Taking a New-Generation Manager Perspective to Develop Interface Designs

Completed Research Paper

Jörg H. Mayer
University of St.Gallen
Institute of Information Management
Mueller-Friedberg-Strasse 8
9000 St.Gallen, Switzerland
joerg.mayer@unisg.ch

Jörg Hauke
Darmstadt University of Technology
Chair of Accounting and Auditing
Hochschulstrasse 1
64289 Darmstadt, Germany
joerg.hauke@stud.tu-darmstadt.de

Reiner Quick
Darmstadt University of Technology
Chair of Accounting and Auditing
Hochschulstrasse 1
64289 Darmstadt, Germany
quick@bwl.tu-darmstadt.de

Abstract

Digital natives are increasingly populating organizations' management. As they have higher expectations with respect to IS accommodating their (non-functional) user preferences, interfaces of management support systems (MSS) are becoming more important. We develop design guidelines for new MSS interfaces from a new-generation manager perspective. We compile a set of requirements from a literature review and based on a multiple-case study we synthesize five guidelines: (1) use sparklines to present information at a glance and complement them with tooltips to access details, (2) support economic value-added concepts as a "must-have" and be aware that self-service predictive analyses make them more valuable, (3) draw managers' attention to critical events in real-time by sending notifications to their smart devices, (4) to harvest the knowledge of different users, integrate collaboration capabilities into MSS interface designs, (5) align different information media with managers' device selection and do not forget their mobile offline use situations.

Keywords: *Information systems (IS) analysis and design, human factor in IS design, user-interface design, corporate management, digital natives, management support systems (MSS), requirements analysis, multiple-case study*

Introduction

Information systems (IS) intended to help managers are known as *management support systems (MSS)*. They have a five-decade tradition (Ackoff 1967; Elam and Leitner 1995; Mintzberg 1972; Rockart and Treacy 1989; Wixom and Watson 2010) and serve as an umbrella term for management information systems (MIS), decision support systems (DSS), executive information systems (EIS), and more recently, knowledge management systems (KMS), and business intelligence (BI) systems for managers (Carlsson et al. 2009).

Besides their relatively stable content given by legal regulations and management accounting requirements (functional IS perspective), MSS design currently entails two interesting aspects from their *non-functional IS perspective*. On the one hand, digital natives are increasingly present in organizations' management, along with digital immigrants who have learned to engage with IS as adults and developed into MSS users over the years (Vodanovich et al. 2010). On the other hand, due to technical progress such as multitouch, direct manipulation user interfaces (hereafter referred to simply as interfaces) and the emergence of smart devices, managers should be able to operate MSS themselves—even when they are mobile (Wixom et al. 2010).

These new-generation managers more naturally accept MSS, but have higher expectations with respect to IS accommodating their user preferences. For example, they question MSS without configuration mechanisms (Wixom and Watson 2010, Winter 2011). Following Vodanovich et al. (2010), especially the way digital natives use IS will lead to a fundamental shift in IS research. A new MSS design must therefore broaden its scope beyond pure deployment ("plan, build, run") to include managers' IS use and impact perspectives (Marchand and Peppard 2008). In applying such an "IS design for use," *interfaces* are becoming more important. As managers' direct interaction MSS application, their software components evolved over the last years from simple text fields, buttons, menus, and tiny icons into a palette of interactive functionalities, including exception reporting, collaboration, and context-sensitive "do more" functions (Tidwell 2005). However, a MSS design for use from a new-generation manager perspective is barely covered in the literature (Sumita et al. 2010).

The objective of this article is to develop *design guidelines for new MSS interfaces*. We focus on MSS because IS use is not mandatory for managers, and in the worst case, they dissociate themselves from organizational dictates and refuse to use IS. Therefore, it is especially important to make MSS attractive to managers by ensuring that they perceive them as useful (Mayer et al. 2012b). Furthermore, the MSS interface market is constantly evolving given that vendors like SAP purchased Business Objects (BO) in a USD 6.3 bn deal (SAP AG 2007) and IBM did the same with Cognos (USD 5 bn, IBM 2007) in order to combine their data warehouse (DW) technology with latest smart interface technology. Under these considerations, we develop the proposed guidelines from a new-generation manager perspective and apply the latest MSS technology. We will answer two research questions:

- What are new-generation managers' requirements for new MSS interface designs?
- In order to accommodate these requirements, what are suitable guidelines for such designs?

In addition to Hevner et al.'s (2004) artefacts—constructs, models, methods, and instantiations—the proposed *guidelines* contribute to theories that specify how IS artefacts should be designed based on kernel theories (Vaishnavi and Kuechler 2007). In doing so, we follow the constantly emerging tenets of design science research (DSR) in Human-Computer Interaction (HCI, Benbasat 2010; Hevner and Chatterjee 2010). Applying Peffers et al.'s (2006) process model and emphasizing "build" and "evaluate" activities, we motivate this article in terms of gaps in MSS designs and suggest guidelines for new interfaces to address them. After laying the foundations for our research questions, we outline our research model. Based on results from a literature review, we compile a set of requirements criteria for new MSS interface designs. We then describe our multiple-case study and, with the insights gained from a within-case and cross-case analysis, we synthesize the proposed design guidelines. The article concludes with a summary and avenues for future research.

Foundations

According to ISO 9241-110 (2008), interactive MSS are a combination of software and hardware components that receive input from managers and communicate output to support them in performing their management tasks. *(User) interfaces* are "[...] what users see and work with to use a product" (Hackos et al. 1998). Such applications are a combination of software components that conform to a model composed according to a standard (Councill and Heinemann 2002). End-user devices (hereafter referred to simply as devices) are the physical component of MSS handled by the user (Laudon and Laudon 2012). Today, besides the more established notebooks (including tablet PCs, ultrabooks, etc.), smart devices (smartphones and tablets) stand out (Gartner 2011). Complementing stationary use, MSS interface designs have to cover the growing importance of mobile use (Mayer 2012). We define *mobile MSS* as IS offering services for managers as they move from place to place, especially outside their fixed workplace, where technology is accessible, but not necessarily embedded within the environment (Lyytinen and Yoo 2005).

