Exploring Design Requirements of Fleet Telematics Systems Supporting Road Freight Transportation: A Digital Service Side Perspective

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Abstract. Road freight operators (RFOs) optimize their fleet management processes using fleet telematics systems (FTSs). Therefore, the selection of FTSs by RFOs is driven by transport specifications from the customer side leading to substantial search costs. However, FTSs vary significantly in their design requirements to assist road freight operations. Hence, we analyze 74 web pages from FTSs of existing telematics vendors to elicit 31 design requirements (DRs) which we aggregated into nine requirement sets (RSs). Subsequently, 42 practitioners from five digital road freight service enterprises experienced in using FTSs validate the DRs and evaluate their importance with RSs following the Analytical Hierarchy Process (AHP) method. The results reveal that DRs and RSs promoting driver monitoring and IT integration are perceived more important than items promoting fleet and logistics support. Our contribution sheds light on an emerging topic in logistics and establishes a knowledge base that guides the design of future FTSs.

Keywords: fleet telematics system, road freight transportation, AHP, design requirement, digital transport management

1 Introduction

Digital technologies provide new opportunities for freight transportation in societies to optimize processes and reduce operational costs [1]. Particularly, road freight operators (RFOs) managing their commercial road fleets are increasingly attracted by nascent innovations and the development of information systems (IS) to achieve competitive advantages [2]. Telematics systems represent a technological enabler on the way toward advanced road fleet management that "[…] *connect the vehicle with the dispatching office, which means operations can be optimized dynamically while they are running.*" [3, p. 69]. Consequently, fleet telematics systems (FTSs) emerge growingly in the freight forwarding industry, allowing real-time communication and data transmission from truck fleets, freight assets (e.g., truck, trailer), and drivers to manage entire road fleets [4, 5]. Such FTSs enable a vast array of data benefits gained from road fleet assets and provide new data-driven possibilities for RFOs to optimize fleet operations, ensure vehicle and driver compliance, and offer advanced services to customers [6–12]. Since the generated data can be further integrated with other operational IS (e.g., Transport Management System (TMS)) FTSs can improve operational decision-making from a multifaceted stance for RFOs [4, 13]. At the same time, telematics-based platforms arise in the market to process the data from FTSs to realize digital transport management [14]. For instance, the digital platform provider RIO Cloud integrates FTSs from RFOs operating vehicles from different manufacturers to aggregate data for advanced decision-making. This leads to efficient fleet management based on the features of FTSs fostering connected and automated freight operation in a prospering telematics industry [5, 15]. Although FTSs seem to bear the potential to transform assets into "intelligent equipment" [16] by providing new data service opportunities [17], their selection is a challenging task for RFOs since the features must comply with transport requirements particularly from the shipper side leading to high search cost in a specific business domain.

Against this background, the design of FTSs does affect technological innovations in the transport and forwarding industry, even though this topic is still an understudied research area by scholars [2]. Given the scarce scientific contributions, existing research does mainly investigate FTSs as part of an integrated system (e.g., [4, 5, 15]) or discuss the impact of digital innovations for transport processes (e.g., [1, 2]). Given the potential of telematics technologies to support freight transportation, the emergence of FTSs in combination with digital platforms reveals new opportunities for design developments in IS research found in truck transportation [18]. Thus, this research aims at contributing to existing knowledge about the design requirements of FTSs for road fleet assets toward data-based road freight transportation. Consequently, we study the following research question (RQ) in this paper:

RQ: What are the design requirements that guide the development of fleet telematics systems to support road freight transportation?

To answer our research question, we collect data of vendors from the telematics market to establish a knowledge base of FTSs that initiates the described problem following a design science research (DSR) approach [19]. Afterward, we analyze the collected data and create a list of design requirements (DRs) and requirement sets (RSs). To decide on the applicability and importance of these DRs and RSs, we invite practitioners from five digital road freight service providers that are experienced with FTSs. Our study follows the Analytical Hierarchy Process (AHP) method enabling the creation of rankings of identified DRs and RSs. From the DRs and RSs ranked in this study, the optimized selection of DRs emphasizes guidance for a modular-based service concept and the identification of general knowledge to address the identified problem. From the findings of our study, FTSs are positioned to achieve digital road freight transportation for optimized fleet operations.

