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Abstract. Advances in mobile technology and wearable devices as well as enhanced integration between information systems (IS) allow greater efficiency and new service offerings. Especially for location-dependent field service scenarios, new opportunities for hybrid value creation arise. Until now, leveraging sensor data of products and mobile work support for field service mostly remains a promising, yet unused potential. Also, first successes are scattered around various industries going digital. Thus, this paper explores the current state of research on mobile work support for field service by using the methodology of a systematic literature review (SLR). Based on a keyword search yielding 1899 contributions and 94 papers that were analysed in-depth, our contribution is two-fold: First, we present a comprehensive overview of the current state of research and central issues for mobile work support throughout the entire service lifecycle. Second, we outline directions for future research and relevant challenges in theory and practice.

Keywords: Mobile work support, field service, service science, hybrid value creation, systematic literature review

1 Introduction

In today's digitalized and service-led economy, field service plays an increasingly important role [1]. Heavy equipment machinery in rather product-oriented industries like manufacturing [2–6] or healthcare [7–10] is characterized by a long lifecycle and a high acquisition price. Facing shrinking margins, manufacturers have started to expand their business by also offering maintenance repair and overhaul (MRO) services addressing technical support of such capital goods [2, 4, 11]. Hence, the service business is gaining in importance and becomes more competitive. As the installed base on the clients' site cannot be moved, technical customer service (TCS) has to be sent out to provide on-site service. Products and services become more and more interlinked and combined to so-called product-service bundles resulting in hybrid value creation [12–14]. As field service is characterized by expensive provisioning, it is exposed to three threats [1, 15]. First, partnerships are strengthened in the service business resulting in *more co-creation and a higher complexity in the service ecosys-*

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tem [12]. Product-related information about the installed base is needed to perform highly specialized service resulting in new opportunities for hybrid value creation. Second, organizations face *higher service complexity* as the intricacy of machinery and plants increases resulting in a higher information-intensity [1, 16]. Mobile technology has to be leveraged to provide context-specific information and knowledge for both blue-collar as well as white-collar field service. Third, organizations face a *changing context of the service business* [17]. In terms of labour, the economy is confronted by an aging workforce, and this might increase pressure on the labour market for a mobile workforce. At the same time, service organization might face an increasing percentage of non-experts within their workforce. Hence, it becomes necessary that remote experts provide ad hoc remote assistance leveraging mobile technology. Taking a market perspective, increasing competition as well as cost-pressures in the service business, call for an effective and efficient workforce supported by adequate IS. The importance of leveraging mobile technology for field service has already been recognized in prior work [1, 15, 16, 18–21]. However, applications in practical and productive scenarios were often limited to prototypical implementations due to the prevailing boundaries of technology. Besides solely taking advantage in a private context, trends like mobile computing and consumerization are gaining attention in an enterprise-context. The growing dominance of mobile computing and the natural use of consumer-oriented mobile technology drive innovation and the redesign of organizations' traditional work methods [15, 18]. In particular, mobile work support in for blue-collar service has special requirements concerning user-centricity and -interaction as well as the integration of the service process [16]. Emerging technological innovations like augmented reality and wearable computing might be powerful tools to address these specifics and challenges of highly complex service in the field, help to execute service processes efficiently and enable service innovation [13, 22].
The purpose of this paper is to investigate the status quo of how field service is enabled adequately by IS and mobile work support and to derive directions for future research on how to benefit from the technological trends addressed above. Consequently, the following guiding research questions are formulated:

(RQ1) *What is the current state of research and what are central issues for mobile work support for field service?*
(RQ2) *What are directions for future research on enabling field service by mobile technology and IS?*

To address the research questions adequately, Webster and Watson [23] claim that it is essential to conceptualize existing knowledge on a topic before conducting a SLR. The concept of service has been defined differently in several fields of research. Our understanding of service draws on the service-dominant (SD) logic that was significantly shaped by Vargo and Lush [24] and taken up by Chesbrough and Spohrer [25] within the field of marketing. Rai and Sambamurthy [13] draw on this foundation by emphasizing the relevance of IS. Within the scope of this paper, service is understood within this business context following the SD logic. Furthermore, Maglio et al. [26] claim that research on service science should take a systems perspective. Since service systems can be characterized as complex socio-technical systems [20, 26], adequate IS and mobile technology support play an ever more important role in the development and operation of such service systems [19]. Böhmann et al. [19] identify *service architecture*, *service systems interaction* and *resource mobilization* as relevant areas for service systems engineering. Research on service architecture, focusing on developing modular architectures for integrated solutions and proper interaction within and between service systems, seems to be important. Digitalization, the internet of things (IoT) and recent technological advances in mobile technology can be considered as a game changer for location- and context-dependent field service and support new interaction models and scenarios for hybrid value creation. Hybrid value creation aims at bundling services and products into innovative offerings [12, 13, 27]. Table 1 provides a brief overview of definitions of the most relevant concepts used within this paper to develop a common understanding for our investigation.