Focusing on IS design, *cognitive fit* is an accepted theory from HCI which states that decision making is efficient and effective when a problem is presented in line with an individual's approach to problem-solving (Vessey 1991). The theory of task-technology fit (TTF, Goodhue and Thompson 1995) is a user-evaluation construct for IS success, which describes the degree to which IS accommodates users' tasks. More recently, Gebauer et al. (2010) extend the TTF theory to mobile IS and highlight the importance of its context with regard to distraction and connectivity issues imposing requirements on the interface design. Andersson and Henningsson (2010) point out additional aspects such as different smart devices with different screen sizes needing to be addressed by the interface designs. Liu et al. (2011) include the individual in the TTF model and differentiate between structured tasks for which individual differences can be ignored and unstructured tasks for which individual differences are relevant.

Following Mayer et al. (2012b), such models enhance understanding of IS fit in terms of what factors should be included in an IS model, while ignoring *how* these factors interact with one another. Furthermore, these models help to understand of IS phenomena, but they do not directly provide advice on the design of (innovative) artifacts (Gregor and Jones 2007). Most important, the higher managers are positioned within the organization, the more they exhibit a highly individual attitude to IS. In the light of such idiosyncrasies, merely deploying IS is no longer sufficient. In contrast, MSS design that would meet the individual IS use characteristics of all potential managers is untenable from an efficiency perspective. By adapting situational method engineering, which covers the development of methods accommodating different situations of (IS) projects and situation (Brinkkemper 1996), adaptive reference modeling, which deals with models having the capability to conform to different application through configuration (Becker et al. 2007), design for artifact mutability, defined as the changes in the state of the artifact anticipated in the theory (Gregor and Jones 2007), and configuration of standard software (IEEE 2005; ISO 2003), *"IS design for use"* provides a way to achieve such a balance by segmenting classes of requirements (Marchand and Peppard 2008; Winter 2011).

Therefore, we assign our research to TTF theory and take new MSS interface design for use as our case example. Besides the technology (MSS frontends) and task (new-generation managers' corporate management), we take managers' typical MSS user-group preferences as a starting point for our interface design and—corresponding to the TTF theory—specify "IS fit" as the way MSS frontend features accommodate their user-group preferences (Goodhue and Thompson 1995; Zigurs and Buckland 1998). *User preferences* describe differences in the way managers use MSS. They result in requirements with respect to how MSS should provide functions or services. We define *requirements* as prerequisites, conditions, or capabilities needed by managers using IS (IEEE 1990).[1] *Design guidelines*, in turn, go beyond mere requirements to serve as predefined actions specifying how IS is brought to life (Hoogervorst 2009).

[1] Both the terms requirements and expectations focus on future MSS design. However, expectations are more of a passive way to await the future: "A strong belief that something will happen or be the case" (Oxford Dictionary 2013). By contrast, in order to deal with the proactive mode of asking managers about their business perspective on MSS, we choose "requirements" as our wording.

State of the Art

We focused on leading IS research outlets provided by the London School of Economics (Willcocks et al. 2008)[2] and complement them with four journals from HCI selected by their AIS ranking (AIS 2013)[3] and added proceedings from ICIS and ECIS. To access the journals, we used EBSCOHost, ProQuest, the ACM Digital Library and AIS Electronic Library. Based on our prior research (Hauke et al. 2013), our keyword search (Table 1) yielded a total of 383 hits. After qualifying them, we end up with 72 hits in total. A final back and forward search revealed *92 publications* to be relevant for our purpose.

Table 1 Keyword search string

		OR					
AND		Management support system	MSS	Executive information system	Decision support system	Business intelligence	Data warehouse
	OR	Dashboards	Frontend	User-interface	Manager	Mobile	Requirements
		Antecedents	Criteria	Determinants	Elements	Evaluation	

Bearing in mind the research questions on new-generation managers' requirements for MSS interface designs, we structured the publications we examined in terms of the elements of IS design theories they employ and their research approach they apply. If publications could be classified in more than one cluster, we used the category for which it had the most arguments and made the most sense. We just differ between methods well-known in research as follows. Figure 1 depicts the results. *(1) Elements of IS design theories:* According to Walls et al. (1992), IS design theories consist of two elements (Figure 1):

(a) *User requirements* consist of functional and non-functional aspects (Sommerville 2010). The first address "what" IS are supposed to do or must do (purpose). The latter, in turn, reflect "how well" MSS interface designs perform their function within their environment (Paech et al. 2004).

(b) *Design guidelines* contribute to both models and methods. Models outline concrete systems, specific IS features, or combinations of these (Gregor 2006). Complementary methods, in turn, describe the process of building IS (March et al. 1995).

(c) Complementing Walls et al. (1992) findings and based on findings from HCI (Zhang et al. 2002), an IS user analysis segments user groups and different user-group characteristics that influence managers' MSS use. The effects of (various) uses occurring to managers while using IS, complement our "*IS design for use*" proposal.

(2) Research approach: The research approach influences the granularity of requirements and design principles identified, from high-level findings such as "appropriate technology" to detailed MSS interface software components such as "drill-downs to an upstream ERP."

(a) Publications with a *behavioral focus* explain phenomena from practice. They rely on observations and apply empirical methods (Urbach et al. 2009). We researched structural equation models (SEMs) such as IS success models (De Lone et al. 2003), technology acceptance models (Davis 1989; Venkatesh et al. 2003), and combined models (Wixom et al. 2005), which most often employ surveys and experiments for analysis (Podsakoff et al. 2003). Concluding the list, case studies (to explore an as-is status in practice) are another way of conducting behavioral research (Yin 2009).

