Position Paper

The Traveller Information Services Association (TISA) is a market-driven membership association with worldwide scope, established as a non-profit company focussed on proactive implementation of traffic and travel information services and products based on existing standards, including primarily RDS-TMC and TPEG technologies.

TISA's mission is to develop and promote open standards and policies that

- facilitate a timely and cost-effective deployment of TTI services and products that save end users time and money, increase traffic safety, and minimize environmental impact
- improve the quality and minimize the cost of such services and products by maximizing interoperability worldwide

With this Position Paper, TISA wishes to provide advisory information to all concerned with Traffic and Travel Information services and products. It represents the consensus opinion of all TISA membership organisations in areas of business and technology.

TISA Position

On

Quality of Traffic Information

Executive Summary

This position paper provides a travel and traffic information service (provider and client) perspective on the topic of quality of traffic information, consolidated and endorsed by 100+ TISA members, collectively representing the entire traffic information value chain. TISA aspires to contribute to the wider understanding and awareness of the importance of quality in travel and traffic information services. It also aims to further enhance the benefits of the end recipient of these services, the drivers.

Various stakeholders can be identified along the traffic information value chain: road authorities, traffic information service providers, content providers, police and rescue organisations, radio broadcasters, automobile clubs and salvage companies, PND/navigation device manufacturers, software providers, etc. TISA and its members are mainly concerned with the *Service* part of the value chain. This Paper focuses its considerations and recommendations on the *Service* part, and emphases the position and requirements of *Traffic Information Service Providers, and Traffic Information Client Manufacturers/Integrators.*

The user benefit of real-time traffic information very much depends on the degree of quality and detail of data informing about the current situation on the road network and in the entire transport system. This data should be available 24/7, and should cover the entire road network. At the same time, it is crucial that efforts in gathering traffic data should always respect and safeguard data privacy and security.

Traffic Information Service Providers are primarily competing on quality and timeliness of their service. It is well accepted by all transport stakeholders that the real-time traffic information (road-network status) has to be both 'true' (valid) and well-timed when reaching the driver. This applies even more for safety-related traffic information.

Achieving and maintaining a high level of quality of traffic information is a key factor for road safety and thus beneficial not only for the individual driver, but also for the traffic management and consequently for the society at large. The reliable provision of high quality traffic information to the end-user is of vital importance to achieve this safety benefit. In this position paper, requirements and key components for an effective and efficient quality management of traffic information in the context of travel and traffic information services are elaborated both from an operational and from a technical perspective. A number of methods and practices are considered, including detailed discussions of real-world examples from various service providers.

TISA recommends the following approach with regards travel and traffic information service provisioning:

- Implementing a comprehensive end-to-end quality management, both within an organisation (internally) as well as with suppliers and customers (externally)
- Application of quality assessment/assurance procedures and quality metrics that are commonly agreed – at least on a national level, preferably internationally – or working on international standardization of such methods and metrics
- Establishing, or intensifying, collaboration along the value chain, in particular between public and commercial entities
- Ensuring fair competition among Travel and Traffic Information Providers based on comparable and compatible methods for assessing quality in the provisioning of traffic information (safety-related traffic information services do not provide grounds for competition, as these are services for the benefit of the society at large).

In a nutshell, Quality of Traffic Information is dependent on four core components which should be consistent through the value chain. These four components are: Road Coverage; Content Accuracy & Completeness; Delivery channel and reception coverage; User Interface. The degree of alignment of these four components across the value chain for traffic information determines the level of benefits enjoyed by the user.

This Position paper further elaborates on quality and completeness considerations for these four components. End-user evaluation methods as well as industry accepted quality assessment methods are both discussed in this Paper. The discussions and the work on quality of traffic information will continue within TISA and through liaison with different organisations. Interested parties are invited to contact the TISA Executive Office (info@tisa.org) for further information.

Contents

1 INTRODUCTION

This position paper represents a consolidated TISA view (from a traffic information service perspective) on the subject of traffic information quality. The purpose of this position paper is to create a common understanding of what determines the value of traffic information and what are the expectations and requirements regarding content, coverage, and consistency. It further elaborates on the potential to harmonize processes across content and service providers to increase the value and benefits of such services for the end user. The position paper originates from a request of the EIP+ platform [1] to TISA regarding a *service provider perspective* on the topic of traffic information quality. After an initial presentation by TISA at the EIP+ annual forum in Rome in November 2015, the work continued in the form of a Task Force under the TISA Quality Working Group, resulting in the position paper (this document).

TISA is developing, maintaining and standardizing two widespread communication protocols for the dissemination of traffic and travel information: TMC (ISO 14819 [2]) and TPEG (ISO 21219 [3]). Both have a strong focus on road traffic. Services are deployed worldwide [4, 5], nurturing a substantial ecosystem with many stakeholders, ranging from car manufacturers and 1st/2nd tier automotive suppliers over service and content providers to small, specialized software, hardware or consulting firms.

The provisioning of traffic information usually involves multiple organizations. Service providers obtain (part of their) content from different content providers, e.g. from public or commercial road authorities, vehicle fleets or other content aggregators. Discussing the subject matter 'quality of traffic information' therefore also involves the quality of technical and administrative processes as well as collaboration models.

As mobility has become a fundamental cornerstone of the modern world, a shared view of what makes traffic information valuable, accepted by Service Providers *world-wide* (at minimum the front-runners in EU, USA, Asia-Pacific), can further increase the quality of traffic information as an end-user service on a global scale. In Europe, the European Commission's ITS Action Plan [6] has an influence on European service providers, since the implementation of Priority Actions B and C [6, 7] requires a certain degree of harmonization of parts of the traffic information services across Europe.

In the area of cooperative ITS, where traffic information is relayed between vehicles via different communication channels and protocols (peer-2-peer ad-hoc communication, or aggregated and quality controlled by service providers), collection and dissemination of traffic information can be faster, but quality and consistency are much more difficult to control.

A common understanding of what 'quality of traffic information' means may also help and promote the harmonized presentation of traffic information in the vehicle. This is especially important for safety-related traffic information, which should be presented timely, clearly and unambiguously, causing minimal distraction to the driver.

The 100+ TISA membership has held a dialogue on what constitutes quality in provisioning of traffic information and has endorsed the positions stated in this TISA paper. In doing so TISA, aspires to contribute to the wider understanding and awareness of the importance of quality in travel and traffic information services and it also aims to further enhance the benefits of the end recipient of these services, the drivers.

2 SCOPE OF THIS POSITION PAPER

For the sake of clarity and for establishing a common terminology, the concept of a value chain is introduced. This value chain allows a further precision of the scope of this position paper.

2.1 *Traffic information value chain*

In 2012, TISA published a document detailing the different stages of the value chain [8]. For the sake of simplicity, only the highest aggregation level is provided in Figure 1. For further details, the interested reader is referred to [8]. All traffic information services are basically deployed along the same value chain, with varying degrees of complexity:

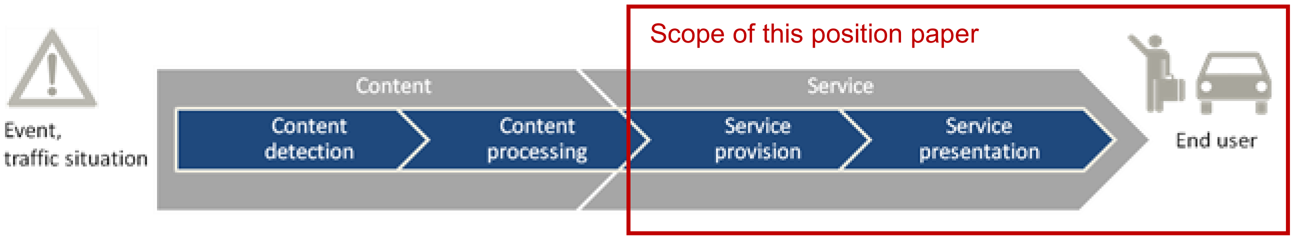

Figure 1: TISA value chain and scope of this position paper

Along this simplified value chain, different stakeholders take a role in detecting and processing traffic-related events (the *Content* segment in Figure 1) or in the provision and presentation of services to end-users (the *Service* segment).

Note that the different parts of the value chain reflect a logical, or functional, segmentation. In some cases, a stakeholder may in fact cover several stages of this value chain. Often, there may also be several stakeholders covering the same stage of the value chain within a given region, creating a competitive marketplace and options to choose from for the stakeholders in the following segments. Further, the value chain is not static for a given region, as it may change over time with stakeholders entering or leaving a market or region.

Table 1: Terms and definitions related to Figure 1

Event	A typical traffic situation (e.g. the traffic flowing normally on a given road) or an unusual incident (e.g. a traffic jam) or a local danger (e.g. fog)
Content detection	The observation of an event with the help of measurement equipment, or alternatively as being observed by humans (e.g. an accident as seen by a witness and reported to the police). Content detection also includes the gathering of information and events using communication equipment.
Content processing	The accumulation of information or events in a content management system, where all information is processed and evaluated. This stage often involves plausibility checks and quality control.
Service provision	The processed content is enriched with content from other sources, reformatted and prepared for transmission to the end-user, then transmitted as a service to the end-user by means of wireless communication (e.g. radio, mobile cellular transmissions) or wired communication (e.g. internet via physical, cabled connections).

Service presentation	The Service is received with an appropriate device, such as radio, mobile phone, navigation device or a personal computer. After reception, relevant messages are extracted from the service and rendered into the form most appropriate for presentation to the end-user (e.g. icons on a navigation devices map display, or message lists on a mobile phone, or audio output).

2.2 Perspective of this position paper

Traffic information is collected and distributed by different parties. Various stakeholders can be identified along the value chain: road authorities, traffic information service providers, content providers, police and rescue organisations, radio broadcasters, automobile clubs and salvage companies, PND/navigation device manufacturers, software providers, etc.