Table 1. Definitions of relevant concepts

Concept	*Definition*	*Sources*
Mobile work	The concept of mobile work refers to mobile workers performing mobile tasks in a mobile context across locational, temporal and contextual boundaries by means of mobile technology support.	[7, 28, 29]
Service	Application of specialized competence (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself.	[19, 24]
Service system	Represent any value co-creation configuration of people, technology, value propositions connecting internal and external service systems between service providers and service customers.	[26, 30]
Field service	Facility-based service refers to on-site service delivery, whereas field-based service (after-sales support) is adducted at the customers' facility.	[1, 15, 16, 19]
Hybrid Value Creation	The process of creating value (hybrid products) by combining products and services into innovative offerings.	[12, 27]

2 Methodology

Okoli and Schabram [31] discuss different types of literature reviews. For answering the research questions stated above, the methodology of a SLR based on an established framework seems an adequate approach as it provides a highly rigorous foundation for advancing knowledge and uncovers areas where future research is needed [23, 31]. For the sake of following a rigorous approach, we adapted the methodology by vom Brocke et al. [32] based on Webster and Watson [23]. This approach was chosen since it provides highly actionable and consistent guidance for synthesizing the findings of existing work and deriving directions for future research.

2.1 Search Strategy

The search strategy comprises the determination of the population, the selection of resources, the derivation of search strings, and the inclusion and exclusion criteria.

Population. We only allowed peer-reviewed journals in the first place. As the topic also involves technical aspects and focuses on the IS domain, major IS conference proceedings were considered as well [33]. Thus, AIS Electronic Library (AISeL) was added to target major IS conference proceedings besides the major scientific databases listed in Table 2. Taking the introduction of the iPhone in 2007 as a milestone, we analysed papers published during the last ten years.

Search Terms. With regard to the research questions, an initial set of keywords was used. Based on screening titles, abstracts and keywords, the initial keyword list is iteratively supplemented by adding additional terms addressing technical support for mobile work. Performing the search with permutations of the final keywords *(mobile application, mobile computing, mobile device, mobile system, mobile service, mobile support, mobile work, after-sales service AND field service, maintenance and repair, service technician, customer service)* yielded in a total number of 1899 publications.

Inclusion and Exclusion Criteria. By reading title and abstract and keywords of the publications, the following criteria were applied. First, we included publications meeting at least one of the following criteria:

1. Mobile work or service provisioning supported by mobile technology is a central topic of the publication.
2. Field service is a central topic of the publication.
3. Mobile work support by mobile devices and/or mobile information systems is addressed within the publication.

Second, articles that do not focus on mobile work support and service enablement by IS and/or other technical systems, were excluded. In addition, we excluded publications that exclusively analyse dedicated technical aspects of a mobile IS (e.g., papers on security in the context of wireless communication technology, network infrastructure, and mobile application development). We also excluded publications taking a technical service perspective (e.g., web services, mobile electronic services, papers addressing the concept of service-oriented architecture).

2.2 Relevant Literature

Table 2 provides an overview on the results of our search. With the application of inclusion criteria, the relevant papers could be narrowed down to 198 publications. An article was included in the event that one of the inclusion criteria matches. Applying the exclusion criteria, we skimmed over the publications and excluded 119 papers leaving us with a set of 79 papers obtained from keyword search after eliminating duplicates. In order to obtain a comprehensive set of publications, we conducted a forward and backward search. Especially in a multidisciplinary field of research across multiple research domains, this step is crucial for identifying literature that is both well recognized and relevant [23, 33]. As a result, this step yielded in 15 additional relevant papers. Thus all in all, we obtained a total set of 94 scholarly articles.

Table 2. Results of literature search

Database	*Final Keyword Search*	*Applying Inclusion Criteria*	*Excl. Criteria, - Duplicates - No Access*	*Net hits*
AISeL	54	36	19	17
EBSCOhost	480	51	33	18
Emerald	129	8	1	7
ProQuest	302	25	16	9
ScienceDirect	445	27	17	10
Web of Science	489	51	33	18
Forward and backward search	-	-	-	15
∑	**1899**	**198**	**119**	**94**

2.3 Literature Analysis and Synthesis

All papers in the final set of 94 papers were read completely. To synthesize the information [23, 33], they were classified among several dimensions into categories to answer the research questions in a structured way. First, papers were classified among the mutually exclusive categories proposed by Cooper [34] in terms of meta characteristics for a foundational understanding of the body of knowledge. Results are stated in section 3.1. Second, papers were classified among well-established *Service lifecycle stages* [35, 36], *Mobile work task characteristics* [7, 37], as well as the categories *Industry focus* and *Aim of the paper* that emerged from literature.