(b) *Design science research in IS* covers ideas and frameworks for the conceptual design and implementation of IS in order to "create a better world" (Walls et al. 1992). We differentiate between single items, broader list approaches, and frameworks focusing on the relationship between requirements and guidelines.

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[2] This catalog incorporates not only mainstream IS journals, but also social studies. We chose the five top journals from each set, namely: MIS Quarterly, Information Systems Research, Information & Management, the Journal of Management Information Systems, and Decision Support Systems, as well as the European Journal of Information Systems, Information & Organization, the Information Systems Journal, the Journal of Organizational and End User Computing, and the Journal of Information Technology. The Senior Scholars' Basket of Eight Journals (AIS 2013) is an alternative catalog, but more limited to those journals in the "IS field" focused on behavioral, business-oriented IS research.

[3] The International Journal of Human-Computer Studies/Man-Machine Studies, Human-Computer Interaction, the International Journal of Human-Computer Interaction, and ACM-Transaction on Human-Computer Interaction.

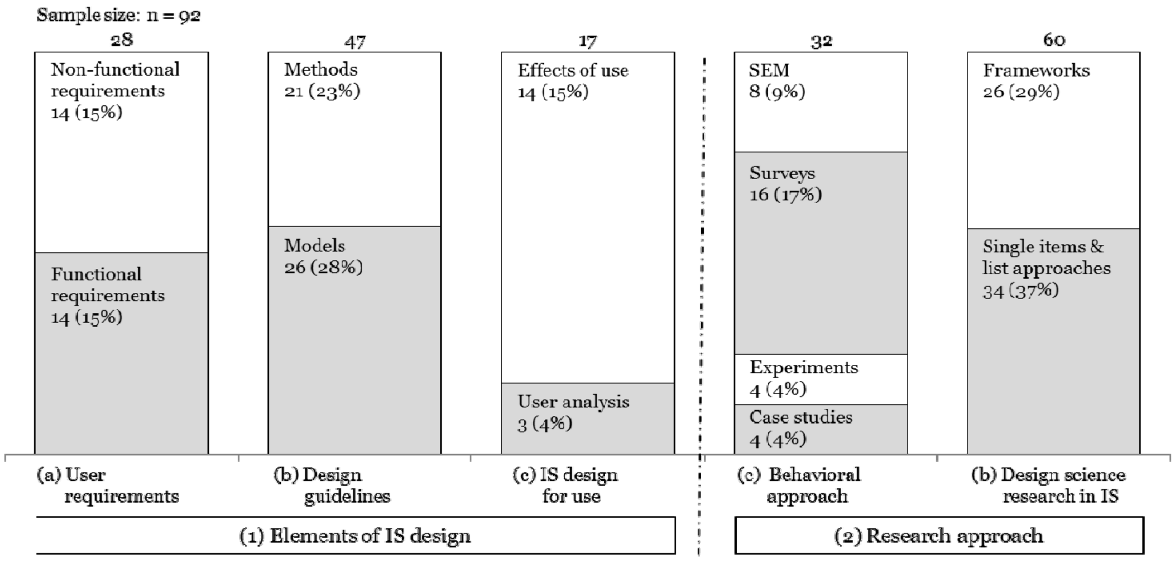

Figure 1. Results of a literature review (based on Hauke et al. 2013)

The various elements of IS design (column 1-3 left, Figure 1) drive the following list of examined shortcomings: *(1a) User requirements lack a sound requirements analysis:* For both types of requirements, just 14 out of 92 publications focus on either functional or non-functional requirements (Figure 1, first column left). Taking Yigitbasioglu and Velcu (2012) as an example, most of these references merely derive a simple list of requirements without a rigorous development process or a distinct structure of requirements. SEMs, in turn, apply rigorous research methods, but are barely applicable in practice, as they need extensive surveys or focus more on organizational impacts of IS design rather than on specific requirements (Mayer and Marx 2010). Thus, a *first research question* is how to develop a rigorous set of new-generation managers' requirements for new MSS interface designs without losing practical relevance.

(1b) Guidelines lack mobile IS designs: 47 of the 92 publications cover either methods or models for designing IS interfaces in general. For example, Warmouth and Yen (1992) structure IS software components into information presentation, dialog control, and analytical functions. Few (2006) presents a model of an effective dashboard design, concentrating on the impact of visual elements such as bar charts. Regarding mobile IS, Wixom and Watson (2010) identify web browsers as a first step towards pervasive MSS, whereas Yuan et al. (2010) state that apps promise new freedom to managers in accessing, generating, and disseminating information beyond the desktop PC. However, most publications do not pay attention to specific issues for mobile IS design (Wu et al. 2011).

(1c) "IS design for use" lacks necessary elements for practical application: IS use for different display types (e.g., color-enhanced graphics and tables) or functions (e.g., drill-downs, filters) are explained by different authors (Benbasat et al. 1986; Chatterjee et al. 2009; Warmouth et al. 1992). However, only three of 92 articles are based on a facetted user analysis. Articles on "IS design for use" theory, such as Winter (2011), remain at a generic level. To accommodate the growing range of managers' working styles, only Mayer et al. (2012b) propose a MSS configuration model and Nutt (1986) examines appropriate information sources in different use situations of the decision making process. Thus, our *second research question* covers design guidelines for an interface design to make MSS more attractive for managers. In doing so, we expose their business perspective on (mobile) IS design.

Set of Requirements

We propose Popper's (2002) deductive method[4] and apply the *principle of economic efficiency* as an appropriate starting point for requirements development. It is a well-known paradigm in business re-

[4] Deductive reasoning is the process of extrapolating from one or more general statements (premises) to reach a logically certain conclusion (Sternberg 2009).

search addressing the ratio between benefit and cost (Samuelson 1983). Thus, the following set of requirements criteria for new interface designs is oriented towards what is economically feasible (positive benefit-cost ratio), and not what is conceptually or technically feasible. Table 2 shows the results.