TISA and its members are mainly concerned with the *Service* part of the value chain as depicted in Figure 1. Nevertheless, a service provider can also be a content detector and content processor. In such instances, the service providers have control over the quality in the entire value chain (end-to-end). This Paper will be focusing its considerations and recommendations on the *Service* part, emphasising the position and requirements of *Traffic Information Service Providers, and Traffic Information Client Manufacturers/Integrators.*

Nonetheless TISA sees a clear benefit of harmonization also with the *Content* part of the value chain. TISA therefore maintains liaisons with relevant stakeholders and developments in the content part for *traffic information* (e.g. DATEXII) and welcomes a close collaboration with any organisation that coordinates the harmonization of the content part in the value chain for *travel information*.

3 TISA VIEWS ON QUALITY OF TRAFFIC INFORMATION

3.1 *Quality requirements for data and services*

Quality is an important topic with regards to both traffic data and traffic services. TISA members that maintain B2C[1] relations notice that the customers' expectations regarding quality of traffic information are rising: not only highways, but also secondary and urban roads shall be covered; end users expect a detailed reporting of accurate positions and travel delays instead of just receiving information on the mere existence of a traffic congestion; roadworks shall be reported to end users with exact start & end location instead of being given only approximate locations or road segments.

Operating a Traffic Information Service is a process that involves multiple actors and process steps. As the strength of a chain is determined by its weakest link, all actors along that process chain need to maintain a continuous high quality of service. Each of the steps in this process chain (cf. Figure 1) needs to address quality requirements regarding the:

- Availability of the data;
- Road network coverage in the service area;
- Processing time between content detection and service delivery/presentation;
- Accuracy and completeness, including data latency (up-to-dateness of information) and validity.

These parameters are commonly used as key performance indicators (KPIs) on quality between different entities along the value chain. TISA recognises that the accuracy and completeness of traffic data are difficult to validate, since commonly used data protocols still lack some of the required data elements. Also ground truth data is not always readily available. Availability and coverage of traffic information services on the other hand can be readily measured and compared based on a range of well-established KPIs.

3.2 *Quality criteria and quality assessment methods*

TISA recommends that harmonized quality criteria and relevant measurement methods are defined. A dedicated Quality Working Group within TISA has evaluated the QKZ method [9, 10] and developed the harmonized TISA Qbench method in 2016 [11]. Both are now well established and widely used (see Section 8).

Quality criteria and quality assessment methods should be based on *the quality of the end-user experience on the road*. TISA thus recommends that the following four core elements are considered:

i) Road Coverage
ii) Content Accuracy & Completeness
iii) Delivery Channel and Reception Coverage
iv) User Interface

While individual quality assessment methods could address only some of these core elements, TISA suggests that a comprehensive evaluation of quality of traffic information has to consider assessing all core elements.

3.3 *Quality management of data and services*

Quality is a characteristic (represented by a set of properties) that has to be controlled throughout the entire value chain of traffic information service provisioning. We refer to this as *horizontal quality management*.

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[1] B2C = business-to-customer, i.e. an organisation that maintains a business relation with end users and consumers

Horizontal quality management does not only employ quality checks and controls on technical aspects (i.e. the data processing), but also on all aspects involving human interactions or decision-making as well as how the service is finally presented to the end user.

TISA recommends that a systematic quality management is performed both *internally*, i.e. within the organisation itself, as well as *externally*, i.e. with data suppliers, customers and other external stakeholders. After an agreed and stable quality level has been achieved, focus should be shifted towards continuous quality maintenance and quality improvement.

The internal quality management should define a suitable quality assurance process, ensuring that internal quality metrics are established and procedures are in place (data validation, data quality & systems monitoring, a solid understanding of process variations and their impact on quality). Important elements for establishing an adequate quality assurance process are the following:

i) Setting explicit quality targets,

ii) Defining clear organisational responsibilities to ensuring regular quality reporting, and

iii) Establishing corrective measures, such as issue tracking and feedback mechanisms.

The external quality management should rely on harmonised KPI’s, explicit service level agreements as well as realistic and dependable quality assessment practises, including test teams manually verifying service information on-site (preferably through test driving in real traffic conditions). Tracking defined KPIs over time means that a service provider is able to steer its service’s evolution of quality, and judge impact of quality improvement actions by a cost-benefit analysis. Regular quality reporting, feedback and issue management are further key elements to ensure realistic and reliable traffic information quality management.

Nowadays, all commercial and public traffic information service suppliers have some form of quality measurement/management system in place for their real-time traffic information data, covering at least quality of traffic flow and travel times. Such measures are essential for participating in the competitive traffic information service market. However, TISA sees the need and a benefit for all stakeholders to extend this level of quality assurance into safety-related traffic information as well as public-private partnerships.

3.4 Harmonisation of quality metrics and quality management across stakeholders and regions

TISA recommends harmonising quality metrics and quality management processes across stakeholders and geographic regions. This includes collaboration and harmonisation between public and private actors along the value chain. Specifically for safety related traffic information and corresponding services, where the safety of road users is a common, non-competitive interest of both public and private sector, such collaboration and harmonization is needed.

To be effective, TISA recommends such collaboration at least on a supra-national, or better global, level with an international effort on harmonization and standardization. Individual per-country or per-state procedures leave much room for interpretation and could result in a ‘Babel Tower’ of incompatible approaches. Since travellers roam across borders, it is logical that they have the same quality expectations regardless of geographical region or country. The public-private actor collaboration in traffic information provisioning should therefore address standardized protocols and/or profiles; relevant quality metrics, key performance indicators (KPIs), quality assessment and assurance methods as well as suitable service level agreements.

TISA suggests that regarding harmonised/standardized procedures and interfaces, all stakeholders need to develop a profound understanding and mutual agreement of suitable measures and their impact on traffic information quality. Based on such common understanding, a supra-national harmonization can be achieved. For all these efforts, the road user roaming across national borders and urban/rural roads must remain in the focus.

The above mentioned harmonisation should strive to eliminate the current 'babel of technical languages' that currently exists concerning interfaces along the value chain of traffic information services [12]. Standardized protocols for traffic and travel information, such as the ISO 18419 [2] and ISO 21219 [3] developed and maintained by TISA are important steps in that direction. Nonetheless, the lack of global standards for other parts of the value chain allows for proliferation of proprietary solutions that do not necessarily adhere to the same quality requirements for all.

TISA supports a supra-national harmonisation on quality and quality management for traffic information provisioning, since that is far more effective than an attempt to define e.g. quality criteria on national level for each stakeholder in the value chain. The large number and variety of business models as well as the multiplicity of actors along the value chain on a global scale would make this an ineffective endeavour. Notwithstanding a preference for harmonised quality management and processes, TISA considers it counterproductive to require 'the same quality levels everywhere', as the requirements in different countries may vary significantly regarding the content or maturity of ITS implementations.

4 TRAFFIC INFORMATION PROVISIONING: TRENDS

In the beginning, traffic congestions on major roads were provided with traffic announcements interrupting regular radio programs. Since then, delivery of traffic and travel information to end-users has been expanded to use a variety of different mobile communication systems, notably broadcasting, which besides spoken announcements use RDS-TMC and TPEG, teletext in TV services and the Internet to deliver content.

RDS-TMC was originally devised as a protocol for information delivery serving a mobile end-user who wishes to obtain understandable traffic information when in a locality using a language other than her/his native language. This communication protocol enables the device to present the information in the language of choice of the end-user. RDS-TMC's limitation is that it relies upon pre-determined phrases - often not exactly what the service provider would wish to communicate to the end user.

This technology was adopted and evolved for use in navigation systems. These systems became able to determine whether traffic incidents affected a user's itinerary, and hence were able to provide tailored warnings to drivers. RDS-TMC however, faces yet more limitations in terms of the location coverage, the number of events transmitted, and granularity and coverage of road networks.

Figure 2: TPEG world-wide coverage (2015)

With the development of TPEG a wider variety of client devices could be reached. As a result, much more information on any kind of location could be delivered by a wider variety of dissemination technologies. With respect to language independence, indeed TPEG technology goes a step further by *decomposing* the information into essentially single words, which can be more readily translated into various languages. In addition, the TPEG message construction concept allows for the available information about an event to be assembled into potentially very rich and informing messages, as according to the wishes of the service providers.

4.1 Content accuracy and completeness

The user benefit of real-time traffic information very much depends on the degree of quality and detail of content informing about the current situation on the road network and in the entire transport system. This data should be available 24/7, and should cover the entire road network. At the same time, it is crucial that efforts in gathering traffic data should always respect and safeguard data privacy and security.

With regards to infrastructure, current attempts to improve the quality of traffic information require the traffic environment to be sufficiently homogeneous for accommodating a close interaction between traffic management and road users. Nevertheless, while transport infrastructure and traffic management is nowadays practiced in many countries, it is still very heterogeneous in terms of quality and the availability of:

i) Systems as deployed, whether located at central stations, road side, or for communications;

ii) Services, for example incident management, traffic information, road works, etc.;

iii) Content, e.g. congestion and incident data and;

iv) Processes, e.g. governance and operational procedures.

Moreover, the traffic networks of the different countries are very diverse themselves, comprising e.g. urban roads, motorways or regional networks. Equally diverse are the involved ITS domains and use cases, addressing private traffic, VRUs, parking, public transport, etc.

With regards to Traffic Information Service Providers, they are primarily competing on quality and timeliness of their service. It is well accepted by all transport stakeholders that the real-time traffic information (road-network status) has to be both ‘true’ (valid) and well-timed when reaching the driver. This applies even more for safety-related traffic information. On the other hand, traffic information rendering the journey safe and comfortable should be reached by both the vehicle and the user, if he/she so wishes.

