website (common)
- one service provider offering a national travel information website and mobile service (common)

- national authority for urban/inter-urban integration (occasional)

Typically these services have not been publicised to service providers and hence little commercial use is currently made of the data.

3.1.3 Service - impact on business case

The third Collaboration Case "Service" is considered below.

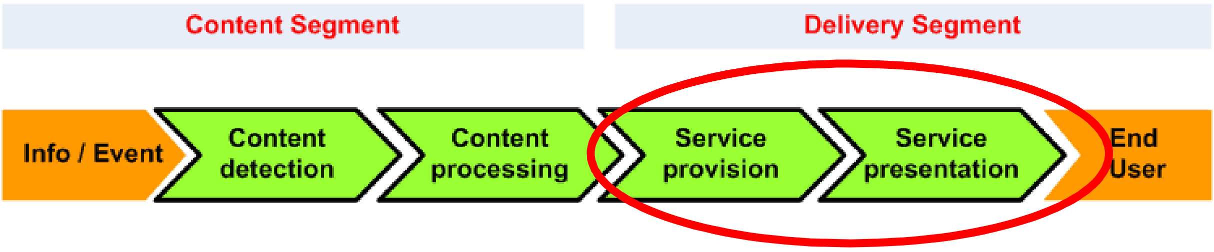

Figure 10 – Collaboration Case 3

German Local Roads Authorities

Local road authorities are currently active mainly in two distinct areas:

1. More and more cities are publishing traffic information as well as local events via the Internet. In addition browser-based services for the Internet mobile services are becoming more important. All these services are covering the current traffic situation whilst more advanced services are also providing traffic state predictions.
2. Some cities have also established a strong cooperation with broadcasters in order to provide TMC-based traffic information for navigation devices. Information provision is therefore becoming an element of the local traffic management strategies.

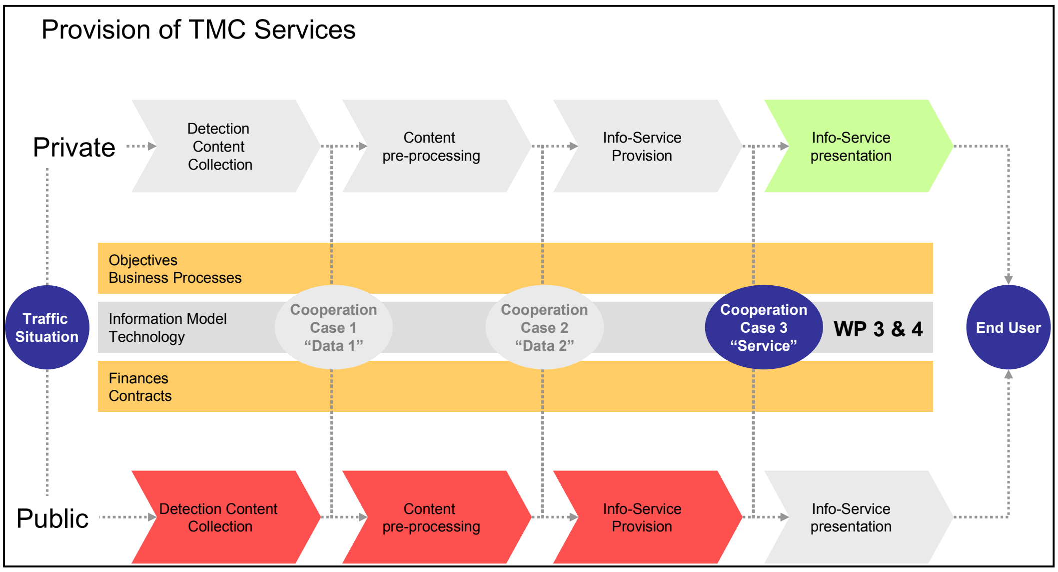

Figure 11 – Example Provision of TMC Services

The expected value for the cities of such services is the strong contribution that they make to their local traffic management objectives and the associated increase in road safety. In order to set up seamless services broadcasting based on RDS-TMC could be a perfect blueprint for a cooperation and business model because the involved partners are close to a win-win-situation. The public authorities are publishing information for their own purposes meaning traffic management and road safety. The private side (car and navigation device manufacturer) are able to integrate additional content in to their navigation services.

The broadcasters are playing an important role in this value chain, because traffic information has a significant value for the program offer, and whilst the end user is not willing to pay for traffic information, interest in the information is very high. This means that users prefer radio stations that broadcast high-quality traffic information. Information here is a tool for customer retention. In total we have three stakeholders along the chain which have a dedicated benefit to participate in the service offer without exchanging money. That is the reason why TMC was quite successful in the last years. (The UK situation is very different – see detail below)

Looking to new generation of seamless services the positive experience made by TMC should be considered. The car2car communication technology enables the road operators to transmit management information directly to the motorists. This supports traffic management strategies in a more efficient way. The new technology allows a shift from an infrastructure-based approach to new services. They have two advantages:

1. The information distribution can be tailored to the current trips of the travellers. If the information is more relevant the acceptance will be increased. Furthermore the balance of the network can be improved if the origin-destination relations can be considered more in detail.
2. The road operator is saving money by offering services instead of infrastructure-based technology.

With a view to possible cooperative business models there is a need to clarify how the road operator organizes the operation of the service. An approach which uses the road operators' own technical infrastructure is possible, as well as the commissioning of delivery by a service operator. The experiences from the past have shown that road operator wants to have full control over the content. PPP models, which do not guarantee this ownership, failed in the past.

UK Local Roads Authorities

In common with their German counterparts, increasing numbers of UK local roads authorities are publishing traffic information on public websites. However, the direct use of TMC or TPEG by UK local roads authorities is very much more limited, and (in the authors' knowledge) currently consists only of a very few TPEG integrations with the BBC (the national broadcaster). The cooperation case has been discussed in the UK in the past [Graham08] but this has not led to significant deployments or uptake.

