Analysis of options for the creation of safety-related traffic information based on vehicle-generated data

Berichte der
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Fahrzeugtechnik Heft F 146

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Abstract – Kurzfassung

Analysis of options for the creation of safety-related traffic information based on vehicle-generated data

This report documents the concept, evaluation and results of the evaluation project aimed at identifying promising approaches to process vehicle-generated safety relevant traffic data. In particular, an interview-based approach was chosen to gain expert insights from the members of the “EU Data Task Force - Data for Road Safety” project as well as from German stakeholders.

The first phase of the research project aimed at developing solution options for the processing of vehicle-generated data – starting at the access of vehicle data at OEM backends and ending with the provision of traffic information to service providers – for Germany, based on insights from DTF members. Additionally, in order to evaluate different solution options for the processing chain, relevant evaluation criteria were identified via input from road authorities, “Landesmeldestellen” and broadcasting services.

In the evaluation phase of the project, solution options were scored in detail along the extensive list of evaluation criteria, considering utility, technology, organisation and cost aspects . To consider different strategic positions, four scenarios, spanning the dimensions investment and time-to-implementation, were defined. Each scenario influences the overall scoring through individualised weights effectively assigned to each criterion. In addition to the evaluation of merits, potential risks were identified and quantified in terms of impact and probability for the different solution options.

Finally, the total scores of the solution options were compared and weighed against their potential risks to identify high-scoring and thus promising solution options. The highest rated solutions were analysed in detail regarding their strengths and weaknesses in each scenario and put into the context of strategic decisions.

Analyse von Optionen für die Herstellung von sicherheitsrelevanten Verkehrsinformationen basierend auf fahrzeuggenerierten Daten

Dieser Bericht dokumentiert die Konzeption und Vorgehensweise zur Evaluierung sowie die Evaluierungsergebnisse unterschiedlicher Vorgehensweisen für die Herstellung von sicherheitsrelevanten Verkehrsinformationen basierend auf fahrzeuggenerierten Daten. Hierfür wurde ein Interview-basierter Ansatz gewählt, um Expertenmeinungen der Mitglieder des „EU Data Task Force - Data for Road Safety“ Projekts sowie deutscher Stakeholder aus dem Umfeld des Verkehrswarndienstes und der Straßenbetreiber zu erhalten.

Im Rahmen der Konzeptionsphase wurden verschiedene Vorgehensweisen für die Herstellung von sicherheitsrelevanten Verkehrsinformationen – angefangen bei der Anbindung von Fahrzeugdaten am OEM-Backend, bis hin zur Verfügbarmachung von Verkehrsmeldungen an Stakeholder – auf Basis der Gespräche mit DTF-Mitgliedern entwickelt. Damit die verschiedenen Vorgehensweisen evaluiert werden konnten, wurden Bewertungskriterien anhand der Anforderung von Straßenbetreibern, Landesmeldestellen und dem Rundfunk festgelegt.

In der Evaluierungsphase erfolgte die detaillierte Bewertung der verschiedenen Vorgehensweisen entlang der umfangreichen Liste an Bewertungskriterien aus den vier Hauptaspekten Nutzen, Technologie, Organisation und Kosten. Um verschiedene strategische Positionierungen zu berücksichtigen, wurden vier Szenarien erstellt, die die Dimensionen Investment und Umsetzungshorizont abdecken. Die Szenarien beeinflussen die Gesamtbewertung durch individualisierte Gewichte auf jedem Bewertungskriterium. Zusätzlich zur Bewertung der Vorzüge wurden außerdem potenzielle Risiken identifiziert und hinsichtlich Schweregrad und Eintrittswahrscheinlichkeit für die verschiedenen Vorgehensweisen quantifiziert.

Abschließend wurden die Gesamtbewertungen der Vorgehensweisen verglichen und den verbundenen Risiken gegenübergestellt, um herausragende Lösungen zu identifizieren. Die besten Lösungen wurden im Detail hinsichtlich ihrer Stärken und Schwächen in jedem Szenario analysiert und in den Kontext der strategischen Entscheidung gesetzt.

Contents

The evaluation tool for the report is available in the electronic BASt archive ELBA at https://bast.opus.hbz-nrw.de.

Das Evaluationstool zum Bericht ist im elektronischen BASt-Archiv ELBA unter https://bast.opus.hbz-nrw.de abrufbar.

Definitions

Evaluation-related definitions

Evaluation category:

Clusters multiple, related evaluation criteria.

Evaluation concept:

Result of phase 1 that provides a methodology to score different solution options with regards to the evaluation criteria.

Evaluation criterion:

Specific aspect applied for evaluating the different solution options.

Evaluation perspective:

Related evaluation categories are grouped into evaluation perspectives.

Evaluation tool:

Excel-based implementation of the scoring matrix. Contains the scores, weights and graphs of all solution options with regards to their evaluation criteria, risks and scenarios.

Input provider:

National or international, public or commercial entity that has been involved in the processing of vehicle data and was therefore interviewed to share their knowledge and vision as part of this evaluation.

Recommended action:

Final result of the evaluation project that will conclude the findings. This will include a recommended solution option and the recommended next steps for Germany.

Risk factors:

Risk factors assess the impact and likelihood of a possible future event on the solution options. Risk points are evaluated separately from the evaluation scores and are determined for each solution option.

Risk points:

The aggregated risk, determined through impact and probability of each risk factor, for a solution option.

Scenario:

Depending on the overall data strategy Germany chooses regarding SRTI, various scenarios with different prioritisations and framework conditions have to be considered. Scenarios change the weighting of evaluation criteria and thereby the resulting aggregated scores.

Score:

Rating of a solution option with regards to one evaluation criterion.

Score Card/Weights:

Weights assigned to the evaluation criteria in order to build a ranking of solution options.

Solution option:

Possible data processing architecture that is evaluated in the project.

Stakeholder:

Public entity that is directly involved in the provision of SRTI in Germany or Luxemburg and was therefore interviewed to share solution requirements as part of this evaluation.

Data Task Force related definitions[1]

Data (L2):

The raw data that can be used for creating road safety related minimum universal traffic information. This data is collected via any private and/or public source, also referred to as “road safety related traffic data” (as defined in article 2-m of Regulation 886), also referred to as “Level 2 Data”.

Data (L2’):

Data (L2’) is an enriched version of Data (L2) created by cross referencing the Data (L2) across multiple L2 data sources and/or through data harmonisation and cleansing of the Data (L2), also referred to as “Level 2 Prime Data”.

Data (L3):

Any extracted, aggregated and processed road safety related traffic information, offered by public and/or private road operators and/or service providers to End Users through any delivery channels, also referred to as “L3 Information” or “Road Safety Related Minimum Universal Traffic Information” or “SRTI” (as defined in article 2-n of Regulation 886.

SRTI:

The EU delegated regulation 886/2013 specifies eight safety related traffic information (SRTI) categories:

a) Temporary slippery road;

b) animal, people, obstacles, debris on the road;

[1] The official definitions for L2, L2’ and L3 data are still to be discussed and finalised in the Data Task Force Tech Group (DTF 2020a).

c) unprotected accident area;

d) short-term road works;

e) reduced visibility;

f) wrong-way driver;

g) unmanaged blockage of a road;

h) exceptional weather conditions.

1 Introduction

In 2010, the EU published Directive 2010/40/EU (EU 2010) on the framework for the deployment of Intelligent Transport Systems (ITS), aiming to set standards for provision and exchange of multimodal travel information services (MMTIS), real-time traffic information (RTTI), safety-related traffic information (SRTI) and safe and secure truck parking areas (SSTPA). This data needs to be provided to the public via dedicated national access points (NAPs) that are organised by the respective EU member states.

The EU Delegated Regulation No 886/2013 (EU 2013) defines the goal and specifics of providing SRTI to road users. The SRTI event types are summarised into eight categories:

a) temporary slippery road

b) animal, people, obstacles, debris on the road

c) unprotected accident area

d) short-term road works

e) reduced visibility

f) wrong-way driver

g) unmanaged blockage of a road

h) exceptional weather conditions

EU road authorities, vehicle manufacturers and commercial providers established the Data Task Force - Data for Road Safety (DTF) in 2017 with the purpose of improving data sharing of SRTI in the EU, especially between the automotive industry and the road authorities. Vehicle manufacturers (OEMs) are providing certain safety-related event messages from their fleets that can be aggregated into an anonymized traffic information feed. A twelve months proof of concept (PoC) was started on June 3, 2019 (DTF 2019). During the PoC phase, member states are aiming to explore the development of first use cases, data format standards and technological architectures while promoting the endeavour to stakeholders, new partners and the public. In the vision, SRTI can be accessed by service providers via the NAP and end users will receive the information via their on-board systems, broadcasting channels or other third party providers.

1.1 Aim of this project

For the duration of the PoC test phase, the DTF members Luxemburg and Germany, represented by the Luxemburg Ministry of the Economy (MECO LU) and the German Federal Ministry of Transport and Digital Infrastructure (BMVI), joined forces with the goal of starting off with creating a cooperative solution for receiving and processing vehicle data.

In this context, Luxemburg has taken the lead of the technical integration, system development and the processing of the different data sources, including setting up an IT infrastructure within the PoC. Complementing, Germany is evaluating possible solution options for setting up the data processing infrastructure from a strategic perspective. The latter is the aim of this research project which is to be concluded by the original end of the DTF PoC phase[2].

The stakeholder group of this project, apart from BASt and MECO LU, consists of the Luxembourgish Ministry of Mobility and Public Works and the German road authorities (Straßen.NRW, ZVM Bayern), the “Landesmeldestellen” (Polizei NRW, Polizei Bayern, Polizei Hamburg) and public broadcasting services (HR and WDR). These public institutions are representatives of the main public recipients, producers and broadcasters of safety-related traffic information in Germany. In the future, they are expected to be key users of vehicle-generated SRTI.

The goal of this project was to evaluate different solution options and to recommend the best long-term solution for Germany and its stakeholders regarding the processing of vehicle-generated data

2 The original end of the PoC phase was deter-mined to be June 2nd, 2020. The members of the DTF agreed to prolong the duration of the PoC until the end of October 2020.

in order to produce near-time and high quality SRTI. In this regard, the project will define and evaluate different solution options in terms of cooperation of two EU member states, EU-wide developments, use of a commercial product (buy case) or the assignment of the development of a German-specific solution (make case). In addition, combinations will be considered along the different roles in the data processing chain.

1.2 Structure of the project

The project was executed over a period of approximately three months from March 2020 to June 2020.

In the beginning, the framework for the evaluation was created. Using an interview-based approach, national stakeholders as well as international input providers were interviewed in order to understand both the requirements (stakeholders) and national visions (input providers) for a data processing solution. Input from the former was especially leveraged to formulate evaluation criteria along the four perspectives of utility, technology organisation and cost, while the latter supported the definition of solution options. In total, ten solution options are developed, additionally considering role synergies as well as strategic focusses. Due to similarities in design, they are clustered into four groups: Service Creation, Data Access, Outsourcing and Full Value Chain.

For the evaluation of the solution options and their inherent risk, a bottom-up approach with a subsequent top-down validation was applied. As a framework, an Excel-based evaluation tool was built. Within the tool, the evaluation is executed by analysing each solution option against all evaluation criteria and filling the evaluation matrix. Based on this, total solution scores are calculated by additionally weighting the evaluation criteria based on strategic scenarios for Germany. In parallel, various risks were identified and quantified, in terms of impact and probability, within a risk matrix. Most of the risk factors address the future feasibility of the solution options.

In the final part of the project, the top scoring solution options were selected and compared, their strengths and weaknesses were analysed and recommendations for actions for Germany were formulated. These strategic recommendations, together with further detailed conclusions, are outlined in a separate document.

1.3 Aim and structure of this document

This document summarises the evaluation concept, the evaluation and the results.

Chapter 2 describes the evaluation concept, its fundamentals and the tool-based evaluation. Different solution options developed in a structured Greenfield approach – without building on existing ideas – in Chapter 3 and the defined evaluation criteria that were derived from several interviews with stakeholders and input providers are stated in Chapter 4.

The precise approach for filling the evaluation matrix and deriving aggregated scores for each solution option is found in Chapter 5. In detail, the key evaluation aspects per criterion can be found in Chapter 5.1. Strategic scenarios and the weighting of the evaluation criteria is given in Chapter 5.2. The sensitivity analysis of the evaluation factors is given in Chapter 5.3, Furthermore, Chapter 5.4 defines the analysed risk factors that might have an impact on the future feasibility of a solution option and the final validation steps are described in Chapter 5.5.

The first results of the evaluation are stated in Chapter 6.1, whereas Chapter 6.2 compares the strengths and weaknesses of each top solution. Selected solution options are compared and strategically positioned in Chapter 6.3 and Chapter 6.4.

Concluding, Chapter 7 addresses some remarks on the interpretation of the evaluation, limitations of the evaluation and on the transferability of the results to another EU member state.

In addition, the appendix gives an overview of all interviews, a detailed view on the evaluation criteria and the used references.

In addition to the written report, the developed excel-based evaluation tool is a key component of the evaluation project. It includes all of the details of the evaluation as well as the evaluation results and supports the results shown in this document.

1.4 Limitations and dependencies

The project start in the mid of March was dependent on the duration of the PoC phase of the DTF. The Memorandum of Understanding signed in summer 2019 was originally set to expire on June 2, 2020 and any results from this evaluation were expected to have been derived before that point in time. The continuation of the DTF partnership and extension of the PoC phase until October 2020 was agreed upon towards the end of this project in May. Therefore, it did not influence the timeline of this project.

During the discussions of the DTF Tech Group meetings, several OEMs and commercial providers had outlined and promised the availability of their vehicle data streams to the group. At the start of this project, only one OEM was connected to the Luxembourg server and had started streaming a limited amount of L2 events. Originally, this project had intended to include the evaluation of data sources and their data quality in order to analyse their potential for road safety. Due to the limited availability of data sources, the focus of the project was changed to a conceptual, strategic evaluation. Over the course of the project, additional OEMs and commercial providers started publishing data into the DTF ecosystem. Although the additional information was considered in the evaluation, the overall approach of the project remained strategic in nature.

The start of the project also coincided with the limitations of movement by the European governments as a reaction to the COVID-19 pandemic. As a result, the project was executed fully remote and all contacts and discussions with the Federal Highway Research Institute (BASt) and within the DTF Tech Group as well as with stakeholders and input providers had to be organised as online video and phone conferences.

2 Methodological approach of the evaluation

In order to develop recommendations for action for the contracting entity BASt, a methodology was defined that focuses on an interview-based approach and applies a dedicated evaluation tool for the analysis.

First, in order to understand the current developments for processing vehicle-generated data in the context of SRTI as well as the expectation of B2C providers towards the new data source, interviews were held with relevant stakeholders and input providers. Based on their views and opinions, adequate solution options as well as a catalogue of requirements was developed.

Second, the findings of the interview-based approach were inserted into an evaluation-tool, with dedicated segments for the evaluation scoring, a scenario analysis, as well as a risk analysis.

Finally, the results of the analysis were consolidated and visualised in order to identify high-scoring solution options within respective scenarios as well as their risk. All together, the results led to the derived recommendations for action.

The evaluation will not consider the analysis, validation or comparison of vehicle data sources and generated L3 SRTI data, respectively. This data was only scarcely available during the project duration. Nevertheless, some data observations and documentation on the data processing has been used to gain sampling insights into the data basis.

2.1 Interview-based approach

In the conceptual design phase of the project, the interviewed parties were divided into two groups. The first group, called the stakeholders, consisted of German entities expected to have an interest in the new SRTI data feed and its integration into running systems and processes in Germany. The second group, called the input providers, consisted of players from the Data Task Force Data for Road Safety PoC (member states and commercial providers). These players were consulted for insights into their decisions regarding the design, implementation and vision for processing OEM-data.

For the more extensive stakeholder interviews, a road map of topics and questions was prepared to guide through the interviews (2-3 hours). In this context, the interviewers could learn from the stakeholders about requirements and framework conditions that are needed to be considered when comparing and evaluating solution options.

Input provider interviews were comparatively shorter (30-60 minutes) and focused more on the visions and insights of the experienced players. As key aspect, these interviews provided a better understanding of possible solution options, as well as respective strategic motivations and challenges.

All interviews were documented in meeting minutes and any additional remarks or clarifications by the interview partners were included in the final scripture.

2.2 Fundamentals of the evaluation

Based on the insights generated in the stakeholder and input provider interviews, the solution options, evaluation criteria as well as risk factors were identified. In the evaluation, the solution options and risk factors were scored according to the previously obtained insights.

Therein, the evaluation considers the following fundamentals:

- The evaluation is comparable:
  All solution options are held to the same standard and graded on the same scoring scale.
- The evaluation is transparent:
  All considerations in the decision process are disclosed in detail.
- The evaluation is comprehensible:
  All results are thoroughly justified and explained.
- The evaluation is documented:
  All conversations and discussions that went into the evaluation are well documented in a standardised format.

Ultimately, the collected information, the evaluation criteria and the developed solution options are transferrable and can be considered and used by other member states as well.

2.3 Tool-based evaluation

As a framework for the evaluation, an evaluation matrix tool is implemented and used for the scoring, scenario analysis and results analysis. The matrix contrasts different solution options with relevant evaluation criteria, as shown in Figure 1. The solution options (Chapter 3), based on insights generated in the input provider interviews, are found in the columns of the matrix, while the evaluation categories and more specific evaluation criteria (Chapter 4), displaying the key requirements regarding the solutions, make up the rows of the matrix.

In the evaluation, each solution option will be scored with regards to each evaluation criterion in the corresponding table field. The scoring for each evaluation criterion will be done on a scale from 0 to 3, with each grading step having predefined requirements. The specific scoring definitions can be found in the evaluation matrix of the evaluation tool as well as in Appendix B.

To account for different potential market strategies, a scenario analysis functionality is included in the evaluation tool. This allows considering a prioritisation among the evaluation categories and their criteria by applying dedicated weight factors. In each scenario, a limited number of weight points are distributed distinctly among the categories and relative distributions within evaluation categories are applied to the criteria. Ultimately, different strategic scenarios can be analysed by having different sets of weights depending on the priority focus within the scenario.