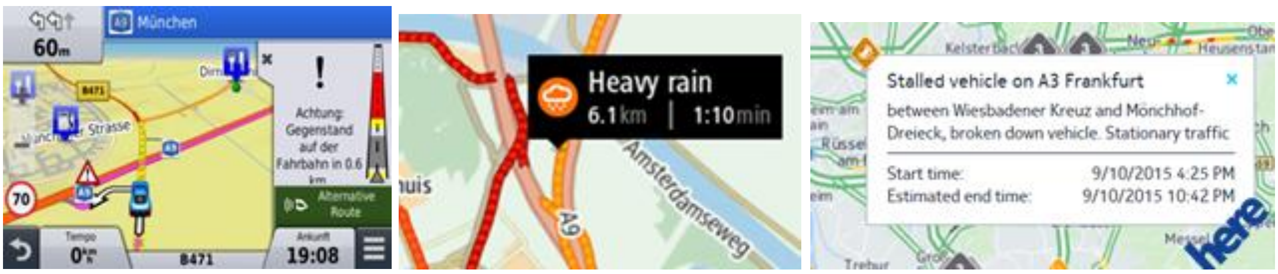

Figure 3: Examples of Safety Related Traffic Information

At the same time, the rapid development of modern traffic telematics solutions and the steady increase in the connectivity of stakeholders stimulates the flexible use of transportation modes (intermodal as well as intra-modal). Conversely, the reliability, fluidity and predictability of the road network play a crucial role for the planning and deployment of traffic management.

4.2 Holistic approach

As driving takes place ‘door-to-door’ and there are no restrictions confining driving to only take place within a specific administration area, traffic management should not be confined within local borders either. It should rather be understood as ‘taking place at the national level’ (and eventually at the supra-national level). This requires that traffic information and traffic management policies/plans are available from all involved road operators and public authorities, covering the entire road network, and not only highways. Traffic information and traffic management plans for lower class roads, including their inter-connection points, should also be made available from all road operators and they should exhibit the same level of detail and consistency. Holistic traffic management, aiming at catering for the individual driver, requires that collaboration between public and private stakeholders is based on sustainable business models.

4.3 Feedback and improvement

The *feedback provided by the vehicles* on road and traffic conditions via the interactive traffic management will be beneficial for traffic content providers as well as traffic management service providers. The sensors of (automated) vehicles will generate larger amounts of high quality data as well as opportunities for validity checks. Essentially, it makes the provision of traffic information more efficient and effective. Moreover, the increased interaction between vehicles, roadside and central infrastructure will enable a more effective and efficient traffic management, resulting in a more reliable and effective transportation system.

In summary, high quality service in traffic information entails the constant availability of high quality, detailed and timely data with regards to the current status of the road network and the entire transport system. This service should cover the entire road network. Data and services should be available at all times, in a standardised format across operators and providers in all countries. Moreover, if seamless data services are to be offered, the existing diversity in traffic environments should be eliminated by harmonisation as much as possible across Europe and internationally.

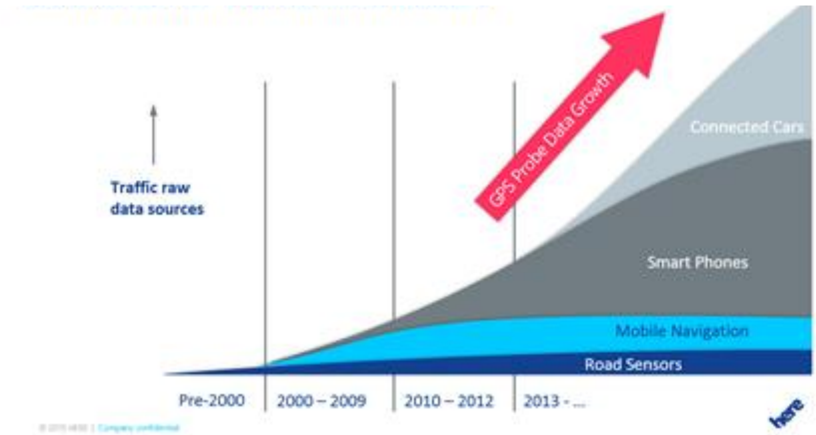

Figure 4: Traffic (big) data enables high precision traffic information
(source: HERE)

4.4 Interactive traffic management

Roadside service providers deliver traffic information to their clients also based on traffic management plans of public authorities, when available. The traffic management data and plans need to be made available and accessible to all service providers in a secure manner using standard interfaces. The success and value of such services is, among others, also related to the quality of traffic management plans in terms of reliability, availability and timing.

A new trend in traffic information services is *interactive traffic management*. Based on the collaboration of service providers and public authorities, this latest trend involves the enablement of vehicle interaction with the traffic management centres (TMCs) via service providers (SPs). The concept is termed as Traffic Management 2.0 [13] and is seen as the evolution of current traffic management practices which are based more on loop detectors and static traffic data used by traffic management centres. In the current traffic management practice, traffic management centres do not have a direct collaboration with in-car data providers and OEMs. The increased use of floating car data (FCD), including the wider coverage this offers with regards to real-time traffic information, is being exploited for advancing traffic management practices and providing better traffic information. In TM 2.0 a number of road stakeholders are called to cooperate into providing a more holistic traffic management practice which takes into account and accommodates for the individual driver's needs while at the same time it also satisfies the objectives set by the public authorities and the traffic management centres for the collective benefit of road network users.

Figure 5: The TM 2.0 concept

5 TRAFFIC INFORMATION PROVISIONING: KEY VALUE DRIVERS FOR USERS

Timely traffic information informs road users about unusual traffic situations. When provided with traffic information, users become more alert, and in some cases they are also provided with the option to avoid traffic incidents (e.g. jams, accidents, roadworks or other unsafe driving situations) on their itinerary. In general, from a user perspective, the following three key drivers determine the value of their experience:

i) Safety;
ii) Travel time support; and
iii) Decision support for route selection.

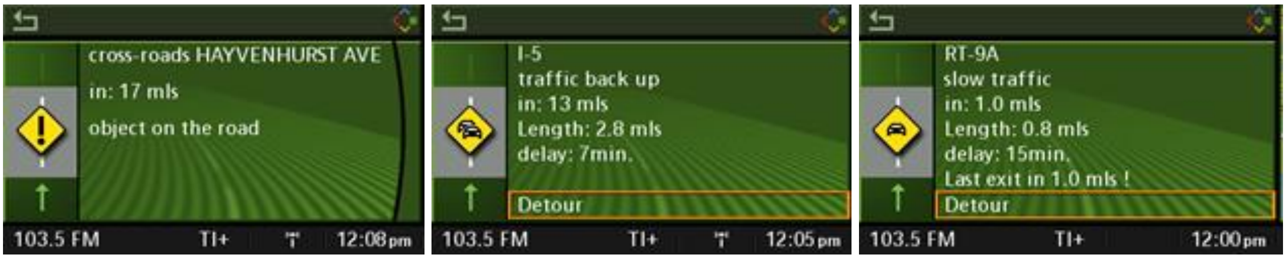

Figure 6: The three key drivers for users: Safety, travel time support/impact, alternate route selection

5.1 Safety: Alerting the driver in time about traffic problems

Safety, the first of the 3 key value drivers of traffic information provisioning, entails that the driver does not encounter potentially dangerous traffic conditions unexpectedly. Thus, to warn a driver in time for e.g. an object on the road (see Figure 6, left) the traffic service needs to accurately indicate in time the location of:

- The tail of a traffic queue
- The exact start and end location of accidents and other unusual travel conditions

With regards to safety, the accurate reporting of the nature and location of real-time traffic conditions is important. However, unless the information is in the vicinity of the driver, this information is not of great value. With regards to coverage, such information should undoubtedly include all classes of roads in the network.

5.2 Effective travel-time support

Travel-time support mostly involves the accurate estimation of time-of-arrival for the user's itinerary. Experiencing delays due to both congestion (see Figure 6, centre) or incidents needs to be factored in for a realistic estimate of a user's expected time of arrival. Reliable travel times reduce stress for the driver (e.g. being trapped in congestions) and can also prevent stress-induced aggression (road rage). Hence, travel and traffic information services need to support a user's travel-time estimation by including the following in their service:

- Travel times, delays, and closures.
- Slower, and user understandable, changes of travel times when updating information.

For travel-time support, both actual and predictive conditions are important. The exact start and end location of traffic conditions is important together with accurate information on travel times that covers the entire road network (local roads included). Travel time estimates should not fluctuate wildly back-and-forth over subsequent updates, as this may confuse end-users.

5.3 Decision support for alternate-route selection

Decision support helps the driver in navigating traffic by finding the best route for the given traffic conditions, both actual and predicted. Drivers should not only be offered an estimate for traffic delays, but they should also be supported with information on alternative routes so that their decision-making at relevant points along the route (see Figure 6, right) is based on valid and high quality information. Thus the following aspects need consideration:

- Road network coverage to include alternative routes;
- Accurate indications of congestion and incident impacts with respect to (last) exit opportunities on a congested road;
- Reliable inter-/extrapolation of incident impacts and delays for predictive advice ahead.

For decision support, both actual and predictive conditions are important.

6 THE FOUR CORE COMPONENTS OF TRAFFIC INFORMATION QUALITY

Quality of Traffic Information is dependent on four core components which should be consistent through the value chain. These four components are:

- Road Coverage
- Content Accuracy & Completeness
- Delivery Channel and Reception Coverage
- User Interface

The degree of alignment of these four components across the value chain for traffic information determines the level of benefits enjoyed by the user. The next sections describe quality and completeness considerations for these four components.