Table 2 Requirements for MSS interface designs (based on Hauke et al. 2013)

Economic efficiency	**Design criteria**		**Evaluation criteria**		**Description (references)**
Solution capabilities (IS output)	Interface design	Information presentation	EC 1	Graphical quality	How is the first "look&feel" and is the basic screen design consistent? (Hung et al. 2012; March et al. 2007)
		Dialog control	EC 2	Self-service user guidance	How intuitive is the user guidance and is the menu logical and consistent? (Warmouth et al. 1992)
			EC 3	Different types of dialog control	Are all drill, filtering, sorting functionalities supported? (Kimball 2008)
	Functions	Various display formats	EC 4	Spreadsheet capabilities	How is the support of already known spreadsheet functionalities? (Eckerson 2011)
			EC 5	Graphic types with features for interaction	How is the variety of visualizations and the support of interactions? Do tooltips provide additional information? (Shneiderman 2010; Yigitbasioglu et al. 2012)
			EC 6	Business concepts "out of the box"	Are economic concepts such as portfolios or balanced scorecards supported? (Galloway 2010)
			EC 7	Exception reporting	Is it possible to define exceptions and to visualize them? (Houghton et al. 2004)
		Specific requirements	EC 8	Data manipulation layer	Is there a layer between the DW and the interface presentation for manipulation? (Power et al. 2007)
			EC 9	Copying hierarchies from the warehouse	Is it possible to copy already defined hierarchies from DW? (Talwar et al. 2012)
		Collaboration	EC 10	Comments	Is it possible to leave comments to support collaboration across the company? (Rosen 2007; Shim et al. 2002)
		Mobile use situation	EC 11	Adapting report designs to smart devices	How comfortable is the mobile support (e.g., report transformation for smart devices)? (Mayer 2012; Gong 2004)
			EC 12	Different information media	Are there different information media (PDF, web, app) available to fit characteristics of smart devices? (Wixom et al. 2010; Yuan et al. 2010)
		Other requirements	EC 13	Advanced print functions	Is it possible to define different printing areas (e.g., graphics, graphics and tables etc.)? (Eckerson 2011)
			EC 14	Import function for authorization concepts	Is it possible to import permissions from DW and is there a separate permission layer on report level available? (March et al. 2007)
			EC 15	Data mining	Are data mining functionalities available to identify data patterns? (March et al. 2007)
	Information management	Flexibility	EC 16	Customizing function for the GUI	How flexible is the tool for modification to accommodate individual working styles? (Mayer et al. 2012b)
			EC 17	Programming language for add-ons	Is there a possibility to add individual add-ons? (Mayer 2012)
		Integration	EC 18	Degree of integration	Are all required export and import formats supported? (Cheung et al. 2006)
Resource requirements (IS input)	Effort	Cost adequacy	EC 19	Cost adequacy	What is the amount of money to be spent for implementation? (Schober et al. 2011)
		Time adequacy	EC 20	Time adequacy	How much time needs to be spent for implementation? (Schober et al. 2011)

While the costs of designing MSS can be identified to some degree, the ability to quantify IS value is limited (Patas et al. 2012). Providing surrogates, we apply the black-box method which balances the IS input needed with its output (Todd et al. 1987). In doing so, we differentiate between the basic criteria of solution capabilities (IS output) and resource requirements (IS input). The former refers to the benefit of interfaces for supporting managerial decision making, the latter covers information, methods, models, and manpower in terms of cost and time needed to generate the output.

Solution capabilities (IS output): Referring to the IS success model, IS output can be specified with different information and IS characteristics relevant to users. We take the MSS *interface design* in general as our first design criteria and propose their graphical quality (EC 1) as a first item (Hung et al. 2012; March et al. 2007). Measuring consistency and the "look&feel" of the dialog control, we propose self-service user guidance with a consistent menu structure (EC 2, Warmouth et al. 1992), and different types of dialog control such as drill-functionalities, filters and sorting mechanisms (EC 3, Kimball 2008).

The five *functions* for MSS interfaces start with various display formats. They cover spreadsheet capabilities (Eckerson 2011) to provide a familiar environment for new-generation managers (EC 4) and different graphic types with features for interaction which allow freedom for information presentation (EC 5, Shneiderman 2010; Yigitbasioglu et al. 2012). As companies apply business concepts, MSS must offer economic value-added concepts, portfolio techniques or balanced scorecards etc. "out of the box" (EC 6, Galloway 2010). Furthermore, MSS have to cover exception reporting so as to gather information at a glance (EC 7, Houghton et al. 2004). Other requirements cover company-specific data manipulation to satisfy reporting standards (EC 8, Power et al. 2007) and copying hierarchies from a data warehouse to the interface (EC 9, Talwar et al. 2012). Collaboration capabilities including comments or on-topic communication mechanisms are important for covering the increasing co-operative work (EC 10, Rosen 2007; Shim et al. 2002). To handle mobile use situations, adapting stationary report designs for smart devices (EC 11, Mayer 2012; Gong and Tarasewich 2004) and supporting different information media such as PDF, web, and apps (EC 12, Wixom et al. 2010; Yuan et al. 2010) are also important. Other requirements include advanced print functions of content which is only visible on demand (EC 13, Eckerson 2011), import functions for authorization concepts (EC 14), and data mining functions (EC 15, March et al. 2007).

Information management is specified into IS flexibility and IS integration. The first accommodates the growing range of manager working styles, use cases, and access modes (Mayer et al. 2012b) and covers customizing functions for the graphical user interface (GUI, EC 16) and a programming language for add-ons (EC 17). Integration subsumes the capabilities to implement different data sources and data output formats (EC 18, Cheung et al. 2006).

Resource requirements (IS input): Resources required to generate the output, described before, are specified in terms of *effort* differentiated by EC 19 and EC20 "cost and time adequacy" (Schober et al. 2011).

Multiple-Case Study

We adopted a *multiple-case study* as our research method, so that we could examine contemporary phenomena in a real-life context. Using Eisenhardt' four-step framework (1989) to characterize our approach on hand, our (1) objective is to gain insight into the shortcomings of MSS interfaces in practice.