3 Results and Current State of Research

First, it can be noted that mobile support for field service activities is a relevant topic on both scientific literature and practice. We can conclude that early literature on mobile work support strongly emphasizes technical challenges of connectivity, security [10, 38] and caching as well as the handling of connectivity issues [39]. Whereas in early years, an accumulation of contributions focusing on requirements engineering can be identified, papers published at a later time put more emphasis on frameworks, models and reference architectures. The reason for this might be advances in integration capabilities calling for rather structuring contributions.

3.1 Meta Characteristics

Our analysis is based on 60 journal publications and 34 publications published in conference proceedings. The applied research methods can serve as an indicator of research maturity of a field [33]. 6 publications are SLRs, 32 publications are case studies, 22 are quantitative studies, 14 are conceptual publications, 18 are studies on illustrative artefacts and 2 are studies using mathematical modelling. The fact that the majority of the studies use qualitative research methods can be considered as an indication of the low maturity of this field of research. The majority of the papers (74) can be assigned to the field of IS, while 7 publications are related to operations management (OM) literature, 3 papers originate from the field of management literature, 3 focus on quality management (QM) in the field of engineering and construction and 7 papers originate from the field of computer science (CS). 80 papers focus on research outcomes, 8 papers focus applications and 6 papers focus on theories.

3.2 Lifecycle and Objectives

In existing work on service science and hybrid value creation, a lifecycle perspective is a valid approach to get a comprehensive view on service systems [5, 11, 21]. Whereas very detailed models exist [40], we decided to use the model proposed by Becker et al. [35, 36] for categorization purposes, who distinguish between three lifecycle stages for service systems: (1) *planning & development*, (2) *operations* and (3) *replacement* of service systems. Within our analysis, we draw on these well-established lifecycle stages by adopting them as a structural frame for classification purposes. However, the replacement phase does not seem to have any relevance. Hence, only the relevant stages are addressed in the following.

Planning & Development. A little less than one third of the papers (32) explicitly focus on the planning & development stage. First and most fundamental, 16 publications aim at *identifying requirements and critical success factors (CSF)* of IS supporting field service provisioning and mobile work. The CSF as well as requirements do not seem to depend on a dedicated industry focus, particularly in the manufacturing industry and in technical customer service scenarios. However, high requirements in terms of effective information processing seem to exist [1]. By addressing this highly complex and interdependent context, the work of Matijacic et al. [41] and Fellmann et al. [42, 43] provides a first step to fill the gap of mobile requirements for mobile information systems. Second, concrete *implementations and prototypes* are discussed in 8 illustrative papers that primarily evaluate proposed system architectures. Third, 26 publications propose *frameworks or reference architectures* for IS supporting mobile work and field service. Due to the complex system landscape, proper systems architecture seems to be crucial for comprehensive support of mobile work. In their pivotal studies, Yuan et al. [44] and Zheng et al. [28] investigate the differences between stationary office support and mobile work support. Furthermore, they identify differences between mobile and stationary work by investigating the relationship between the mobile context, mobile workers, mobile tasks and technologies. Finally, they propose a fundamental framework for the alignment of mobile work and mobile task characteristics. In addition, Ben Moussa [39] categorizes mobile tasks in a sales context of mobile work. Despite the fact that these frameworks are highly relevant for mobile work support, only the contribution of Andersonn and Henningson [45] provides concrete guidance on the development of mobile work applications and systems. Fourth, *enablers and challenges for transformation* of introducing mobile work support are discussed in 12 publications. Whereas Aleksy and Stieger [17] focus on investigating the right input method in the context of industrial field service in the manufacturing industry, Yang et al. [46] focus on the reduction of misunderstandings in the context of healthcare messaging systems.