6.1 Road coverage

To be useful and to provide a consistent user experience, traffic information must cover the door-to-door route of a (vehicle) traveller. Hence, the road coverage of a traffic information service needs to cover as many roads and road categories as possible, from inner cities to rural areas / from residential roads to major highways.

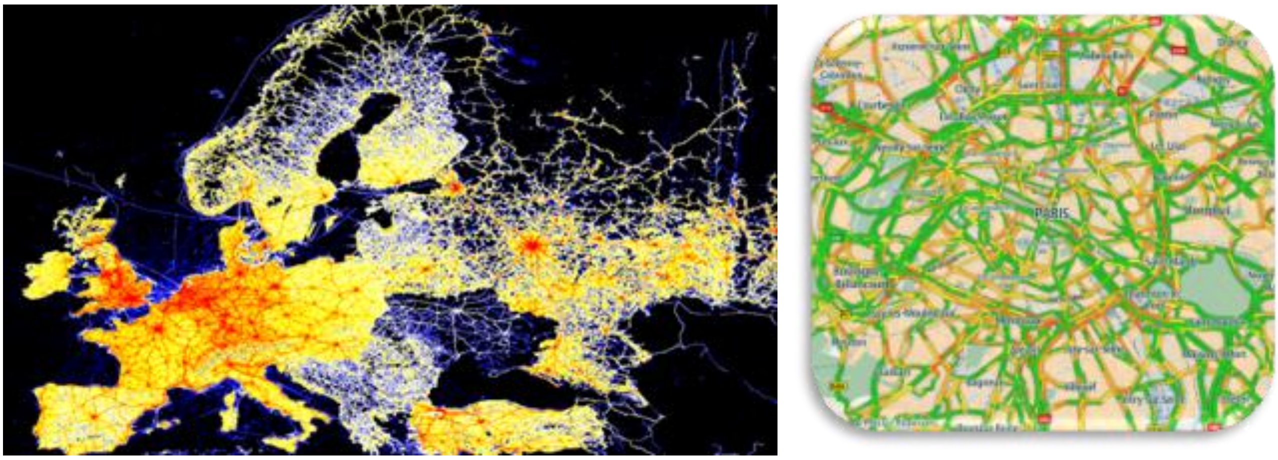

Figure 7: Sample extent of overall Road coverage in Europe, and local road coverage in Paris (source: TomTom)

6.2 Content accuracy and completeness

A traffic information service is critically dependent on the accuracy and timeliness of its content, and hence also on the quality of content being provided by 3rd parties, where applicable. Content accuracy and completeness can be looked at from the perspectives of content coding, location referencing, and timing (timeliness and latency of content provisioning).

<u>Content coding</u>

Content coding has to be as detailed as possible. Instead of coding an event as a general 'accident', providing more details such as that it is an 'accident involving a lorry' with 'two lanes blocked' is more helpful for an end-user as it enables him/her to better assess the situation.

International standards often provide many options and alternative ways to code content. TISA recommends restricting the variety of options in encoding traffic information in a content feed that such a standard provides (e.g. DATEXII as used by public authorities). Co-existence of many variations/national profiles hampers the correct and timely automation and compilation of traffic information by service providers, and more to that, it requires much alignment effort to still achieve an internationally consistent service. A supra-nationally agreed single profile/interface would be more preferable as well as a more international orientation (e.g. using English as fall-back reporting language for traffic information) for harmonised content coding.

Location referencing

Given restrictions of some location referencing standards, particularly the one used for RDS-TMC, data feeds provided by content providers (road, emergency authorities etc.) should be as 'open' as possible. This implies the following aspects:

- Content providers should use open, spatially accurate location referencing systems for geographic data. This will allow service providers, who are likely reworking this content with multiple location referencing systems at the service provision level, to translate information into the location referencing used for a given service.
- Content and service providers need to ensure that information on direction and location of event messages is relevant to end users, and avoid just making the geographic information available regardless of its relevance to them (and their location).

Timeliness and latency of content

Content accuracy in terms of timing of events can be broadly broken down into two categories: *scheduled* and *unscheduled* events.

- Scheduled events include traffic related information such as roadworks, major events etc. These should be given to service providers in advance. Often, records of road authorities serve a different purpose to the traffic service providers. This results in experiences such as a road being designated for works over a number of weeks but the actual works on road only being for a few days. To better cater to the need of traffic information services, road authorities are recommended to manage this with an additional field designating 'active, pending and expired' values to indicate whether the works are yet to occur, on road, or done.
- Unscheduled events and especially accidents are difficult to quality-check due to their transient nature. As service providers compile data from multiple sources such as incidents and probe data for speeds quality-checks can be conducted by reviewing probe data (where available) in order to validate impact on traffic flow of manually entered events.
- Both for unscheduled and scheduled events, any change over time (including content updates, and event ending) has to be monitored and provided towards service providers. Default, assumed, event durations can cause users to question the validity of information and the quality of service at large, especially if while passing the designated incident location, the event is already over.

In both categories however the interfacing between content and service providers should be aimed at providing content in a timely manner with an encoding that is able to preserve all accuracy and completeness of the content provider's source information. Additionally, wherever appropriate, validity checks should be put in place, to cross check information / data coming from different sources before content is disseminated to the end user.

6.3 *Delivery channel and reception coverage*

Traffic information is typically disseminated to the end user (or the respective vehicle being driven by the user) by means of one of the following four distinct modalities:

- Mobile navigation devices (also referred to as nomadic devices), that may receive / retrieve traffic information using channels such as RDS TMC via FM radio; TPEG via digital radio (DAB+, HD Radio) or mobile Internet connection, either via standardized (open) protocols (typically TPEG) or as end-to-end proprietary (closed) solutions
- Car in-dash systems, that use the same reception channels as mobile navigation devices
- Smartphone applications, that retrieve traffic information via mobile internet, typically as end-to-end proprietary protocol solutions
- Spoken traffic announcements (TA) interrupting radio programs, provided via FM radio or digital radio

The choice of delivery channel impacts the amount of information that can be provided to the end-user (e.g. capacity limits, transmission capacity) as well as the speed and potential repetition rate with which information can be provided; a prioritisation of information by the service provider is typically required to make sure that the most relevant (e.g. safety related) information is provided with the smallest delay to the end-user. The nature of the delivery channel also plays an important role. Each channel has its pros and cons. For example, a broadcast channel is very well-suited to provide information with a high reliability to many end-users at once (but capacity limits must be respected by the service provider) whereas a mobile internet channel can provide individual information on request (but may potentially get congested when providing information to all users at once).

The type of information that may be sent to the end-user is also influenced by the delivery channel, or rather, the combination of the delivery channel and the end-user device. Navigation devices and smartphone apps can potentially transmit any type of information, specifically that which is graphically represented (e.g. by means of logos, icons etc.) and/or they can provide map-based information, where the relationship of traffic information to specific locations is very transparent. Simpler receivers may use text-based data to present traffic information to the user. On the other hand, spoken traffic announcements are presented acoustically to the end-user, which may limit the amount of information conveyed, but makes possible that it is provided with high quality (e.g. by including expected delay times when reporting events). Spoken announcements have a clear advantage with respect to graphically represented information in that they are much less distracting to the end-user / driver as they do not demand that he diverts his attention (eyes) away from the road.

The communication protocols used to convey information via the dissemination channels also have a large impact on the detail with which traffic information can be presented. On the one hand, there are great differences among communication protocols on the coding, specificity with regards to events (e.g. the number of possible events that can be covered by TPEG is much larger than for RDS-TMC). On the other hand the position resolution that can be achieved strongly depends on the protocol used (e.g. RDS-TMC can only resolve locations based on pre-set location lists, whereas TPEG uses geo-referencing mechanisms with which any location on a map can be addressed); furthermore, protocols such as TPEG allow the use of linear and area-based locations.

The various dissemination channels that are currently in use, each has its advantages and disadvantages. In general though, a dissemination technology which enables a faster delivery and offers more comprehensive and precise characteristics better enables a high quality traffic information service to be delivered to the end-user.

6.4 User interface and service presentation

Service presentation is the process of preparing the content received as part of a service in such a way that useful information can be presented to the End User. One and the same message could for instance be displayed as an icon on a car navigation map if the device features a high-resolution graphical display, or as text message in case the device has only a few lines of alphanumeric display, or as an audible announcement in case the device has text-to-speech capabilities – all from one and the same content.

On one hand the information has to be rich enough and machine readable to be presented to the end-user in a high quality manner. On the other hand, traffic information should not distract drivers from driving. With regards to navigation devices, end-users should be able to choose the level of information to be displayed on their device and filter the level of detail according to situation (see Figure 8). Further details about the traffic information can be provided to the end user (via their navigation device) on demand if this is an option made available by the device. Regarding Safety Relevant Traffic Information (SRTI) a harmonized presentation in terms of used icons and text is highly recommended by TISA. This will make the same message easy to recognize even when transmitted over different communication channels; hence drivers will be warned consistently and effectively. Today drivers are mobile over different countries and different cars. Several applications are being used. As a result, with regards to SRTI, TISA recommends that drivers are provided with the same level and kind of information from outside the car as well as from a device used while driving.

