Paper number ITS-TP0054

Quality Requirements related to Congestion Tail Warnings

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Abstract

Many traffic accidents on motorways are caused by rear-end collisions, most of which can be attributed to congestion. It is likely that these collisions are caused by carelessness and misjudgment of the driver. Public and private stakeholders provide solutions for detecting congestion and congestion tails, and for transmitting a congestion (tail) warning to road users. At the moment (at least in Germany), no quality requirements for the detection of and the warning for congestion tails exist. However, quality requirements are being considered necessary to ensure a good quality of services to decrease the number of rear-end collisions in traffic jams. Moreover, quality requirements are desired by public authorities to better assess offers from commercial providers. This paper discusses a project on the development of a requirements catalogue for congestion tail detection data, and a concept for a test field to enable the practical evaluation of the requirements in this catalogue.

Keywords:

Traffic information, Congestion tail, Quality requirements

Introduction

Many traffic accidents on motorways are caused by rear-end collisions, most of which can be attributed to congestion. Since congested conditions on the (German) road network will continue to rise (BMVI, 2014) also the risk of rear-end collisions in traffic jams is expected to increase. Hence, as one measure to prevent such accidents, drivers are informed on congestion ahead, especially on the tail position of the traffic jam, so that they can adapt their behaviour accordingly, when approaching the traffic jam (BASt, 2012).

There are different stakeholders providing solutions for detecting congestion and congestion tails, and for transmitting a congestion (tail) warning to road users. Well-known solutions are based on roadside infrastructure and include for example induction loops for the detection of congestion and Variable Message Signs for the transmission of congestion information to the road users (see Figure 1).

Figure 1 – dWiSta: dynamic sign post with integrated traffic information [THOMAS Verkehrstechnik]

Vehicle-based solutions for the detection of congestion tails, such as Floating Car Data, and for the transmission of congestion tail warnings, such as navigation systems, are considered promising tools that can also create synergies in quality and optimization between the various infrastructure-based and vehicle-based solutions.

In general, today's technologies for the detection of real-time traffic events and the transmission of information regarding such events, such as congestion, differ significantly across European countries. Therefore, the European ITS Platform (EIP) is working on an acceptable solution for minimum quality requirements for real-time traffic information including safety-related traffic information (EIP, 2015). However, quality requirements for congestion tail information are not within the scope of this project.

At the same time, quality requirements for congestion tail information are being considered necessary to ensure a good quality of these real-time traffic information services to decrease the number of rear-end collisions in traffic jams. In addition, such quality requirements are desired by the public authorities to better measure and compare the offers from different commercial providers in future calls for tenders.

This paper discusses a project that has been granted to Rapp by the Federal Highway Research Institute in Germany (BASt). The main objectives of the project are to:

- Create a requirements catalogue for congestion tail detection data
- Develop a concept for a test field to enable the practical evaluation of the requirements in this catalogue

Before providing possible quality criteria and minimum requirements for congestion tail information, more information is given on the research area by discussing the value chain for real-time traffic information and the current and near-future solutions for detecting congestion tails and transmitting congestion tail warnings to road users. Also the changing roles of key actors are discussed, since the

definition of quality (and thus the definition of quality requirements) highly depends on the respective key actor.

Value chain for real-time traffic information

The entire process of detecting congestion tails and gathering congestion tail warnings up to presenting this content to the road user (i.e. the driver of a vehicle) involves many actors. This process can be depicted by the following value chain for Traffic and Travel Information in its most simplified form (see Figure 2).

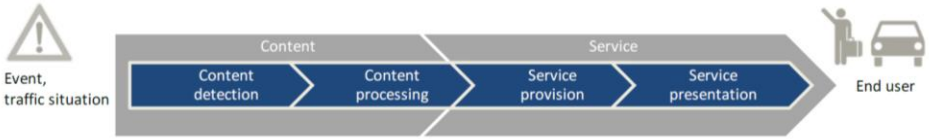

Figure 2 – Terms and Definitions for the Traffic and Travel Information Value Chain (TISA, 2012)

Each step is considered to add a certain value compared to the previous step by processing, aggregation, and refinement of the information. The Content segment comprises the actual observation or measurement of a traffic jam, together with the collection of such information (Content detection), after which all data are refined and prepared (Content processing). The Service segment prepares the content for the transmission to the road user (Service provision), which is then presented on e.g. a VMS or navigation system.

Detection of congestion tails

For the detection of congestion, real-time and accurate information on the traffic situation is required. This information can be based on visual notification (e.g. by the police) and on measured data, which can be detected by infrastructure- or vehicle-based measurement systems.