In consequence, the UK RDS TMC services are operated exclusively by commercial operators – Trafficmaster and Inrix, with the service and content under the sole control of the commercial providers. For local authorities to include their data within these services it is necessary for the authorities to establish a suitable co-operation model with the service providers.

Private Sector viewpoint

There is currently poor alignment between the information provided to drivers by local and national highways authorities and that delivered by commercial service providers. This is primarily because highways authorities publish tactical travel information via roadside infrastructure (or not at all), whilst the commercial service providers generally publish their data to in-vehicle devices, such as navigation systems.

The result of this situation is that there are frequent conflicts between the data displayed on roadside infrastructure, and that displayed on in-vehicle displays, resulting in drivers being confused or misinformed by the conflicting information [HA10].

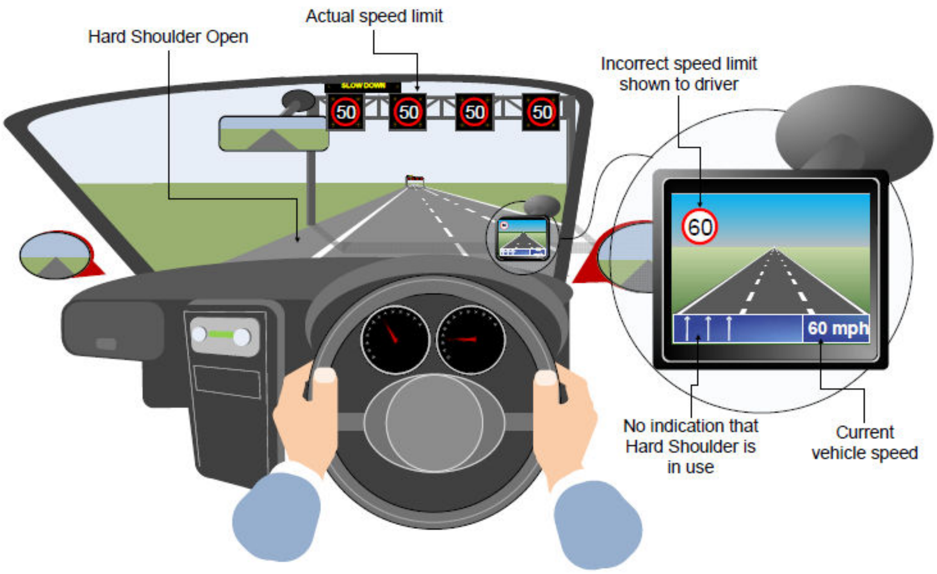

Figure 12 – Current conflict between roadside technology and in-vehicle devices

This effectively de-values the significant investments made by both the Service Providers and local and national authorities in their data collection infrastructure.

The need for consistency of information displayed in-vehicle and at the roadside is therefore equally important to the service providers and public sector.

In-addition to offering the potential to improve consistency between in-vehicle and roadside displays public authorities also have the opportunity to unlock vast cost savings in the medium term by working with the service providers to increase the reliability of information displayed on in-vehicle devices, as over time this will reduce or even ultimately remove the need for and reliance upon separate roadside display infrastructure. This will considerably reduce capital and ongoing costs as well as delivering environmental sustainability benefits.

To highlight the potential cost savings and value of making such data available seamlessly, the UK Highways Agency has estimated that the cost per km of infrastructure construction to support its Managed Motorway infrastructure, based on the UK M42 pilot scheme is (£3.2m /km) [DfT08]. If this is applied to the total number of committed lane kilometres that will operate under the UK's planned Managed Motorway regime (547 lane kilometres) [BTIM], then the cost to the UK authorities of Managed Motorway infrastructure construction will be approximately £1.7 billion.

Using the current Managed Motorway programme as an example, the potential cost savings to the UK public authorities on infrastructure construction alone through seamless data availability to commercial service providers could clearly be substantial. In addition, there would also be considerable maintenance cost savings and environmental benefits associated with removing such roadside infrastructure.

The scale of these potential savings indicates that there is a compelling business case for public authorities to ensure that their ITS and traffic management systems are capable of being seamlessly integrated with the data sets of commercial service providers, and to actively engage with the service providers to ensure that urban and national data can be seamlessly integrated within the commercial providers' services and delivered to future in-vehicle devices.

Section 2 identified potential tactics to encourage uptake of urban data services and thereby increase the seamlessness of services overall: the creation of profiles, with validation, and a directory of services. Realistic costs cannot be determined until further analysis, but the indicative costs for a national roads authority are:

- Modify an existing information service to conform to a profile: €30k
- Create a simple web-accessible directory of services (using existing web facilities): €10k (or obviously significantly more if richer features are needed)
- Maintain directory of services infrastructure: €1k / annum
- Promote directory on an ongoing basis to ensure it is well used: €5k / annum

Further in the future, the Highways Agency is planning for in-vehicle traffic management, where in-vehicle displays convey traffic management information on a lane-by-lane basis, as shown in the following figure (from [HA10]). A driver receiving this information on inter-urban roads managed by national authorities will come to expect similar information on local roads managed by local authorities. This sets a requirement on making data available from local authorities as well as national operators. The deployment of in-vehicle traffic management is anticipated to proceed from 5 to 20 years from now [HA10], so although the requirement must be taken into account in SEAMLESS, it is not amongst the highest priorities to progress in the short term.

Figure 13 – Speed limit inside the vehicle

3.2 Data characteristics necessary for effective services

Data Interface Technology

As discussed in the previous chapters from a technology perspective the discussion must distinguish between the delivery of urban data and the delivery of seamless services. The value chain introduced in WP 1 shows different interface types for these two business cases. Analysing the developments over the last five years it is important to recognise that the usage of standardised interfaces is becoming more and more important.