For (2) data collection, we chose *semi-structured interviews* based on our set of requirements (Table 2). This technique is more interactive than a survey and should generate answers that are more suitable for our purposes, especially in terms of comparing several running MSS interfaces and examining their differences. Two representatives of each vendor (Table 3) demonstrated the functionality of their MSS interfaces according to the outlined requirements. Each live demonstration took three-hours in which two authors of this article took part and complemented the sessions with predefined, but open-ended questions to obtain in-depth data, while ensuring comparability between responses (Fontana et al. 2005). The researchers formulated conjoint *as-is values* on a 5-point Likert scale from 1 ("very low") to 5 ("very high") for each solution by rating the interface functionalities based on the outlined requirements. In case of slight differences in their evaluation, the researchers discussed their arguments more in detail leading finally to a conjoint evaluation as mentioned before.

For the *to-be values*, semi-structured interviews with two managers from each of the companies listed in Table 3 were conducted. All of these companies operate their management reporting with this MSS interface. Again, the two researchers were involved in the interviews: one concentrated on the interview itself and the other on documentation. In about 60-minute interviews, and the same procedure as for the as-is values, the interviewees were not only asked to provide to-be values for each criterion of MSS interface design, but also about deeper insights into their proposed avenues for future interface development.

(3) Regarding the selection of appropriate cases, we chose extreme examples in which the aspects of interest are transparently observable. We not only concentrated on large vendors for MSS interfaces, but also included both a "hidden champion" with outstanding innovative components and a smaller vendor concentrating on ease-to-use IS (Williams 2005). The selection is based on Gartner's Magic Quadrant for BI Platforms (Hagerty et al. 2012, Table 3). The same principle was applied to select the companies to be examined. Large companies have the financial capability to implement appropriate IS, but may nevertheless struggle with the complexity of business requirements and the IS architecture landscape (Marchand and Peppard 2008). We selected three *large international operating companies* and *one smaller company with an innovative BI department* (Table 3).

(4) Regarding the data analysis and presentation, we performed a *one-off analysis* (single-time analysis) and gave the software vendors and interviewees the chance to comment on our interviews and the related as-is or to-be values within a week. Once all interviews were completed, we cross-checked the as-is values from the live-demonstrations against the requirements the interviewees expressed (to-be values).

Within-Case Results and Interview Partners

Vendor A is a small but innovative niche player that focuses on easy-to-use interfaces contributing to managers' self-service analysis. *Vendor B* is a medium-sized hidden champion with high market growth (Table 3). Its core business is interactive MSS interfaces, bearing in mind the growing importance of smart devices. *Vendor C* is one of the BI market leaders with a broad number of software products. Five years ago, it acquired an interface vendor and integrated the new products into its portfolio. Besides interface solution C, vendor C has recently begun to bring an alternative interface to the market, which is closer to its own technology than the interface in case C. This new interface is in a pre-release stage.

Table 3 Company and vendor characteristics

Vendor characteristics (as-is values of MSS interface designs)				
	Vendor A	**Vendor B**	**Vendor C (two different interfaces)**	
Revenue [bn USD]	0.027	0.562	19.306	
Employees	>100	3,088	55,765	
Market share	<1.6%	3.1%	16.0%	
Growth rate (2010-2011)	27%	25%	8%	
Presenter	Software engineer and senior account manager	Senior sales engineer and account manager	Senior product manager and product manager	Senior software engineer and product manager
Gartner analysis (Hagerty et al. 2012)	Niche player	Hidden champion	Leader	
Company characteristics and interviewee (to-be values of MSS interface designs)				
	Company A	**Company B**	**Company C**	**Company D**
Revenue [bn USD]	41,376	0.720	99,691	19,306
Profit [bn USD]	1,797	0.061	8,393	4,665
Employees	163,788	2,183	111,141	55,765
Industry	Automotive supplier	Audio electronics	Chemicals, consumer products	Enterprise software
Department	Corporate management	Business intelligence competence center	Management reporting	Corporate management (of vendor C)

Company A is a large automotive supplier. It recently defined a self-service MSS blueprint to provide self-service access to its managers with respect to the group reporting including predefined analysis. Besides stationary use, it currently brings its MSS onto smart devices. While this company is fairly satisfied with its interface design, it is intending to visualize business concepts (e.g., portfolios, value-driver trees). *Company B* is a large audio electronic engineering company. Its BI competence center started to establish MSS a few years ago and today, it focuses on making its MSS mobile. This company is satisfied with the functionality of its MSS interface and some of the requirements (e.g. the use of different information media, EC 12; advanced print function, EC 13; programming language for individual add-ons, EC 17) are even more successful than expected. *Company C* is a leading chemical company. Its IT department maintains the BI architecture, whereas the management accounting defines the content, navigation and interface designs. Its level of satisfaction with its MSS is poor, although the interface was "state of the art" two years ago. Now, it spends a considerable amount of money building workarounds to satisfy its business requirements. *Company D* is the software vendors' own management accounting department. It is the first customer gone live with its interface on January 1st, 2013. Besides the stationary MSS use, its focus is to support managers' mobile MSS use situations.