Infrastructure-based detection technologies include for example:

- Inductive loops
- Detectors (radar, laser, infrared)
- Cameras
- Automatic License Plate Recognition

Vehicle-based detection technologies include for example:

- Floating Car Data (FCD), e.g. GPS, GSM, speed profiles
- Extended Floating Car Data (XFCD): e.g. information from brakes, rain sensors, etc.
- Cooperative Systems (V2X): e.g. via WLAN / ITS-G5

Infrastructure-based detection solutions are mostly public data sources, whereas vehicle-based detection solutions, particularly FCD, are mostly commercial data sources.

Given the spatial-temporal dynamics of congestion, especially vehicle-based detection technologies are suitable to detect respective shockwaves and congestion tails. Through data fusion, for example the integration of infrastructure- and vehicle-based detection data, the accuracy and the reliability of traffic information, such as congestion (tail) warnings, can be improved significantly (see also Figure 3).

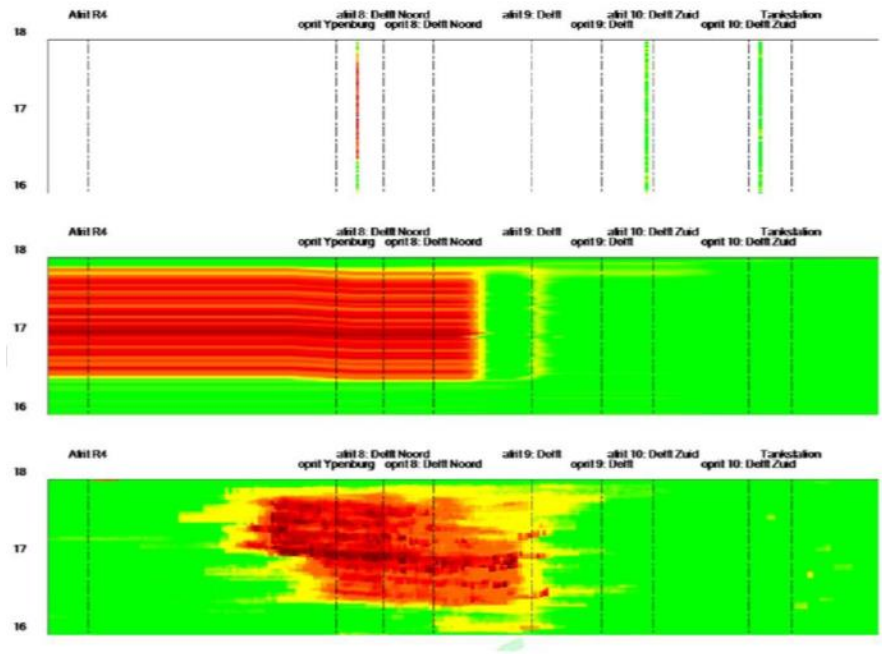

Figure 3 – Congestion data from induction loops (top), data smoothed out between fixed measurement locations (middle), fused data (bottom), by team Be-Mobile (NDW, 2015)

Transmission of congestion tail warnings

The traffic information landscape has changed fundamentally through technical innovations in recent years, and with it also the possible solutions for the transmission of congestion tail warnings to road users (e.g. using LTE, DAB, FCD, V2X). This trend causes a paradigm shift in the way in which road and traffic data are being collected, processed and distributed to the end user.

Congestion tail warnings are provided by service providers. In general, a distinction can be made between public and private (commercial) service providers:

- Public sector service providers: are borne by the public sector and financed by taxpayers' money. The information chain is traditionally based on public data sources. Collection, processing and fusion of traffic data is done by public actors, such as road authorities, road

operators and the police. They are governed by different guidelines.

- Commercial service providers: build and finance their own systems and are not subject to state regulation. These providers use mostly alongside public data sources their own collection systems, e.g. based on FCD. Examples of commercial service providers are:
    - Manufacturers of end user devices (e.g. TomTom, Bosch, Continental, ...)
    - Telecom providers (e.g. T-Systems, Vodafone, ...)
    - Car manufacturers (e.g. Daimler, BMW, Volkswagen, ...)
    - "Service & Content" providers (e.g. INRIX, HERE, Google, ...)

Where the public sector service providers use public system solutions for the transmission of congestion tail warnings, such as VMS and radio, commercial service providers use commercial system solutions, such as smartphone apps and navigation systems (e.g. see Figure 4).