Example (Germany)

In the past only a very limited number of cities provided data for services running outside their own technical environment. The interfaces were more or less proprietary solutions designed and developed by technology providers. Currently we see harmonisation activities driven by the overall standardisation needs of the traffic sector as well as by the MDM – Mobility Data Marketplace. In the field of local road data the following interfaces are in place (see WP 1):

- OTS 2 is aiming to interface services and components in distributed technology environments. It supports the two data structures OCIT-I and DATEX II. OTS 2 is the standard technology for MDM interfaces to urban data.
- OCIT-C is more focussed on the data structure itself and is aiming to provide a comprehensive description of all data types, which are relevant in an urban environment. This is driven by the technology supplier. OCIT-C uses SOAP as a standard communication interface.
- OCIT-O is the UTMC equivalent standard in the DACH region for field device communication, covering all information from raw and aggregated data (from detectors) to signalling data and status messages (recently introduced).

In the future the pure car2infrastructure communication interface developed by ETSI and CEN will play a significant role in order to introduce seamless interfaces. At the moment these activities are not well supported by local road authorities, at least not in Germany. Today the technology suppliers mainly drive the development.

An important aspect to consider here are the possible requirements and impact on legacy systems. This is extremely important since the average lifecycle of traffic equipment used by road authorities is approx. 15-20 years, and for field devices even 30-40 years is not unusual. As described in earlier sections, private service providers who want to get access to public data for improving their applications and services are facing not only a wide variety of different independent public bodies but also the fact that many systems are not state-of-the-art.

Nevertheless, much information required for seamless services has to be taken out of existing systems of the public road authorities. The required data might be stored in databases in the centre, but in some cases (especially for dynamic data) it might even reside in field devices, e.g. in the traffic signal controllers for the traffic phase assistant example in those types of systems, where the actual algorithm is run in the controller and not in the centre. In case of the latter option, the information might be transferred to vehicles locally (e.g. 802.11p) or via backbone interfaces from the centre to Service Providers. This is an instructive example since it may imply that an interface between the traffic signal controller and the central computer has to be developed in order to support such data, which may incur significant cost. As a concrete example from current projects, in sim^{TD} the City of Frankfurt am Main had to upgrade the centre – field-device interfaces from OCIT-O 1.1 to OCIT-O 2.0 to be able to transmit the data required for running the FOT.

In order to achieve seamless integration of public authority data into commercial services, the public sector should recognise the key distribution formats of the commercial sector and existing in-vehicle device market, and seek to provide data in formats that can be most readily integrated in to these pre-existing services.

As identified in WP1, the key distribution format used by the commercial sector to in-vehicle devices is ALERT-C (and XML TMC for connected devices). In future TPEG and XML TPEG formats will also begin to emerge, and other bespoke XML formats will be potentially be required for dedicated smartphone based applications.

Whilst there are well known weaknesses with TMC based methodologies, such as granularity of location referencing (partly overcome by use of offsets) and limited message types, it should also be recognised that there are significant and immediate benefits to be gained by achieving seamless data integration in to pre-existing services which already have many millions of deployed terminals operational on a pan-European scale.

Previous approaches that have relied on delivering data via dedicated in-vehicle terminals or simply awaiting for the development of appropriate terminals at some future point in time (e.g. GATS) have a poor track record of commercial success.

In the medium term the public sector should also engage with the various standardisation bodies that drive the evolution of TMC and TPEG, in order to shape the evolution of these standards so that they evolve in a manner that best displays the data that the public sector can provide.

To illustrate the above point Trafficmaster has expended significant effort within the UK to integrate the currently available DATEX II feed of the Highways Agency into the Trafficmaster systems architecture, so that HA data can be seamlessly integrated with other content from Trafficmaster and re-distributed through Trafficmaster data distribution channels such as RDS TMC. In consequence, the integration of additional DATEX II feeds from other public authorities would pose a much lower technical challenge than the integration of a new feed format, and would therefore have the most viable business cases for Trafficmaster.

Service Interface Technology

In the case of cross stakeholder cooperation for navigation services RDS-TMC is the only interface which is under operation today. Cities are setting up cooperation with local and regional broadcasters. Furthermore they work on the density of local TMC-Point-Location for the geo-referencing of urban traffic information content. Broadcasters currently do not support TPEG but the situation will change in the context of the market introduction of DAB.

In addition to the broadcasters the automotive sector is now stepping in providing more advanced traffic information services for cities. Here TPEG-TEC and TPEG-TFP is used for the communication between the service provider and the cars. In this case the automotive sector is using IP as communication protocol for TPEG. Furthermore the navigation manufacturers are using their own formats.

Georeferencing

Georeferencing is one of the most important questions discussed in the last 10 years and is still unresolved. A pre-defined referencing schema like the TMC-Point-Location was a powerful solution for the first service generation focussed on the motorway network. The urban situation is more complex and advanced traffic information services require on-the-fly location referencing schemas allowing a flexible addressing of locations and road segments. The first method was AGORA-C developed by an industrial consortium. For AGORA-C a licence model is in place meaning the usage is not free of charge. OPEN-LR is a second approach developed by TomTom. Currently TomTom is offering OPEN-LR free of charge including a library for system developers and a public extension for DATEX II. From a TomTom viewpoint OPEN-LR is free of IPR of other companies. Currently the union of German regional broadcasters (ARD) is developing a third approach and preparing a corresponding TISA use case, with the intention of making this approach an integrated part of the TPEG specification. The technical requirements of seamless services in urban areas will be fulfilled by all three approaches. However, from a commercial and political perspective implementation of services will not take place until there is widespread agreement as to which of the three available approaches will be adopted as the industry standard.

Data and Service Quality

Today for a public-private cooperation in the field of data exchange and service co-cooperation there is no quality schema in place. All cooperation is working on a “best-efforts-basis”, meaning the public side is offering what is available but without a service level agreement (see section 4.1). In the future the quality issue will get more important, especially as more players will be involved in the industry. In this context the German research project Traffic-IQ is developing a quality schema covering the whole value chain of traffic information services. Each service providing data will publish a quality index that can be interpreted by the services, which are using the data.