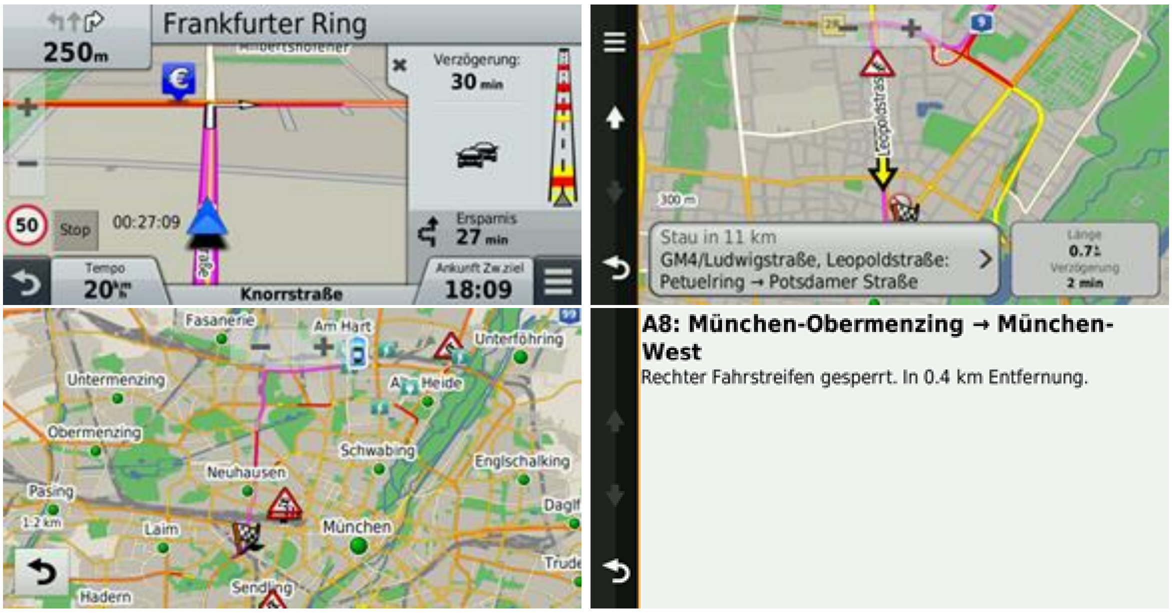

Figure 8: Level of Detail according to UI and situation, Colouring, Icons, short Text and Details (source: Garmin PND)

7 Quality of Traffic Information: Quality and Quality Criteria

End-users have high expectations for the quality of both flow and incident/event information. Service providers need to be mindful of these user expectations when designing the user experience.

There is an expectation for high location precision and timeliness among end-users. With regards to incidents, this end-user expectation is reflected in a need to know the exact start and end locations of a traffic incident. In addition to having this fine spatial resolution, traffic incidents are expected to have a fine temporal resolution as well. Notification of an incident should be promptly provided to the end-user after it first develops, and such notifications should likewise be cleared promptly. With regards to information flow, the user expectation is likewise strong for granular locations to indicate congestion. TMC traffic locations by itself it is not anymore an acceptable granularity for the traffic messages, due to the demand of the users for location precision. The implementation of offsets (traffic messages reported in smaller segments than the TMC location granularity), and dynamic location referencing methods have helped to answer this demand of users. For both traffic incidents and flow, the user expectation can be generalized to having highly accurate spatial and temporal visualization of traffic conditions.

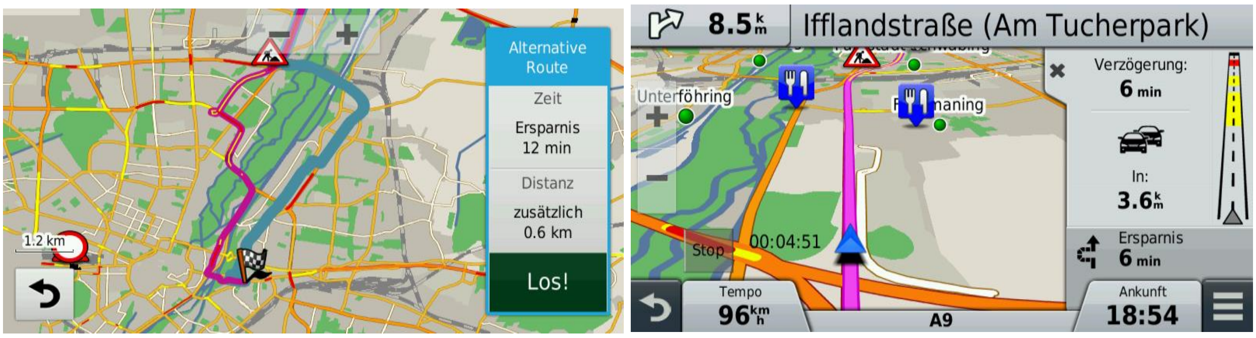

Figure 9: User presentations with combined flow and incident information
(source Garmin)

The user expects flow and incident information to relate to each other and expects to see a clear relationship of flow and incident information when provided together. For example, if there is a congestion event due to roadworks, the user, if he is stuck in the traffic, expects to see clearly the roadworks reported in his device and to see that traffic flow is likewise congested around the roadworks (see Figure 9). This can represent a challenge due to the different ways flow and incident data are collected. While flow is automated and there is a possibility to have several sources for the same extent of road (enabling cross-validation and fusion), incident data is most often manually collected and originating from a difference source, which may introduce a degree of inconsistency. Some incidents may be legitimate incidents, and indicated to the user as such but they may not be impactful to traffic flow. This can cause a disconnect between incident and flow to the user. Service providers are using several ways to validate incident data and that involves the use of alternative sources like cameras on the road, apps where it is possible to report traffic events, and cross correlation analysis of probe data and incident data. These validation efforts should improve the linkages between incident and flow information.

A final user expectation is for consistency, regardless of the geography the user is traveling in. A user crossing a border from Italy to Switzerland, for example, desires his navigation experience to work seamlessly even as he moves from one country to the next. To this end, there are a lot of efforts being made to standardize the nomenclature used to report incidents and congestion. For example, Alert C codes are a standardized way of transferring incident and congestion messages from traffic service providers to users.

7.1 End-user evaluation of traffic information

End-users evaluate quality based on their own, **personal**, real-world experiences and observations made while driving. Because of this, quality criteria and evaluation should aim to reflect the **end-user experience on the road.** From a service provider perspective, four key quality performance indicators have been identified:

- **Accuracy and appropriateness of safety notifications:** end-users will easily be able to compare incident safety notifications received in vehicle with the actual conditions viewed on the road. A high degree of concordance is expected.
- **Detection of incident and congestion events:** end-users will assess the detection accuracy of received incident and congestion events. Users will evaluate whether detection occurs at the right spatial location (the start and end points of the event) as well as accurate time of the detection. Users will use their own drives as ground truth to assess the accuracy of these events. In this way users will infer proper detection and error rates for these events.
- **Accuracy of visual representation of flow and flow severity level:** end-users will view their navigation system while on a specific route or navigating general. Many navigation systems show flow severity levels as traffic overlays to the map. Users will assess the colour shown on the map against their own perception of traffic severity for the road being driven. This creates a situation in which the user is conducting a perception-based comparison in real-time on each section of road driven.
- **Travel time error**: end-users are sensitive to total travel time of their trip. Most navigation systems include an estimated time of arrival, which computes travel time, taking into account traffic conditions across the chosen route. Travel time error measures the accuracy of the travel time estimation, comparing the estimate with the actual travel time in vehicle (ground truth). While users ultimately seek a highly accurate travel time, they may have particular sensitivity to travel times that are too optimistic and underestimate their time of arrival, causing them to be late.

7.2 Quality of Incident data

By using floating car data (FCD) it is possible to automatically detect and correct road closures, even when they are not reported by official sources. It is possible to measure a lack of real-time GPS probe data in the road network, indicating a closure if the amount of real-time floating car data does not match the expected amount of GPS probe data. In this case a service provider's fusion engine may create an automatic closure report.

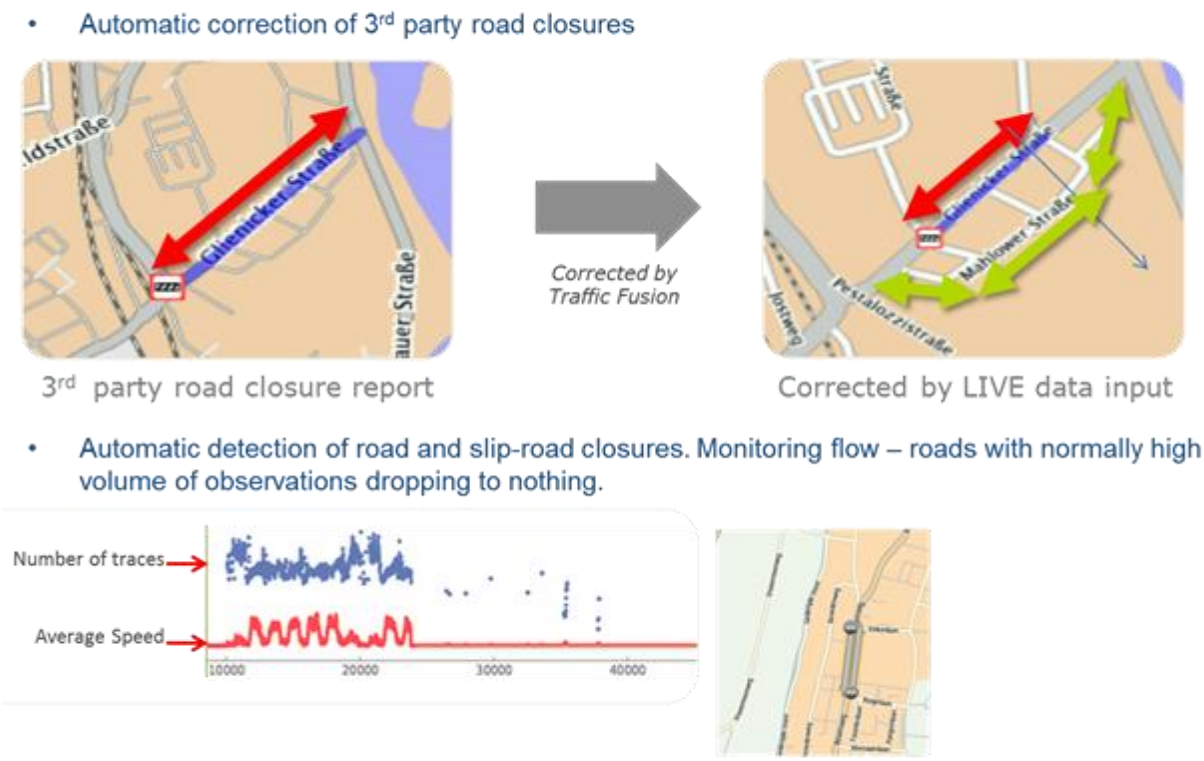

Figure 10: Example of validation of reported road and slip-road closures with probe data
(source TomTom)

Besides automatically detecting road closures, service providers also receive road closures from the public traffic authority's data feeds. This data is also used in the fusion process. Often, however, the closed stretch on the road that the public authority warned about, does not represent reality- either because of a delay in initiating works or because the stretch is longer/shortest than anticipated. Service providers, by the use of GPS data, can verify and correct a closure message indicating the actual closed stretch by removing closed stretches where GPS data is measured but also by extending a closure if this is being indicated by the GPS data (see Figure 10). This means that a road closure message can be completely removed or that the closed stretch is shortened or enlarged by service providers when their GPS feedback does not agree with what the Public Authority has announced. Such quality (cross-validation) checks help improve the quality and completeness of traffic information.