Operations Stage. A little more than one third of the analysed publications (37) explicitly address the operation of service systems. Key themes are *effects of technology use, assessment of technology acceptance* and *improving information management*. First, 16 papers could be identified that investigate the *effects of technology use* in a mobile work context. It can be concluded that these publications primarily have a confirmative character and use quantitative methods which indicates a high level of maturity of the field of research. Multiple studies can furthermore verify that overall service performance increases when mobile technology is used adequately [18, 47–49]. Supporting the provisioning of field service results in enhanced responsiveness, cost savings, higher accuracy and fewer errors, and superior service quality due to improved information access, greater productivity and efficiency [9, 18, 47–51]. Second, 6 studies exist that investigate the *technology acceptance* of mobile solutions that support field service, mobile commerce [52], health and mobile sales activities, drawing on the technology acceptance model of Venkatesh and Davis [53]. Especially in the health sector, acceptance of mobile work support seems to be a central issue [9, 47, 48, 54]. Third, the *improvement of information management* can be identified as a separate category, as the majority of unsuccessful service is caused by a lack of information [1, 55, 56]. Becker et al. [56] find that depending on service process characteristics, different information needs arise. In addition, technology is far from being exploited in a gratifying way [29]. Especially the lack of systems integration is addressed as a central issue in several studies [41–43]. Therefore, adequate mobile work support and integrated IS can be considered to be crucial. Table 3 provides an overview on the objectives and outcomes of analysed papers.

Table 3. Objectives and outcomes of analysed papers

Aim of the paper	*Papers identified*
Frameworks, Models and Reference Architectures	26
Requirements Engineering and Critical Success Factors	16
Effects of Technology Use	16
Challenges, Enablers, Transformation	12
Technical implementation and prototypes	8
Current Concepts	7
Acceptance	6
Improve Information Management	3

3.3 Industry Focus

In terms of the industries addressed, we find that a large majority of publications (52) do not have a specific industry focus. However, research on mobile work support that is focused on dedicated industries exists; the majority of these specific publications address explicit requirements of the respective industry. The health and pharmaceutical industry are directly addressed by 16 publications. In this context, the readiness of the organization and acceptance of mobile technology and real-time communication and collaboration using mobile technology are especially relevant topics [10, 46, 47, 57]. Mobile work support for TCS, on the contrary, seems to be addressed by a different community closely interlocked with the manufacturing industry. In both contexts, special requirements might justify dealing with varying aspects of mobile support separately and detached from general research. In the manufacturing industry as the main area of application, basically two motivational factors for effectively leveraging mobile technology can be identified. First, complexity of machines and plants is increasingly resulting in higher requirements in terms of knowledge and information-intensity [16]. This is especially true for service and maintenance processes. Second, literature suggests that the manufacturing industry often lacks IS integration, resulting in complex challenges in providing an unified view of relevant data for TCS [17, 42, 45, 58]. Taking the example of MRO, Zolnowski et al. [5] see the need for a comprehensive installed base management of machinery instances that have to be maintained. This data can be used to keep track of the service history. Multiple attempts to tackle this and other challenges by proposing frameworks or reference architecture can be identified [42, 43, 59]. However, only isolated practical challenges are addressed. A unified architecture is still missing. In the healthcare and pharmaceutical industry, studies primarily focus on the effects of using adequate technology [9, 47, 48]. Furthermore, our analysis reveals that the challenges are not explicitly addressed within this industry. Table 4 provides an overview of the addressed industries.

Table 4. Industry focus of investigated literature

Industry Focus	*Papers identified*
General	52
Health and Pharmacy	16
Manufacturing	11
Construction	6
Banking	3
Electricity	3
Public Sector and Education	3

3.4 Fit between Mobile Work and Mobile Task Characteristics

Different tasks demand varying mobile work support. Hence, a fit between task characteristics and mobile technology is proposed [28, 44, 52, 60–62]. Based on well-established mobile task characteristics [7, 37] papers were categorized as exemplary outlined in Table 5. The importance of this task-technology fit and its positive effects on task performance is also supported by a pivotal study by Geber et al. [61]. Especially in information-intensive MRO service processes, mobile technologies offer great opportunities for improving process performance resulting in a high service quality [63].

Table 5. Classification of mobile tasks

Mobile task	*Examples*	*Relevant literature*
Routine tasks	Travelling expenses claim, time recording	[39, 43, 52, 57, 64]
Communication and decision making	Collaboration with remote experts, decision making, based on prior service incidents	[9, 46, 49, 50, 52, 59, 65, 66]
Documentation	Service reports, leads management	[16]
Information access and processing	Machine (service) history, current status of installed base data, CAD drawings	[1, 42, 55, 62, 67–71]

3.5 Service Activities Supported by Mobile Technology

Two kinds of service exist that call for different requirements in terms of supportive mobile technology: blue-collar service and white-collar service. Based on analysed literature, mobile support for white-collar work has rather poor industry focus. As an example for the latter, sales activities could be identified [39, 47, 49, 52, 59, 72]. In contrast, blue-collar work such as MRO usually has an industry focus with dedicated requirements in terms of technical mobile work support and processes [41, 50]. Therefore, dedicated industry requirements have to be considered, especially in relation to mobile support for blue-collar field service.