Figure 4 – Data sources and transmission solutions from TomTom Traffic (PC Welt, 2015)

In this project, the focus lies on quality criteria for congestion tail data collected on German motorways on the basis of (X)FCD and coded with a suitable method (e.g. OpenLR), and congestion tail warnings that are provided on-trip via end user devices (e.g. navigation system) using digital radio (DAB+) and/or mobile broadband (e.g. LTE) technologies.

Changing roles of the key actors

Not only the technologies but also the roles in the value chain of traffic information are changing. Many actors are involved in the market for real-time traffic information services, and cooperation, particularly between private and public parties, is important (see also Figure 5).

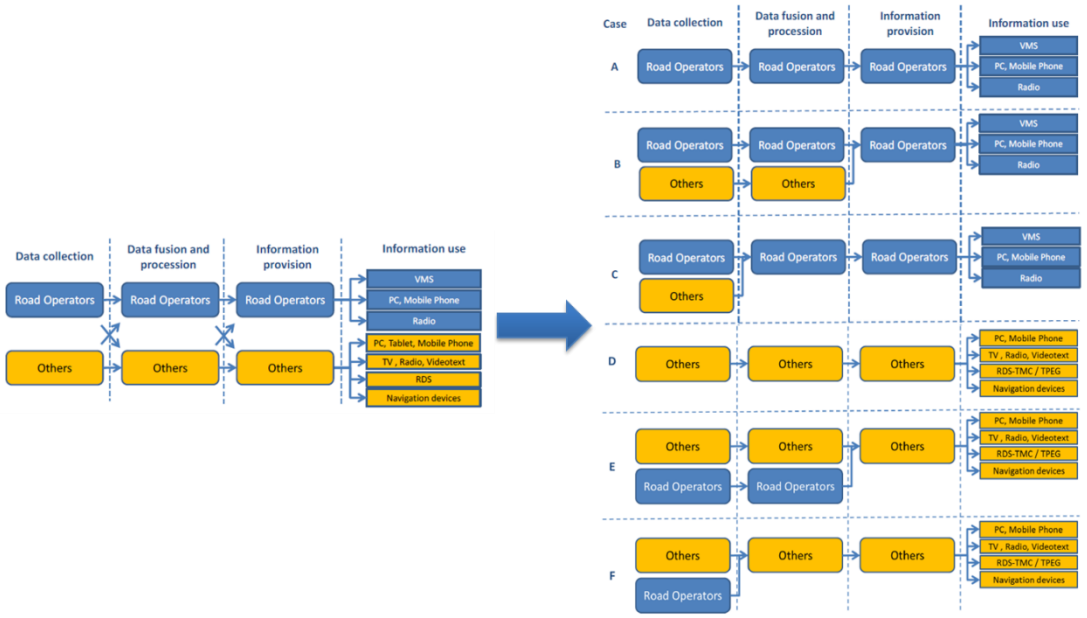

Figure 5 – Historical (left) and current/future (right) organisational structure of traffic condition and travel time information service (EasyWay, 2012)

The result of this project should be used as a basis for decisions by the public sector on how to proceed with data and warnings on congestion tails. However, defining quality requirements only might not raise the quality of the traffic information service, but rather the *implementation* of these requirements. Several scenarios with different business models for the public and the private sector can be distinguished, for example:

- Scenario 0 (current status): There are no generally valid and supplier-neutral quality requirements. Each actor detects congestion tail data and/or transmits congestion tail warnings in their own way.
- Scenario 1: Generally applicable and supplier-neutral quality requirements are defined and should result in a more uniform manner for the detection of congestion tail data and/or the transmission of congestion tail warnings. Otherwise nothing changes, e.g. the public sector continues to use only the public data sources and the public transmission methods.
- Scenario 2: As scenario 1, but with the difference that the public sector also uses data from commercial providers (data fusion) to generate a better quality of their own data and warnings.
- Scenario 3: As scenario 2, but with the difference that the public sector provides a data platform, where "all" congestion (tail) data is being collected and processed (data fusion), so that the "best" quality of congestion tail data is available for all actors.

Quality criteria for congestion tail detection and warning

The overall objective of the project is to improve road safety by reducing the number of rear-end collisions in traffic jams. Various studies indicate that congestion tail warnings can help to prevent such collisions. Congestion tail warnings should warn drivers in case of relatively dangerous

congestion tails, that quickly move backward and require a short and strong braking phase. For an effective congestion tail warning, in particular a reliable localization of the queue tail and a timely transmission of the warning to the driver are indispensable.

From a driver's perspective, congestion tail warnings should be accurate, timely, precise, relevant and non-distracting. These aspects served as input for the derivation of various quality criteria (see Table 1).