7.3 Meta data for safe use of traffic information

Last but not least, safety is an important aspect of traffic information quality. The direct impact – both positive and negative – of traffic information quality is rather obvious: accurate and timely warnings alert the driver, increase his/her preparedness for whatever comes ahead on the road, and result in reduced speed and increased alertness by drivers on the road (as for example in the case of adverse weather or heavy traffic). Likewise, inaccurate or outdated information have a negative impact, since the attention of the driver will decrease after several false positive reports or the driver may start to neglect traffic information after a number of non-reports.

This becomes even more pronounced when advanced driver assistance systems come into play, automated driving becomes a commodity, or vehicles drive fully autonomous. With increased automation, or autonomy for that matter, vehicles rely on on-board sensors, which have already under ideal conditions (e.g. unobstructed view) a limited range of these sensors due to physical limitations. In difficult situations (obstructed view, unfavourable propagation conditions, interference, etc.), this range can be substantially reduced. Accurate traffic information becomes vital for traffic safety in such situations as it 'extends the viewing range' of an automated/autonomous vehicle and prepares the driving algorithms for an imminent danger even if that is still beyond the range of its on-board sensors. This information will be processed by mathematical algorithms that control the vehicle on the road. The quality of traffic information and adequate meta-data about its reliability suddenly become crucial in this context, since the corrective factor "driver", who interprets traffic information by applying human reasoning and draws the right conclusions in a given context, is "removed from the equation".

The legal community is also becoming increasingly attuned to metadata's importance and requirements, but they also recognize that there are problems with standards and the identification of the essential metadata. There are several examples in which courts in the United States have looked at various questions involving metadata, not specifically regarding to autonomous driving or traffic information, but that is just a matter of time until the first units in the market get involved in accidents. By the moment, courts will have to decide when and how metadata can be used on a case-by-case basis, at least until a well-defined and standardized normative is defined.

To ensure the validity and admissibility of evidence from electronic systems (vehicles in this case), the legal system has further specified detailed requirements for the preservation of records and the preservation of data about those records. These requirements increasingly direct attention to supportive data, or metadata, to substantiate core authenticity functions such as the date, time, and original, actual author(s) of documentation actions, including legitimate alterations [14].

8 Quality of Traffic Information: Quality Assessment: An Integral Part of the Operation

The prior section discussed the quality criteria expectations of end-users. This section describes the quality assessment methodologies available to assess the end quality of traffic information. The relevant methodology is dependent on what aspect of traffic quality needs to be measured.

Broadly, the following aspects of traffic quality are typically measured:

- Congestion and Incident Events
- Flow and Travel Time
- Level of Service

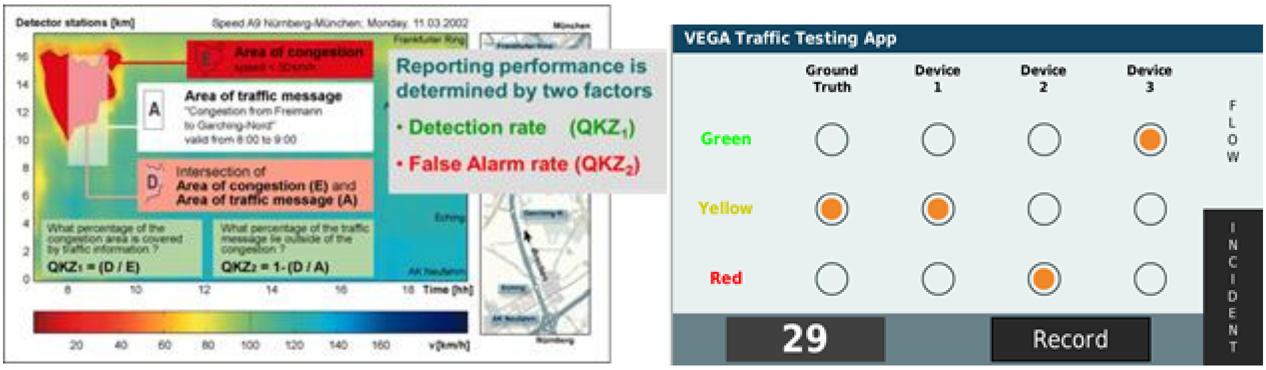

Figure 11: QKZ method (left), and (GARMIN) interface to capture traffic flow status during drive tests (right)

For measuring accuracy of congestion and incident events, a number of methods are commonly used by TISA service providers. One method is the QKZ assessment [9]. The QKZ method measures detection rate and error rate. It is reliant on the creation of an infrastructure using stationary detector data in order to generate the quality measures used. The later QFCD method [15] extended the QKZ approach towards ground truth collection via drive testing. This method was successfully deployed in the USA [10].

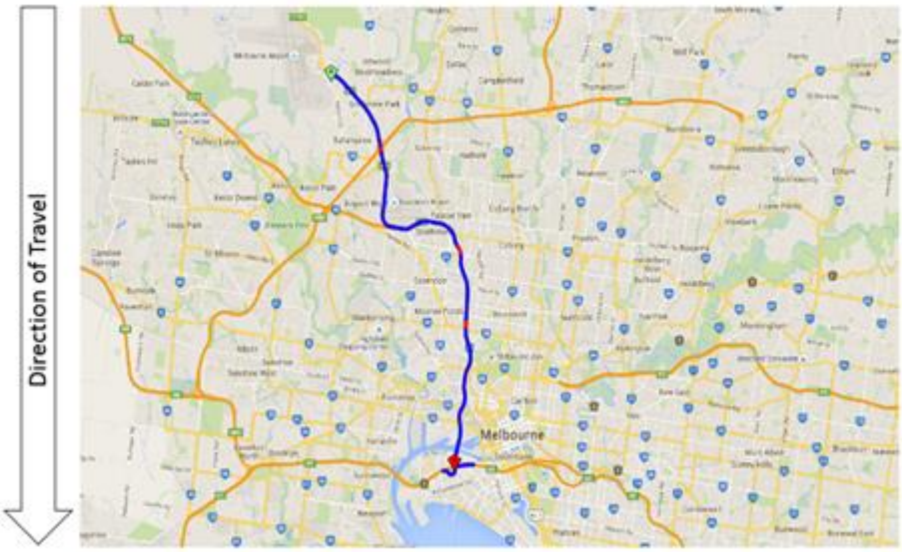

Figure 12: QKZ assessment using quarantined probe data: Journey under analysis
(source: Intelematics)

QKZ can also be generated using 'quarantined' probe data to give greater road coverage. A service may set aside a small portion of its probe data (i.e. quarantine it) for quality assessment -- this probe data is not used in the creation of traffic information.

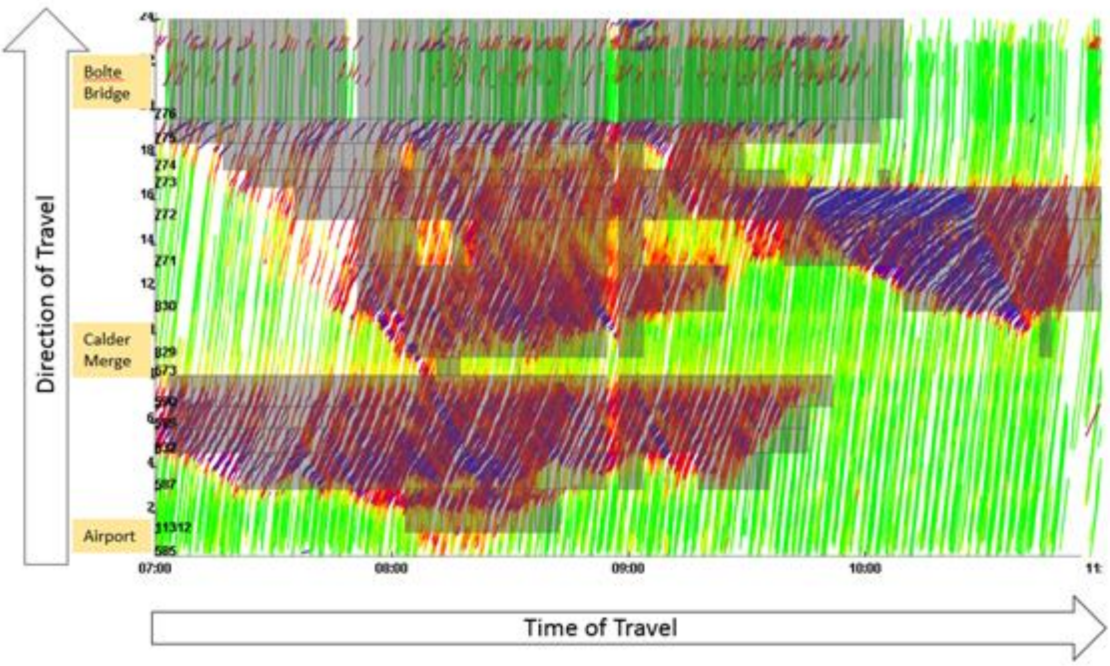

Figure 13: QKZ diagram depicting the traffic flow along Melbourne Airport to the CBD journey over time
(source: Intelematics)

Figure 12 shows the journey under analysis: Melbourne Airport to the Center of Business District; Figure 13 shows the QKZ diagram that depicts the traffic flow along that journey over time. In the Figure 13, green, yellow, red and blue lines represent probe trace speeds over links, and grey boxes represent TMC message output. The expected QKZ result in this diagram is that the majority of red/blue (blue is stationary) lines shall to be 'covered' with a grey box.