4 Directions for Future Research

We propose to structure RQ2 in accordance with our analysis for RQ1 and Becker et al. [36], by distinguishing between the two relevant stages *planning & development* and *operations.*

4.1 Future Research Addressing the Planning & Development Stage

Five main directions are suggested regarding research addressing the planning and development stage. First, foundational literature on service systems engineering provides sound guidance for the development of technical elements [21, 73]. However, literature on IS and mobile technology for supporting field service and mobile work does not make vivid use of these methods, but explicitly should do so for services which combine technology and highly person-oriented parts [74]. We call for future research leveraging and improving these valuable tools. Second, rather technical literature mostly takes a frontend and device-centred perspective. Which field service tasks can be supported by innovative mobile technology such as wearable devices? Furthermore, an integration of currently independent information silos in combination with smart equipment and IoT provides new opportunities for hybrid value creation and calls for research on all-encompassing predictive service triggered by the installed base itself. Third, modularization is an effective concept that enables reuse, faster service development and configuration of service systems [75]. It should be addressed in future research on technological enablement of field service, as in other domains in a systematic way [76]. Fourth, regarding transformation and the introduction of mobile work support, it is not only technical aspects that should be considered. The alignment with processes, cultural and organizational aspects such as acceptance should be evaluated in later lifecycle stages and also considered during implementation. This can be accomplished by future research on human-centricity and early stakeholder involvement. Fifth, using mobile technology in the context of field service opens new potential for measuring the performance of the mobile workforce [16]. There is conceptual research on service performance measurement [77] and service controlling [64]; nevertheless, to date, this aspect is omitted and should be addressed adequately within the context of IoT and smart equipment.

4.2 Future Research Addressing the Operations Stage

There are three main suggestions for research addressing the operations stage. First, particularly for dominating maintenance and repair service in the manufacturing industry, the integration of several IS (e.g., customer relationship management systems and technical information about the installed base) can be identified as a pivotal challenge [17, 42, 45]. Smart integration of backend systems should be addressed in future research. Second, foundational literature in the field of service science is able to provide a comprehensive view across all lifecycle stages of a service system as well as the interplay of people, organizations, shared information and technology as relevant elements of a service system [36]. However, investigated literature in the field of work support almost exclusively focuses on mobile devices and technical aspects although identified challenges often lie in providing a comprehensive view of relevant data by integrating information from various IS in the backend. Third, the impact of trends like consumerization and mobility and innovative opportunities for hybrid value creation is barely addressed [5]. We call for future research investigating how IS integration, the effective use of advanced mobile technology like wearable devices and augmented reality as well as consumerization enable new service business models and which constituting elements these business models need to have.

5 Conclusion

This SLR contributes to discussions of how advancements for field service can be achieved by leveraging the potentials of mobile technology and integrated IS. Two research questions guided this study. We have looked at the current state of research on mobile work support in the context of field service (RQ1) and derived directions for future research (RQ2). In terms of RQ1, there is no doubt that mobile technology provides new opportunities for field service and hybrid value creation in general. The results presented in Section 3 are foundational for future research on effective field service support and hybrid value creation based on predictive service data of connected products. Integration of IS among the lifecycle and effective exploitation of innovative mobile technology in complex service ecosystems have been identified as key directions for future research (RQ2).

As any SLR, this paper faces limitations that are due to the literature selection process. By identifying relevant concepts beforehand and carefully selecting keywords on this basis, we tried to reduce the risk of missing out on relevant works. Still, there is the possibility that we have omitted important works. Hence, especially a more detailed and thorough analysis of practical oriented literature might have further increased the insights.

The scholarly contribution of this SLR is two-fold. First, it provides a representative and comprehensive overview of existing literature on mobile work support for field service. The structured scientific knowledge can be used to effectively exploit innovative mobile technology for field service in future research. Second, this contribution identifies how research on innovative technology like wearable devices and integrated IS can be leveraged for effective and efficient field service which is highly relevant for practice. In combination with condition monitoring and remote service technology [5] close integration between product- and service calls for hybrid value creation throughout the entire lifecycle [12]. Smart, connected products and advanced analytical capabilities are revolutionizing the way products are monitored and serviced. Wearable devices enable effective and efficient service processes and service innovation [15]. Efficient and effective hybrid value creation scenarios in complex ecosystems between manufacturers, operators and dedicated service organizations become necessary and need to be designed and operated accordingly.

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