Data quality – in terms of required characteristics for an effective service – is influenced by all links of a service chain. As depicted below, data may take different paths to reach the end user, depending on the application scenario, technology available, and business considerations.

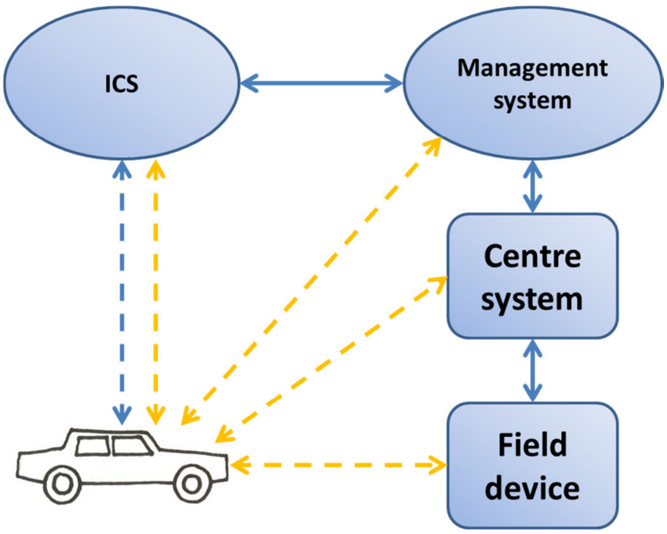

Figure 14 – Possible paths for data flow

Systems like this offer many possibilities for fine tuning system performance and hence influencing the Quality of Service (QoS): Components, systems, delay, bandwidth, processes, etc… For the publication of a QoS, all these parameters and interconnections need to be taken into account per application. Standards usually govern transmission details like data models and formats, but some parameters still need to be defined and agreed amongst partners (e.g. in Interchange Agreements). Some suggestions are given with the following (non-exhaustive) list:

- Type of data: ‘mass mass data’ (individual vehicle data, FCD raw data), mass data (aggregated measurements), other aggregated data

- Mode of capture: cyclic, event-driven
- Mode of transmission: push/pull, partial/full, …
- Timeliness of the data
- Update procedures
- Maintenance agreements
- …

There currently appears to be a lack of consolidated effort to provide a framework that will integrate all these parameters into a single scheme in order to support the Seamless business case. Such a 'quality framework' might eventually require legislative support in one way or another to be sufficiently robust for having real impact on markets. Initiatives like QUANTIS[1] may prove be a starting point here.

4 Current Business Models and Use Cases

4.1 Other Projects

Business model considerations in recent projects often appear to be pre-defined or at least significantly biased by the project's specific framework conditions. Technology or policy preferences of the project consortium seem to leave little room for development of an unexpected outcome. The range of scenarios found and promoted is substantial and ranges from promoting regulatory frameworks on the one hand to totally market driven approaches on the other. A balance of the two extreme options seems most likely to be expected for the future.

Nearly all of the considered finished projects distinguish between several implementation scenarios or at least business cases.

CVIS for instance shows three possible scenarios which are characterised by different angles of approach, which are safety and efficiency driven (Public scenario), freight and fleet services driven (Commercial scenario with focus on commercial freight and fleet services) and traffic info services driven (Personal scenario with focus on traffic information services).

- In the public scenario the "strong demand for mobility services and comfort is the crucial driver of change" [CVIS 10] where the cost of the service is fully paid by government. This means in fact the provision of public funding and standards to drive the cooperative systems market and ease the situation in urban and interurban areas.
- The second scenario, the commercial scenario, focuses on the commercial freight and fleet services, stating that increasingly networked logistics services in combination with the demand for reducing costs and regulations within will drive cooperative systems in that area. Payment is entirely on the end user side here.
- In the last scenario the consumer is the driving factor, demanding high quality real-time traffic information on modern integrated electronic devices. Payment again is with the end user in this scenario.

The PRE-DRIVE C2X Project is not using scenarios but defines two business cases (data services and comfort & infotainment) to identify and assess business impacts: "This makes

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[1] www.quantis-project.eu

the business case an excellent decision support and planning tool that projects the likely financial results and other business consequences of the potential implementation of the PRE-DRIVEC2X system" [PRE-DRIVE 2010]. For the use of the business cases a methodology was used, the PRE-DRIVE Business Case Logic:

Figure 15 – PRE-DRIVE Business Case Logic [figure from drive-c2x.eu]

The PRE-DRIVE C2X Project validates the two business cases

- by the Project / work package / use cases definition,
- the definition of objectives and the scope as well as
- the business case logic tree & financial metrics,
- the setting up of the assumptions & indicating the sources and, finally
- the establishment of the sensitivity analysis & scenario

The project states that "At the end of the project, it can be concluded that extensive and commonly accepted calculation models have been developed and applied, which address socio economic and business economics aspects. Also, first estimates about the viability and investment potential have been calculated".

In SEAMLESS, the point of view of the three main classes of stakeholders is given in the following sections, illustrating the different views on the topic. It follows the scheme of the CVIS approach dividing the topic into public, commercial and personal view.

4.2 Public

As mentioned above the support of traffic management strategies is the main interest of local road authorities. Considering this fact the discussion has to include both financial and political aspects. Currently in Germany no common agreed financial schema is available for the data exchange and the service cooperation. In most cases each partner involved in the value chain is covering its own costs.

In the future the MDM will provide standard contracts for public-private-cooperation. They are blueprints for the negotiations between the stakeholders but not mandatory, meaning the cities are free to introduce modification. The discussion shows also that the consideration of traffic management strategies in private services is part of the contract.

National roads operators typically have information services that contribute to services reaching users at the end of the value chain, and there is a desire to reach as many road users as possible. National operators also typically have services that directly reach roads users. The availability of seamless services including both urban and inter-urban data may increase the overall uptake.