2 Research Background

2.1 Data-driven Value in Road Freight Transportation

To process complex transport logistics tasks, IS play an important role in operational transport management encompassing planning, execution, and monitoring [2]. In recent years, technological innovations, such as digital technologies and automation, driven by start-ups started to transform the freight transportation and forwarding service industry by providing digital business models and digital intelligence [20–24]. This resulted increasing in digital transport and logistics systems leading to new forms of digital service providers (e.g., digital freight forwarders) and emerging concepts enabling smart forwarding and logistics [20, 25–27].

However, the road freight industry is disrupted by digital transformation due to a fragmented market and innovative services emerge for advanced fleet management opportunities based on data generated from freight assets [1, 28]. To give an example, data retrieved from road fleets are gained to optimize vehicle routing and crew, support the quality of freight dispatching and planning, maintain safety, and enable predictive analytics [29, 30]. In this context, RFOs (e.g., carriers, forwarders) that operate in a complex environment with legally binding requirements have recognized that improved IS have a positive impact on service quality and profitability [31] since their use is crucial for achieving a sustained competitive advantage [32]. This phenomenon applies in particular to road fleets since IS facilitate communication and execution of logistics operations with physical road freight fleets.

The technology used to achieve road fleet optimization is telematics systems that provide a variety of functions to support road fleet operations mainly focusing on trucks [4, 5]. Integrated solutions for managing the physical flow of freight with other elements connected to vehicle status, transport operations, freight order execution, and monitoring are known as fleet management systems (FMSs) [15]. Similarly, a well-established IS for road freight operations is represented by Transport Management Systems (TMSs) applied by RFOs and shippers to process transport orders. Both FMSs and TMSs help to decide on the most economic transport scenario enabling data-driven transport management [33] for road fleets in terms of time, capacity, performance, and distance to improve operational cost and mitigate the effects to the logistics environment. Furthermore, real-time data gained from road freight assets offer growing value for other transport stakeholders (e.g., insurance companies) to support risk assessment from freight operations and driving performance (e.g., accidents) [10, 34].

2.2 Fleet Telematics Systems for Road Freight Transportation

The practical application of telematics technologies in the road freight business sector focuses mainly on the geolocation of a vehicle while it is on the road [35]. Likewise, a range of data services to manage several road fleet vehicles simultaneously exists to ensure efficient and optimized transport operations [4, 7, 15]. This results particularly for the optimization of fuel consumption by trucks with the objective to continuously optimize consumption rates and reduce emissions [36, 37].

While FMSs represents solutions based on IT to be applied for the management of trucks through surveilling processes and monitoring of vehicle status, one should likewise mention telematics technologies applied to transportation units, such as containers, or trailer. Therefore, existing telematics vendors offer solar track & trace devices to transmit real-time information (e.g., temperature) of the freight loaded, the position of the units, and other sensor-enabled data according to customer specifications [38]. For this reason, the FTSs in this study addresses an IS based on telematics technologies for **road fleet assets** comprising truck assets powered by an engine and controlled by a driver, and freight assets carrying the freight loads and connected to truck assets.

Following the basic structure of an FMS and for the purpose of our study, an FTS "[…] *consists in data collecting, processing, transmitting and analyzing within three subsystems: a data acquisition subsystem, a data processing subsystem and a subsystem for displaying contents to users.*" [15, p.60]. In the data acquisition subsystem, relevant data is retrieved from road freight assets equipped with telematics technologies by control area network (CAN) bus standard interface and positions systems (e.g., GPS). The collected data is transmitted by a data communication subsystem via a network (e.g., GSM) and centered by a cloud-based middleware connected to a data server. Subsequently, data is transmitted to a web front or mobile apps to make them visible to freight dispatchers, truck drivers, or road fleet operators. Furthermore, the transmitted data can be integrated with IS (e.g., TMS) via API interfaces to exchange data between the systems.

Overall, FTSs show a modular structure facilitating the implementation of other elements in the systems. From the elements and structure of an FTS (Figure 1), data-driven value propositions arise through a modular-based service approach which emerges increasingly through the integration with digital platforms. Hence, innovative business models emerge for the vehicle manufacturer and other digital road freight service providers toward "Connected-Truck-Services" [17]. Given the scope of varying design specifications based on the modular concept, this study aims at analyzing the design requirements of FTSs to support road freight transportation.