In addition, a risks analysis is included as well. Risks related to the evaluation criteria are identified as risk factors and then scored according to their

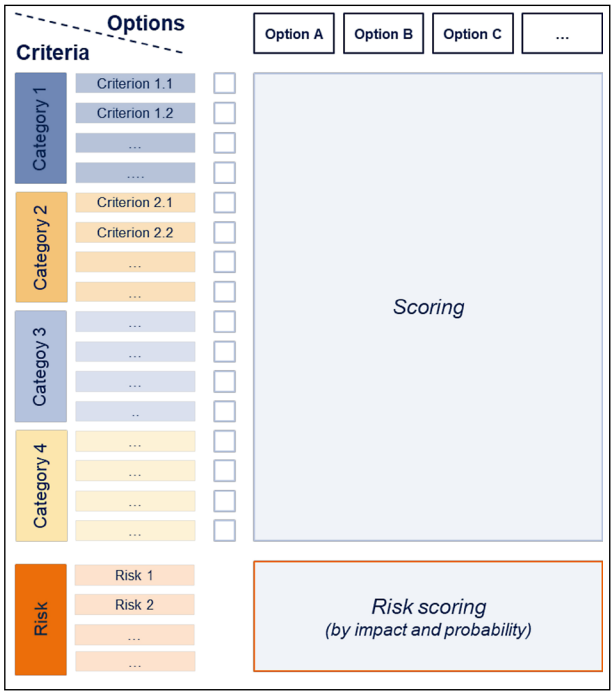


Fig. 1: Schematic build of the evaluation matrix.

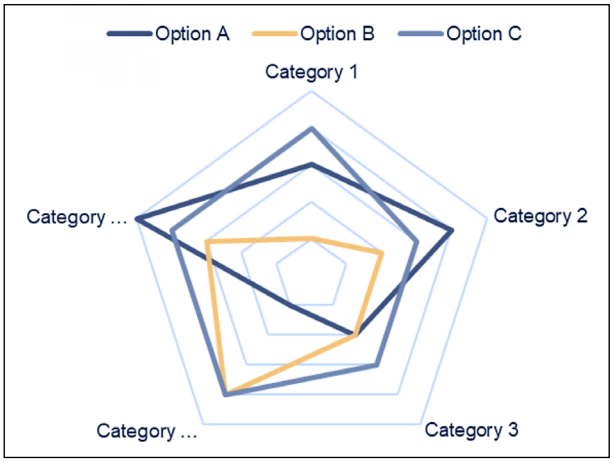


Fig. 2: Schematic preview of the spider chart.

impact and probability of occurrence for each solution option. In addition to the evaluation score, the risk points flow into the overall evaluation of the solutions options.

2.4 Visualisation of the evaluation of the solution options

Through the evaluation and scoring, a quantifiable side-by-side comparison of all solution options in different scenarios was enabled. The scoring and respective comparison was visualised using spider (or radar) and bar charts which plot all category scores of the solution options against each other (cf. Figure 2). In this schema, evaluation categories are clustered to compare strengths and weaknesses of solution options in thematic areas. Additionally, a dedicated comparison of the top scoring solution options was developed.

3 Solution options to process vehicle-generated data in order to produce safety-related traffic information

The generation of safety-related traffic information (SRTI) follows several steps of data aggregation and processing to extract critical warning messages from vehicle-generated data. In this process, different players can be involved, including OEMs, commercial providers and EU member states which results in different possible solution options for an EU member state to set up the value chain required to make SRTI available. In order to evaluate a recommendation for action, a basic selection of solution options to be evaluated has to be determined. Within this chapter, the motivation for different option groups is derived. Furthermore, unique solution options per group are defined. The evaluation of the solution options as per the evaluation criteria listed in Chapter 4 is described in Chapter 5.

3.1 Introduction to the roles along the data processing chain

Starting at the OEM, the data processing along the value chain is comprised of the following roles (cf. Figure 3):

- The “L2 Data Access Interface Provider” provides access to L2 data. This data is pre-processed by the OEM and usually no longer contains raw sensor data. Examples for events or values delivered are ABS, windshield wiper, breakdown calls or temperature. The access to the data is provided by the OEMs themselves or a delegated entity.
- The “L2 to L2’ Aggregator” processes L2 data from various sources. This includes (to some degree) the cleansing and harmonisation of the data. The OEM allocation available in L2 data is typically not removed at this processing step.
- The “L2’ Data Access Interface Provider” provides access to the processed L2 data (as described in the previous role). Therein, the access to the data of the various sources is made accessible in a consistent manner.
- The “Service Creator” processes L2 or L2’ vehicle data in order to create L3 data. The L3 data no longer contains vehicle or OEM specifics but rather specifies an event within the SRTI categorisation. In addition, further non-vehicle data sources can be used or fused with the data in order to enhance the resulting information. For example, multiple traction control triggers together with temperature data acquired from a weather provider could lead to a “temporary slippery road due to ice on road” event.
- The “L3 Data Access Interface Provider” makes SRTI events available as L3 data. This data can then be accessed by e. g. regional B2C providers such as road authorities, traffic management and others.

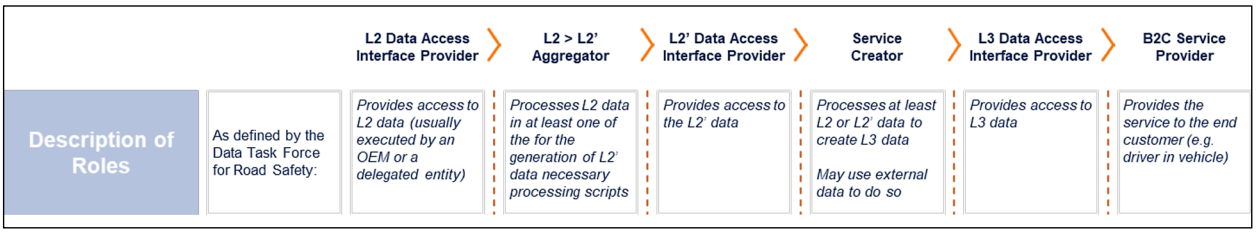


Fig. 3: Description of roles as understood by the Data Task Force Data for Road Safety PoC.

- The "B2C Service Provider" makes the SRTI data available for the end user, e. g. via dashboards, apps, broadcasts, traffic control systems and more.

3.2 Overview of approaches of other member states and commercial providers

As the focus of the project, the evaluation of different solution options will lead to an action recommendation for Germany on how to enable each role along the value chain to make SRTI data accessible in Germany. The realm of solution options to be evaluated within this project is especially motivated by field reports and insights of other EU member states as well as commercial providers that have stated different approaches and plans for processing data within the DTF Role Matrix (DTF 2020d) and on the MDM platform (MDM 2020). In dedicated meetings, representatives from institutions of different countries and companies were interviewed:

- Luxembourg – Ministry of Economy: In the current context of the DTF, Luxembourg and Germany have agreed to cooperate in the processing of vehicle-generated data and creation of SRTI events. In this setup, the implementation of aggregation and creation services is currently done by Luxembourg. During the PoC phase, the developments are directed by the Ministry of Economy as part of the data-driven innovation strategy with the goal of understanding the full value chain, from first data insights to intelligent service creation. Regarding the latter, it is especially of interest to implement advanced SRTI use cases or even to utilise AI-methods. After the PoC phase, the responsibility for implementation into operation will be handed over to the Ministry of Mobility and Public Works.
- Luxembourg – Ministry of Mobility and Public Works: In addition to the meeting with a representative of the Ministry of Economy, an interview was conducted with a representative of the Ministry of Mobility and Public Works, who will take over the operation of SRTI broadcasting after the end of the PoC. Currently, it is planned to continue the development of the prototype for processing OEM data intelligently. Still, no final decision has been made regarding a roadmap to operationalise the prototype. The long-term availability of dedicated resources is a significant challenge so that cooperations with other countries will continue to be considered.
- Luxembourg – PoC Implementation: In a separate meeting, Luxembourg's specialists from the two contracted IT providers gave insights into the applied IT stack, the implemented data model as well as the vision of an AI based service creation solution to make SRTI messages available to stakeholders in Datex II format.
- Austria: In Austria, the publicly owned corporation Autobahn and highway financing stock corporation (ASFiNAG) is responsible for providing SRTI on the major road network. ASFiNAG is providing their L2/L2' infrastructure data to the DTF in a parallel branch to an up and running C-ITS data feed. Currently, the Austrian approach does not envision processing OEM data for SRTI but rather to obtain fused and aggregated L3 data from a service creator active in the DTF. Such an enhanced SRTI stream would be integrated into the existing traffic management center. Consequently, Austria could envision an EU-wide approach for processing OEM data and making resulting SRTI available.
- Finland: In Finland, the government-owned company TrafiCom is responsible for providing traffic warnings. As part of the NordicWay project, TrafiCom is involved in connecting and sharing traffic data among the Scandinavian countries. SRTI is seen as a part of the larger vision to gather and provide large amounts of open data in a shared ecosystem for public and private use cases.

- HERE: HERE is one of the two private companies with a focus on location and traffic data currently active as commercial provider in the DTF. As a provider of global such data via a dedicated platform, HERE would be able to fulfil all of the above roles. The strategic focus of the company lies at the beginning of the value chain, connecting all OEMs and making the data available in a harmonised, consistent manner. While HERE can also enable third parties to implement service creation within dedicated workspaces on the HERE platform, it is not yet clear whether the company will develop L3 data internally.
- Netherlands: In the Netherlands, the Ministry of Infrastructure and Water Management is responsible for making SRTI data available. Utilising the capabilities of the National Data Warehouse, the Dutch approach aims to integrate OEMs directly or via their delegated proxy services to gain access to L2 data and then to implement all data processing steps along the value chain, including the B2C service provision, to provide simple SRTI events. Dedicated and intelligent services requested by road authorities, traffic management or others are to be implemented separately and financed by the LVMB (National Traffic Management Council).
- Spain: In Spain, the Directorate-General for Traffic (DGT) is responsible for providing SRTI. Currently, the DGT already has a data platform (DGT 3.0) in place. The platform integrates various data sources such as road detectors, traffic lights and others and provides incident- and traffic-related messages to road users and other stakeholders. The vision for vehicle-generated data targets the integration of L2' data which is, for example, provided by HERE, into the platform. The data will be used to validate and improve existing SRTI use cases, especially on main roads and extend the service of L3 messages for secondary roads which are currently not included in the data coverage.
- TomTom: TomTom is, besides HERE, the second private company focussed on traffic and location data currently involved as commercial provider in the DTF. In general, the services of TomTom focus on the areas of road traffic, HD maps and safety information. As a service creator in the DTF, TomTom creates L3 information at the end of the data processing value chain. To make such SRTI information available, TomTom aims to provide a L3 data feed back into the DTF-ecosystem as well as make the data available to road users in a bundle with existing commercial products.

A chronological list of all interview partners is also found in Appendix A.

3.3 Analysing synergies and strategic focusses for solution option development

The possible solution options were derived out of the insights gained during the interviews but also from complementary analysis. In summary, three main focal points were identified for the definition of adequate solution options (cf. Figure 4).

Role synergies: The roles within the value chain offer the potential for synergies when taking on more than one position. First, the aggregation or service creation is always closely tied to the subsequent access provision role. As a L2 to L2' Aggregator, the data also has to be made available as a L2' Data Access Provider and in analogy, a Service Creator has to make the developed SRTI events available as L3 Data Access Provider. Secondly, synergies can be gained in data access provision across all levels acting as all L2 Data Access Provider, L2' Data Access Provider and L3 Data Access Provider.

Strategic focus: The value chain includes two different strategic aspects. First, having direct access to new data sources and secondly, building up the expertise required to harmonise data and implement SRTI use cases within the service creation. Depending on the strategy of the EU member state, both aspects, only one aspect or no aspect is important.

Suitable players: Focusing on the OEMs, commercial providers and member states currently involved in the DTF, as well as their strategy for SRTI, it becomes clear that not all players are equally suited for each role. For example, most OEMs only intend to provide raw L2 data and no further services. On the other hand, specialised service providers exist to provide platforms for general data access or service creation.

3.4 Solution options to be considered in the evaluation

In the following, four different option groups are defined. Each option group has a specific strategic focus for Germany within the roles and possibly makes use of complementing cooperations or outsourcing to fill any missing roles. This results in two to three unique solution options for role distributions within each option group. In all presented solution options for Germany, the B2C service provision is done by broadcasting agencies, traffic authorities, Landesmeldestelle or other B2C service providers. Together, these unique options then form the set of solution options to be evaluated for Germany.

Focus on Service Creation roles

The Service Creation options focus on developing intelligence within the Service Creator role. In this setup, this service is valued higher than direct L2 data access and L2' harmonisation. Instead, the required L2' data and is accessed via another EU member state or commercial provider (cf. Figure 5).

- Service Creation – Cooperation: In a cooperation setting, Germany relies on another EU member state who takes on the roles as L2 to L2' Aggregator and L2' Data Access Interface Provider.
- Service Creation – EU Solution: In a second option, an EU-wide L2' aggregation solution can be strived for. The first steps of the processing chain would be centralised, while the service creation would occur decentralised in each country.
- Service Creation – Commercial Provider: In analogy, the commercial provider solution option sees a private player in the roles of creating and providing L2' data for Germany.

In all three solution options, the Service Creation and L3 Data Access Interface Provider will be developed and operated by Germany.

Focus on Data Access roles

The Data Access options focus on the first steps of the value chain, especially having direct access to

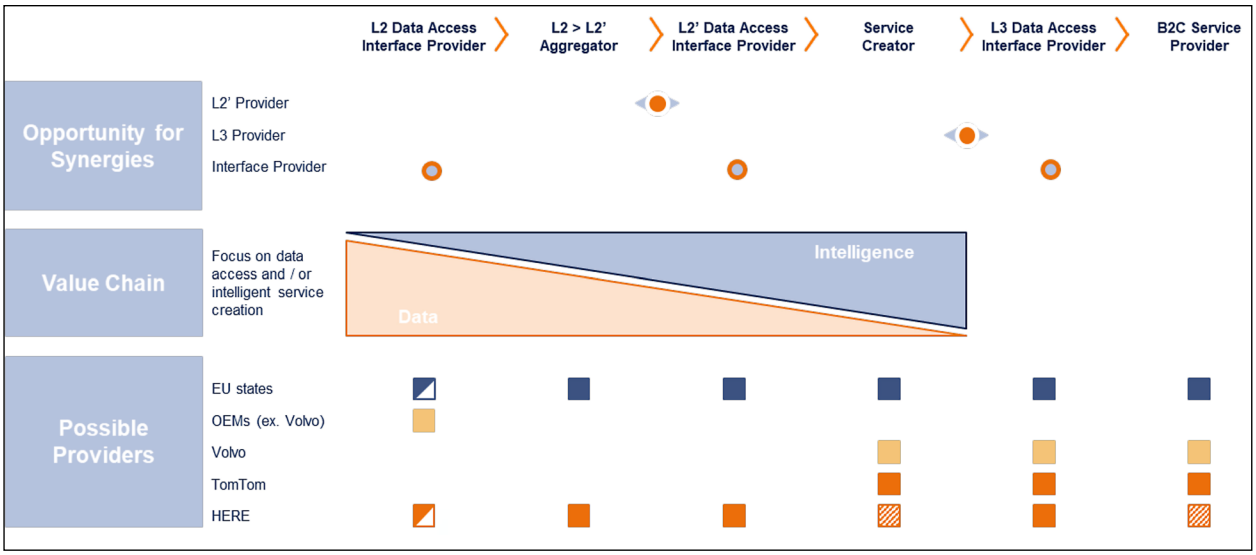


Fig. 4: Opportunities for synergies, the focus on data and/or intelligence, as well as the coverage of providers were three aspects helpful in deriving solution options for Germany.

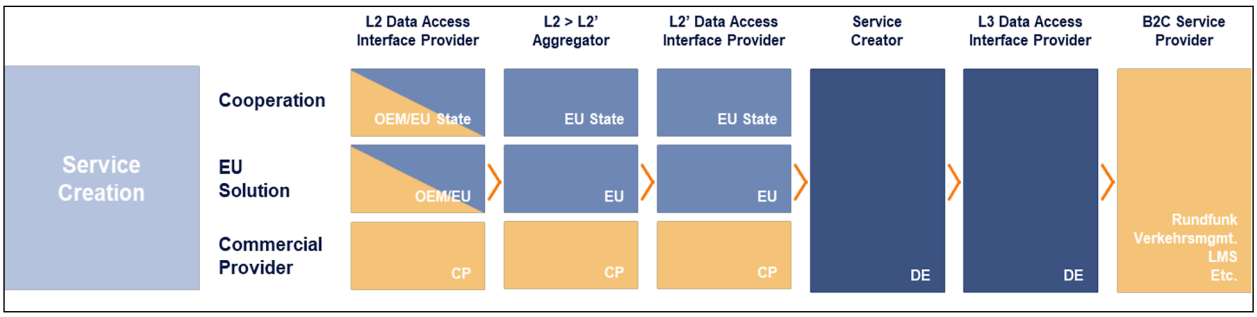


Fig. 5: Within the "Service Creation" options, Germany solely focusses on creating and providing intelligent L3 SRTI.

OEM L2 data and owning the harmonisation to L2' data. The intelligence within the service creation is outsourced to a cooperating EU member state or commercial provider who provides L3 data back to Germany (cf. Figure 6).

- Data Access – Cooperation: In a cooperation setting, Germany relies on another EU member state to provide (intelligent) L3 SRTI messages.
- Data Access – Commercial Provider: As alternative, intelligent L3 SRTI based on Germany's L2' data can be provided by a commercial player.

In both solution options, the L2 to L2' Aggregation and the L2' Data Access Interface will be developed and operated by Germany.

Focus on Outsourcing

The Outsourcing options outsource all data access and data processing responsibility from Germany up to providing L3 data access for the B2C service providers. This option set includes the LU-DE Cooperation model which is the current approach taken by Germany within the Data Task Force Data for Road Safety PoC (cf. Figure 7).

- Outsourcing – LU-DE Cooperation: Within the LU-DE Cooperation, Luxembourg builds up the technical infrastructure to access and process vehicle data. This includes all steps from OEM data access to the development of intelligent L3 data creation.
- Outsourcing – EU Solution: The EU Solution envisions a centralised creation of SRTI from vehicle-generated data for all EU member states.
- Outsourcing – Commercial Provider: The third solution option considers outsourcing all roles in the value chain to a commercial provider.

In all three Outsourcing solution options, Germany does not develop any data processing role. Germany is only responsible for enabling access to the L3 data within the role as NAP.

Focus on the Full Value Chain

The Full Value Chain options see Germany in all roles along the value chain, up to the B2C Service Provider. Depending on the extent of intelligence and additional data sources considered in the creation of L3 data this can be achieved via a slim or advanced solution (cf. Figure 8).