- In cases where public sector data services are consumed by private sector service providers, the potential increase in uptake is a matter for private sector to assess – this is considered further in Section 4.3 below.

- In cases where public sector provides information services direct to road users, the availability of similar urban services may increase the overall ease and efficiency of use of the whole set of services, and may provide opportunity for federation of services.

Urban roads operators have a similar motivation to national roads operators, desiring maximum uptake of services derived from their data. Section 2 showed that data services from local authorities are emerging. However, the fact that major service providers are not yet using these urban services or even aware of them suggests that the local authorities have not yet given full consideration to this aspect of their business model.

4.3 Private

The cost base of commercial information providers generally breaks down in to three key areas:

Data Generation
This covers the costs associated with generating the traffic information database, and includes the costs of:

a) Operating and maintaining any fixed traffic data collection infrastructure
b) The costs of communicating with such fixed infrastructure
c) The costs associated with sourcing probe data, either from the companies own end customer devices (e.g. TomTom and Trafficmaster) or from suitable devices deployed by other organisation (e.g. INRIX)
d) The costs of sourcing cellular handover data from mobile network operators
e) Costs payable to any other sources of data utilised, or incurred in collecting the data from such sources
f) The costs of processing the data collected in order to generate an accurate real-time traffic information database

Channel-Specific Distribution Costs
These cover the costs associated with the distribution of the resulting traffic information through specific distribution channels, for example:

a) The costs of formatting data into an appropriate form for dissemination via the channel
b) If broadcasting, it would also include the costs of acquiring the broadcast spectrum used (RDS or DAB), and the costs of inserting the data in to the broadcast media
c) For premium rate telephone services it would include the costs of the Interactive voice response systems, the telecommunications lines, and any revenue shares paid to the network operators or marketing partners
d) For voice based radio reports it would include the costs of the broadcast artists and systems to support them

Other Operating Costs

These costs cover areas such as sales and marketing, accounting and other similar central support costs

A successful commercial operator needs to ensure that the revenues generated through each individual distribution channel, cover all the channel specific costs, and provide an appropriate contribution to data generation costs, operating costs and profit.

Business Model for In-vehicle Services

RDS TMC and DAB TPEG

As previously described the most common distribution format to in-vehicle devices used by the commercial sector are broadcast services such as RDS TMC, and in future DAB TPEG.

RDS TMC is a very simple broadcast service, with limited bandwidth and limited potential for encryption, hence the commercial business model that has evolved to support this distribution channel is a simple one-time licence fee, paid by the device supplier (automotive OEM, or navigation set maker) to the Traffic Information provider.

This business model is viable because the channel specific cost of operating a broadcast service is essentially fixed and is independent of the number of receiving devices. Accordingly, as long as a service provider has a good understanding of the number of licences to be sold over a given period it can amortise the broadcasting costs accordingly on a per device basis.

This one-off licence fee generally provides access to the commercial providers RDS TMC Traffic Information broadcast for the 'lifetime' of the device.

For DAB TPEG services similar models are also likely to emerge. The increased bandwidth available within DAB also provides the opportunity for service encryption techniques to be introduced, offering the potential for the introduction of licence fees for defined service periods in future.

Connected Services

Connected in-vehicle services have also emerged in recent years, using either a dedicated SIM card embedded within the in-vehicle device (e.g. TomTom's HD Traffic Service), or using the end-users existing SIM card within their Smart phone (e.g. various Traffic Apps).

The services that use a dedicated SIM card have tended to adopt a business model where the device provider (automotive OEM, or navigation set maker) includes an initial period of service usage and data communication within the base product price, after which it becomes necessary for the end-user to pay an ongoing subscription in order to continue to receive the traffic service. This model is necessary because the annual cost operating a connected service using 3G/GPRS connectivity varies in direct proportion to the number of active SIM cards deployed.

Connected services that utilise the end-user's existing SIM card do not need to take account of the cost of on-going data usage (as the end-user is effectively paying for this aspect of the service themselves), and in-consequence these services still tend to be priced on a one-off licence fee basis

How the increased availability of urban traffic data in a standardised/harmonised format, would benefit these business models

In general, it is unlikely that the availability of urban traffic data in a standardised and harmonised format, will dramatically impact the business models that are already in place in the short term. This is because:

a) If such public data is available to one commercial operator then it will by definition have to be made equally available to all operators. It is therefore highly unlikely that one commercial operator will be able to gain a significant competitive advantage through access to such data

b) Some existing data sets of the commercial data providers are currently regarded as superior to those of the public sector in terms of quality, coverage and accuracy.

Hence the addition of urban traffic data will in the short term serve only enhance the existing commercial services.

In the longer term however, as more and more data is made available from the roadside infrastructure of the public authorities, a situation could be envisaged where the need for commercial providers to invest in additional data sources such as 'probes' etc. becomes irrelevant, as the incremental data generated from these 'proprietary' sources adds minimal value to the quality of the traffic services provided through a vast array of urban and national data made available from publically operated infrastructure.

At this point in time the data generation costs of the commercial sector would essentially become redundant and could be eliminated. In an open market economy, this is likely to result in a significant reduction in the level of commercial service pricing as only the channel-specific and other operating costs would remain.

4.4 End User / Driver

End users typically view traffic information as 'free of charge', as the vast majority of business models that support the each distribution channel actually result in the traffic data being delivered to the end user without payment of an obvious charge being made:

RDS TMC (and potentially DAB TPEG)

These services are normally provided for the 'lifetime' of the vehicle, or navigation set, with the supplying automotive manufacturer or navigation set maker paying the traffic information provider a single one-off fee for the service. Clearly this fee is ultimately paid for by the end user/driver, but it is not separated from the price of the vehicle and/or navigation set, so the end user/driver has a perception that the traffic service that is included within their navigation system is free of charge.