Drive testing is also used for the evaluation of incident data. Drive testing results typically are restricted to a binary analysis which assesses match rates between reported and observed traffic events. A further systematization of incident data assessment was undertaken by the Dutch research institute TNO and resulted in the QSRTI method [16]. This method adapts the QKZ/QFCD method for the purpose of quality assessment for Safety Related Traffic Information to, firstly, fit the quality criteria definitions by the European Road Authorities in the EIP+ platform [17] and secondly, to be able to assess "minimum" type requirements, including accepted reporting tolerances and even some "best effort" values on the most basic quality level.

8.1 Obtaining ground truth

There are several other methods used to assess accuracy of traffic data from a flow and travel time perspective. In assessing accuracy of this type of data, the first decision is what type of ground truth to use. Driver ground truth is perhaps the simplest option. Driver ground truth requires a trained driver and field car, collecting accurate GPS data from test drives on targeted routes and times. While driver ground truth testing has several advantages, including simplicity and true user experience, the resource costs for this type of testing make it difficult to use extensively for many locations and times. Given the costs of driver ground truth, alternative ground truth measures are also in use. A key alternative is to use probe and sensor data in an offline mode to build a reference traffic state that functions as ground truth. The advantage of the reference traffic state is its scale, allowing the ability to test all geographies at all time periods. Other ground truth approaches in use include the use of Bluetooth sensor data, vehicle license plate pairing, and camera technology.

8.2 Assessment of flow accuracy

Once the ground truth approach is determined, the method for assessing flow and travel time accuracy also needs to be chosen. The TISA QBench methodology [11] is a travel time based accuracy measure compatible with different ground truth collection methods. TISA QBench focuses on travel time accuracy in congested road conditions, typically 50% of speed limit. It includes a number of additional parameters which influence the benefit given to a traffic provider in over or under reporting congestion. In addition to TISA QBench, there are a number of other flow metrics commonly in use which gauge traffic speed accuracy. There is variation across the industry in these metrics and their implementation. Common metrics include percentage accuracy within a defined speed band, average absolute speed error (typically also within a defined speed band), and speed error bias measures. Another measure related to flow is a level of service classification based on speed. Travel time measures may include percentage accuracy on a travel time basis and travel time bias.

<u>Automated Qbench using probe data</u>

Qbench scores can be generated using quarantined probe data to evaluate service quality. This has the following benefits:

- Much greater area coverage across metropolitan areas than floating car drives
- 24/7 temporal coverage allowing analysis to be conducted on a daily, weekly monthly basis to assess long term trends and patterns.

Figure 14 shows a “QBench Map” for a selection of cities and quarters, showing the geographic distribution of contributions to a 24/7 QBench score. Motorway and arterial scores are shown together in this one map.

Figure 14: A QBench map of Melbourne and surroundings
(source: Intelematics)

The width of each TMC link (road section) is representative of how much that link contributes to the total congestion measured in that city (on a logarithmic scale). The colour of each TMC link represents the QBench score for that link, taken alone, as follows:

Green:	QBench greater than +0.7
Yellow:	QBench between 0.4 and 0.7
Orange:	QBench between 0.2 and 0.4
Red:	QBench between 0 and 0.2
Grey:	No Validation probe data. No Score.

These QBench maps allow for a large degree of granularity with scores provided down to the individual link level and minimum 24 hour time span. Longer time spans of 2 weeks are typically used in analysis as traffic conditions will be dynamic from day to day. Longer sample times give a better picture of roads and segments that require further analysis.

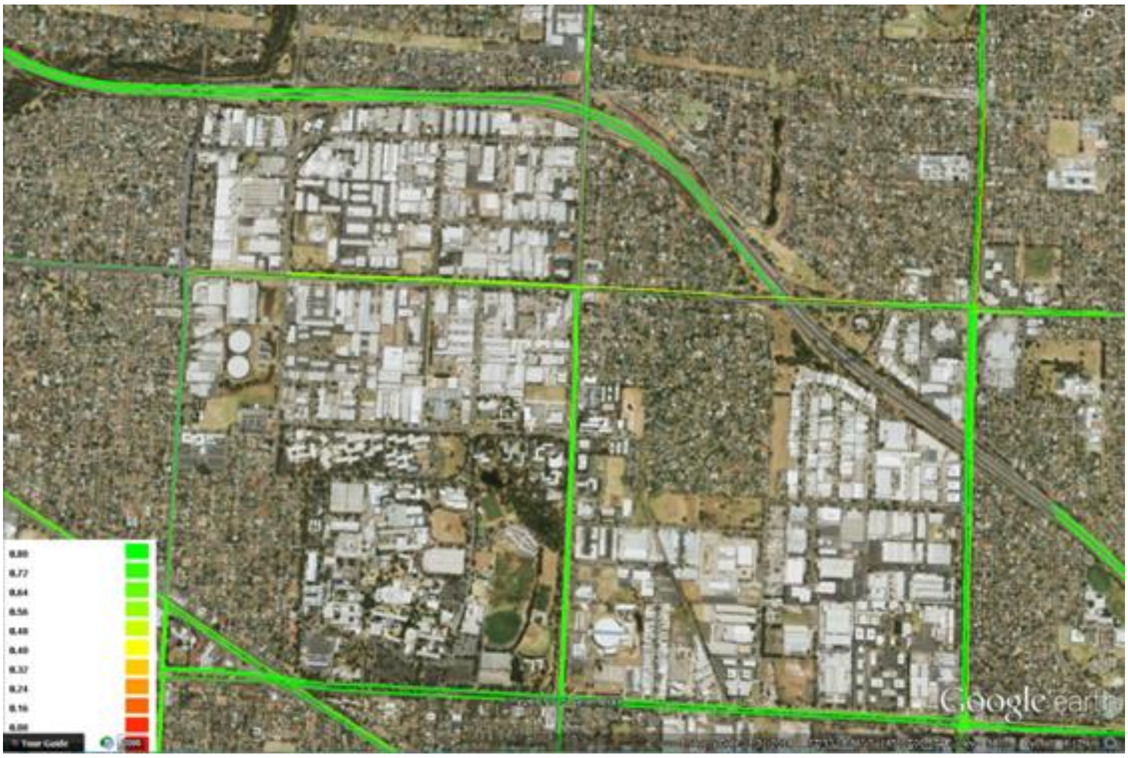

Figure 15: QBench map zoomed in on the Notting Hill area of Melbourne and centred on Blackburn road
(source: Intelematics)

Overall Daily scores can also be produced for service areas: for reporting and an overall health check of the quality of flow data. Figure 15 shows a zoom of the Notting Hill area of Melbourne centred on Blackburn road. This illustrates an overall 'good' speed calculation result from quarantined probe data. Grey links show for links with no test data for the day.

<u>Drive testing for level of service assessment</u>

A third aspect of traffic quality frequently measured is level of service (LoS). A LoS measure is gauging the accuracy of traffic information from a colour perspective, based on the flow severity level shown on a navigation system. This aspect of traffic quality is typically assessed from a user's perspective, given the more qualitative nature of what colour level is appropriate to a particular road condition.

Figure 16: Drive testing interface for level of service assessment
(source: HERE)

Testing involves the collection and analysis of user perception data (see Figure 16 for an example in-vehicle drive testing interface). Some of those methods are quite simple and only require the collection of perception data by the end users at a defined interval (i.e. every 30 or 60 seconds) or every time that traffic conditions are changing. This collection can be supported with the inclusion of video cameras. At the end, the collected used perception data is used as ground truth reference and is as a result compared against the traffic information under analysis. Analysis may use the confusion matrix (or contingency table) to calculate metrics showing detection and precision rates for different traffic levels of service.

9 Process quality expectations for traffic information provisioning

Quality management in traffic information is a two way process: internal and external. The process of collection and fusion of data, the verification of the truthfulness and the clear allocation of roles throughout the chain of work within an organization have to be defined and respected by those involved. As Traffic information is a chain procedure, all of its parts have to abide to clear and strict criteria of quality. Horizontal quality management means that the organisation employs quality checks and balances not only on the technical aspects of the traffic data process but also on human interaction (services aspects). Have a common understanding of quality and quality requirements throughout the value chain is a prerequisite for end-user quality.

9.1 Internal quality management

Internally, quality targets and clear responsibilities for ensuring regular quality reports and corrective steps are vital for quality management. Issue management and feedback, back-up systems and 24-hour service and response are essential for an internal quality management process, which is of course under the exclusive control of the respective organisation.