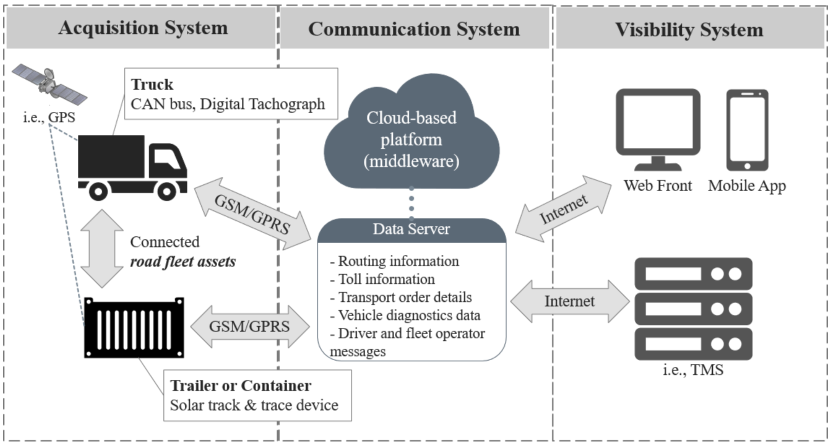

Figure 1. Elements and structure of fleet telematics systems based on [15]

3 Research Method

In this paper, we apply the Analytical Hierarchy Process (AHP) method to evaluate an established knowledge base of FTSs to answer our research question. In the next section, we present general information on the AHP method. Subsequently, we explain the process of data collection and aggregation of a knowledge base from existing telematics technologies offered by vendors in the road freight market. Furthermore, we outline the participants involved and presents details for the tasks for validation and evaluation of the collected data.

3.1 Analytical Hierarchy Process Method

Design science is a well-established discipline for IS research to provide design artifacts following various process steps [39]. Since we analyze existing FTSs from the market, we explore the importance of their features by the process of evaluation leading to a new design project for future IS [40]. Therefore, our evaluation strategy based on existing artifacts follows Venable et al. [41] that "*emphasizes formative evaluations early in the process, possibly with artificial, formative evaluations*" [41]. We adopt an evaluation approach of Feine et al. [42] who explore design knowledge for chatbots based on the work of Karlsson et al. [43]. Feine et al. [42] utilize their results to prioritize rankings for design knowledge of chatbots promoting different design features and design principles following the Analytic Hierarchy Process (AHP). AHP is a decision-making method based on pairwise comparisons between different aspects of a problem, resulting in their relative importance [44]. A refinement of the AHP definition emphasizes that it "*relies on the judgements of experts to derive priority scales*" [45]. This promising method has been widely applied in IS research for ranking critical success factors (e.g., [46]) and the support of decisions making and prioritizations involving different participants [43]. Following this line of thinking, "*the resulting priorities are relative and based on a ratio scale, which allows for useful assessments of requirements*" [43]. Consequently, if the evaluation comprises n elements, then n*(n-1)/2 pairwise comparisons need to be executed. Moreover, raters decide for each pairwise comparison which aspect is more important and indicates the extent between the elements. The elements can be aggregated to make the evaluation process more efficient and the resulting hierarchies form the basis for comparisons by participants [42]. To ensure consistency of the generated values, a consistency ratio (CR) is typically used to indicate the significance of inconsistencies. That is, if the value of CR is lower or equal to 10%, consistency is assumed. Therefore, we applied the online "AHP Priority Calculator"[1] to compile the CR of our results during the evaluation. However, we decided to accept the results even in the case of a CR value greater 10%, since repetition of pairwise comparisons with study participants is intended along the later stages of a DSR project. In addition, our evaluation study focuses on the hierarchical list of the evaluated DRs and RSs of FTSs based on the values obtained from participants, which is an accepted approach in IS research (e.g., [42]).

[1] https://bpmsg.com/ahp/ahp-calc.php (accessed on 2021-08-05 and 2021-08-11)

3.2 Elicitation of Vendor Requirements for FTSs

Descriptive knowledge enhances the understanding of existing artifacts in the IS field driven by technological innovations [47] that centers knowledge based on design science research activities comprising theories, experiences, expertise, and existing artifacts [19]. However, in this paper, we contribute to existing knowledge by analyzing design requirements of existing artifacts referring to an identified problem [48]. In the background section, we pointed out that scientific literature examines FTSs mainly in the context of FMSs and we noticed that scholarly efforts for FTS design are not exhaustive. Therefore, we derive requirements by available features from objects [49] represented by FTSs in the real world. To analyze the design from FTSs, we study existing telematics technologies offered by vendors following two steps: (1) we analyze web pages of vendors that offer FTS solutions and identify their DRs, (2) we refine the items and aggregate the findings in overarching requirement sets (RSs).