Voice based Radio Reports

Listening to traffic bulletins on the radio is still one of the most common methods used by motorists to access traffic news, and this method of access further underpins the perception that traffic information is free of charge to the end user.

Connected Services

Connected services which require a SIM card have attempted to change users perceptions of traffic information being free of charge, by introducing annual fees for continued access to the service after an initial period of free usage. However, the long term viability of these 'paid for' models has yet to be proven given the immaturity of the market and the low levels of take-up of paid subscriptions currently being reported. For example, TomTom claims that the conversion rate to paid subscriptions for TomTom products is currently 25% (4).[2]

Connected services that utilise the customer's SIM card generally follow the model of the service being free of charge to the end user. Examples include: Nokia Drive, where navigation and traffic information (for Symbian based Smart Phones - Nokia Drive 3.08) is included with the phone free of charge and many of the most popular traffic apps for smartphones such as the apps from The Highways Agency, The AA and RAC in the UK are all free to download.

[2] TomTom Annual Report of Accounts 2011

How the increased availability of urban traffic data in a standardised/harmonised format, would benefit these business models

In a market where the vast majority of end user/drivers perceive that traffic information is available 'free of charge', the availability of additional urban traffic data, in a standardised format, will not dramatically change the overall market structure.

This said by releasing more sources of data to the market on a free of charge basis, it enables the market to continue to deliver high quality traffic services that support the dynamics that enable this model to be maintained for the end user.

4.5 Factors driving the evolution of new business models

Recent studies on cooperative systems have observed that while there is considerable effort to define architectures and protocols for cooperative systems, directed from the top down, at the same time across most facets of ICT there is a groundswell of development, based on smart phone or other mobile devices, which bypasses the architectural effort. These developments cannot yet achieve everything envisaged in the cooperative systems domain, because they lack integration with the vehicle platform and the infrastructure, but they may achieve high coverage of road users and with much quicker lifecycles than the architecture-led developments. Such developments are of course taken into account as a channel for end-user delivery within existing business models. Some even consider that such development paths may fundamentally change business models.

4.6 Use Cases

4.6.1 Traffic Light Phase Assistant

The term Traffic Light Phase Assistant is used collectively for different objectives and applications (including some not yet known or developed). The common characteristic is their need for information describing the near-future behaviour of traffic signals. Usually this covers

- Operating state of controller
- Signal program
- Current signal
- Time to green and time to red

both for the current situation ('real-time') and often also for the future (short term prediction, 'next changes' or schedule).

Even more detailed data can cover information for instance about

- Traffic adaptive or fixed time control
- Cycle-time
- Special operation control (for emergency vehicles)
- Public transport priority active or
- Manual control.

This dynamic data can be enriched by static information about the controller (type and control method, signal groups, quantity and design of signals, etc.).

In many cases detailed geographical information about the whole junction (topology information) and especially its stop lines is also provided.

The source of information can vary between the controller itself or some central system (when the central system has active control about the signals and knows their states).

This already implies that there are different possibilities for design of the communication chain: From the signal controller to some vehicle, information transfer can use hops on different central systems on the one hand (which might lead to latency problems) or use field devices for communication, such as an IRS (ITS Roadside Station). For the latter one, new communication protocols and data models need to be developed, like in the project sim[TD].

As stated above, the usage of this use case can spread a wide range for vehicle manufacturers and/or passengers:

- Visualisation to the driver
  - Current State of signal
  - Time to Green / Time to Red
  - Speed Advice (economic driving)
  - Green Wave visualisation
  - Red light violation (warnings)
  - Reminder on Green
  - More exact calculation of navigation routes
  - …..
- Vehicle behaviour
  - Red light violation (automated braking)
  - Adapted speed control (economic driving)
  - Adapted fuel consumption
  - Improvement of start/start automatic
  - Automated driving
  - …

In summary, especially three aspects are addressed with this use case:

- Information aspects, also from psychological point of view
- Economic aspects (via driver or directly via technical systems)
- Traffic security aspects

Especially on the technical side of vehicle behaviour, a lot of possibilities can be considered regarding this use case, but there is always the challenge to meet the narrow range between fully automated vehicles and sufficient autonomy of the drivers.

4.6.2 Journey times

The availability of journey time information varies widely across Europe.

In UK there is relatively good availability, indicating that roads authorities see a business case for its collection and dissemination. Section 2 showed that journey time is present in 11 out of 12 sample UTMC systems. In some of these systems the data is published to public websites, and in two cases it is republished in information services which may be consumed by service providers. The national authorities also provide journey times, and these are consumed by service providers.

The private sector also provides journey times, indicating that there is sufficient value in the data to justify its collection.

In Germany however, due to legislation on cameras, there is generally no journey time available from urban traffic systems.

The business case for use of journey times within the value chain will therefore depend on such national characteristics, but in the UK at least the analysis in the preceding sections is directly applicable for the use of journey times.

4.6.3 Other Use Cases

The ERA-NET ROAD Mobility call noted an interest in “virtual signs”, e.g. in understanding how road authorities might move from physical roadside sign infrastructure to in-vehicle ‘virtual’ signs or in recommendations for harmonisation of "virtual" traffic signs.

Two separate cases must be recognised: the use of in-vehicle displays to reproduce mandatory traffic management instructions, as an alternative to roadside infrastructure, and the use of in-vehicle displays to mimic the appearance of roadside displays for the purpose of presenting traffic information.

The case of mandatory traffic management instructions is mentioned above and considered in detail in [HA10]. The main obstacle is the existence of a significant non-equipped population of road users for whom fixed infrastructure is still required. Any future European legislation to ensure a fully equipped population currently appears too remote to justify any focus on this topic in the SEAMLESS project.