Cross-Case Results

Both, the to-be and the as-is values were obtained by applying a 5-Point Likert scale. In favor to minimize subjectivity (especially individual preferences as the single basis for evaluation), the evaluation was conducted by two researchers. The differences between the as-is and to-be values are the design gaps of each MSS evaluation criteria. The *maximum difference* per line is visualized by a bar chart (Figure 2, column 6-7). Being aware of the debate on applying statistics to small sample sizes, we follow Norman (2010) by applying the median. Although our analysis is even possible with arithmetic means—with one restriction regarding EC 9 (gap=1 using the arithmetic means)—we prefer the median due to its robustness against extreme values. We calculated the *median* $\tilde{x} = \frac{1}{2}(x_{\frac{n}{2}} + x_{\frac{n}{2}+1})$ across the gaps between the to-be and as-is values (gap = "to-be" minus "as-is" value) over all cases (column 6 with a line chart). The negative gaps (as-is > to-be) were set to zero. Considering the poor satisfaction level of company C and the extreme values, we recalculated the median by excluding company C (Figure 2, column 7). We did that to show that our analysis is still valid, with just one exception of "EC 7." As we determine our cut-off for design gaps greater than value "1" (Figure 2, column 6-7, dashed line), we examined *five major gaps*. No major gaps were found concerning (graphical) MSS interface design, information management, and effort. The examined gaps are all located within the function design criteria. The insights can be specified as follows:

EC 5: Graphic types for managers' interaction need enhancement. Graphics are an effective method for showing complex information in an easy-to-understand manner. All companies rated EC 5 with four or higher on our to-be rating scale. This leads to a median gap of 1.25 (without company C 1.00). Company A is satisfied with its MSS, which means that all graphic types needed for their visualizations are covered. Even tooltips are possible and its managers recognized the importance of not overloading graphics with information, but rather showing more details on demand by hovering the element. Company B has issues, as there are restrictions regarding the adaptability of tooltips. Comments cannot be performed. Company D's MSS lacks different graphic types such as waterfall charts and geographic maps. Its MSS does not provide capabilities for manipulating tooltips, although this is demanded by the companies' users. Company C has the same gap (1.5) as company D. It can decide between different graphics, but struggle to define interactions between different visualization elements such as "graphic-table" or "graphic-graphic."

EC 6: Business concepts "out of the box" are missing. All companies apply economic value-added concepts, portfolio techniques or balanced scorecards for their corporate management. Thus, they expect their MSS to offer such business concepts "out of the box" (EC 6). Three out of four rated this with "5" (very high), which leads to the second highest median gap of 2.50 (without company C 2.00). Currently, company A (gap 2.00) has manually rebuilt interfaces' default business concepts and what-if analyses, through enabling users to make changes to values, in order to see the impact along the value-driver tree, for example. The solution of company C is not flexible in terms of making changes in composition, and changes therefore result in a cost-intensive adaption process (gap 3.00). Company D (gap 3.00) has not yet started to establish business concepts. On company's B MSS roadmap is predictive intelligence intending to visualize their business concepts with easy-to-use analyses, but expect to face minor obstacles (gap 1.00) in rebuilding the concepts manually due to the lack of such concepts available "out of the box."