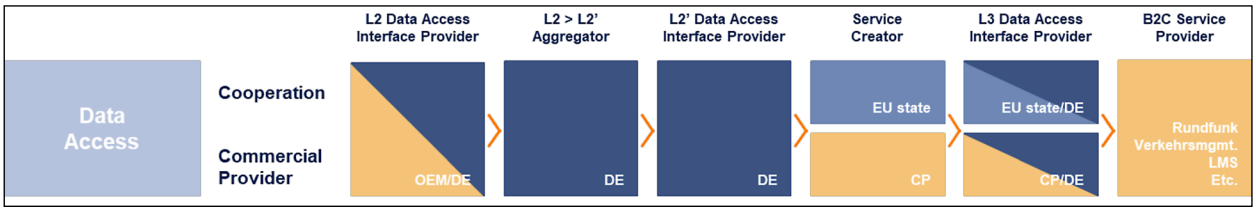


Fig. 6: The Data Access options value direct access to OEM data and outsource service creation.

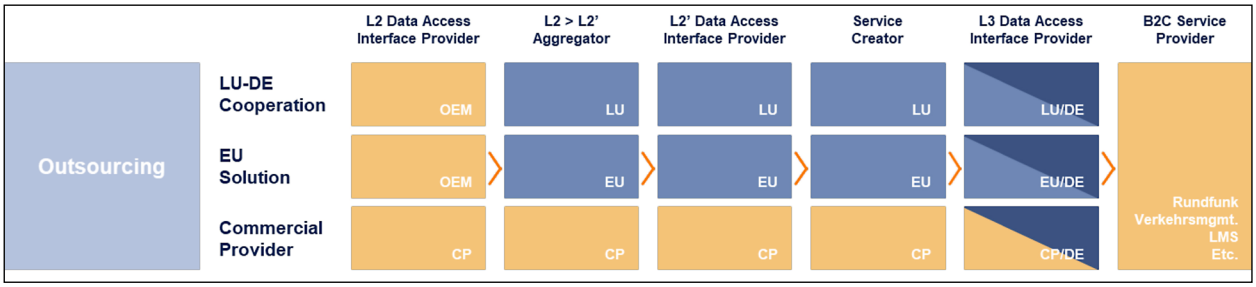


Fig. 7: In outsourcing all roles, Germany is only responsible for providing L3 data access.

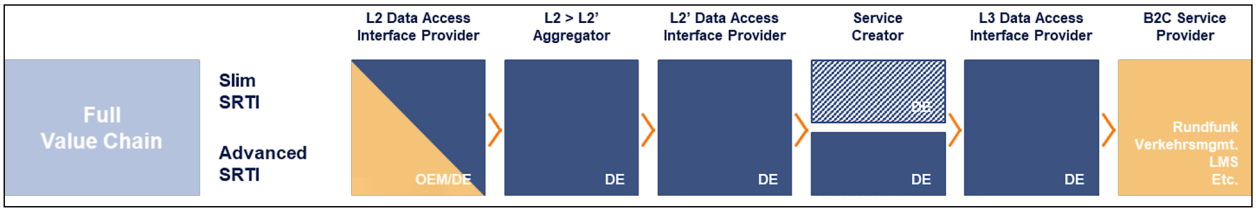


Fig. 8: In the Full Value Chain options, Germany processes and provides data within all roles.

- Full Value Chain – Slim SRTI: Within the Full Value Chain approach, the Slim SRTI option focuses on providing simple SRTI from vehicle-generated data without the implementation of intelligent algorithms.
- Full Value Chain – Advanced SRTI: In contrast, the Advanced SRTI option depends on strong data analytics and machine learning capabilities for the implementation of advanced SRTI and event lifecycle management within the service creation.

In both solution options, Germany will develop and operate all roles across the value chain.

3.5 Additional comments on the differentiation of the solution options

Overall, the presented option groups can be differentiated by highlighting the combined roles of L2 > L2' Aggregator and L2' Data Access Interface Provider as well as the role of Service Creation. Fulfilling only one of these two aspects leads to either a Data Access or Service Creation focused strategy, while focussing on neither or both leads to an Outsourcing respective Full Value Chain approach.

Service Creation vs. Data Access

In both the Service Creation and Data Access options, the German focus is only on a specific segment within the roles. For Data Access the strategic focus is to have raw access to the OEM data, without any other provider in-between. The solution option highly values the data and data integrity. In contrast to this, the Service Creation options emphasize the development of intelligent SRTI messages dedicated to the German stakeholders. There is no priority for having direct access to L2 data.

Outsourcing vs. Full Value Chain

In the option groups Outsourcing and Full Value Chain, both segments, in other words all roles, are filled by one player. For Outsourcing, Germany is not involved in the data processing at any step and only makes L3 data available via the NAP. Opposed to that strategic approach, all roles are filled explicitly by Germany within the Full Value Chain approach.

4 Definition of the evaluation criteria

The evaluation criteria are based on insights generated from interviews with key stakeholders for SRTI in Germany. As shown in Figure 9, the criteria

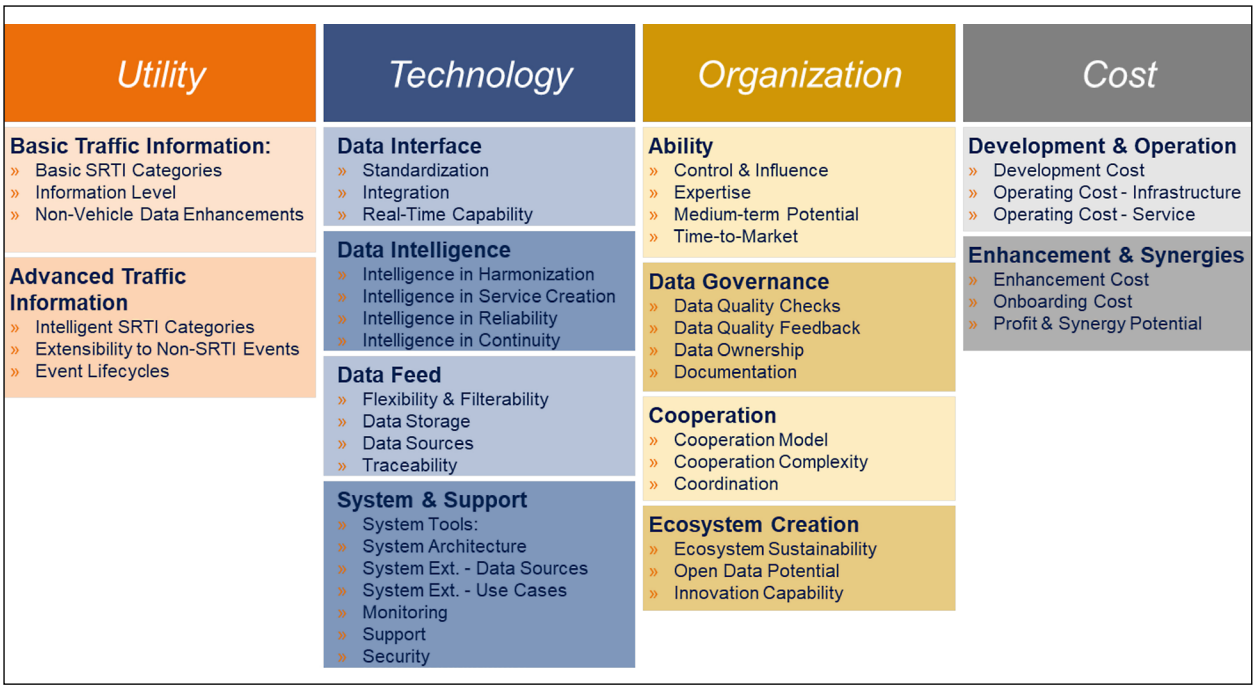


Fig. 9: Overview of evaluation criteria allocated to respective evaluation categories with the four perspectives (utility, technology organisation and cost).

are grouped into categories and assigned to four perspectives: Utility aspects, technical aspects organisational aspects and cost aspects.

For each perspective, the corresponding evaluation criteria are summarised in categories in the following paragraphs.

For the evaluation, each criterion will be scored on a scale from 0 (limited) to 3 (very good). The full definition of the criteria as well as the description for the scoring steps for each criterion are detailed separately in the evaluation tool.

All evaluation criteria, if not specified otherwise, refer to the expected or assumed state of the solution option in the case that it has not been developed yet.

4.1 Stakeholder inputs in order to define the evaluation criteria

To support the definition of the evaluation criteria, dedicated interviews were conducted with representatives from key German stakeholders for SRTI. The core of the interviews involved understanding the expectations of the stakeholders regarding the vehicle-generated data and the requirements and priorities they have.

- Landesmeldestelle der Polizei Bayern: The Verkehrsmeldestelle Bayern is responsible for traffic warning services in Bavaria. Similar to their colleagues in NRW, the stakeholder is interested in any traffic warnings that can increase traffic safety. Through the combination of high automation and manual supervision, less reliable raw data can be handled. An important focus for Bavaria is to stay up to date with technological developments and innovations on the traffic data market.
- Landesmeldestelle der Polizei Hamburg: The Verkehrswarndienst is responsible for traffic warning services in Hamburg. Similar to their colleagues in NRW and Bavaria, the stakeholder prioritises speed over accuracy for safety-critical warnings like wrong-way drivers. For less urgent messages, a high quality of information and a stable data feed is expected. Like their colleagues from other public institutions, they will gladly share their experience and feedback on data quality issues, once a test feed is live.
- Landesmeldestelle der Polizei NRW: The Landesmeldestelle in NRW is responsible for traffic warning services in NRW. In this role, the stakeholder is especially interested in vehicle-generated data in order to increase the accuracy and decrease the latency for object on road, accident and wrong way driver events. Additionally, the non-SRTI event end-of-queue is also of interest. Beyond others, it is a requirement for the Landesmeldestelle that the L3 data is highly reliable and processed automatically.
- Public broadcasting services – HR and WDR: The public broadcasting services are responsible for providing drivers with current traffic information, such as accidents, traffic jams or wrong way drivers. The potential of vehicle-generated data is very promising to this stakeholder, as the data could complement existing sources and increase the coverage and accuracy of the service. Giving an example to their feedback, as part of the editorial work, the broadcasting services are very interested in the verifiability of the source as well as in a lifecycle management for SRTI events.
- Straßen.NRW: Straßen.NRW is a state enterprise tasked with the planning, construction and operation of motorways and state highways. The interest in vehicle-generated data is derived from the traffic management perspective. For example, Straßen.NRW use traffic information from various sources to operate traffic control systems, such as digital speed limits. The real-/near-time capability as well as the potential for an automated integration of vehicle-generated data can improve the current service to increase road-safety. Key aspects of relevance to Straßen.NRW are data quality assurance for user acceptance as well as service creation intelligence to ensure continuous events in time and space.
- Zentralstelle Verkehrsmanagement Bayern: The ZVM Bayern is responsible for collecting and providing different data feeds via their traffic information system (VIZ) to the public and other providers. SRTI latency is not a top priority for the VIZ but data quality is expected to be high with significant L2 data pre-processing. The VIZ is capable of fusing data feeds of all kinds as well as being mirrored in a test environment. On an organisational level, the ZVM has a good reciprocal working relationship with their commercial data providers.

A chronological list of all interview partners is also found in Appendix A.

4.2 Focus on utility aspects

From a utility perspective, a good solution provides the requested functionality for relevant use cases with a high level of information. These aspects will be grouped in the following categories and scored in the corresponding evaluation criteria:

Basic Traffic Information

- Basic SRTI categories scores how extensive simple SRTIs and their sub-categories are made available.
- Information level scores the amount of essential and optional information included in the SRTI messages.
- Non-vehicle data enhancements scores the consideration of other data sources in the creation of SRTI messages.

Advanced Traffic Information

- Intelligent SRTI categories scores the level of intelligence that goes into extracting the more complex SRTI types.
- Extensibility to non-SRTI events scores the option to provide and share additional event types like end of queue locations.
- Event lifecycles scores the availability of status updates, event endings and other lifecycle-relevant information in SRTI messages.

4.3 Focus on technological aspects

From a technological perspective, a good solution uses standardised interfaces, intelligent algorithms and the right tool stack in order to traffic information in real-time. These aspects will be grouped in the following categories and scored in the corresponding evaluation criteria:

Data Interface

- Standardisation scores the adherence and conformance to common L2 and L3 standards like SENSORIS (Sensoris 2020) and DATEX II (DTF 2020c).
- Integration scores the ease of integrating the data feeds into existing TIC systems as well as the required integration work to onboard new B2C service providers.
- Real-time capability scores the latency of the SRTI messages and considers the structure of the data processing chain.

Data Intelligence

- Intelligence in harmonisation scores the sophistication of the data cleansing and harmonisation steps.
- Intelligence in service creation scores the sophistication of the service creation steps.
- Intelligence in reliability scores the extent of confidence and ground-truth checks.
- Intelligence in continuity scores the presence of continuity checks for event states with lifecycles.

Data Feed

- Flexibility and filterability scores the ability to prioritise and balance messages and their properties according to individual needs.
- Data storage scores the possibility for archiving and accessing data history as well as considering the duration of storage.
- Data sources scores the number of available OEM and non-OEM data sources involved in the service creation.
- Traceability scores the transparency of message origins as well as the documentation of involved data sources for aggregated SRTI messages.

System and Support

- System tools scores the capability and performance of the utilised tool stack.
- System architecture scores the modularity and scalability of the solution.
- System extensibility – data sources scores the ease of integration for new data sources.
- System extensibility – use cases scores the ease of developing additional use cases and including proprietary algorithms as well as the adaptability of the system to include new use case information.
- Monitoring scores how well the system handles and reports errors and incomplete data streams as well as the detail and transparency of the reporting process.

- Support scores how well stakeholders are supported in integrating, operating, developing and upgrading the solution on their systems.
- Security scores how well the data is protected against access and manipulation.

4.4 Focus on organisational aspects

From an organisational point of view, a good solution has a clear definition of responsibilities, might enable cooperation and will promote innovation. These aspects will be grouped in the following categories and scored in the corresponding evaluation criteria:

Ability

- Control and influence scores the degree of autonomy the stakeholders have over the development of algorithms and use cases.
- Expertise scores the experience of the designated parties in their respective roles as well as the value of knowledge gained in each position.
- Medium-term potential scores the possible improvements and additions to the solution over time as well as the learning curve.
- Time-to-market scores how soon the solution can be implemented as well as possible impacts on the planned timeline due to upcoming decisions and logistic dependencies.

Data Governance

- Data quality checks scores the performance of data quality verification and validation. Additionally, the number and quality of independent checks and reports are considered.
- Data quality feedback scores the extent of feedback to be relayed back upstream in the process chain as well as the availability of data quality reports.
- Data ownership scores how well the responsibilities and processes for data ownership, quality and security are defined and enforced.
- Documentation scores how well the data processing steps, APIs and service creation algorithms are documented.

Cooperation

- Cooperation model scores how well the solution enables cooperation synergies between countries and between public and private entities as well as the impact of national and EU regulatory aspects on cooperation.
- Cooperation complexity scores the organisational processes for decision-making and the general alignment of goals between involved parties.
- Coordination scores the overhead for coordination and steering, the impacts of geographical barriers and the distribution of roles and costs between the partners.

Ecosystem Creation

- Ecosystem sustainability scores the properties of the ecosystem with regards to monopoly risks and the dependency on individual players as well as the number of independent data brokers.
- Open data potential scores the extent to which the SRTI enters public domain and is accessible to interested parties.
- Innovative capability scores how much the solution encourages competition, innovation and continuous improvement. Furthermore, the barrier of entry for new parties and the possibility to act as a platform for extending into commercial business cases are considered.

4.5 Focus on cost aspects

From a cost perspective, a good solution is efficient in its use of money and resources during initial setup, operation and future enhancements. These aspects will be grouped in the following categories and scored in the corresponding evaluation criteria:

Development and Operation

- Development cost scores the cost of development considering the degree of outsourcing.
- Infrastructure operating cost scores the cost of operation and maintenance considering the degree of outsourcing.
- Service operating cost scores the cost of providing service levels and support considering the degree of outsourcing.

Enhancement and Synergies

- Enhancement cost scores the cost of development, integration and testing of new data streams and algorithms.
- Onboarding cost scores the cost of onboarding other countries or stakeholders.
- Profit and synergy potential scores how much synergy is created in the various cost areas and includes the potential for replacing existing processes. Additionally, the amount of income and funding generated by the system is considered.

5 Evaluation

At the core of the evaluation project is the quantitative scoring of all ten solution options (cf. Chapter 3) along the forty-four evaluation criteria (cf. Chapter 4).

In the following sub chapters, a short explanation for the evaluation scores, documented in the dedicated evaluation tool, is provided for each criterion – highlighting the reasons behind scoring certain solutions favorable in comparison to others. Additionally, the strategic scenarios applied to the evaluation will be defined and motivated, as well as the risk analysis described and detailed.

After having filled the Excel-based evaluation tool with the respective evaluation and risk scores, as well as scenario weights, the ratings are summarised in the results. Figure 10 visualises the relation of the different analysis tabs in the evaluation tool, as well as the calculation logic behind the scoring. In more detail, individual scores per criterion are specified on the evaluation tab and multiplied with a scenario-specific criterion weighting. The resulting weighted average per evaluation category is furthermore multiplied by the scenario-specific category weighting, resulting in the final weighted evaluation score. In parallel, the risk scores are specified in the risk tab of the evaluation tool. The quantified risk points are determined by the product of risk impact and probability, aggregated across all risks.

The analysis of the results and corresponding visualisations can be found in Chapter 6.

5.1 Filling the evaluation matrix

The filling of the evaluation matrix, shown in Figure 11, is based on numerous interviews with experts and stakeholders (cf. Appendix A for a full list). While the interviews are fully documented in their corresponding meeting minutes, the key arguments and visions relevant for the evaluation can be found within the evaluation matrix as well as in the more detailed description of the key evaluation aspects per criterion – across all solution – below.

Most evaluations and corresponding scores are based on expectations of future implementations and visions as well as of expert views, since none of the solution options was up and running at the time of the evaluation. The respective uncertainties regarding the solutions are considered in a separate evaluation of risks, as described in Chapter 5.4.

The consideration of declaring some criteria of outstanding importance to be potential “show stoppers”, if not available, was abandoned because it is assumed that all essential requirements will be fulfilled in all solution options.