Consequently, we elicited functions from existing FTSs solutions applied in practice by conducting a web content analysis to derive DRs and RSs [50]. The objective of our approach was to look at the design of FTS in practice and to collect a range of available DRs from telematics technologies applied by RFOs. Since telematics systems for road fleets are emerging vastly (e.g., driver's compliance [5] and IS integration [7]), their applicability in practice offers opportunities for future innovations matching design science requirements [51]. Thus, the collected data helped us to compare the different solutions and to determine the relevance of DRs which seem to be most important for the design of FTSs from a vendor perspective. For the selection of FTS, the web page "Telematik-Markt"[2] was used to identify relevant FTSs from the market. This led to a "TOPLIST" of telematics vendors from the countries Germany, Austria, Switzerland that allowed us to compile a **purposive sample** including 74 vendors supporting the selection of units for our analysis [53]. Additional technical details and other product information provided without functional relevance of FTSs were ignored.

To analyze the data, we systematically analyzed content from web pages of FTS vendors according to Lai and To [51] and condensed final FTS functions. The findings were discussed among the authors and from the interpretation of our data, we arrived at a final set of DRs assigned to overarching RSs. The elicited DRs were assigned to a defined structure that makes them comparable and enables the evaluation of DRs at a later stage. This concept follows the design template recommended by Rupp [54] and Feine et al. [42] to describe the functional design requirements. Following the view of Rupp [54] and Feine et al. [42] we describe a subsystem (e.g., FTS) including the legal commitment (e.g., shall: legally binding, should: not legally binding, will: future requirements), the activity (e.g., driver interaction, vehicle interface requirement), and an object of interest (e.g., driver, truck). To give an example, an FTS (i.e., system) should (i.e., legal commitment) support communication (i.e., activity) by individual messages with truck drivers (i.e., object). From the results of our web page analysis, we assigned the gained knowledge to the framework and formalized Ds. The articulation of our requirements was performed with the legal commitment *should* and hence justifies the modification of DRs according to individual situations in practice [42, 54]. Overall, a

[2] https://telematik-markt.de/toplist#.YSx4AedCSv4 (accessed on 2021-06-16)

list of 45 DRs was compiled. After sorting duplicates and merging similar DRs according to their functional purpose, a final list of 31 mutually exclusive DRs and their occurrences from 74 FTS solutions from our market analysis results is shown in Table 1.

Table 1. List of elicited design requirements

DRs	Description	Occ.
DR1	The FTS should be able to customize performance indicators and road fleet reports.	54
DR2	The FTS should be able to record operating hours based on the use of equipment.	33
DR3	The FTS should provide truck geo positions based on GPS or GLONASS.	53
DR4	The FTS should be able to control fuel consumption and relevant truck metrics.	21
DR5	The FTS should process and transmit truck diagnostic data.	21
DR6	The FTS should enable the tracking and planning of vehicle activities.	28
DR7	The FTS should be able to generate virtual geo areas and enable "geofencing".	35
DR8	The FTS should provide satellite-based positions of freight assets in real-time.	24
DR9	The FTS should be able to surveil the integrity of freight assets including freight loads.	19
DR10	The FTS should process and transmit diagnostics data of freight assets.	10
DR11	The FTS should enable integrated order processing and transport management.	30
DR12	The FTS should support route navigation and transport planning.	48
DR13	The FTS should be able to support freight transport workflow and digital documentation.	17
DR14	The FTS should support communication with truck drivers by individual messages.	42
DR15	The FTS should enable scoring on the driving style and support eco-driving analysis.	27
DR16	The FTS should detect the driving and resting times of drivers compliantly.	30
DR17	The FTS should promote a remote tachograph download service compliantly.	37
DR18	The FTS should be able to support driver expenses resulting from working hours and bonus payments based on driving style.	21
DR19	The FTS should be able to check driver's license.	10
DR20	The FTS should be able to identify drivers and promote electronic logbooks.	23
DR21	The FTS should be able to support the management of loading equipment.	5
DR22	The FTS should be able to support integrated notifications for inbound logistics.	9
DR23	The FTS should be able to support the physical security of trucks and freight assets based on event notifications.	3
DR24	The FTS should be able to support the safety of drivers by personal alerts.	4
DR25	The FTS should be able to support camera-based event detection.	8
DR26	The FTS should be able to support the charging status of hybrid and electronic trucks.	3
DR27	The FTS should be able to optimize AI-based freight and vehicle dispatching.	2
DR28	The FTS should be able to connect with tracking technologies for single loading units.	2
DR29	The FTS should promote data integration with transport management systems.	4
DR30	The FTS should be able to connect to third-party tachograph data providers.	8
DR31	The FTS should be able to integrate a platform-based marketplace.	3