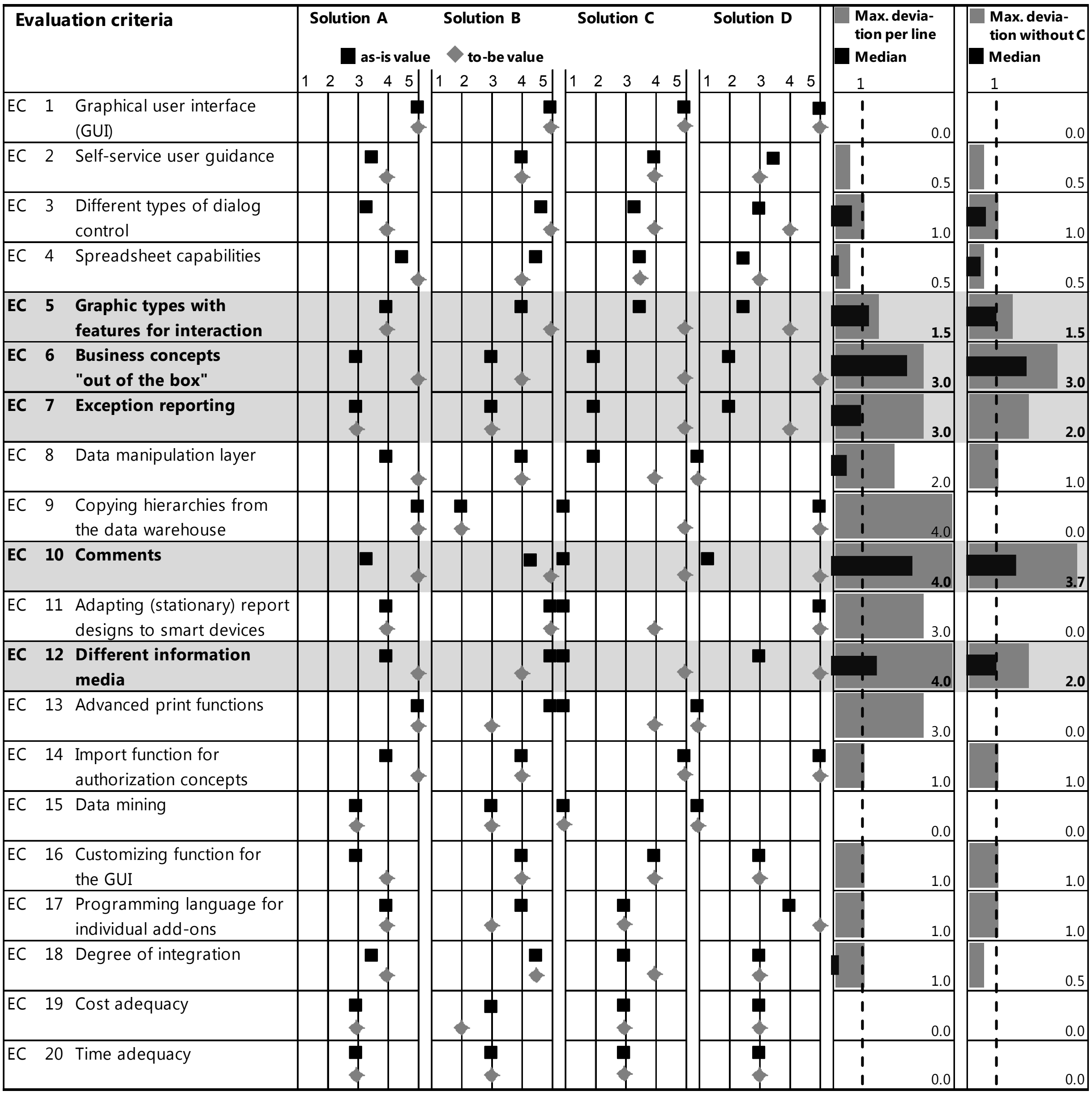

Figure 2 Cross-case comparison of companies' MSS interfaces

EC 7: Exception reporting functionalities are limited. Exception reporting (EC 7) is a powerful functionality for gathering important information at a glance (median gap 1.00). Two out of four companies address the highlighting of exceptions with symbols or colors. Companies A and B highlight their exceptions at the cell level, so they have the capability to define deviations on every KPI and display their range of deviations in tooltips. Company D applies exception reporting only for its CxO-level reporting. As its MSS only supports the definition of deviations line-serially and not cell-based, their as-is/to-be gap is 2.00. Company D faces the greatest gap (3.00) in performing exception reporting, as its MSS needs extensive workarounds to establish exception reporting with an individual definition of exception. All companies mentioned the importance of informing their managers immediately about major deviations in their preferred KPIs, but such a process of notification has not yet been implemented.

EC 10: Collaboration features, especially comment functions are inappropriate. Addressing cooperative work, MSS interfaces need to incorporate comments (EC 10). All companies rated collaboration features with "very high" (5), as they see great potential in accelerating knowledge transfer. This criterion incorporates the greatest shortcoming in our case study (median gap 2.67, without company C 1.67). The MSS of company A has an implemented workflow for the release of new information if the KPIs are out of the predefined deviation range. Thus, the employee in charge needs to comment on the deviation before the report can be released. Nevertheless, its solution does not satisfy its requirements completely. It has concerns about the storage of such comments in their DW, as it is their philosophy to maintain only one DW (gap 1.67). Company B's collaboration features are rated as basic, although its interface has annotation capabilities (gap 0.67). The users are able to take screenshots and can add notes before sending them per e-mail to other persons. In 2013, the BI department will begin to extend collaboration features to enable users to communicate with each other in reference to the corresponding KPI in their MSS. Company C has the same requirements of cell-based annotation capabilities, but their solution does not provide such functionalities out of the box (gap 4.00). Company C sees these communication features as a first step towards e-collaboration. Company D's MSS incorporates only the dispatch of screenshots via e-mail (gap 1.67). It expects features to communicate at the KPI level, but it sees difficulties both in aggregating comments to a higher level, storing them in and the definition of visibilities in their DW.

EC 12: Mature interfaces to support mobile MSS use are missing. The companies surveyed expect mobile IS to make their managers more efficient. In doing so, they expect MSS to support different information media (EC 12). Just one company rated this criterion other than 5 ("very high"), yielding a median gap of 1.50 (without company C 1.00). This trend is recognized by vendors, as they invest time and resources to making their MSS interface mobile. Company A provides a mobile access via web browsers customized to mobile screen size and automatically dispatches PDF-reports, but this does not meet its requirements for a mobile offline access (gap 1.00). Company B accesses its MSS predominantly with mobile devices. In the mobile context, vendor B exceeds its expectations by providing a native app with a mobile offline access mode. Company C's mobile requirements are not fulfilled by its interface design (gap 4.00), due to the lack of state-of-the-art web technologies (e.g., HTML 5). Thus, it sends PDF-files to its managers' smart devices. Nevertheless, company C is planning to provide an extensive mobile IS support adapted to different mobile use situations, such as accessing data with high topicality (e.g., exceptions) by smartphones or data with long validity (e.g., standard reports) to be accessed with tablets. Company D's expectations are high, but could not be met by its interface yet, as it is looking forward to support its mobile workforce even in situations where is only limited network coverage (gap 2.00). All companies expect to support managers' mobile offline use situations (e.g., plane), but they mentioned security concerns (e.g.; loss, theft) to be investigated in detail, as critical data is stored on the mobile devices.

Discussion

Building on the insights of the above analysis and bearing in mind the latest trends in MSS technology demonstrated by the software vendors (Table 3), we synthesize five design guidelines to answer our research questions regarding for new interfaces.

Design guideline 1 (regarding EC 5): Use sparklines to present information at a glance and complement them with tooltips to access details. Besides the span of different graphic types that new MSS interface designs need to consider to improve managers' information gathering, they want interface designs to reveal valuable content better and to make that content more interactive for their self-service analysis than MSS currently do (EC 5). New sparklines (microcharts) can help to show information such as company performance in a time series rather than showing KPIs purely in terms of their actual value in a table. However, to keep such an information presentation clear and at evident at a glance, both only essential information should be displayed and a consistent color coding (e.g.; revenue: black, costs: grey, profit: green, loss: red) will accelerate managers' information gathering process. With regard to the expectation that new-generation managers wish to conduct self-service analyses of details and associated comments (EC 10), complementary tooltips are an appropriate interface feature and complementary capabilities enable "drill-throughs" even to the downstream IS. In order to minimize the response time of such analyses, data should be preloaded. Besides company A, all companies stated their intention to enable such interactive capabilities in future.

Design guideline 2 (EC 6): Support economic value-added concepts as a "must-have" and be aware that self-service predictive analyses make them more valuable. The interviews revealed that all companies use economic value-added concepts for their management purposes. Economic value-added concepts need to be implemented according to the data structure defined in the companies' DW and, due to the occurrence of content changes in these business concepts, fast adaption mechanisms must be implemented as well. However, the IS vendors do not support these business concepts "out of the box" (EC 7). For example, company C addressed the shortcoming by manually building it at great effort. Our in-depth examination showed that this is also true for other standard business concepts such as balanced scorecards. In addition to the MSS interface visualization capabilities (design guideline 1), we propose providing basic predictive "what-if" and "how to achieve" analyses along the KPIs to simulate the effects of changes on upstream values. We recommend using slider technology—increasing or decreasing values by intuitively sliding a bar—to easily manipulate values in a value-driver tree that visualizes the composition of KPIs in order to manage the company. To leverage the power of the stored data in companies' DWs, we propose self-service predictive analyses. These analyses on KPIs–executed by the new-generation managers themselves–should be guided in an easy-to-apply approach, without requiring substantial statistical knowledge.