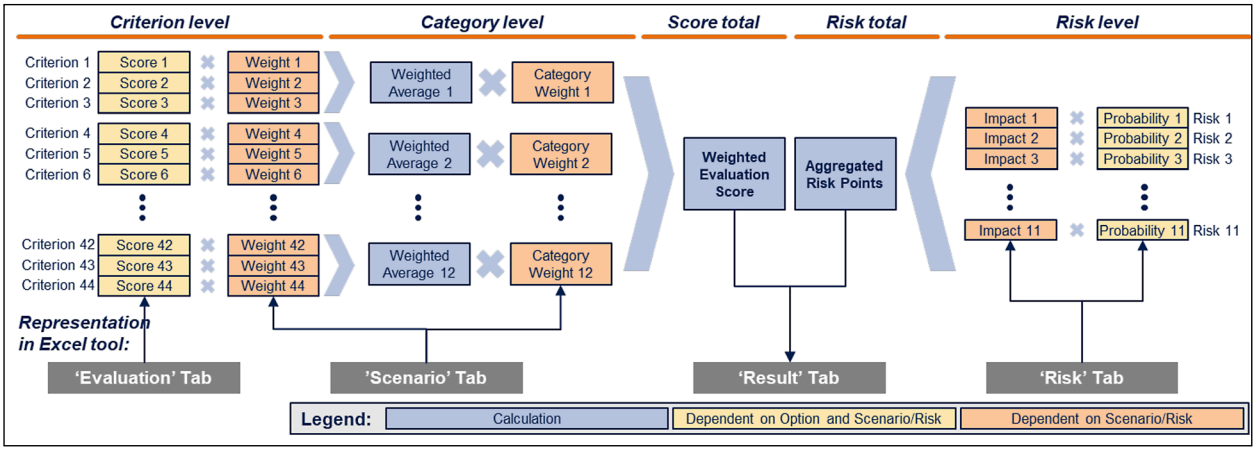


Fig. 10: Depiction of the calculation logic to determine the weighted evaluation score and aggregated risk points.

5.1.1 Utility aspects

Basic Traffic Information

- Basic SRTI Categories: In this criterion, the extent of basic SRTI categories that are made available is evaluated. Basic SRTI categories include unprotected accident area, exceptional weather conditions, slippery road or reduced visibility. It is expected that all solutions will be able to provide some, if not all, of these categories. There is no differentiation in scoring.
- Information level and event types: In this criterion, the extent of information within a provided SRTI message is evaluated. In an analogy to the other “Basic Traffic Information” criteria, all solutions are at least expected to provide the basic (minimum required) information – location, timestamp, event. Extensive further information is expected in solutions that build on a more intelligent service creation. This especially includes commercial provider solutions, the LU- as well as German Advanced-SRTI-approach. Commercial providers are not expected to increase the information level of their free product significantly, unless they are contracted to do so, like in the option Outsourcing.
- Non-vehicle data enhancements: In this criterion, the inclusion and fusion of non-vehicle data is evaluated. This can be infrastructure data or weather data coming from other providers, such as local Landesmeldestellen. Solutions in which Germany is in the service creation role or is working closely together with a cooperation partner score higher due to the influence Germany will have on including such additional sources in the processing.

Advanced Traffic Information

- Intelligent SRTI categories: In this criterion, the extent of intelligent SRTI categories and sub-categories that are made available is considered. This includes e. g. detailed information for the category slippery road, such as ice or gasoline, as well as more complex categories themselves, such as unmanaged blockage of road, wrong way drivers and more. The greater the intelligence in service creation (such as enabled by commercial providers, Luxembourg in the Cooperation or the Advanced SRTI-approach in Germany), the higher the likelihood for more intelligent SRTI-events.
- Extensibility to non-SRTI events: In this criterion, the delivery of non-SRTI event messages is evaluated. This considers whether option solutions do or will have the potential to produce L3 messages that go beyond the context of the DTF, like end of queue locations. In the current

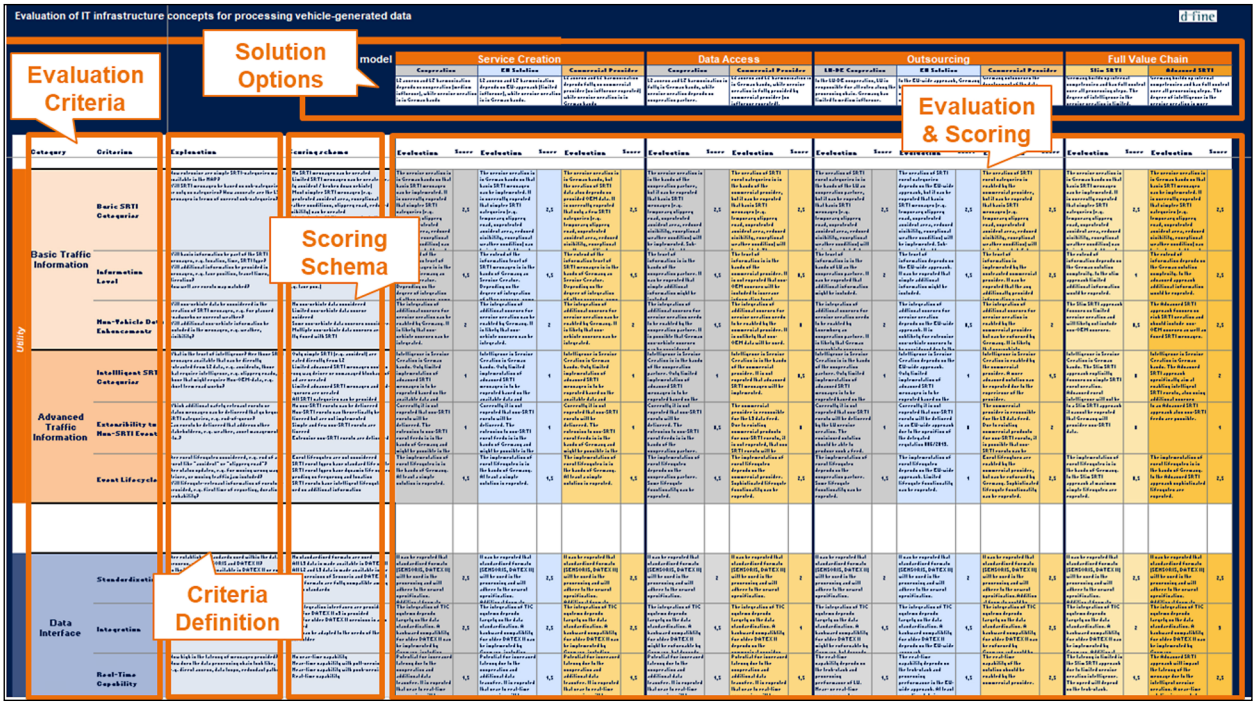


Fig. 11: Overview of the evaluation sheet with the evaluation criteria, their definitions and scoring schemas as well as the filled-out evaluation and scoring for each solution option and criterion.

developments, most approaches focus on the provision of SRTI-messages. The only approach that scores high in this criterion are commercial provider solutions that would be bought by Germany and where the defined scope includes such non-SRTI data.

- Event lifecycles: In this criterion, the intelligence of lifecycle events is evaluated. Especially those option solutions that utilise commercial providers as service creators score high, due to the experience of these players to provide traffic information including the lifecycle information. Additionally, the Advanced SRTI approach by Germany has the potential to implement intelligent lifecycle management, while all other solutions most likely will focus on limited and simple functionality.

5.1.2 Technological aspects

Data Interface

- Standardisation: In this criterion, the standardisation of solutions and APIs is considered. Here all solutions score similarly high because it can be expected that SENSORIS (L2) and DATEX II (L3) will be used to make data available.
- Integration: In this criterion, the integration of SRTI-feeds into the systems of the B2C providers is evaluated. In Germany, most providers rely on TIC-systems for the data processing. Currently this kind of system can typically only process DATEX II v2 files. Accordingly, especially those option solutions where Germany has control over or can influence the service creation score high. In these solutions, a backward compatibility with the older DATEX II version is more likely.
- Real-time capability: In this criterion, the real-time capability, i.e. the latency of supplied SRTI messages, is evaluated, as well as ability to provide a push or only pull service for SRTI messages. In general, there are no large discrepancies expected between the different solution options. All solutions are expected to provide messages in near real-time, possibly targeting a client pull approach. Solutions focusing on an established technology stack, such as commercial providers or an advanced implementation approach, score higher with the potential of real-time implementation and a push service.

Data Intelligence

- Intelligence in harmonisation: In this criterion, the intelligence in harmonisation of L2 data to L2' data is evaluated. All solutions are expected to exhibit at least simple harmonisation algorithms. Again, solutions utilising commercial providers or envisioning an advanced approach score higher due to the intelligence within the solution.
- Intelligence in service creation: In this criterion, the intelligence in service creation of L3 information is evaluated. It is again expected that all solutions have at least simple aggregation algorithms in place, as these are required to generate L3 information from the accessed L2 OEM data. Again, solutions utilising commercial providers or envisioning an advanced implementation score higher due to the intelligence within the solution.
- Intelligence in reliability: In this criterion, the intelligence in reliability, i.e. the availability of confidence and ground-truth checks, is evaluated. It is again expected that all solutions provide at least simple confidence checks to ensure the quality of the L3 information. Ground-truth checks, on the other hand, are not expected unless specifically enforced in an advanced approach or enabled by a commercial provider.
- Intelligence in continuity: In this criterion, the intelligence in continuity, i.e. algorithms for smooth lifecycle events, is evaluated. Stakeholders, such as road authorities, are expecting smoothed out lifecycles instead of "on-and-off flickering" of events. Limited to simple functionality is expected in all solutions, while again those solutions that include more extensive intelligence within the service creation role score higher. These are especially the Advanced SRTI approach, as well as solutions utilising commercial provider capabilities.

Data Feed

- Flexibility and filterability: In this criterion, the flexibility in filtering and periodisation of the SRTI feed is evaluated, respectively. This includes the possibility to distinguish between fast information availability and high reliability of information. The filtering and flexibility in the SRTI feed mainly depends on the service creation and L3 data access interface provider. It is expected that the flexibility and filtering will meet the requirements by German stakeholders at its best, when these

roles are fulfilled by Germany. In addition, it is expected that the commercial provider as well as the various cooperation models can realise the filtering and prioritisation – however these solution options need to meet the requirement of all member states and hence might be less Germany specific.

- Data storage: In this criterion, the possibility of storing and providing historical data within the limits set by the terms and conditions of use is evaluated, e. g. in the view of minimum requirements specified by German directives. In general, data storage is important in the service creation role in order to reproduce generated SRTI messages. In that sense it is expected that data storage will meet the German specific requirements when Germany fulfils the service creation role. In addition, depending on the commercial provider data storage (as well as data interfaces) might be one of the core competencies of the provider, where they score better than a cooperation solution.
- Data sources: In this criterion, it will be evaluated if it is expected that all OEM data will be available and connected to the solution. In addition, solutions will score better if non-vehicle data will be available as data sources as well. It is expected that commercial providers have the highest interest to connect as many OEM data sources as possible because they are interested in bringing as many users onto their platform as possible. However, the availability of non-vehicle data sources might be limited, as they cannot recuperate the costs and are required to provide the information to the ecosystem for reuse. In a cooperation or German solution, the available data sources might be limited due to a local focus. However, one part of the advanced solution might be the connectivity to all possible data sources.
- Traceability: In this criterion, the traceability of generated messages is evaluated, i.e. can the solution indicate, how many events or different data sources are behind a generated SRTI message. This traceability can be realised best if the whole processing chain is implemented by a single provider. Hence, the Full Value Chain solutions, as well as the Outsourcing options, score better than the solution options that are based on multiple players. In addition, in the Service Creation and Data Access solution options the traceability might be easier to realise in a cooperation with another member state than in an EU-wide solution or with a commercial provider.

System and Support

- System tools: In this criterion, the expected technology stack is evaluated. It is expected that all solution options can be built on a state-of-the-art tool stack. Here the commercial provider might have a general interests in providing a competitive solution, whereas in a cooperation or German solution the tool stack can be selected based on the requirements. For the LU-DE-Cooperation, state-of-the-art tools are in place already.
- System architecture: In this criterion, the IT and data architecture is evaluated. Here the modularity of the solution is of special importance, such that single parts of the processing chain can be exchanged independently. A modular system architecture is of interest for all providers, especially if different actors are involved in the value chain. Here, a common understanding of the data levels is important in order to exchange solution components for components of another provider. The products of the commercial provider might already be able to handle this modularity based on the standards. Other solutions still need to prove their modularity. The L2-L2' aggregation module in the LU-DE Cooperation fulfils that part – the service creation is currently under development and needs to be reviewed later.
- System extensibility – data sources: In this criterion, it is evaluated how easily new data sources can be integrated, especially if they follow standards in data format and connectivity. This criterion will only depend on the first roles in the data processing chain. Here, it is expected that commercial providers have the highest capability and interest to connect new data sources easily as they become available. For the EU solution, the extension of data sources is of interest but the prioritisation may have to be aligned between all partners. For developments by Germany or cooperation options, the extension of additional data sources might be good as well but the interest will depend on the local coverage and value add.
- System extensibility – use cases: In this criterion, the possibility to implement additional use cases is evaluated. Here it is considered how easily

appropriate or even proprietary algorithms can be integrated. This criterion will only depend on the service creation role in the data processing chain. The extensibility to new use cases is best if that part in the data processing chain is done by Germany or in a cooperation. In addition, commercial providers have the capability to implement new use cases but might need an economic incentive to do so, as is the case in the Outsourcing solution group but not in the Data Access and Service Creation solution options, where the commercial provider simply offers its standard product to the DTF ecosystem. In an EU solution, the extensibility of additional use cases might be possible but needs a common view such that the solutions will not end up with member state-specific implementations.

- Monitoring: In this criterion, the system support in terms of error reporting, logging, outages as well as transparent reporting processes are evaluated. It is expected that all solutions will provide monitoring services. The commercial provider might have an established monitoring that might be less transparent for the other actors. Cooperation partners might be a bit more willing in sharing monitoring results. In a Full Value Chain solution option, the implementation of the error reporting and logging functions can be implemented and shared with the end user. However, this functionality is not available right now and hence not fully proven.
- Support: In this criterion, the support for integrating the data streams in the service provider's infrastructure, data feed upgrades as well as support in German language is evaluated. It is expected that full support in German language is possible of the Full Value Chain solutions, as well as in the solution outsourced to a commercial provider. For all other solution options, the level of support may depend on the parts done by Germany. For the LU-DE Cooperation the support might be partly in English language. For the solution option in Service Creation as well as Data Access based on a commercial provider, the commercial provider might charge for the support service.
- Security: In this criterion, the security standards of the different solutions are evaluated, especially how well the system is secured against unauthorised data access. It is expected that a certain security level will be implemented by all solution options. However, if system components are already in place and are even used in a productive environment, they will score better. Here, it is expected that commercial providers have the most experience in securing a solution against intrusion. In addition, the LU-DE Cooperation already has some security components in place.

5.1.3 Organisational aspects

Ability

- Control & influence: In this criterion, the rating tends to go down the more players are involved because more stakeholders and opinions have to be considered when making decisions. Working with private entities is assumed to be easier because of the clear hierarchy between customer and supplier. On the other hand, if an off-the-shelf product is involved from a commercial provider, the amount of control over development is expected to be limited. In the area of international cooperation, an EU-wide solution is expected to allow for the least amount of control and influence by any single country.
- Expertise: In this criterion, two aspects are considered: the pre-existing expertise of the player in their role as well as the strategic value of expertise gained in the role. It is assumed that the expertise in service creation is more valuable than the expertise in data aggregation, since the value of data lies more in its harvesting as a resource and less in the technical know-how that goes into data processing. Furthermore, it is assumed that commercial providers have proven expertise in data aggregation and service creation due to their market experience. In the case of cooperation, Germany would still be able to gain some insights into the data processing but not as deep as if Germany would be responsible for this step.
- Medium-term potential: In this criterion, the fact that solutions improve over time is considered. Whereas commercial providers may already operate near their full potential in terms of algorithmic sophistication, public players are expected to have a much steeper learning curve with the challenges of data fusion and service creation. The functionality of a publicly funded solution is also expected to catch-up to private providers in many areas over time.

- Time-to-market: In this criterion, the maturity of the solution is rated as well as potential impacts on the delivery timeline. Commercial providers are expected to have a shorter time-to-market than public authorities, especially if they plan on negotiating a partnership agreement with their potential cooperation partners. Even a public authority that does not plan to join any form of international cooperation assumed to be at a disadvantage in this area because the technological framework will have to be established first. Since commercial providers are already operating in the vehicle data market, their solutions are expected to be ready to deploy with few adjustments.

Data Governance

- Data Quality Checks: In this criterion, quantity and quality of data validation are considered. The more partners are involved in the solution, the more independent sources are expected to implement, perform and validate data quality gates. On the other hand, commercial providers, due to their extended experience in data fusion, might have market leading data quality and confidence checks in place as well as access to many of the same open data sources as the public authorities.
- Data Quality Feedback: In this criterion, the availability of data quality reporting and feedback processes are considered. The least amount of feedback interaction is expected with commercial providers, as they may tend to limit insights into their intellectual property and might deny customisation requests from individual customers regarding their large-scale product services. The most effective feedback channels are expected for national, public solutions, where Germany can implement feedback from its stakeholders directly into its product without having to align with any second entity.
- Data Ownership: In this criterion, the processes and responsibilities regarding data rights, security and quality are considered. Any interaction with a third party will require clear definitions of responsibilities and security measures. Any interaction with commercial providers is expected to cause some conflicts regarding the border between public and private data rights. Public partners, on the other hand, are expected to be more bureaucratic in setting up and enforcing data ownership processes and responsibilities. A German solution is expected to have the least potential for conflicts in all areas as well as the strongest process synergies for data governance.
- Documentation: In this criterion, the documentation of processing steps, interfaces and algorithms is considered. A Germany-specific solution is expected to have the least amount of documentation, since few interfaces with other players exist. Private providers have detailed documentation of their API capabilities but are usually not sharing the details of their algorithms. Within international partnerships, the complexity and public nature of the cooperation is expected to provide the most detailed documentation along the entire data processing chain.

Cooperation

- Cooperation Model: In this criterion, the cooperation synergies between countries and between public and private entities are considered. In general, cooperation potential is assumed to increase the more public partners are involved. A centralised EU-wide approach is expected to have the greatest synergies for public cooperation. In models that involve private partners, no significant synergies are assumed, unless multiple countries request the same commercial service which cannot be guaranteed at this point.
- Cooperation Complexity: In this criterion, the organisational processes for decision-making and the general alignment of goals between involved parties is considered. In general, cooperation complexity is assumed to increase the more partners are involved. A cooperation is expected to have a better alignment of goals because it can be considered a prerequisite for a partnership. Commercial providers are assumed to involve the least amount of complexity, due to strict separation between public and private operations and a clear customer-provider relationship. A German “in-house” solution, by definition, includes little to no cooperation complexity.
- Coordination: In this criterion, the operative overhead for coordination and steering, the responsibility structure and potential geographical and language barriers are considered. Coordination challenges are expected to increase with the number and

diversity of players involved, including commercial providers. Cooperation options are expected to have limited geographical and language barriers with some overlap of responsibilities. Steering of private providers might need intensive coordination and from time to time also change request discussions, while proprietary solutions do not face any external coordination challenges.