Based on the elicited DRs, we further aggregated the list with descriptions into superordinate RSs. Therefore, we built a structure defined by the gained pieces of knowledge to formulate purposive RSs. Finally, nine overarching RSs from 31 DRs are listed in Table 2 that state the assignment of DRs ranging between two and seven DRs.

Table 2. List of requirement sets

Requirement Set	Description	DRs
RS1: Data Record and Reports	Provide the FTS with the ability to record operating hours and compile customizable fleet performance reports.	DR1 – 2
RS2: Truck Monitoring	Provide the FTS with monitoring functions of the truck to collect and transmit vehicle data in real-time.	DR3 – 7
RS3: Freight Asset Monitoring	Provide the FTS with monitoring functions of the freight assets to collect and transmit equipment and freight load data in real-time.	DR8 – 10
RS4: Workflow Assistance	Provide the FTS with the ability to support efficient transport order and fleet operation workflow.	DR11 – 13
RS5: Driver Monitoring	Provide the FTS with monitoring functions of the driver to achieve transparency, comply with legislation and enhance communication.	DR14 – 20
RS6: Logistics Support	Provide the FTS with the ability to support the logistics process efficiently.	DR21 – 22
RS7: Road Freight Security	Provide the FTS with the ability to support physical security and personnel safety.	DR23 – 25
RS8: Technological Connections	Provide the FTS with the ability to connect to innovations for vehicles, AI technologies, and tracking technologies.	DR26 – 28
RS9: IS-Integration	Provide the FTS with the ability to integrate data with TMSs, third-party providers, and platform-based marketplaces.	DR29 – 31

3.3 Participants for Validation and Evaluation

To validate and evaluate our elicited 31 DRs together with the nine RSs for the design of FTSs, we conducted an empirical survey with practitioners following the AHP method. For the selection of participants, we approached five enterprises that operate with FTSs solutions to realize digital transport management of customers such as shippers and RFOs. Therefore, the selected participants are suitable for our topic since (1) the enterprises are familiar with existing FTSs, and (2) the participants understand the transport process by RFOs since they integrate FTSs with other IS.

We asked 53 employees from the five enterprises to validate the elicited DRs and evaluate all items assigned to the aggregated RSs using two online surveys anonymously. Overall, 42 employees completely finished the validation and AHP evaluation tasks. The participating employees are composed of 14 software engineers, nine cloud developers, eight consultants, three data scientists, four digital logistics specialists, and four sales representatives. In essence, the mean age was 37.36 (SD =5.47), and to measure their experience of using FTSs, a five-point Likert Scale with a scale ranging from 1 (no experience) to 5 (very high experience) was used. The average experience of all employees was 3.84 (SD = 0.91).

3.4 Validation and Evaluation Task

Two tasks were prepared for participants by separate links to conduct anonymous online surveys related to our topic: (1) a survey to validate our findings of DRs presented in Table 1, and (2) a subsequent survey to evaluate DR and RS importance. The task in the first survey started with a general introduction to the topic. Subsequently, we collected details of the participants (e.g., years of working experience). Then, we asked the participants to apply a Likert Scale for the elicited DRs, ranging from 1 (not relevant) to 5 (highly relevant) according to their FTS experiences.

Afterward, a second survey link was shared with the same participants to evaluate a pairwise comparison of the importance of the identified RSs associated with validated DRs from the first task. Thus, DRs were presented on the display in pairs in order to allow the participants to evaluate the pairwise items on a scale ranging from 0 (both DRs are equivalent important) to nine (one RS is extremely important). As a result, 36 pairwise comparisons of RSs had to be evaluated by participants. The same approach was applied to all 31 DRs which we reformulated to make them suitable for the survey format. To this end, the participants evaluated 31 DRs assigned to nine RSs leading to a total of 48 pairwise comparisons. Overall, the participants performed 84 pairwise comparisons starting with an assortment of RSs followed by clusters of earlier validated DRs associated with RSs.