Multiple data-centres are recommended in order to minimise the impact of any system downtime due to failure or maintenance. This measure should make it extremely difficult for the traffic information feed to customers to be interrupted. As back office has parallel running servers, this will ensure the highest availability of traffic information services and in the case of operational incidents, a 24/7 monitoring team has to be available.

Moreover, using floating car data (FCD) from various sources, and not limiting the sources to one, further enhances quality in traffic information. As cars drive on all roads that are open, TISA service providers are able to measure travel time and speeds on all roads. Even when construction works take place, forcing traffic for example to go on a temporary lane or drive on the other side of the duel carriageway, TISA service providers will still be able to measure travel times and speeds due to the map matching process.

The verification of traffic information from various sources, before disseminating it to the end-user, is of crucial importance. This means that data which is collected (be it automatically or manually) needs to be checked and verified by two independent sources before dissemination (except in special cases such as wrong-way drivers when timing is of the utmost importance). Content and service providers shall operate with trained, knowledgeable staff guided by a clear quality assurance policy.

9.2 External quality management

External quality management shall be focused to achieve needed service levels to meet end-user and provider needs. This includes 24/7 data availability and updates, road coverage to include all roads, timeliness of data (not only measured from the stage of detection to that of publishing of the information but also with regards to expiration and deletion of events), and explicit service level agreements, expressing commitment to customers and stakeholders.

Drivers use traffic information in order to navigate to their destination as fast and as efficiently as possible and this determines to a large extend how quality is perceived by users on the road. Hence it is always essential for traffic information service providers to execute test drives to support the statistical quality test results. Despite the low sample size that test drives provide (it is not possible to drive past all jams) this method does provide a view of traffic information quality.

Figure 17: Test drives for assessing quality of traffic information (left) (source: TomTom) **and sample recording input screen (right)** (source: Garmin)

Such test drives are conducted by traffic information service providers (see Figure 17, left), their clients (see Figure 17, right), and also independent organizations validating quality or comparing different service providers. Figure 17, left shows how a typical test drive is carried out with many different navigation devices placed in a car driving in traffic.

Service level agreements should clearly define roles and responsibilities and most importantly, they should define the commitment of those involved in the chain. Such explicit service level agreements regulate that quality is the guiding principle of any end result. Service level agreements are common-place with commercial service providers. In the Netherlands, the public content provider National Data Warehouse (NDW) also has set service level agreements for flow data.

TISA believes that external quality management will benefit from harmonised set of KPI's, explicit service level agreements, and real-world quality assessment practises, including test teams manually verifying service information on location (possibly with test drives). Regular quality reporting, feedback, and issue management are also key elements towards not only improved, but also attested quality in traffic information.

10 Collaboration between service providers and (public and private) content providers

Quality of traffic information is a transversal issue. It does not (and should not) only be the responsibility of one traffic stakeholder – as it provides grounds for competition in the market place. Service providers use the quality of the traffic information they provide as a competitive advantage and price it accordingly. On the other hand, public authorities, despite recognizing the value quality traffic information has with regards to safety and security, rarely compete on these terms with either the private sector or their counterparts in other regions in Europe. Pricing quality on differing sets of objectives (service vs safety) is the result of the different priorities guiding the work of the two traffic stakeholder groups (public authorities vs. private traffic information service providers).

Service level agreements that clearly define roles and responsibilities and most importantly set the commitment on those involved in the chain can regulate that quality is the guiding part of the end result.

10.1 A shared understanding of the different priorities of traffic information stakeholders

A common understanding of the different priorities of traffic information stakeholders is the basis of successful collaboration models. If there is no 'win-win' in such partnerships, then there is little motivation for collaboration to take place.

More specifically, traffic management today falls under the responsibility of road operators who have agreed on traffic management plans and measures aiming at the general public benefit. The latter often includes, but is not limited to, measures promoting low CO_2 emission targets or the prioritization of environmental-friendly transport modes (such as walking or bicycle use over the use of private vehicles). More to that, road operators, on behalf of the public authorities, deliver a service which is paid by tax-payers money and forms part of the general state/city budget. On the other hand, traffic service providers, including the road-network infrastructure industry, the traffic information service providers and the automotive industry, aim at keeping their individual customers satisfied. Profit and customer satisfaction is what gives to the industry competitive advantage in the market. For private traffic information service providers the public benefit ranks lower than individual demand for fast and efficient service.

Creating a shared insight amongst actors in the process of detecting, processing, and distribution of Traffic Information: only this will identify the steps where "improvements" are possible, resulting in more timely sharing of better quality traffic information. In this process a close collaboration between the various partners is essential, to create the improvements at the start of the value chain which will lead to better quality at the end of the chain. Vice versa the identification of feedback loops could be beneficial to signal that some events may already have ended, and traffic flow has already returned to normal.

A first necessary step is to clarify, organise, and harmonise the Safety Relevant Traffic Information value chain across the stakeholders. Starting with mapping the current steps in the process, from the detection of an event until providing the information to service providers and beyond, blind spots and bottle necks can be identified and tackled. When the process is clarified, partners in the value chain can organise themselves with the aim of close collaboration, and aim for the creation of the necessary feedback loops on quality issues and on ensuring the further improvement of the process.

10.2 Harmonised / standardized way-of-working and interfacing

With regards to a harmonised/standardized way-of-working and interfacing, a deeper understanding of all stakeholder's needs along the traffic information value chain is needed so that a supra-national (EU) profile/interface is agreed by all as well as a more international orientation (e.g. using English as reporting language for traffic information, not 24 official languages in the EU) taken in its approach. The focal point being the international user, who, we all recognise, transcends national borders and urban/rural road classes and is hence outside the exclusive reach of any particular traffic information service provider.

The existence of a "babel of technical languages" with regards to working and interfacing along the value chain of traffic information services is well acknowledged within the traffic service providers industry [12]. Protocols on traffic information used within the traffic information value chain, such as TMC and TPEG are both used by TISA service providers, as it provides services according to its clients' demands. Nonetheless, the lack of a set standard on dissemination of traffic information content towards service providers allows for the proliferation of different protocols and interfaces that do not necessarily adhere to the same quality standards (and comparative assessment is not possible when diverse systems are concerned).

Especially for the interface with content providers, TISA recommends international harmonisation: variations and profile differences should be eliminated. An internationally agreed best practice list and a harmonised profile (e.g. for DATEXII content provisioning) will allow easier content coding and compilation by service providers.

10.3 Interaction with external stakeholders

The external stakeholders involved in the traffic information value chain, are not only the data providers, whose sources are used so that TISA service providers can have the 'bigger picture' of what is happening on the road. It is also the non-users, the passengers, the ones calling and reporting incidents directly to the company traffic department. It is also the competing service providers in the market, who work towards bettering their service and it is also the regulators in the market, who wish to make a level playing field, based on quality of services and safety of users. Interaction with stakeholders, external to the close circle of traffic service providers and understanding of their needs will bring awareness and quality of service.

A stronger collaboration with external stakeholders such as road authorities is the first step in order to achieve a better understanding of the types of those events which are critical to live services and formatting and hence a standard to communicate it. This includes feedback of results of Service provider test drive programs and clarification to Content providers of what road data is required from the Service Provider's point of view.

Furthermore, coordination with road authorities on traffic management and traffic management plans is important too. As an example, to increase the credibility of advice on alternate-routes provided by information service providers, TISA recommends that this information is coordinated by the relevant national bodies (e.g. road authorities) so that the advice given to the end-user is consistent, and also consistent with respect to potential other traffic situations in the same area. In that respect the interactive traffic management initiative, set up by the TM 2.0 platform [13] is a promising development.

11 Summary and conclusions

TISA acknowledges that quality is essential for the usefulness and end-user acceptance of travel and traffic information services. Making an effort is not enough – it is crucial to provide reliable traffic information to the end-user since it is a key factor for road safety. TISA strongly recommends taking a comprehensive, harmonized and actively managed approach on quality. Maintaining a consistently high quality of travel and traffic information services requires *precise and specific* quality management practises across the whole value chain, both *internally* within an organisation as well as *externally* between entities along the value chain, including towards content providers and users.

TISA considers that quality management should at least include clear quality targets (key performance indicators, KPIs) and service level agreements (SLAs), well-defined processes and procedures comprising regular quality monitoring and corrective actions, issue management and problem tracking, including stakeholder feedback mechanisms – all being required for achieving a minimum (critical) level of traffic information quality that is now expected and demanded by travellers.

Specifically for real-time traffic information services (traffic flow), quality is a differentiator and competitive advantage. In this realm, the market regulates itself: providers of low quality services are left at a disadvantage and will eventually have to leave the market.

On the other hand are safety-related traffic information services (incidents, accidents unexpected road conditions) a non-competitive realm, where interests of public and private actors intersect: increasing the safety for all road users. The end-user must be able to rely on the provided safety-related traffic information. If quality is guaranteed in that context, services may not only fail to warn of dangers ahead, but can also provoke unsafe traffic behaviour.

TISA strongly recommends collaboration between public and private actors along the value chain – all the way from content detection to service provisioning – for achieving and continuously improving the quality specifically of safety-related traffic information.

To be effective, TISA strongly recommends such a collaboration of Safety related Traffic Information to be arranged on at least a supra-national, or better global, level with an international orientation on harmonization/standardization – individual country-by-country or state-by-state arrangements leave to much room for incompatible approaches. The way forward towards improving the quality of travel and traffic information services points towards standardized protocols and/or profiles; appropriate quality metrics, KPIs; end-to-end quality assessment and assurance methods as well as reliable service level agreements.

Last but not least TISA sees a need in a tighter collaboration between public and commercial entities, in the area of traffic management. In this way information services can be aligned to travellers's expectations vis-à-vis the traffic management plans and policies of public road authorities. Travel and traffic service providers have to adjust their services to these plans and policies with the aim in mind to keep end-users best informed and satisfied.

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