Ecosystem Creation

- Ecosystem Sustainability: In this criterion, the risks of know-how and access monopolisation and the dependency on individual players are considered. From an economic perspective, any government-operated role is expected to remove the level playing field for competition in that area. At the same time, if only one commercial provider is contracted, the network effects will gradually work towards a private monopoly which also endangers an SRTI ecosystem.
- Open Data Potential: In this criterion, the extent to which the SRTI is publicly available is considered. Depending on the final legal agreements of the DTF, it is possible that L3 data which is generated by public authorities, enters the public domain. Private companies, on the other hand, are expected to publish their L3 SRTI messages only within the DTF ecosystems to participating members. At the time of writing, no final agreement regarding this topic has been reached, therefore all solutions are currently rated equally.
- Innovation Capability: In this criterion, the potential for innovation and continuous improvement of quality and functionality is considered. Innovation generally tends to be greater in the private sector, due to the competition and incentivisation present in free markets. In general, innovation can be increased by an active exchange of ideas and know-how by as many partners as possible but require incentives to do so. The overall lack of competition and corresponding incentives is expected to reduce the overall potential for innovation, especially in single-country solutions.

5.1.4 Cost aspects

Development & Operation

- Development Cost: In this criterion, the costs for the initial development of the solution are considered. Commercial providers are expected to be able to keep development costs relatively low because they can offer their standardised service with added customisations. Furthermore, it is assumed that more cooperation partners lead to less development costs per member. An in-house development of a solution or parts of a solution from scratch is expected to be the most costly option.
- Operating Cost – Infrastructure: In this criterion, the costs for operating the solution are considered from an infrastructure standpoint. Commercial providers are expected to be able to keep infrastructure costs moderately low, due to mostly scalable platform architectures. Furthermore, it is assumed that more cooperation partners lead to less infrastructure costs per member. An in-house operation hosted on Cloud or German infrastructure is expected to be the most costly option when compared to the other options.
- Operating Cost – Service: In this criterion, the operating costs for providing service levels and support are considered. Overall the costs in this criterion do not scale nearly as well with the number of member states as other development and operation costs, e. g. due to language or member state-specific support. Some synergies are assumed, if the technical service is centralised across multiple parties. Commercial providers are expected to demand additional fees for service level agreements, compared to public authorities who may not explicitly charge fees.

Enhancement & Synergies

- Enhancement Cost: In this criterion, the cost of developing and integrating new data streams and algorithms is considered. Analogous to development costs, the financial burden mainly depends on the number of partners that share the initial investment.
- Onboarding Cost: In this criterion, the cost of onboarding other countries or stakeholders is considered. Solution options that are geared towards multiple partners are expected to have finished multiple onboarding processes of members once they are up and running, therefore the costs are assumed to be lower than single-country solutions that are expanded for the first time. Commercial providers are expected to

have an easy onboarding process, due to their existing platform structures.

- Profit & Synergy Potential: In this criterion, the cost and process synergies as well as the potential for developing income from funding or fees are considered. The most synergy potential is expected from solutions that include several roles along the processing chain because knowledge and expertise in vehicle data and IT can be shared within the organisation and increase the overall cost efficiency. Some additional research funding may be generated by dedicated national solutions. Lastly, data platforms that allow the integration of private business models based on traffic data may generate some income in the future.

5.2 Definition of strategic scenarios and weighting of evaluation criteria

Within the evaluation tool, different scenarios have been defined in order to represent various possible German strategic positions. The strategic scenarios have been designed depending on the time-to-market and the investment for entry into the vehicle data ecosystem, c.f. Figure 12.

To specify strategic approaches in which Germany envisions to be a pioneer in the ecosystem, the terminology Early Adopter is chosen to indicate the fast implementation speed. Depending on the investment, as well as the strategic focus on quality or cost, the Early Adopter strategies are separated into a Low Cost and High Quality approach. To further differentiate between the solutions that focus on a Follower approach, the Follower terminology is used to describe a reactive low cost approach while the Future-Proof terminology describes the high quality approach.

The four strategic scenarios are described in more detail in the following:

Early Adopter – Low Cost: In the Early Adopter – Low Cost scenario, Germany is looking for a satisfying and valuable solution that is slim rather than advanced, has good value for money and fulfils most of the use cases of the stakeholders but is limited in the most advanced ones. The limited, basic functionality allows for a short term implementation.

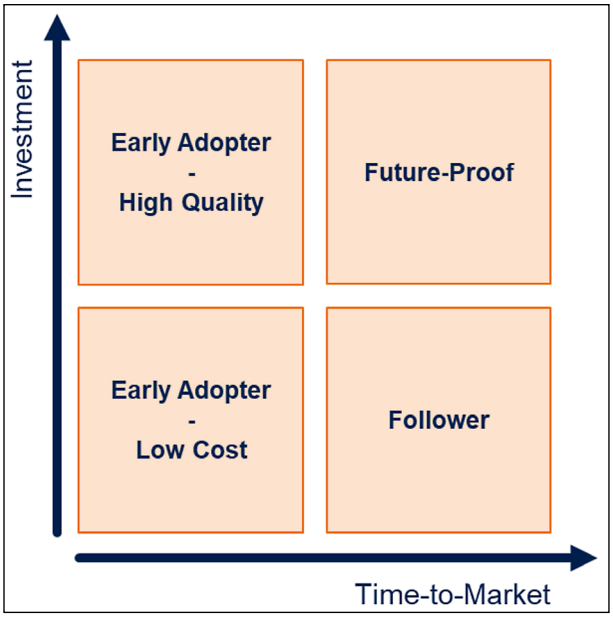


Fig. 12: The strategy scenarios are determined by the required investment and the time-to-market.

Early Adopter – High Quality: In the Early Adopter – High Quality scenario, Germany wants to catch up technologically and analytically with the pioneers (other EU member states as well as commercial providers). For that, Germany is willing to invest money, drive innovation and support the creation of an ecosystem. The significant input of resources is expected to allow the project to finish in a timely manner.

Follower: In the Follower scenario, Germany wants to follow the other EU member states and adapt proven solutions to the Germany case. This scenario is more cost-sensitive and less innovative. Basic traffic information within a stable environment are more important than advanced information in an innovative framework. Because functionalities have to be developed and proven valuable by other players, this scenario takes place on a longer time scale.

Future-proof: In the Future-proof scenario, Germany is looking for a future-proof solution that is built on a platform with a scalable, future-proven IT stack that enables current as well as future use cases. In that scenario, the value-add and innovation of the solution is more important than the costs for development and support during operation. Because the expertise and infrastructure will have to be built from scratch, the time horizon is longer.

The different weighting for the strategy scenarios is done on the level of the evaluation categories (see

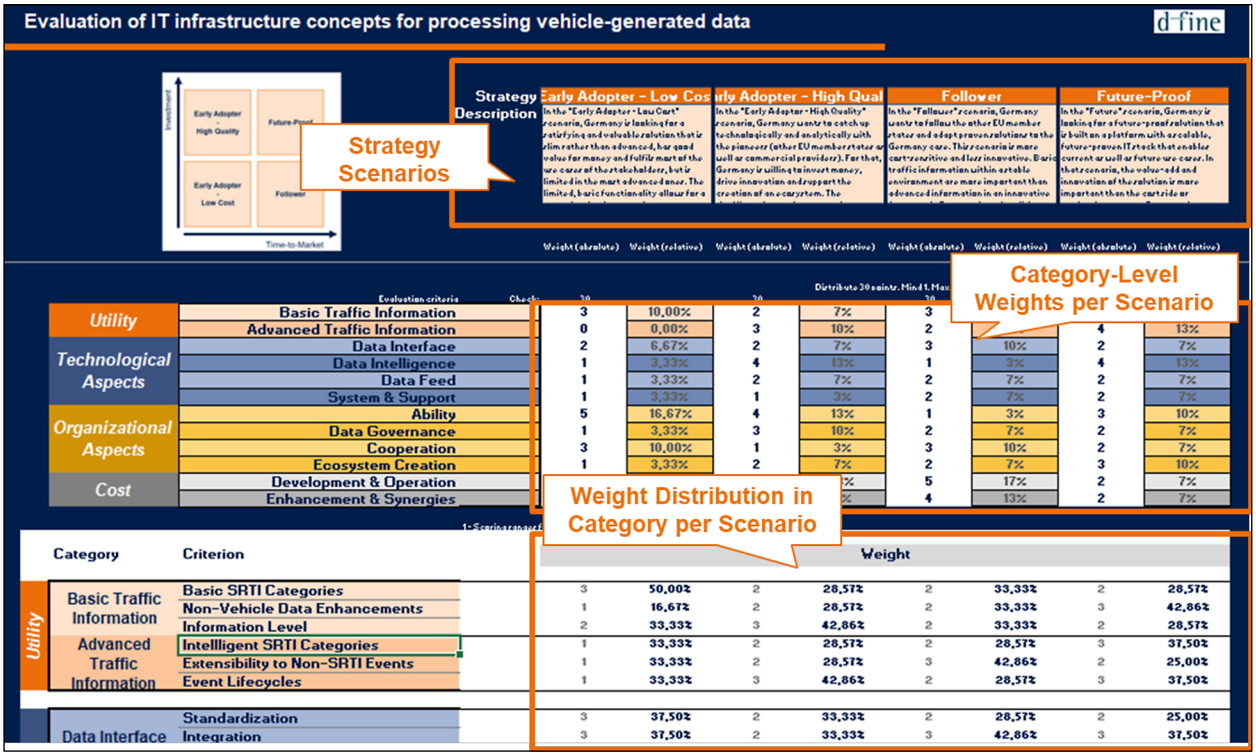


Fig. 13: Overview of the scenario sheet, with a definition of the four strategy scenarios (top), their corresponding weights for each evaluation category (middle), as well as the relative weighting of evaluation criteria within each category (bottom).

Category-Level Weights per Scenario in Figure 13). Furthermore, additional weights are defined at the evaluation criterion level to reflect the relative weighting of evaluation criterions within an evaluation category (see Weight Distribution in Category per Scenario). The multiplication of the category-level weight and the criterion-specific weight within a category produces the overall weight of the criterion within the evaluation.

5.3 Scoring sensitivities

Using the scenario-specific category weights as well as the relative distribution of weights among criteria within categories, the overall contribution of each individual criterion to the overall score can be determined.

The aggregation of weighted scores, as shown and described in the beginning of Chapter 5 (cf. Figure 10) is a linear combination of the individual evaluation scores per criterion, where each criterion contributes a certain percentage to the total score. For example, if an evaluation criterion is weighted as 25% of its category and the category itself makes up 10% of the total score, the evaluation criterion makes up 25%*10% = 2.5% of the total score. This number is the sensitivity of the total score with regards to the specific evaluation criterion. More so, this means that a change of the criterion score by one point (e. g. from 2 to 3) will impact the total score by 0.025 points. The sensitivities of all criteria and categories are calculated in a dedicated column of the evaluation tool.

In this linear model, the calculated sensitivities are both a display of the total contribution of certain criteria and categories towards the final score as well as an indicator of how much the final score changes, if the underlying ratings are modified.

The sensitivities of the total score with respect to individual criteria can ultimately be used as a measure of robustness of the solution towards changes in assumptions, strategy and framework conditions.

5.4 Definition of risk factors

The evaluation of solution options is done based on the vision and future expectation for implementations within data harmonisation and service creation. Accordingly, significant uncertainties have to be considered within the full evaluation. To accommodate for developments that would negatively affect certain solution options, risk factors

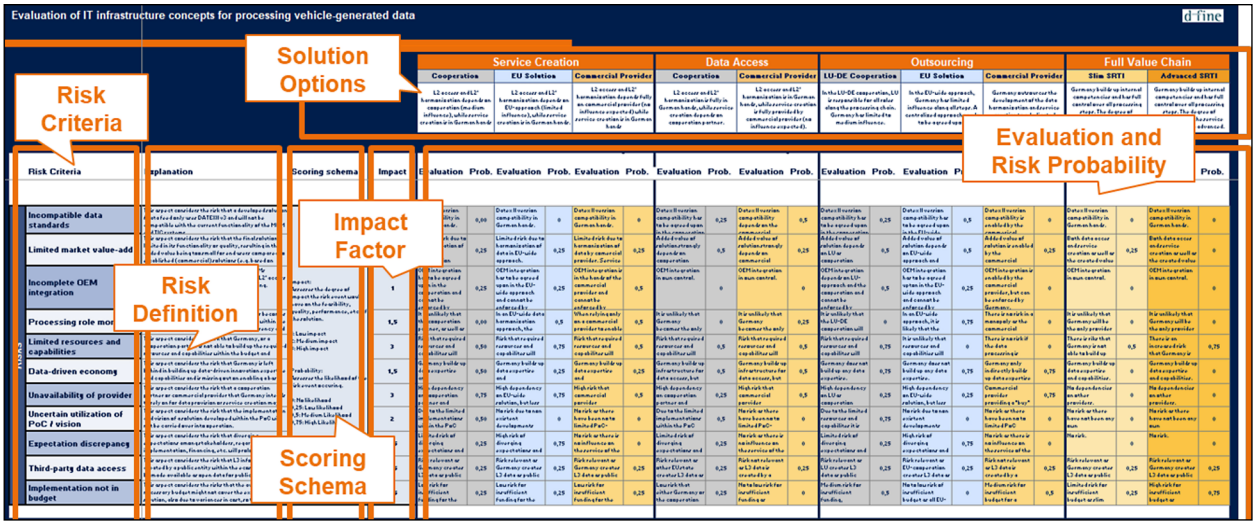


Fig. 14: Overview of the risk criteria including their descriptions and impact factors as well as the evaluation and definition of risk probability for each criterion per solution option.

are identified and rated concerning their overall impact and probability of occurrence (Figure 14). In this approach, the impact of each risk factor rates the severity of the risk in the case of materialisation. The probability per risk factor and solution option rates the likelihood of materialisation.

For each solution option, the impact of the eleven risk factors as well as their probability of occurrence is estimated. The degree of impact is evaluated on a scale from 0 – No Impact, 1 – Low impact, 2 – Medium impact up to 3 – High impact, whereas the probability assessing the likelihood that the risk event occurs: 0% – No likelihood, 25% – Low likelihood, 50% – Medium likelihood, 75% – High likelihood.

The following risk factors have been defined:

- Incompatible data standards (Impact 3):
  This aspect considers the risk that a developed solution/data feed only uses DATEXII v3 and will not be compatible with the current functionality of the MDM (v3 compatibility currently under development) and TIC systems (typically compatible with DATEXII v2). The consequence would be that the systems of German stakeholders might not be compatible with the new SRTI feed.
- Limited market value-add (Impact 2):
  This aspect considers the risk that the final solution is limited in its functionality or quality, resulting in the added value being too small for end users compared to established (commercial) solutions (e. g. based on FCD). The risk is that stakeholders will not use the new SRTI-feed due to no added value.
- Incomplete OEM integration (Impact 1):
  This aspect considers the risk that not all OEMs are connected by the L2' access provider and are missing in the data processing and SRTI-feed.
- Processing role monopoly (Impact 1.5):
  This aspect considers the risk that one player becomes the only provider of a specific role (or roles) within the data processing chain, as well as the transparency and development/innovation risk that are associated with it. This risk does not only concern the German processing chain but the whole ecosystem.
- Limited resources and capabilities (Impact 3):
  This aspect considers the risk that Germany or a cooperation partner is not able to build up the required resources and capabilities within the budget and constraints that may be required for a proprietary solution. The risk is that a more intelligent solution might not be feasible.
- Data-driven economy (Impact 1.5):
  This aspect considers the risk that Germany is left behind in building up data-driven innovation expertise and capabilities and is missing out on enabling a basis for further developments regarding the consolidation of data within the NAP/mobility data platform.
- Unavailability of provider (Impact 3):
  This aspect considers the risk that a cooperation partner or commercial provider that Germany intends to rely on for data provision or service

creation may decide to discontinue their service, due to limited or no contractual bindings or may never initiate the service in the first place. The risk is that the envisioned or even productive solution becomes unfeasible.

- Uncertain utilisation of PoC vision (Impact 2):
  This aspect considers the risk that the implementation and vision of a solution developed within the PoC will not be carried over into operation. The risk is that vision on which the evaluation is based does not hold in such a case.
- Expectation discrepancy (Impact 2.5):
  This aspect considers the risk that diverging expectations among stakeholders regarding implementation, financing etc. will prolong the development of a suitable solution or hinder it completely.
- Third-party data access (Impact 1.5):
  This aspect considers the risk that L3 information created by a public entity within the ecosystem will not be made available as open data for public use. The materialisation of this risk depends on the discussions within the DTF and the new Multi-Party Agreement (DTF 2020b) regarding acceptable use of L3 information.
- Implementation not in budget (Impact 2.5):
  This aspect considers the risks that the available/ necessary budget might not cover the extent of the solution, also due to variances in cost, so that the solution cannot be developed as intended or might have to be stopped during the implementation or operation.

The individual risk points for each solution option are calculated by multiplying the impact factor with the probability of occurrence and summing up this value over all risk factors and are independent of applied scenarios. However, the risk point value is used only as first indicator. In general, the risks of the solution options – at least for those that will be considered as recommendation for Germany – will be visualised and analysed in a more detailed risk matrix.

5.5 Quality checks: Bottom up vs. top down

The scoring of evaluation criteria and risks was done in a bottom-up approach – assigning scores for individual criteria and risk factors per solution options based on the interview insights. Already on this level, the first approach for quality assurance was done by ensuring that assumptions and scoring schemas were applied consistently along each criterion and within each solution option (cf. Figure 15). Furthermore, it was ensured that the similarities and differences within solution groups (i.e. Service Creation and Outsourcing) as well as among similar cooperation models (i.e. EU Solution or Cooperation) were applied correctly.

In a second quality assurance step, the calibration and validation of the scores was done in a top-down approach (cf. Figure 16). In addition to validating the total scores within solution and cooperation model groups for consistency, the category scores and the category weightings of the different scenarios were validated to pronounce the most relevant aspects (e. g. cost categories in the Low Cost scenario). It was ensured that the weighted evaluations on a category level were consistent within the solution option groups as well as among similar cooperation models. Lastly, it was considered that the total scores and risk points correctly quantify the strengths and weaknesses of the solution options.

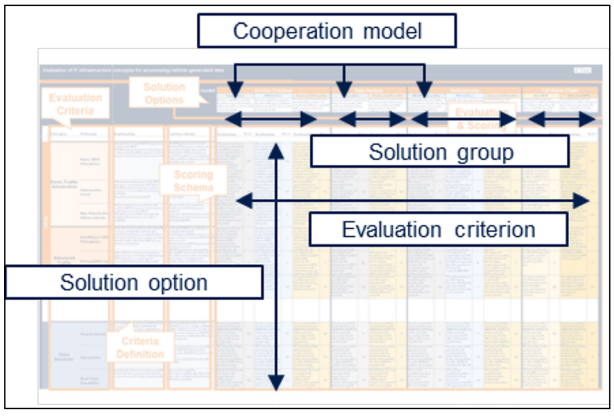


Fig. 15: Bottom-up validation of single scores along solution options, solution groups and evaluation criteria.