Table 1 – Derived quality criteria for congestion tail detection and warning

Aspect from the driver's point of view	Example	Quality criteria	
		Detection	Warning
Accurate	The driver really approaches the tail of a traffic jam.	Hit rate Error rate	Appropriateness
Timely	The driver receives the warning at a suitable distance before reaching the queue tail.	Timeliness	Latency Warning moment Update frequency
Precise	The driver reaches the queue tail where it should be according to the warning.	Positioning accuracy	Warning precision
Relevant	The driver only receives warnings for congestion tails which are located on his own route.		Location relevance
Non-distracting	The driver must be primarily able to drive the vehicle in a complex and dynamic traffic environment.		HMI-based criteria (out of the project's scope)

Within the project, quality criteria for both congestion tail detections (data collection) and congestion tail warnings (service provision) are specified. Since the provision of congestion tail warnings is primarily a matter for commercial service providers, only minimum requirements for congestion tail detection are defined.

Quality requirements for congestion tail detection

Table 2 shows the quality requirements for congestion tail detection, which are, at the moment of writing, under discussion within the Advisory Group of the project. Using the feedback of this group, in which also representatives of commercial service providers participate, it is aimed to define realistic quality criteria and minimum requirements that can be validated in a test field and in the end can make the approach towards dangerous queue ends safer for the driver.

Table 2 – Quality requirements for congestion tail detection data (under discussion)

Criteria	Minimum requirements
Hit rate	The hit rate of the solution must be at least 85%, i.e. the solution must detect with 85% reliability a traffic jam, when there is one.
Error rate	The error rate (false-positive rate) of the solution must be at most 2%, i.e. the solution may not cause more than 2% false detections ("ghosts").
Timeliness (Start and Detection)	The timeliness (start and detection) of the solution must not exceed 3 minutes in 95% of all cases; i.e. the congestion tail data must be provided in 95% of all cases within 3 minutes after the occurrence of congestion (tails) to the service provider.
Timeliness (Update)	The solution must update congestion tail data regularly and at least once per minute; i.e. the updated congestion tail data must be provided to the service provider at least once per minute.
Positioning accuracy	The generated/displayed position of the congestion tail must be in 90% of all cases within a defined deviation of [-750, 1000] m; i.e. the generated/displayed position of the congestion tail must be in 90% of all cases between a maximum of 1.000 m before[1] and 750 m behind the "true" position of the congestion tail.
	The generated/displayed position of the congestion tail must be in 50% of all cases within a defined deviation of [-300, 500] m; i.e. the generated/displayed position of the congestion tail must be in 50% of all cases between a maximum of 500 m before and 300 m behind the "true" position of the congestion tail.

Note that the first two quality requirements, hit rate and error rate, relate to the detection of a traffic jam. These criteria are considered a good starting point, since the correct recognition of congestion is seen as prerequisite for the correct detection of congestion tail data. Still, it must be kept in mind, that not all captured traffic jams will trigger a congestion tail warning.

Since there is no general solution on how to define a traffic jam, let alone the tail of a traffic jam, it is a challenge to determine the "true" or "most plausible" queue tail in order to assess whether the quality requirements are met. This aspect will be discussed in the next part of the project on the development of a concept for a test field on congestion tail detection.

[1] „Before" and „after" as seen from the driver's perspective; i.e. "upstream" and "downstream" of the congestion tail.

Outlook & Acknowledgement

At the moment of writing, the project is about halfway. It will be almost finalised when the ITS European Congress in Glasgow starts. The preliminary outcome of the project will be presented at the congress. The authors would like to thank the members of the Advisory Group, who provided helpful and practical feedback during the project.

References

1. BMVI (2014) Grundkonzeption für den Bundesverkehrswegeplan
2. BASt (2012) Sicherheitswirkungen von Verkehrsinformationen, Heft F 84
3. EIP (2015) Framework Guidelines for Data and Service Quality Requirements, EIP Sub-Activity 3.2 Data and Service Quality Requirements for (Real-Time) Traffic Information incl. Road Safety Related Traffic Information
4. TISA (2012) Terms and Definitions for the Traffic and Travel Information Value Chain
5. NDW (2015) The NDW data fusion project: pilot description and results. In Proceedings *22nd ITS World Congress*, Bordeaux
6. PC Welt (2015) Diese Verkehrslage-Dienste gibt es für Autofahrer (Update): http://www.pcwelt.de/ratgeber/Stau-Warnung-Google-Maps-Tomtom-Verkehrslage-Echtzeitverkehrsinformationen-373385.html (consulted: December 2015)
7. EasyWay (2012) Traveller Information Services, Traffic Condition and Travel Time Information, Deployment Guideline (TIS-DG03-05)