4 Results

From the validation of the DRs, we obtained an average score of 3.95 (SD = 1.03) on the five-point scale indicating a solid knowledge base grounded from our market analysis for the AHP evaluation. The next step was to rank the RSs and DRs in their perceived importance from the second survey. The given scores by participants assigned to RSs and DRs were summarized and we calculated their arithmetic mean and CR values. The mean score of each RS and DR ranged between the rating scale of 0 (unimportant) and 9 (very important) compared to all RSs and DRs. Finally, we obtained a list showing the RSs with their arithmetic mean value based on the weighted quantity and ranked top-down. The average CR value is 18.6%. From the scores assigned by the participants to each DR, the arithmetic mean was likewise calculated and further ranked within the group of associated RS.

The ranking of RSs from our results is presented in Table 3 and indicates that IS-Integration (RS9), Driver-Monitoring (RS5), and Truck Monitoring (RS2) are more important than the remaining six RSs. From the results, we found that RSs aiming at the integration of FTSs seem to be equally important with RSs that support the monitoring of drivers. Likewise, RSs related to the monitoring of trucks indicate similar importance assisting fleet management for inspection and maintenance. In addition, the case for Freight Asset Monitoring (RS3) and data record and reports (RS1) for efficient road freight asset management although their importance is lower. Interestingly, telematics functions in the context of workflow assistance (RS4) and logistics support (RS6) seem to be less important to support road freight transportation.

Table 3. Ranking of requirement sets

Rank	Requirement sets (RSs)	Mean value
1.	RS9: IS-Integration	6.147
2.	RS5: Driver Monitoring	6.054
3.	RS2: Truck Monitoring	5.733
4.	RS3: Freight Asset Monitoring	4.142
5.	RS1: Data Record and Reports	4.094
6.	RS4: Workflow Assistance	2.474
7.	RS7: Road Freight Security	2.449
8.	RS6: Logistics Support	1.326
9.	RS8: Technological Connections	1.127

The results on the importance of DRs specified for FTSs are shown in Table 4 to Table 12 and include the scores and rankings. The average CR values compiled for RSs with more than two DRs assigned ranged between 38.8% to 135.8%.

Table 4. RS1: Data Record and Reports DRs

Ranking	DR	Mean
1.	DR1	5.760
2.	DR2	4.882

Table 5. RS2: Truck Monitoring DRs

Ranking	DR	Mean
1.	DR4	6.867
2.	DR3	6.270
3.	DR5	5.742
4.	DR7	4.923
5.	DR6	4.870

Table 6. RS3: Freight Asset Monitoring DRs

Ranking	DR	Mean
1.	DR10	6.633
2.	DR8	6.296
3.	DR9	5.208

Table 7. RS4: Workflow Assistance DRs

Ranking	DR	Mean
1.	DR12	4.076
2.	DR11	3.115
3.	DR13	2.528

Table 8. RS5: Driver Monitoring DRs

Ranking	DR	Mean
1.	DR15	8.004
2.	DR16	7.582
3.	DR14	6.415
4.	DR18	5.412
5.	DR19	4.649
6.	DR17	3.766
7.	DR20	3.198

Table 9. RS6: Logistics Support DRs

Ranking	DR	Mean
1.	DR22	3.591
2.	DR21	2.250

Table 10. RS7: Road Freight Security DRs

Ranking	DR	Mean
1.	DR23	5.406
2.	DR24	4.103
3.	DR25	3.222

Table 11. RS8: Technological Connections DRs

Ranking	DR	Mean
1.	DR27	3.243
2.	DR28	2.962
3.	DR26	1.962

Table 12. RS9: IS-Integration DRs

Ranking	DR	Mean
1.	DR29	7.171
2.	DR31	6.147
3.	DR30	5.189

For DRs assigned to data records and reports, the participants rank customizable performance indicators and reports (DR1) more important than records of operating hours for the use of equipment (DR2). In the category truck monitoring, DR4, DR3, and DR5 show dominance for the design of FTSs focusing on fuel consumption, positions, and vehicle diagnostic data transmitted. Similarly, the participants evaluate diagnostics data (DR10) for freight asset monitoring as very important compared to satellite-based positions (DR8) and surveillance of freight status (DR9). Furthermore, the participants confirm a high relevance of controlling diagnostic data of road freight equipment toward optimized fleet management [15]. During road freight transportation, data is processed in the form of routing (DR12) and integrated order processing (DR11) representing key features for the design of FTSs. Likewise, in the category of driver monitoring, DR15 is most important for the participants to support enhanced driving style and eco-driving analysis. Since fuel consumed has a significant impact to cost and the environment, this DR arises in combination with driver award systems [8] found in DR18. The detection of driving and resting time of drivers (DR16) presents an obligation in combination with the digital tachograph (DR17), while the download function by this DR is less important than the support of driver check. To support logistics activities, DR22 comprises integrated notification (e.g., estimated time of arrivals) that is more important than the management of loading equipment (e.g., pallets) (DR21).