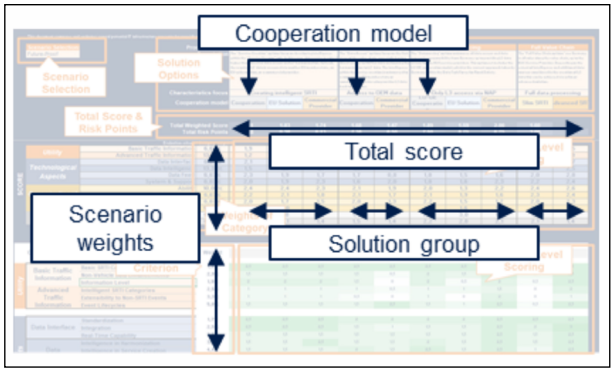


Fig. 16: Top-down validation of total scores along evaluation categories, strategic scenarios and solution groups.

6 Results of the evaluation

As described in the methodological approach, the evaluation results consist of the evaluation scores for all solution options for each of the four scenarios as well as their risk scores. In the following, the scoring that is also available in the supporting Excel-based evaluation too, is presented, including a detailed analysis of the top solution.

6.1 Overall results

The overall results are given by the evaluation scores, a visualisation of the category impact per scenario and their risk points.

6.1.1 Scores across scenarios

According to the scoring calculation described in Chapter 5, the evaluation criteria scores are weighted and aggregated to receive the total scores seen in Figure 18.

The focus of the different strategic scenarios is represented by weight factors attached to the different evaluation categories. As can be seen in Figure 17, depending on the scenario, the categories contribute to the overall scores to a different extent. The detailed weights on category- and criteria-level can be found in the supporting evaluation tool. The scenarios Early Adopter – Low Cost and Follower place a far greater emphasis on cost factors (grey) than their high-end counterparts Early Adopter – High Quality and Future-Proof which in turn prioritise Advanced Traffic Information (dark orange) and technological aspects (blue). Organisational aspects (yellow) share the same portion in all strategic scenarios but with a different sub focus.

Overall, four solution options receive good to very good scores in all scenarios with a clear distinction (cf. orange highlighted boxes in Figure 18). These four solutions are the German Service Creation with EU Data Access, the existing LU-DE Cooperation, the Outsourcing to an established Commercial Provider and the proprietary Full Value Chain solution Advanced SRTI. In addition, the Outsourcing option of an EU Solution as well as the proprietary Slim SRTI offer themselves as viable alternatives to the above mentioned four top solutions when targeting a low cost approach (cf. blue highlighted boxes in Figure 18). While the option Outsourcing – EU Solution also scores well in the Follower scenario, this will not be considered further as a combined EU-wide approach implies that there will only be one solution available – making the concept of leader and follower obsolete.

More detailed, in the Early Adopter – Low Cost scenario which places a high value on limited required investments, the Outsourcing option of an EU Solution as well as the proprietary Slim SRTI score well, just behind the Outsourcing – Commercial Provider.

In the Early Adopter – High Quality scenario which focuses on a fast time-to-market complemented by an advanced implementation approach, especially the Outsourcing – Commercial Provider and Advanced SRTI approaches score highest.

In the Follower scenario, focusing on an approach that builds on learning from others, all previously mentioned top scoring solution options score similarly high, while, as explained, the option Outsourcing - EU Solution will not be considered.

Finally, the Advanced SRTI option achieves the highest score of all solution options in the Future-Proof scenario which prioritises quality and longevity over costs.

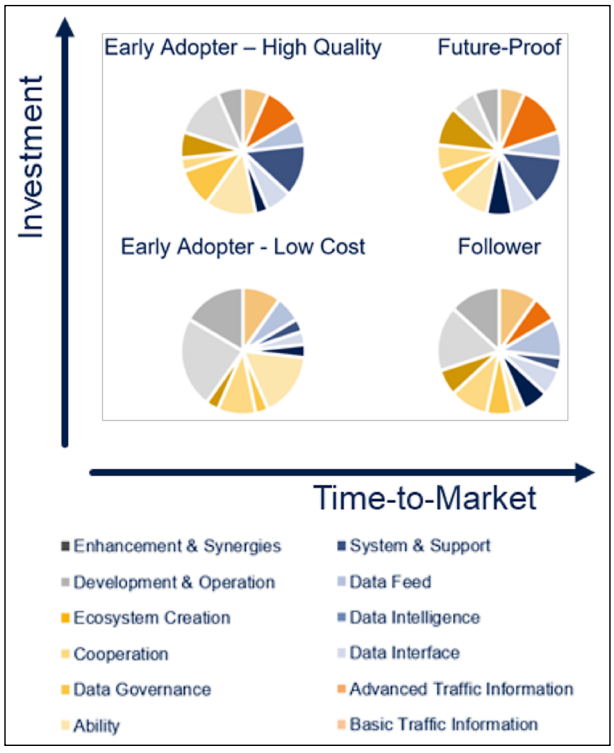


Fig. 17: Scenario weight distributions by scenario and category.

	Service Creation			Data Access		Outsourcing			Full Value Chain	
Scenario	Cooperation	**EU Solution**	Commercial Provider	Cooperation	Commercial Provider	**LU-DE Cooperation**	EU Solution	**Commercial Provider**	Slim SRTI	**Advanced SRTI**
Early Adopter – Low Cost	1.80	1.96	1.86	1.74	1.68	1.99	1.99	2.07	2.02	1.77
Early Adopter – High Quality	1.78	1.87	1.75	1.66	1.50	1.90	1.68	2.05	1.65	2.05
Follower	1.79	1.90	1.71	1.65	1.42	1.93	1.90	1.93	1.74	1.92
Future-Proof	1.79	1.81	1.71	1.65	1.47	1.89	1.57	2.00	1.60	2.16
Visualization of total scores by scenario	2	1.5	1							

Fig. 18: Overview of the overall evaluation scores for each solution option under the four strategic scenarios. Top performing solutions are boxed in orange while two additionally well performing low cost solutions are boxed in blue.

Looking at the solution groups based on the extent of the German involvement in the data value chain, one can see that both solutions with an Outsourcing focus and solutions with a priority on the Full Value Chain generally score well. The Data Access solution group, on the other hand, does not provide any viable option for Germany to pursue further. That is related to the fact that a German role in data access followed by a service creation by someone else would not add value for German stakeholders.

6.1.2 Risk evaluation

To complement the evaluation scoring, the risk points per solution option have to be considered. In Chapter 5.4 several risks were identified that might impact the strategic decision. The largest risks were identified in the areas of resources like budget as well as organisation like provider availability, interfacing and stakeholder management. Overall, cooperative solutions tend to have their attached risks in the areas of organisation, while the proprietary solution options are mainly impacted by resource concerns.

The aggregated risk points are shown in Figure 19. It is seen that most solution options rank similar between 6 and 7.5 total risk points. Especially the two low cost options identified in Chapter 6.1.1, the EU outsourcing solution and the Slim SRTI approach, deviate. The former carries significantly more risk because of the uncertainty of feasibility. This is especially impacted by the organisational and coordinative aspects, with stakeholders having to agree on an aligned strategic approach, budget and financing as well as implementation focus. In contrast, the Slim SRTI solution is fully under

Service Creation			Data Access	
Cooperation	EU Solution	Commercial	Cooperation	Commercial
6.38	6.38	6.13	7.38	6.50
Outsourcing			**Full Value Chain**	
LU-DE	EU Solution	Commercial	Slim SRTI	Adv. SRTI
7.50	**8.75**	6.75	**3.00**	5.00

Fig. 19: Aggregated risk points of all solution options, highlighting the low cost options.

German control and very predictable in its framework conditions.

Due to the large discrepancy in risk between the two high-scoring low cost approaches, only the less risky Slim SRTI approach will be considered in more detail going forward.

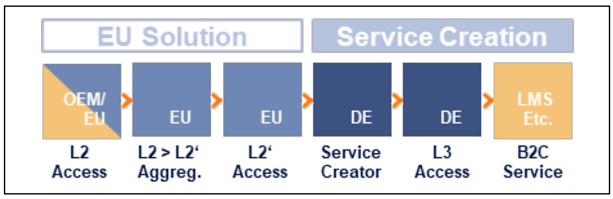
6.2 Detailed analysis of single solutions

After having identified the best solutions for each scenario and considering the risks attached to implementing an EU-wide outsourcing solution, the top four options as well as the low-cost Slim SRTI solution are examined in more detail on the following pages[3].

6.2.1 Option 1 – German service creation with EU data access

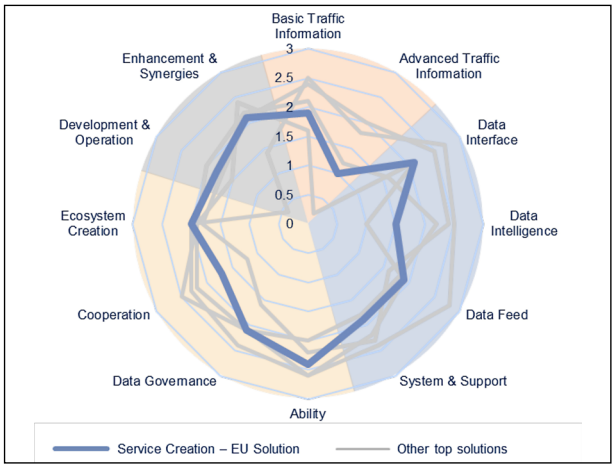
The EU Solution is unique in its combination of powerful centralisation on the data access end and national customisation on the service creation end.

[3] The criterion weights for the Future-Proof and Low-Cost scenarios were used to display the top four respectively the Slim SRTI solutions. The choice of scenario only impacts the displayed category scores slightly, as the main differentiation between scenarios is due the category weights themselves.



It builds on the assumption that most or all EU countries can agree on and set up a standardised data aggregation platform, where all L2 (OEM) data is collected, cleansed and harmonised. In service creation, on the other hand, Germany retains its sovereignty which allows integrating country-specific use cases and data sources into the L3 ecosystem in order to answer to its stakeholders' needs.

Evaluation



Utility aspects

Overall, all basic functional requirements are fulfilled with Germany responsible for service creation.

Due to limited expertise and scope, advanced SRTI intelligence and extensive additional information is not expected.

Technological aspects

Having an EU-wide data aggregation ensures high standardisation, while Germany retains flexibility and extensibility for building custom services.

Interfaces, documentation and transparency have to be agreed upon on an EU-wide level.

Organisational aspects

The high synergy potential for cooperation is tapped in data aggregation, while key strategic expertise in service creation can be gathered simultaneously.

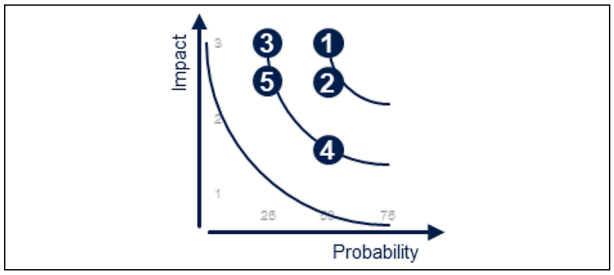
The loss of control and overhead for steering in an EU cooperation is significant and a longer time to market is expected.

Cost aspects

Development and operating costs for data aggregation can be split with many partners.

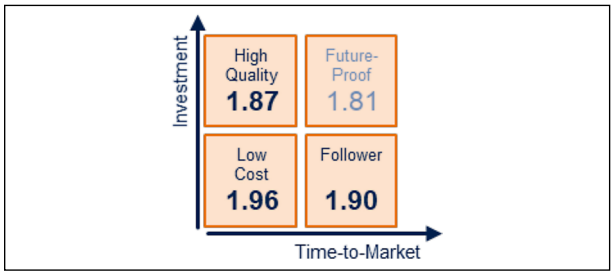
L3 service creation must be developed single-handedly because little synergy potential is expected.

Risks



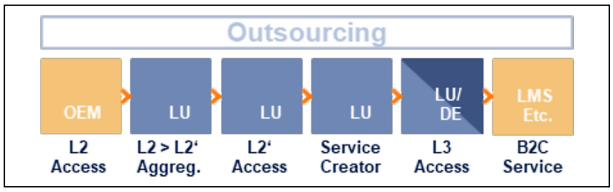
1. Limited resources & capabilities pose the largest risk, since Germany has to build up its own expertise in service creation.
2. Expectation discrepancy endangers any EU-wide cooperation, as consensus decisions are expected to be challenging.
3. If no EU cooperation can be agreed upon, the unavailability of provider risks the project feasibility for Germany.
4. Having only an EU-wide data aggregator poses the threat of a processing role monopoly (unintentionally) stifling innovation.
5. The proprietary development of service creation increases the risk of the implementation not being in budget.

Scenarios and scoring



The effective cost sharing in data access and the high degree of flexibility in service creation make *Service Creation – EU Solution* one of the best options for most scenarios.

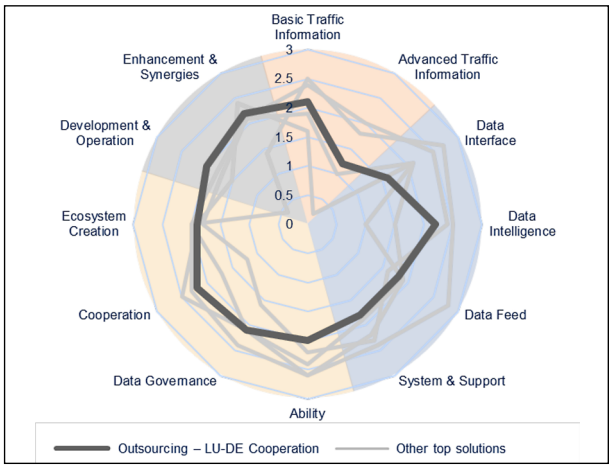
6.2.2 Option 2 – Outsourcing in the Luxembourg-Germany (LU-DE) cooperation



Among the compared solution options, the LU-DE Cooperation stands out as the only cooperation that has already been tested in the field. As part of the PoC phase of the Data Task Force, Germany and Luxembourg have set up a partnership, as described in the introduction of this document.

It is assumed that Luxembourg's planned big data streaming setup with self-learning algorithms will be further implemented as envisioned. Due to the circumstances of Luxembourg having the technology leadership in the cooperation, some dependencies arise for Germany with regards to organisation, scope and costs that show up as risk factors in the evaluation.

Evaluation



Utility aspects

Overall, all basic functional requirements are fulfilled with Luxembourg responsible for service creation.

Advanced SRTI intelligence and additional information is expected to a limited degree.

Technological aspects

The modular big data application using a state-of-the-art tool stack and planned self-learning algorithms is expected to be future-proof and scalable.

The integration of Germany-specific use cases and additional data sources is not guaranteed.

Organisational aspects

The cooperation has already been established and the partners are well aligned.

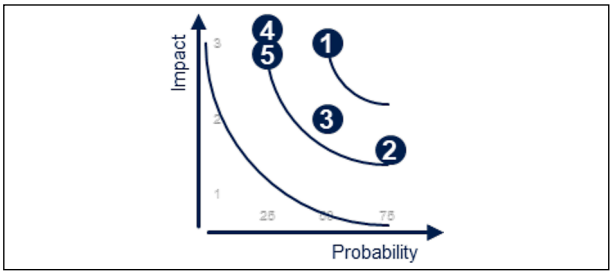
The difficulty of implementing feedback from German stakeholders as well as the organisational uncertainties regarding the continued operation of the service under a different LU ministry remain.

Cost aspects

Development and operating costs for the entire data processing chain are split with the partner.

The long-term budget and financial commitment of the cooperation partner is unknown.

Risks



1. Limited resources & capabilities pose the larges risk, since Luxembourg must be able to carry the development costs long-term.

1. Germany builds little expertise and risks falling behind in the data-driven economy.

2. The implementation of an AI platform is not guaranteed to work which leads to an uncertain utilisation of PoC and vision.

3. Depending on the handover between LU ministries, the unavailability of provider may pose a risk for Germany.

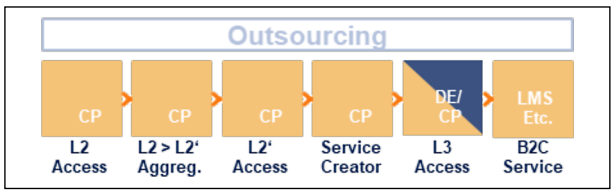
4. Depending on the implementation, incompatible data standards may pose a challenge for German TIC systems.

Scenarios and scoring

The state-of-the art IT concept and established partnership provide a cost-efficient, available and

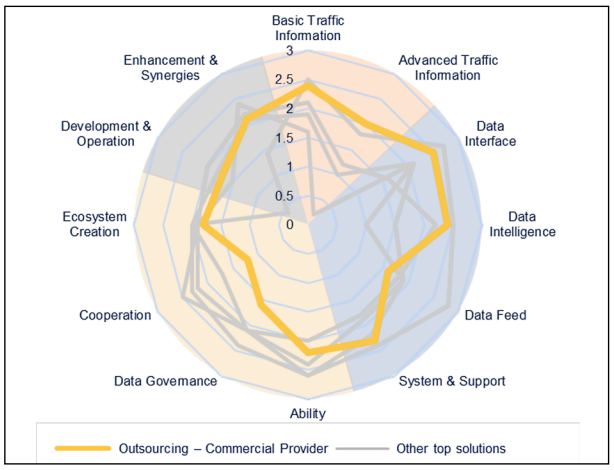
future-proof option for Germany that scores very well in all scenarios.

6.2.3 Option 3 – Outsourcing to an established commercial provider



In contrast to the solution options of commercial provider in Service Creation and Data Access, where a free, standard service is used by Germany, the complete Outsourcing option expects a customized solution with advanced features as a buy solution from a commercial provider. If available, the commercial provider is expected to provide the best data fusion and algorithm technology of all options but also to charge extensively for its service.

Evaluation



Utility aspects

Commercial providers are expected to be able to provide intelligent SRTI detection (e. g. even end-of-queue warnings), as well as integrate further non-OEM data sources.

Most innovations and additional data sources will not be available free of charge.

Technological aspects

State-of-the-art data platforms and algorithms combine usability with high data security.

Choosing a commercial provider will cause technological lock-in effects. Furthermore, limited transparency in data processing and algorithms is expected.

Organisational aspects

Established commercial providers combine market-leading expertise with high innovation and a short time to market.