The case of virtual signs for traffic information has been considered – in particular the concept of a “virtual VMS”. A virtual VMS would have an associated geographic locus – an area and direction(s) of travel – in which the VMS message is appropriate for display. A virtual VMS could be managed by a roads authority in a similar way to traditional fixed VMS. Virtual VMS could even be treated like real VMS within traffic management systems, and could therefore be incorporated into network management strategies alongside real VMS. The actual message could be conveyed optionally by voice or by display on a mobile device. Virtual VMS offer an obvious cost reduction when compared with large-scale expansion of fixed VMS; however this advantage is common to many patterns for disseminating roads authority data to mobile devices, and so the key business case comparison must be between virtual VMS and alternative patterns for mobile services.

The potential benefit of inclusion of the virtual VMS in strategies alongside real VMS is reduced by the fact that it can be expensive to configure some traffic management systems to add VMS, and it may also be expensive to present a virtual VMS interface that simulates the real VMS interface used in those systems. Virtual VMS could also detract from the original operational role of the traffic management system – with the clarity of the operator’s user interface reduced due to the presence of an increased number of signs which are only viewed by a subset of the travelling population.

Virtual VMS allow roads operators control over the area of influence, and also the timing, of a particular traffic message. This might be claimed as an advantage, but it can also be argued it is a disadvantage! The increasingly popular “Open Data” paradigm is for the public sector to make data available and let the private sector innovate in the provision of services with this data. It is expected that most service providers would wish to receive the underlying data from the roads operator and make their own decisions about how and when to distribute to specific locations, using their established processes and technology. There will be some road users who would benefit from knowing the information before they approach a specific geographic locus of a virtual VMS. Of course the geographic locus of a virtual VMS could be very wide, but then the distinction when compared with traffic information message publication in general starts to disappear. A final disadvantage of the virtual VMS concept is the extra delay that may be introduced if human interaction is required in the traffic management system used to set the virtual VMS.

The concept of a road operator's editorial control of traffic information is related to the dissemination of roads operators' routing strategies – a legitimate use case discussed in [DiM 10]. Otherwise, it appears that the business case for this virtual VMS concept for distribution of traffic information is not viewed positively.

5 Conclusion

Cooperative Services and the exchange of data between infrastructure and vehicles are gaining in importance. Currently, the development is driven by private actors, in particular from the automotive industry. However, the road operators see more and more the value in such systems because Cooperative Services can be integrated into the traffic management strategies. Two aspects are of particular strategic interest:

- The comprehensive exchange of data between public and private stakeholders.
- The interaction of the infrastructure information with innovative vehicle systems.

Benefits

The public partners are increasingly seeing the advantages of using data that are offered by private partners. These are used for the operation of the traffic management infrastructure in addition to the roadside detection infrastructure. By using private data the availability of data can be significantly increased and the quality of the traffic management measures will be improved. At the same time the costs for detection can be reduced. Furthermore, the interaction of innovative ADAS and navigation systems with the traffic management infrastructure gives the opportunity to communicate directly with the driver. The acceptance of the measures will be increased significantly. This assumes that the road operator will act as a kind of service provider.

The advantages of cooperation for the private partners are the improvement of their core-products, such as navigation and ADAS. Additional information can support both the driver and efficient engine control. Other important advantages are the improvement of vehicle safety systems. For these reasons, in particular the automotive industry is forcing the development of these systems. A second private group of partners is interested in the commercial distribution of data and information.

Business scenarios

For the first business case, the exchange of data, delivery for payment and the free of charge exchange are both currently under discussion. A payment model represents a business-oriented approach and takes into account the fact that all partners have to spend huge efforts for data collection and data provision. A free public provision of data emphasizes the economic benefits in the transport sector, following other initiatives (e.g. INSPIRE). In the case of paid data provisioning service levels must be guaranteed which is not the case if the data are distributed for free. Both approaches can be established in parallel. However, the introduction of a national marketplace for traffic data is an important building block for establishing a business structure. Examples are the MDM in Germany and NDW in the Netherlands. These two examples support not only the technical exchange of data but they also establish a basis for a national business structure also.

Currently three business scenarios are established for in-car services: (1) Services to support road safety and network efficiency which are offered free of charge. For example a free Traffic Message Channel (TMC) exists in most of European countries (except UK). Stakeholders cooperate along the value chain without a dedicated service fee for the end user. Cooperative systems are following a similar approach. The business model is based on a win-win situation for the stakeholders. (2) For enhanced traffic information (e.g. area-wide LOS) paid services are offered on the market. Both OEMs and the aftermarket combine these offers with the purchase of equipment. (3) A further group of paid services is addressing the needs of the fleet operators. Because of business efficiency savings in the operation of the fleet, the operators are willing to pay a service fee.

The summary shows that different business scenarios are established for both data and information services. A European wide harmonisation of business models is not foreseeable and perhaps not necessary because the service responds to different stakeholder needs. In the future the stakeholders should be supported by guidelines for developing a business structure in order to make the negotiation of contracts easier.

Organizational prerequisite

The basis for a successful cooperation is the creation of appropriate organizational arrangements. The private partners have to ensure that basic knowledge and understanding about traffic management strategies is available in the companies. The road operators have to take the role of a service provider which operates not only the road network but also cooperates with other partners on a commercial basis. On the other hand the technology must be open for cooperation and more flexible. In this context traffic management systems have to respond to the current developments in the service area. Compared to the situation today new requirements on the operation and maintenance of technical systems must be considered.

Furthermore the above proposed marketplace requires a central organizational unit within the institutions (public and private). Such a one-stop shop is prerequisite for successful cooperation.

Quality

The design of an appropriate form of organization has to consider the operational quality management. An exchange of data and information among institutions requires a high quality and reliability of the data. In this context the system set-up is only the first step; more important is operation over a long period without losing quality. The quality management must be based on a comprehensive quality assessment schema describing the current quality of the transmitted information. In addition, a certification of data and services will be required.