5 Discussion

Our study contributes to the knowledge base and theoretical understanding of the FTS market through classification and ranking from a supply perspective. Moreover, the analysis provides insight from a re-design perspective to further improve software already on the market. We were guided by the question of which features should continue to be considered in future iterations of FTS development and in how they are prioritized by system integrators. We answered our RQ in the introduction by providing a set of DRs; however, it likewise illuminated a potential problem of rigid solutions that integrate proprietary hardware and software bundles. Noticeable differences that we found between the experts' assessments can of course be associated with different customer preferences that constitute a converging variety of FTS offerings in the market. Moreover, we see a potential for misfits between individual customer needs and offered FTS solutions [5]. Thus, the future design of FTSs could be addressed by a DSR project that instantiates design principles based on existing frameworks [41]. Customers either must abandon less urgently needed features or accept unrequired features. Thus, it remains to be answered whether RFOs consider FTSs a commodity or whether they draw differentiation from the development of FTS-based service innovations (cf. [55]).

If FTSs are to make a differentiating contribution in the future, we see flexibility as a worthwhile overarching design goal. In this context, integrated systems should recede into the background in favor of the individual features supplied to RFOs as a modular solution space enabling flexible and inexpensive testing, roll-out, and scaling of service innovations. As other industries have already shown, these advantages apply to data-driven offerings sourced from collaborations in a higher-level service system [56]. This conclusion emerges from the finding that integration with further IS (RS9) is a central feature of FTSs and extends it to an architectural scope. Other requirement sets revealed in this study (RS1 – 7) seamlessly integrate into this perspective as modules that can foster cost-effective individualization. However, the key to the successful introduction of modular FTSs is the emergence of comprehensive standards for data exchange to guarantee uniform interfaces that flexibly enable such configurations. A first promising example represents the European standard for electronic Freight Transport Information (eFTI[3]). Such data standards can be established in the market and result in a catalog providing modular FTS services according to situational customer needs that comply with the current European effort GAIA-X aiming for federated data ecosystems.

Finally, the implications are subject to limitations that can threaten the validity of our results. First, there is the threat that our study does not capture essential design features despite careful planning and execution of the analysis. We address this threat by aggregating the design requirements into aggregated sets, which create a significant basis for our conclusions. A second threat results from a selection bias in the group of experts. Although we made every effort to include experts who deviate in their practice environment, additional experts could potentially have further fleshed out the results or even shifted priorities. Third, the generated CR values have indicated a consistency of criterion fulfilled and should have been repeated to for some elements. Reflected against similar approaches in academia (e.g., [42]), we do not see a negative impact on the general findings at this stage such as the structure of the hierarchical list. However, we plan to re-evaluate the findings during a DSR project (cf. [57]) to derive a sound system specification. In essence, we consider this a perspective for complementary work that may yield further inspiring results and help to understand the market and future design goals for FTSs.

6 Conclusion

The overall research objective of this study was to explore design knowledge of FTSs applied in practice to support road freight transportation through the lens of digital logistics. We analyzed the web pages of 74 FTS vendors from the market and elicited 31 DRs that we further aggregated into nine overarching RSs. 42 employees with experience in FTSs from five digital road freight service providers validated the DRs and further evaluated DRs and RSs following the AHP method. Our results reveal that DRs and RSs promoting driver monitoring and IT integration are perceived more important than items promoting fleet and logistics support. We discuss our findings in the context of digital innovations for RFOs and draw avenues for future research. To that end, our study is the first contribution in design science research (DSR) for telematics-enabled freight transportation. It serves as a knowledge base to guide the design of future FTSs toward data-driven service systems supporting freight transportation. We hope that the insights of our study will help to drive road fleet technology research forward and further contribute to novel design knowledge on an emerging topic.

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32020R1056&fr (accessed on 2021-08-05)

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