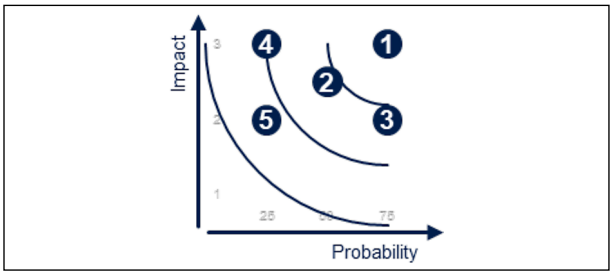
Most feedback will result in change requests and negotiations. L3 data will not be created by a public authority, possibly limiting its use as open data.

Cost aspects

Having an off-the-shelf product may reduce costs, especially if other member states choose the same solution.

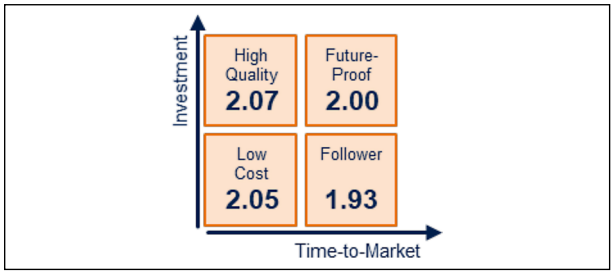
The operating and service costs are expected to be the highest among all options, while future pricing negotiations will leverage lock-in effects.

Risks



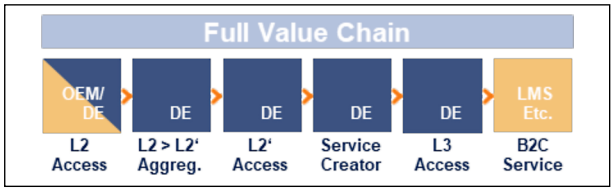
1. The unavailability of the provider due to not offering custom-made solutions risks the project feasibility for Germany.
2. The development of an advanced custom-made solution increases the risk of the implementation not being in budget.
3. Germany develops limited expertise in establishing a data-driven economy.
4. Limited resources & capabilities pose a long-term risk, since Germany has to keep financing a private provider that may alter its terms and conditions.
5. The solution risks having limited market value-add compared to standard commercial solutions (by the same provider).

Scenarios and scoring



The commercial provider solution scores very highly in all scenarios due to having a market-ready and proven product. The risks focus around the availability of certain providers and the overall costs of buying a customized solution from a private entity.

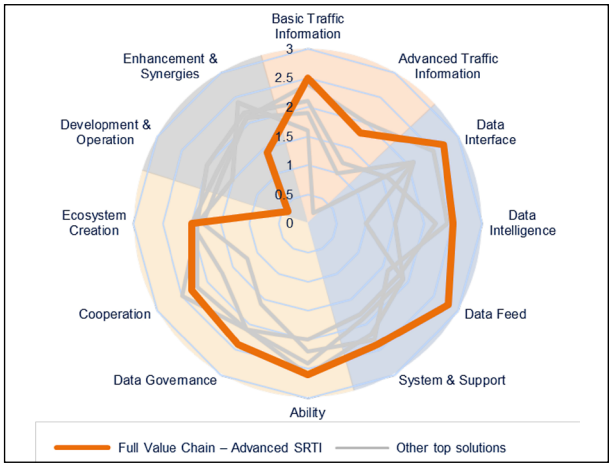
6.2.4 Option 4 – Proprietary full value chain solution "Advanced SRTI"



The Advanced SRTI solution promises the most sophisticated data intelligence of all public provider options, with significant investments into a future-proof framework and the extended integration of public and commercial data sources.

With the flexibility that comes from developing the custom-made solution internally, the end result is expected to fulfil all basic and extended requirements of the stakeholders, with costs and available expertise being the limiting factors.

Evaluation



Utility aspects

Advanced intelligence and integration of all available data sources enable advanced SRTI.

Floating car and other data must be acquired commercially or integrated additionally from other public entities.

Technological aspects

The expected modular and scalable tool stack with AI and big data applications make the solution future-proof.

The entire IT infrastructure has to be developed and built from the ground up.

Organisational aspects

Germany retains full control over implementation and data. L3 data may be available as open data.

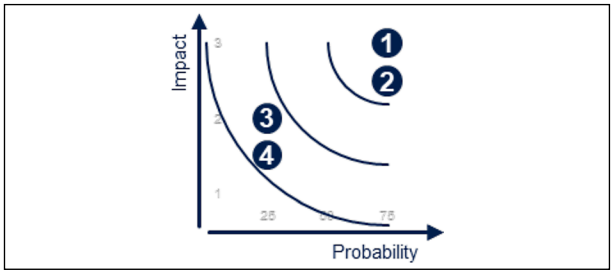
The development is expected to take time, while expertise and innovation have to be proven.

Cost aspects

Processing the data in one place promises interfacing synergies. Stakeholders may be more willing to contribute to a national solution.

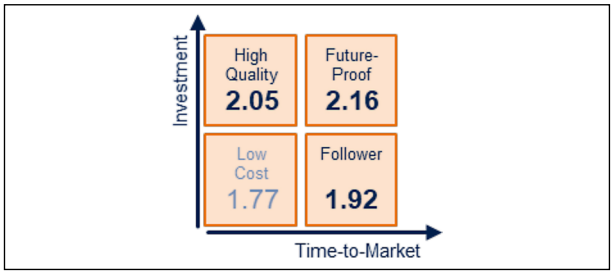
Development costs are expected to be very high and cannot be shared with any partners.

Risks



1. Limited resources & capabilities pose the largest risk, since Germany has to build up its own advanced processing expertise.
2. The development of a self-made solution from ground up increases the risk of the implementation not being in budget.
3. The advanced approach for SRTI generation is not guaranteed to work which leads to an uncertainty in the realisation of the vision.
4. Even for public data publishers, the uncertain form of the Multi-Party Agreement may not allow third-party data access outside of the DTF ecosystem.

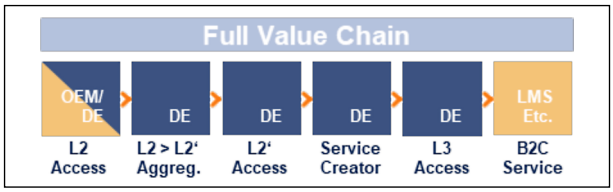
Scenarios and scoring



The Advanced SRTI solution is expected to have the highest quality and best future viability which

makes it the best option for all scenarios, where a willingness to make the required investments exists.

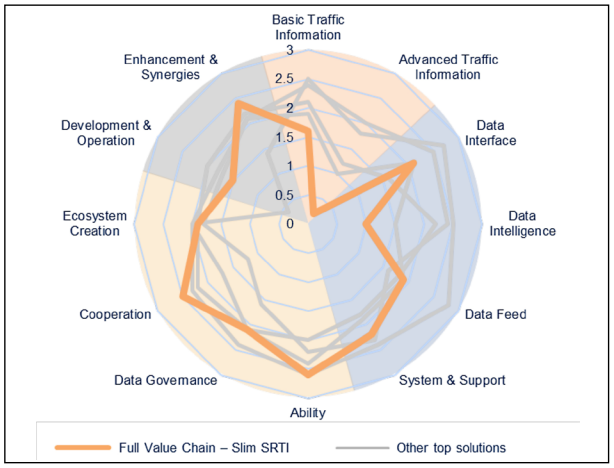
6.2.5 Alternative option for low-cost scenario – Proprietary full value chain solution "Slim SRTI"



The Slim SRTI solution takes the leanest possible approach to data intelligence and organisation, focussing only on the essential requirements of vehicle safety warnings for road users. Aspects like functionality, scalability and customizability are traded off for affordability, robustness and time-to-market.

Having the development in the own hands would allow Germany to act in a timely manner and still have the potential to integrate more advanced requirements, with necessary investments, in the future.

Evaluation



Utility aspects

Overall, all basic functional requirements are fulfilled.

Due to limited scope, advanced SRTI intelligence and additional information is not included.

Technological aspects

The simple IT architecture reduces the complexity, while Germany retains the flexibility to extend its services at a later time.

The entire IT infrastructure has to be developed and built from ground up and the number of data sources is limited.

Organisational aspects

The overall organisation is kept lean. Germany retains full control over decisions and data. L3 data may be available as open data.

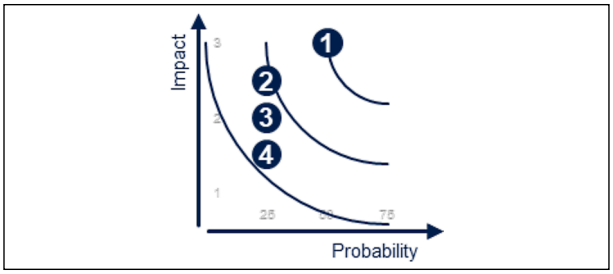
Expertise and future ability have to be proven.

Cost aspects

Processing the data in one place promises interfacing synergies. The limited scope reduces costs. Stakeholders may be more willing to contribute to a national solution.

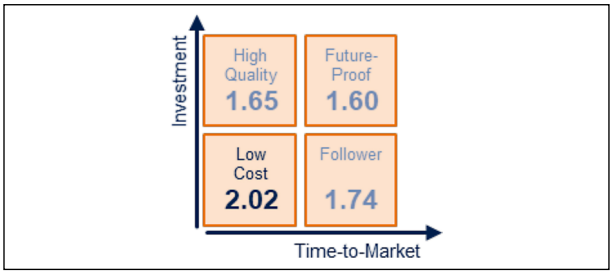
Nevertheless, development costs cannot be shared with any partners.

Risks



1. Limited resources & capabilities pose the largest risk, since Germany has to build up its own processing expertise.
2. The development of a self-made solution from ground up increases the risk of the implementation not being in budget.
3. Only building a Slim SRTI solution may provide limited market value-add compared to standard market solutions.
4. Even for public data publishers, the uncertain form of the Multi-Party Agreement may not allow third-party data access outside of the DTF ecosystem.

Scenarios and scoring



The Slim SRTI option can only be recommended in the Early Adopter – Low Cost scenario, where Germany wants to move quickly, while keeping costs low. If the overall strategy is more long-term focused, other solutions which do not sacrifice functionality for simplicity, are preferable.

6.3 Summary of high-scoring solution options

As previously described, four solution options as well as an addition low-cost approach have emerged as most promising. In the following, the high-scoring solutions will be seen in the context of the respective solution option group and contrasted to the other high-scoring solution options.

Service Creation – EU Solution

Within the Service Creation options, the EU Solution for data aggregation emerges as the best option. It combines the best of two worlds: First, a highly standardised and cost effective L2 data aggregation in a centralised EU-wide approach. Second, the flexibility to develop a Service Creation targeting the specific needs of the stakeholders with the possibility to also enrich the vehicle data with further non-OEM data. In Figure 20 it can be seen that the Service Creation – EU Solution does not score highest in any of the evaluation categories when compared to the four other top-scoring options. Instead, the approach scores well across the board – implying this to be a well-balanced and reliable solution option.

Full Value Chain – Slim and Advanced SRTI

The two solution options from the Full Value Chain group, although similar in roles, differ greatly in terms of scope and therefore costs. While both approaches target a fast time-to-implementation, Slim SRTI tries to provide only the basic functionality required for SRTI. Its biggest strength, apart from cost considerations, is the simplicity in organisation and technology which allows a lean and agile form of project and stakeholder management within a limited scope.

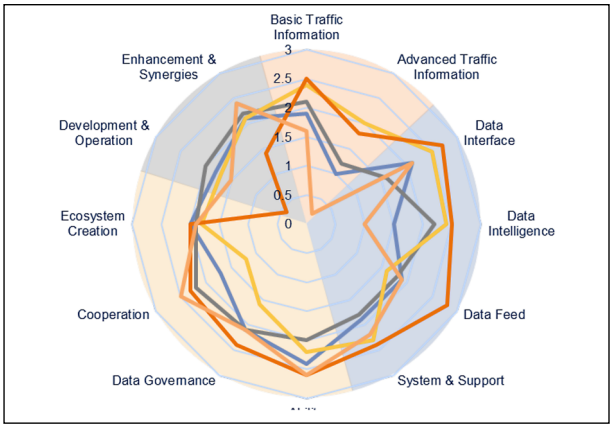


Fig. 20: Spider chart of the highest rated solution options by category scores.

On the other end of the spectrum, Advanced SRTI puts an extensive focus on advanced features and functionality, prioritising quality over cost. As the premium option, it outscores all other top-performing solution options in categories such as Basic Traffic Information, Data Interface, Data Intelligence, Data Feed, System & Support, Ability, Data Governance, Cooperation and Ecosystem Creation.

Ultimately, it is conceivable that a viable approach is to start off with a slim solution that is set up in a way so that it can be expanded with relative ease into a more advanced solution with experience and time.

Outsourcing – LU-DE Cooperation and Commercial Provider

Among the three analysed Outsourcing options, both the Commercial Provider solution as well as the LU-DE Cooperation rank among the high-scoring solution options. Nevertheless they differ substantially in their design, either relying on a buy solution or public development within the cooperation.

Buying a solution from an established commercial provider promises to provide high quality and sophistication due to their extensive experience with fusing and interpreting such data, providing easy to connect APIs and using state-of-the art technology. Accordingly, the solution option scores excellent in the categories Basic Traffic Information, Advanced Traffic Information, Data Interface, Data Intelligence and System & Support. On the other hand, due to being locked-in the platform of the service provider and the switching barriers associated to this as well as the potential non-transparency of such a solution, it scores lowest in Data Feed, Data Governance and Cooperation. Considering the limitation of business models by the Delegated Regulation 886/2013, private players may not even be willing to offer developing the service in the first place, as the solution might not be scalable to other customers and the profit potential is expected to be limited.

In comparison, the cooperation with Luxembourg scores best in Development & Operations as well as well in further organisational aspects. This is especially a proof to the groundwork of the existing partnership and the potential to have a solution operational in the near-term. Even more so, many uncertainties and risks of other third party options can be discarded due to the proven cooperation. Considering the current data-driven economy strategy of Luxembourg and the great vision for processing vehicle-generated data, it needs to be considered as a risk though that such an advanced solution might not be driven all the way into a long term operational mode.

Ultimately, when focusing on an outsourcing solution with an established partner, the *LU-DE Cooperation* is a solid foundation with an interesting vision that has already been proven itself in the PoC phase. In contrast, buying a solution from a commercial provider promises proven high quality and extensive features.

6.4 Strategic context of evaluation results

The goal of the evaluation approach was to identify promising solution options to connect to the sources for vehicle-generated data, process the data and make it available for use by stakeholders. Different solution options leveraging different degrees of collaboration and outsourcing seemed interesting at first glance. Ultimately, considering different strategic scenarios and associated risks, five different solution options as previously described were identified to be most promising.

Thinking ahead, the evaluation results have to be viewed in the context of an overall strategic positioning. For this it is relevant to consider certain constraints, e. g. regarding budget or capabilities, as well as requirements, e. g. regarding data intelligence or development control. Understanding the high performing solution options in the light of the defined strategic scenarios can be a first step towards decision-making.

Low Cost scenario

If budget is constrained and the stakeholders are satisfied with core information included in the vehicle messages provided free of charge by the OEMs, then investments into advanced data fusion and intelligence can be postponed until their availability increases.

In this case, the Slim SRTI is suited well due to its lean organisation and good cost-effectiveness. Outsourcing to a commercial provider can also yield fast results with fewer development costs.

High Quality scenario

If time is limited and Germany does not want to sacrifice advanced functionality in the near-term, an investment into data processing can prove worthwhile.

Developing a custom Advanced SRTI solution from ground up is assumed to meet all requirements, while Outsourcing – Commercial Provider is expected to be the best near-term solution, due to their market position and experience.

Follower scenario

In case Germany is willing to postpone their own entry into the vehicle data ecosystem, choosing a cost-effective solution without sacrificing advanced features becomes more feasible.

In this scenario, several options are possible but it is expected to be the safest path to remain in the proven LU-DE Cooperation.

Future-Proof scenario

If Germany wants to start building their own expertise in the data-driven economy of traffic data, SRTI would be a good place to gain experience and form a basis both technologically and organisationally, for future use cases.

Here, the Advanced SRTI solution is highly recommended, achieving the best score of any option in any scenario. The data processing is built from ground up using a modern tool stack and the stakeholders retain full control over the end product.

7 Conclusions

Within this project, ten different solution options to generate safety related traffic information (SRTI) based on vehicle-generated data have been evaluated. The results of the evaluation build the foundation in order to develop recommendations for action for Germany.

The evaluation was interview-based, with the input from German and Luxembourgish stakeholders as well as European experts from the DTF ecosystem. Based on their feedback, an evaluation concept was created that designs ten possible solution options for data processing and defines 44 evaluation criteria that consider all key aspects of the ranking.

Using a bottom-up approach with a subsequent top-down validation step, the solution options were scored along all evaluation criteria. The scores were weighted and aggregated based on different strategic scenarios that model possible market positioning strategies for Germany. In a separate view, eleven risks and uncertainties were identified and quantified with regards to their impact and likelihood for each solution option.

The evaluation results have shown that four solution options score highest in three of the four analysed strategic scenarios (referred to as “top solution options”), whereas two additional options score highly in the cost-efficient scenario (referred to as “cost-efficient solution options”). The four top solution options have assets and drawbacks:

- Full Value Chain – Advanced SRTI is rated highest in most categories and promises to be the most future-proof solution for Germany but very high development costs may stand in its way.
- Outsourcing – Commercial Provider ensures the best functionality and technology available on the market to be deployed within a short time span. Over time organisational challenges and costs are expected to increase.
- Outsourcing – LU-DE Cooperation has good functionality with the best value for money among the top solutions. Although the partnership is established and proven, the dependency on another organisation poses risks in the future.
- Service Creation – EU Solution combines cheap data aggregation with flexible service creation that ensures a strong position for a future data strategy. Both the EU cooperation and the required German expertise will have to be acquired before the solution can be realised.

From the two cost-efficient options, only the first solution is preferred, since the second one has too many risk points:

- Full Value Chain – Slim SRTI only requires a short development time with little investment while allowing a lean organisation structure. Over the long-term, the limited functionality may prove to be insufficient.
- Outsourcing – EU Solution has the advantage that implementation and operation costs can be split by all member states, however it would require too many EU-wide decisions and agreements and might not consider country-specific requirements.

The recommendation for Germany will be based on these selected solution options and will be discussed for Germany based on the strategic market positioning.

How the results could be interpreted

The focus of the project was the development of suitable evaluation criteria for examining the quality and fit of solution options for the requirements of the stakeholders. With the exception of the established LU-DE Cooperation, the analysed solution options were all developed in a Greenfield approach and are theoretical in nature. Therefore, it is not guaranteed that the assumptions that went into designing the solution options, especially with regards to availability and pricing, will hold true in the future. In particular, this evaluation will not be able to substitute an economic feasibility study that focuses on the cost details of the available processing solutions. However, the evaluation fully considers the requirements of German as well as Luxembourgish stakeholders’ and ranks the solution options according to fit and quality regarding utility, technology organisation and assumptions on cost.