Technology

For a low cost but high quality operation uniform and standardized interfaces between the systems of the partners are required. With TPEG for the communications vehicle-centre and DATEX for the centre-centre communication two comprehensive approaches are now available. These are supplemented by the current standardization activities of ETSI and CEN / ISO, which cover the range of vehicle-vehicle and vehicle-infrastructure communication. For the implementation of standards allows a variety of degrees of freedom. Taking into account the application requirements, profiles limit the freedom. But because partners are working along a value chain singular standards and corresponding profiles are not sufficient. In the future, the transferability of information is getting more important, for example DATEX-TPEG conversion. It also requires an agreement regarding the approach which should be used for geo-referencing.

In implementing urban data exchange services, progress has been made within Europe. The internal usage of different standards (e.g. OCIT/OTS in Germany, UTMC in UK) does not contradict these efforts, if the information is distributed by well-established services like DATEX II and TPEG at the end of the chain. Nevertheless, there are still big differences in the technical design and architecture of central applications. And there are still factors that may make it too expensive for a service provider to consume local authority data services (using UTMC as an example):

- The flexibility in UTMC standards (which has been very useful in general) means that effort is needed (i) to determine exactly what data is available, and (ii) potentially to implement case-specific transformations. UTMC deserves great credit for increasing interoperability and reducing the cost of bespoke integration, but in this case the remaining cost has still been too high to encourage uptake by service providers.
- Although UTMC specifications support modern web services implementations, the most prevalent UTMC exchange technology – CORBA – is now outside the mainstream of ICT and is perceived as more expensive for a new integrator.
- Precise plug-and-play compliance with UTMC specifications may not be assumed by service providers since there are no validation tools.
- There is no easy way for a service provider to discover the available sources of data.
- There is a lack of standard contracts to allow easy use of existing data sources

Conversely, to increase uptake, the following are desirable:

- European specification with widespread uptake
- Tighter specifications, which may be possible by focussing on specific applications of dissemination to in-vehicle devices.
- Use mainstream ICT such as web services.
- Easily available validation tools – if schemas are sufficiently precise then simple schema validation should be sufficient.
- A directory of services to support service discovery by service providers. (A more advanced version of this is automated federation of services, but a simpler directory may be sufficient to encourage uptake).

Overall, this report shows that the business structure must be in line with all technical and organizational aspects of the cooperation. Only a comprehensive viewpoint achieves cost savings and the quality improvement of information.

6 Appendix I - References

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7 Appendix II – Abbreviations

A list of abbreviations and acronyms occurring in this document
(including a selection of projects and companies)

3G	*3rd generation of mobile communication standards*
AA	Automobile Association (United Kingdom)
ADAS	Advanced Driver Assistance Systems
AGORA-C	*A method of georeferencing*
ALERT-C	Event- and Location Codes for TMC (ISO 14819)
ARD	*A German television broadcaster* (Erstes Deutsches Fernsehen)
C2X	Car-To-Car and Car-To-Infrastructure
CCTV	Closed Circuit Television
CEN	European Committee for Standardisation
COBRA	Cooperative Benefits for Road Authorities

	– an ERA-NET ROAD project
CS	Cooperative Systems
CVIS	*A Cooperative Systems project*
DAB	*German digital radio*
DACH	*Region of German speaking countries* (Germany, Austria, Switzerland)
DATEX II	*An interface for exchanging road and travel data*
DEPN	*Subproject of CVIS:* Deployment Enablers
ERA-NET ROAD	*Partnership of National Road Administrations for research programmes*
ETSI	European Telecommunications Standards Institute
FCD	Floating Car Data
FOT	Field Operation Test
GATS	Global Automotive Telematics Standard
GPRS	General Packet Radio Service
HA	Highways Agency
HD Traffic	*A product from TomTom*
ICT	Information and Communications Technologies
INRIX	*A company* (provider for traffic information)
IP	Internet Protocol
IPR	Intellectual Property Rights
IRS	ITS Roadside Station
ITS	Intelligent Transport Systems
IVTM	In-Vehicle Traffic Management
LAN	Local Area Network
LOS	Level Of Service
LTE	Long Term Evolution
M	Motorway
MDM	Mobility Data Market Place (German data exchange node)
NDW	National Data Warehosue (Netherlands)
OCIT	Open Communication Interface for Road Traffic Control Systems
OCIT-C	OCIT-Central
OCIT-I	OCIT-Instations (interface for central layer)

OCIT-O	OCIT-Outstations (interface for field layer)
OEM	Original Equipment Manufacturer
OPEN-LR	Open, Compact and Royalty-free Dynamic Location Referencing
OTS	Open Traffic Systems
PPP	Public Private Partnership (in IT context also: Point-To-Point Protocol)
PRE-DRIVE	*A C2X project*
PTV AG	*German company* (Planung Transport Verkehr; one of the project partners)
QUANTIS	*A Project:* Quality Assessment and Assurance Methodology for Traffic Data and Information Services
QoS	Quality of Service
R&D	Research and Development
RAC	Automobile club (United Kingdom), originated from Royal Automobile Club
RDS	Radio Data System
SAFESPOT	*A Cooperative Systems project*
SEAMLESS	*The ERA-NET ROAD project this document is about*
SIM	Subscriber Identity Module (known from mobile phones)
SMS	Short Message Service
SOAP	*originally:* Simple Object Access Protocol
SPITS	A Cooperative Systems project
TIH	Travel Information Highway
TISA	Traveller Information Services Association
TMC	Traffic Message Channel
TPEG	Transport Protocol Experts Group
TPEG TEC	Traffic Event Compact
TPEG TFP	Traffic Flow Prediction
UK	United Kingdom
UMTS	Universal Mobile Telecommunications System
UTMC	Urban Traffic Management and Control
VMS	Variable Message Signs
WAN	Wide Area Network
WDR	*German radio and television broadcaster* (Westdeutscher Rundfunk)
WLAN	Wireless Local Area Network

WP	Workpackage
XML	Extensible Markup Language