Design guideline 3 (EC 7): Draw managers' attention to critical events in real-time by sending notifications to their smart devices. In order to respect the context in which managers are located, context-aware exception reporting in real-time is a third design guidelines that we propose. The companies surveyed request an effective method of informing managers about important deviations immediately, as managers have limited time for decision making (EC 7). To cope with their differing levels of importance, deviation ranges at the cell level should be individually definable per KPI. Additionally, we propose highlighting exceptions with colors or symbols, as they yield information on the size of the deviation. To enable direct access to the MSS for further details, we suggest real-time notification for critical events by informing via e-mail or messages on smart devices with a teaser about the exception and a "read more" function. Respecting the different situations (e.g., specific meetings, time of the day) in which managers might be involved, we recommend enabling a context-aware notification (e.g., location, time) to limit the disturbance.

Design guideline 4 (EC 10): To harvest the knowledge of different users, integrate collaboration capabilities into MSS interface designs. All companies are intending to implement or extend their MSS collaboration features to ease and accelerate a more direct topic-specific exchange between managers (EC 10). While companies A and B already use collaboration technology, company C is at a more generic level, sending screenshots via e-mail. Company D has not implemented collaboration features, but all companies expect that the collaborative work will increase, due to the global spread of workspaces in larger and more dispersed companies. We propose implementing two levels of annotation faster than sending e-mails. Firstly, enabling comments at the report level for an overall discussion. Secondly, enabling annotations at the KPI level for discussion in greater detail. To learn from the past, access to previously discussed topics is another advantage of implemented collaboration features enabled by storage in the DW. A process of aggregating annotations to be displayed at a higher hierarchical level is necessary in order to draw attention, as some managers may remain with an overall view which is too broad.

Design guideline 5 (EC 12): Align different information media with managers' device selection and do not forget their mobile offline use situations. Different information media (EC 12) are applied by the interviewed companies to support their progressively more mobile new-generation managers. The companies without native app support are intending to deploy them due to their advantages such as mobile offline access and "push"-function. In terms of company-owned smart devices, the focus should be on one operating system to deploy a native app. Apps support especially the mobile use situations of new-generation managers. Such apps combine the advantage of webpages (e.g., easy content deployment) and PDF-files sent via e-mail through a "push" function. In addition, apps enable managers to access their MSS even in mobile offline use situations (e.g., sitting in a plane or a car with a driver, Mayer et al. 2012a), as they enable the storage of data on the device itself. However, security concerns need to be borne in mind, as highly confidential data may be stored on them. In terms of "bring your own device" and the growing diversity of smart devices, web pages for MSS access is appropriate, as it is independent of the operating system. With the advantages of developments in web technologies (e.g., HTML5), apps can be imitated with web pages that have the same "look & feel," but nevertheless lack a "push"-function and mobile offline access. Addressing the selection of content on a limited screen size, we propose twofold. Firstly, provide only the most important information for a quick overview on smartphones, and secondly, for more detailed information, use tablets. The latter have created their own use cases for managers in three respects–as an advanced PDF reader, an electronic typewriter for more complex emailing especially with attached office documents, and for simple ad-hoc analysis "on the fly" (Mayer 2012).

Conclusion and Future Research

The objective of this article was to develop design guidelines for new MSS interface designs. We compiled a set of requirements from a literature review and, based on insights obtained from a multiple-case study, we synthesized five design guidelines from a new-generation managers' perspective. For practice, these guidelines can serve as practical recommendations to use for both as a checklist to improve existing MSS interface designs and to design future MSS interfaces from a new-generation manager perspective. For research purposes, the set of requirements criteria compiled from the literature review should constitute a rigorous starting point for future investigations of MSS interface design.

Regarding future research, managers' working styles should be specified in greater detail. Gender, level of expertise, IS experience, self-efficacy and past device-usage patterns might be important, along with cultural factors affecting especially internationally operating companies. Furthermore, this paper does not include a substantial evaluation of the design guidelines or even the subsequent design of such MSS interfaces. Another avenue for research is therefore to evaluate the relevance of our design guidelines for mobile IS per se. From the perspective of the process model applied here and reflecting the emerging DSR approach in HCI, case studies do not provide a broad understanding of how often phenomena occur in the total population and thus lack generalizability. Focusing on "demonstrate" and "evaluate" activities, a subsequent design cycle should include more instantiations within a multi-case study and a broader empirical analysis to eradicate the current shortcomings. Another limitation is that our evaluation entails some subjectivity and the set of requirements might suffer from subjective influences as well. However, the requirements are driven by the concept of economic efficiency and are directly applicable in practice. For example, our proposal has been applied in a case at an automotive supplier (revenue: USD 49.95 bn, employees: 164,000, production sites: 200) in 2013 to select a new MSS frontend application (Hauke et al. 2013).

Furthermore, we conducted a *one-off analysis* (single-time analysis). This limits the range of our approach, as the requirements of the surveyed companies and vendors will change over time and, thus, our identified requirements, as well as our synthesized guidelines, may become obsolete in the future. We expect the technical progress in both software and hardware to continue. Especially the capabilities of "modern" software will improve rapidly and the development of smart devices such as Google glasses may create new use cases. Accordingly, our guidelines need to be kept up to date. Finally, the method on hand was applied in the industrial sector and in large international companies. However, our guidelines should be useful for the public sector as well, given that the requirements on "modern" IS for managers should basically be the same. Small and medium-sized companies should also benefit from our approach as well. Thus, the outlined requirements and design guidelines contribute to a DSR approach in HCI in general.

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