To which extend the results might be transferable to other EU member states

In general, the evaluation results, the developed solution options, the designed evaluation criteria and the risk analysis are more or less applicable to any other EU member state within the Data Task Force ecosystem in order to develop or evaluate their SRTI data strategy. Nevertheless, some aspects are motivated by a German perspective and need to be reviewed before applying the evaluation concept to another member state, e. g. the evaluation of the LU-DE Cooperation, some scores are evaluated with respect to German stakeholders and the strategic scenarios (defining the criteria weighting) are designed for Germany. On the other hand, it is not expected that the

evaluation criteria, the main groups of solution options or the risk analysis will be different for another EU member state.

Acknowledgments

The project team thanks all interview partners for the willingness to participate in this research project and their openness in sharing and discussing their vision for the data processing chain. In addition, the project team thanks Timo Hoffmann (BASt) for his excellent support and supervision as well as the two additional reviewers from BASt for their valuable and insightful comments.

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A Appendix: Overview of interviews and meeting participation

As part of the interview-based approach, several calls and presentations with stakeholders, DTF partners and interested parties were held.

The documented interviews form the foundation for the evaluation concept. All meeting minutes were aligned with the interview partners.

In addition to the interviews, the project team was invited to participate in the Tech Group meetings of the Data Task Force for Road Safety.

A.1 Interviews with German stakeholders

The following calls with German road authorities, traffic warning services, traffic managements and public broadcasting stations were held:

- 26.03.2020: Straßen.NRW
- 31.03.2020: Landesrundfunkanstalten/Hörfunk (WDR, HR)
- 01.04.2020: Landesmeldestelle NRW
- 02.04.2020: C-Roads Germany Projekt*4
- 22.04.2020: Landesmeldestelle Bayern
- 24.04.2020: Zentralstelle Verkehrsmanagement Bayern
- 05.05.2020: Landesmeldestelle Hamburg

The project team thanks all stakeholders for their willingness to participate in the project and for their input to the evaluation.

A.2 Interviews with EU member states and commercial providers

The following interviews with DTF partners were held:

- 30.03.2020: Luxembourg (Ministry of Economy, Post and Intech)
- 01.04.2020: Netherlands (Ministry of Infrastructure and NDW)
- 08.04.2020: HERE
- 14.04.2020: Spain (Directorate-General for Traffic)
- 21.04.2020: TomTom
- 22.04.2020: Finland (TrafiCom)
- 29.04.2020: Austria (ASFiNAG)
- 04.05.2020: Luxembourg (Ministry of Mobility and Public Works)
- 07.05.2020: Luxembourg (IT provider)

The project team thanks all member states and commercial providers for sharing their vision in processing vehicle-generated data and the insights in their current developments.

A.3 Participation in DTF Tech Group meetings

The following DTF Tech Group meetings were attended:

- 05.03.2020: Meeting, Utrecht
- 25.03.2020: Web Call
- 03.04.2020: Web Meeting (instead of on-site meeting in Birmingham)
- 15.04.2020: Web Call
- 29.04.2020: Web Call
- 13.05.2020: Web Call
- 02.06.2020: Web Call

The project team thanks for the invitation to the Tech Group meetings and the possibility to contribute insights and evaluation results.

B Appendix: Detailed questions to be considered for the evaluation

The solution options outlined in the evaluation concept were scored along several dimensions. These dimensions or aspects, were further grouped into categories and evaluation criteria in the evaluation tool excel file. Each criterion contains

4 Presentation for representatives of various members of the C-Roads Germany Project.

several detail questions that were used as guidelines to delimit the criteria as well as help identify a measure from 0 to 3 on predefined scoring schemes.

B.1 Focus on utility aspects

From a utility perspective, a good solution provides the requested functionality for relevant use cases with a high level of information. These aspects will be scored in the following categories and evaluation criteria with the corresponding questions:

Basic Traffic Information

- Basic SRTI categories will consider the questions:
  How extensive are simple SRTI categories made available in the NAP? Will SRTI messages be based on sub-categories or only on categories?

- Information level and event types will consider the questions:
  Will basic information be part of the SRTI messages, e. g. location, time, SRTI type? Will additional information be provided in the messages, e. g. lane position, travel times, direction? How well are events map matched?

- Non-vehicle data enhancements will consider the questions:
  Will non-vehicle data be considered in the creation of SRTI messages, e. g. for planned roadworks or current weather? Will additional non-vehicle information be included in the messages, e. g. weather, visibility?

Advanced Traffic Information

- Intelligent SRTI categories will consider the questions:
  What is the level of intelligence? Are SRTI categories that go beyond simple SRTI categories made available, e. g. short term road works or end-of-queues?

- Extensibility to non-SRTI events will consider the questions:
  Which additional safety relevant events or status messages can be delivered that go beyond SRTI categories, e. g. end-of-queue? Can events be delivered that address other stakeholders, e. g. weather, asset management, etc.?

- Event lifecycles will consider the questions:
  Are event lifecycles considered, e. g. end of an event like “accident” or “slippery road”? Are status updates, e. g. for moving wrong way driver or moving traffic jam included? Will lifecycle-relevant information of events be provided, e. g. first time of reporting, duration, probability?

B.2 Focus on technological aspects

From a technological perspective, a good solution uses standardised interfaces, intelligent algorithms and the right tool stack in order to provide traffic information in real-time. These aspects will be scored in the following categories and evaluation criteria with the corresponding questions:

Data Interface

- Standardisation will consider the questions:
  Are established standards used within the data process, e. g. SENSORIS and DATEX II? Is the L3 data made available in DATEX II or even via further protocols, such as DENM or TPEG2-TEC?

- Integration will consider the questions:
  How easily can the event feed be included in existing TIC systems? How much integration work has to be done to onboard B2C service providers, e. g. road authorities?

- Real-time capability will consider the questions:
  How high is the latency of messages provided? How does the data processing chain look like, e. g. direct access, data loops, redundant paths?

Data Intelligence

- Intelligence in harmonisation will consider the question:
  Are algorithms for harmonisation/data cleansing in place?

- Intelligence in service creation will consider the question:
  How advanced are the algorithms for service creation, e. g. are artificial intelligence methods applied?

- Intelligence in reliability will consider the questions:
  How extensive are confidence checks implemented, e. g. event type, location and time? How extensive are ground-truth checks included, e. g. validation with traffic cameras?

- Intelligence in continuity will consider the questions:
  Are checks in place to ensure the continuity of SRTI-messages and potentially their lifecycle events, e. g. no frequent changes between slippery road and non-slippery road?

Data Feed

- Flexibility and filterability will consider the questions:
  How well can event types be filtered/classified according to prioritisation and need, e. g. ignore rain updates? Can the balance between latency and quality of information be influenced according to needs , e. g. wrong-way drivers must be responded to immediately, even if confidence is low? Can the three-level classification of SRTI for broadcasting priority be handled?

- Data storage will consider the questions:
  How long is the information of all data providers and service providers archived, e. g. are minimum requirements met (24 months in Germany)? To what extent can historical data be provided?

- Data sources will consider the questions:
  How many OEM data sources are included in the service creation? How many non-OEM data sources are included in the service creation?

- Traceability will consider the questions:
  How well can the creation of an individual message be traced back to its sources? How transparent are the involved data sources in the final L3 message?

System and Support

- System tools will consider the questions:
  Is the tool stack “state of the art”, e. g. allows modern data handling and machine learning implementations?

- System architecture will consider the questions:
  Is a modular data process set up? Can individual parts be exchanged at a later time? Is the system architecture future-proof and scalable?

- System extensibility – data sources will consider the questions:
  How easily are new data sources integrated?

- System extensibility – use cases will consider the questions:
  How easily can additional use cases be developed in the future? How adaptable is the system in including new use case information? (e. g. processing, storage, map visualisation) How easily can stakeholders include proprietary algorithms into the processing?

- Monitoring will consider the questions:
  How well does the system handle and report errors? How well does the system handle and report false, incomplete or empty data streams? Does the system have fallbacks and processes for fast reaction in place? How detailed, transparent and fast is the reporting process?

- Support will consider the questions:
  How well are stakeholders supported in integrating and operating the solution on their infrastructure? How well are stakeholders supported in developing new functionalities for their systems? How well are stakeholders supported in changing or upgrading their systems?

- Security will consider the question:
  Is the system conform to required security standards? How well is the data protected against access and manipulation?

B.3 Focus on organisational aspects

From an organisational point of view, a good solution has a clear definition of responsibilities, might enable cooperation and will promote innovation in the foreseeable future. These aspects will be scored in the following categories and evaluation criteria with the corresponding questions:

Ability

- Control and influence scores will consider the question:

  How much control do involved countries and service providers have over the development of SRTI algorithms? How much control do involved countries and service providers have over the implementation of new use cases?

- Expertise will consider the questions:
  How experienced and competent are the designated parties in their respective roles? How

valuable is expertise gained through this role allocation, e. g. data insights, process and system know-how? How easily can the required expertise be acquired, if necessary?

- Medium-term Potential will consider the questions:
  What medium-term potentials arise when implementing the solution? Which improvements/ additional services can be realised over time? How will the learning curve improve results in the future?

- Time-To-Market will consider the questions:
  How soon can the solution be implemented? How do upcoming decisions and legislations affect the timeline? Do logistic dependencies affect the implementation?

Data Governance

- Data quality checks will consider the questions:
  Which kind of data quality checks are performed? Can blind spots be identified? How well is the data validated against other information? (e. g. other OEMs, weather data) How many entities run independent data quality checks?

- Data quality feedback will consider the questions:
  To what extent can feedback on data quality be integrated in the value chain, e. g. feedback from B2C service providers? Will data quality reports be pushed to all B2C service providers?

- Data ownership will consider the questions:
  How well is the data ownership defined across the players involved in the value chain? How well is the responsibility for the data quality and security defined across the roles? How well defined are processes that support and ensure data quality and security?

- Documentation will consider the questions:
  How well are the data processing steps and service creation algorithms documented? How well are the APIs and the onboarding process documented?

Cooperation

- Cooperation model will consider the questions:
  How well does the solution enable cooperation potential/synergies between countries, e. g. cross-border solutions? How well does the solution enable cooperation potential/synergies between private and public entities? How well is the cooperation supported or hindered by regulatory frameworks, e. g. national, EU?

- Cooperation complexity will consider the questions:
  How many stakeholders are involved in the solution? How well do stakeholders align in their goals, e. g. different countries have different constituents? Are processes in place to align on decision-making, e. g. use cases, data feed integration, etc.?

- Coordination will consider the questions:
  How much overlap between responsibilities exists? How high is the need for coordination and steering? How much may language barriers negatively impact the working efficiency? How clearly can the costs be split across the different parties, e. g. in a cooperation?

Ecosystem Creation

- Ecosystem sustainability will consider the questions:
  How high are the risks of monopolisation within the ecosystem in terms of technical know-how or network/access effects? How large is the dependency on one or several players in the ecosystem? How large is the ratio of independent data sources to brokers within the data provision?

- Open data potential will consider the questions:
  Is all SRTI-related data provided to end users free of charge? To what extent is SRTI-data made available as open data? Can all interested parties access the SRTI without discrimination?

- Innovative capability will consider the questions:
  How much does the solution encourage competition? How much does the solution encourage innovation? How low is the barrier of entry for new parties? How easily does the ecosystem allow for continuous improvement? Does the platform allow the extension into private/commercial business cases?

B.4 Focus on cost aspects

From a cost perspective, a good solution is efficient in its use of money and resources during initial setup, operation and future enhancements. These aspects will be scored in the following categories and evaluation criteria with the corresponding questions:

Development and Operation

- Development cost will consider the questions:
  How expensive is it to develop the solution? How much does outsourcing affect the development costs?

- Infrastructure operating cost will consider the questions:
  How expensive is it to operate the system? How much effort will have to be put into maintenance and operation? How much does outsourcing affect the infrastructure costs?

- Service operating cost will consider the questions:
  How expensive is it to provide service levels? How expensive are Hotline and Bugfixing services? How much does outsourcing affect the service costs?

Enhancement and Synergies

- Enhancement cost will consider the questions:
  How expensive is the integration of new data streams, including development cost and testing costs? How expensive is the development of new algorithms for services, including development costs and testing costs?

- Onboarding cost will consider the question:
  How expensive is the onboarding of other countries or stakeholders?

- Profit and synergy potential will consider the questions:
  How much synergy is created, e. g. in terms of development costs, operating costs or enhancement costs? Might the system have the potential to replace existing processes or systems? How much income or funding can be generated by the system?

Schriftenreihe

Berichte der Bundesanstalt für Straßenwesen

Unterreihe „Fahrzeugtechnik“

2015

F 100: **Verhaltensbezogene Kennwerte zeitkritischer Fahrmanöver**
Powelleit, Muhrer, Vollrath, Henze, Liesner, Pawellek € 17,50

F 101: **Altersabhängige Anpassung von Menschmodellen für die passive Fahrzeugsicherheit**
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F 102: **6th International Conference on ESAR „Expert Symposium on Accident Research“**
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F 103: **Technische Möglichkeiten für die Reduktion der CO2-Emissionen von Nutzfahrzeugen**
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F 104: **Abbiege-Assistenzsystem für Lkw – Grundlagen eine Testverfahrens**
Schreck, Seiniger € 14,50

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Schmidt, Georges € 14,50

F 105b: **Examination of pollutants emitted by vehicles in operation and of emission relevant components – In-service conformity**
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F 106: **Untersuchung des Abgasverhaltens von in Betrieb befindlichen Fahrzeugen und emissionsrelevanten Bauteilen – Austauschkatalysatoren**
Schmidt, Johannsen € 13,50

F 106b: **Examination of pollutants emitted by vehicles in operation and of emission relevant components – Replacement catalytic converters**
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F 107: **Sicherheitsaspekte beim Laden von Elektrofahrzeugen**
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F 108: **Interoperabilität zwischen öffentlichem Verkehrsmanagement und individuellen Navigationsdiensten – Maßnahmen zur Gewährleistung**
von der Ruhren, Kirschfink, Ansorge, Reusswig, Riegelhuth, Karina-Wedrich, Schopf, Sparmann, Wöbbeking, Kannenberg € 17,50

F 109: **Ermittlung des Umfangs von Abweichungen bei Durchführung der Abgasuntersuchung zwischen Messung am Auspuff und Abfrage des On-Board-Diagnosesystems**
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F 110: **Wahrnehmung und Bewertung von Fahrzeugaußengeräuschen durch Fußgänger in verschiedenen Verkehrssituationen und unterschiedlichen Betriebszuständen**
Altinsoy, Landgraf, Rosenkranz, Lachmann, Hagen, Schulze, Schlag
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F 111: **Geräuschminderung von Dünnschichtbelägen**
Schulze, Kluth, Ruhnau, Hübelt
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2016

F 112: **Ersatz von Außenspiegeln durch Kamera-Monitor-Systeme bei Pkw und Lkw**
Schmidt, Hoffmann, Krautscheid, Bierbach, Frey, Gail, Lotz-Keens € 17,50

F 112b: **Final Report Camera-Monitor-Systems as a Replacement for Exterior Mirrors in Cars and Trucks**
Schmidt, Hoffmann, Krautscheid, Bierbach, Frey, Gail, Lotz-Keens
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F 113: **Erweiterung der Software TREMOD um zukünftige Fahrzeugkonzepte, Antriebe und Kraftstoffe**
Bergk, Heidt, Knörr, Keller € 15,50

F 114: **Barrierefreiheit bei Fernlinienbussen**
Oehme, Berberich, Maier, Böhm € 17,50

F 115: **Statischer und dynamischer Fahrsimulator im Vergleich – Wahrnehmung von Abstand und Geschwindigkeit**
Frey
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2017

F 116: **Lang-Lkw – Auswirkung auf Fahrzeugsicherheit und Umwelt**
Süßmann, Förg, Wenzelis
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F 117: **7th International Conference on ESAR „Expert Symposium on Accident Research“ – Reports on the ESAR-Conference 2016 at Hannover Medical School**
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F 118: **Bedeutung kompensativer Fahrerstrategien im Kontext automatisierter Fahrfunktionen**
Voß, Schwalm € 16,50

F 119: **Fahrzeugtechnische Eigenschaften von Lang-Lkw**
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F 120: **Emissionen von über 30 Jahre alten Fahrzeugen**
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F 121: **Laufleistungsabhängige Veränderungen der CO2-Emissionen von neuen Pkw**
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2018

F 122: **Revision der Emissionsmodellierung für leichte Nutzfahrzeuge – Bedarfsanalyse auf Basis einer Vorstudie**
Auf der Maur, Strassburg, Knörr, Heidt, Wuethrich
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F 123: **Motorradschutzhelme – Identifizierung ihres Verbesserungspotenzials unter Berücksichtigung des Motorradunfallgeschehens**
Pollak, Schueler, Bourdet, Deck, Willinger € 19,50

F 124: **Aufbau eines Qualitätsmanagementsystems für die Erfassung und Weiterverarbeitung von Daten für IVS-Dienste**
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F 125: **Untersuchung zu Elektrokleinstfahrzeugen**
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2019

F 126: **Einfluss zunehmender Fahrzeugautomatisierung auf Fahrkompetenz und Fahrkompetenzerwerb**
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F 127: **Erhöhung der Verkehrssicherheit älterer Kraftfahrer durch Verbesserung ihrer visuellen Aufmerksamkeit mittels „Sehfeldassistent“**
Kupschick, Bürglen, Jürgensohn € 16,50

F 128: **Potenzieller gesellschaftlicher Nutzen durch zunehmende Fahrzeugautomatisierung**
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F 129: **Anforderungen an die dynamische Leuchtweitenregelung zur Vermeidung der Blendung entgegenkommender Verkehrsteilnehmer**
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F 130: **Infrastrukturbedarf automatisierten Fahrens – Grundlagenprojekt**
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F 131: **Fahrerassistenz- und Fahrerinformationssysteme (FAS/FIS) – Personale Voraussetzungen ihres Erwerbs und Nutzung durch ältere Kraftfahrerinnen und -fahrer**
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F 133: **Lkw-Notbremsassistenzsysteme**
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Altinsoy, Lachmann, Rosenkranz, Steinbach € 19,00

F 135: **Abweichungen von der akzeptierten Fahrleistungsschwelle in automatisierten Fahrsituationen**
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F 137: **Konzept für die Erzeugung eines ISO-konformen UML-Modells und Generierung eines GML-Applikationsschemas für DATEX II zur Verbesserung der Interoperabilität**
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