A Prototype for Information-Dense IT Project Risk Reporting: An Action Design Research Approach

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Abstract

Project risk management has been proposed as an important topic to prevent the failure of large IT projects. But while literature intensively deals with the risk management process, surprisingly little effort has been put into "the last mile", namely the precise, concise, and unambiguous communication of risks to decision makers. Popular misinterpretations of traffic light-based reports confirm this call for action. Hence, we propose a prototype for information-dense IT project risk reporting including a novel risk report design. This prototype has been designed and applied in a large-scale IT project building on the Action Design Research approach. By drawing on design principles derived from both academic literature and practical experience, we show the advantages of this design compared to traditional IT project risk reports used in business practice. We conclude with an outlook on future work such as the prototype's evaluation in an experimental setting.

1. Introduction

Despite increasing attention for risk management [1], an alarming number of IT projects still do not achieve their goals. According to [2], only 32% of IT projects are considered to be successful, while 44% are challenged and 24% fail.

The reasons for this indication may be manifold. However, it is noticeable that news about failed IT projects often state that none of the "traffic light" symbols has been "red" – in particular on the eve of the disaster [3]. An analysis of well-established software for (project) risk management reveals that "traffic light" reporting – in form of symbols or colored matrices – is extensively applied in risk reporting [4]. Hence, there seems to be a considerable lever for improvement.

The intent of traffic light reporting is to reduce information overload and therefore to focus management attention. When taking a closer look, this approach seems to be counterproductive: A key success factor for project risk management (PRM) is transparency that enables decision makers to assess the criticality of a situation [5]. Traffic light reporting leads to reports with low information density and therefore only little potential to compare and assess developments, which would be necessary for a rational risk evaluation. In other words, traffic light reporting is actually no decision support, but a decision already taken by the author of the report. He or she decided what is important and needs attention, although this is not the responsibility of the report's author, but of the decision maker. To make things worse, it can be observed in business practice that the setting of traffic light colors in risk reports is influenced by political interests. In addition, the danger of wrong assessments of risk situations increases by the fact that a common interpretation of yellow lights in such reports is that "somehow things will work" [3], while the intended message should be "attention, danger". Since risk management in IT projects is usually supported by project management and/or risk management tools, the following research question arises: *Which design principles should tools for IT project risk reporting consider (1) to provide more transparency and to make the content less susceptible to manipulation, and at the same time (2) to still focus management attention and to avoid information overload?*

Regarding risk reporting tools as IT artifacts, a design research approach seems to be appropriate to address this research question. However, as Sein et al. [6] state, existing design research methods "fail to recognize that the artifact emerges from interaction with the organizational context" [6]. Hence, the authors argue that the evaluation cannot follow the development of artifacts in a strict sequence and propose Action Design Research (ADR) as an alternative method. We followed this approach in the context of two large-scale IT projects at one of the biggest employers in the German service sector to

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improve risk reporting by designing and applying an Excel-based prototype for information-dense IT project risk reporting. The key factor for improvement was increasing information density. Therefore, the overarching theme of the prototype has been "information-dense risk reporting".

Taken together, this paper mainly contributes by reflecting our findings derived throughout the process of designing and applying a prototype for information-dense IT project risk reporting as well as by formalizing and generalizing these findings by means of design principles for the visualization of IT project risks. Thus, we offer starting points for the improvement of risk reporting for practitioners and researchers in the fields of risk management and business intelligence.

2. Action Design Research Approach

For the design of our prototype for information-dense IT project risk reporting, we draw on ADR, which has been suggested by Sein et al. [6]. ADR is based on four stages as well as corresponding principles that guide the research process [6] and represents to a large extent the general understanding of design-oriented research as conducted in the German speaking community of Business and Information Systems Engineering (BISE). In contrast to other Design Research approaches (cf. e.g., [7], [8], [9]), ADR does not separate and sequence the design of an artifact and its evaluation. Compared to Action Research, ADR is based on an artifact and outcomes of research can consequently be carried forward more easily [10]. Moreover, Action Research often fails to influence theories due to missing formalization [10]. Therefore, ADR particularly supports ensemble artifacts that "emerge from the contexts of both their initial design and continual redesign via organizational use" [6].

Since the actual perception of a risk report by decision makers and its acceptance in business practice cannot be investigated without actively engaging organizations, we believe that ADR is especially well-suited to address our research question for two reasons:

First, ADR supports research driven by design theories (cf. e.g., [11]) and inspired by problems from practice (cf. e.g., [12], [13]) (stage 1 "problem formulation") that allows for an organization dominant building, intervention, and evaluation of artifacts (stage 2 "building, intervention, and evaluation"). That is, researchers and practitioners engaging in ADR research "challenge organizational participants' existing ideas and assumptions about the artifact's specific use context in order to create and improve the design" [6]. Hence, ADR tries to ensure the relevance, novelty, and usefulness of a proposed artifact by "reciprocal shaping" of the artifact, "mutually influential roles" of researchers and practitioners, and "authentic and concurrent evaluation" [6]. Taken together, ADR helps to structure and guide the design of our prototype for information-dense IT project risk reporting driven by design theories and the current status quo in business practice, its incremental improvement by drawing on the expertise of researchers and practitioners, and the concurrent evaluation of the design efforts by a constant and actual application of the prototype within an organizational context (cf. e.g., [14]).

Second, the application of ADR helps to reflect on the design and redesign of the artifact ("guided emergence") and consequently to "generate and evolve design principles" that partly might have been already derived from theory and practice in stage 1 to guide the initial design process (stage 3 "reflection and learning") [6]. Based on these findings, ADR asks for a generalization of the outcomes by universalizing the problem and the proposed, specific solution as well as the inductive derivation of design principles that incorporate the attained findings (stage 4 "formalization of learning"). Hence, we believe that ADR facilitates deducting general recommendations that help to improve risk reporting based on the visualization of information.

The remainder of this paper is organized in accordance with the above mentioned stages. We first outline the theoretical foundations and the specific organizational setting of our research (stage 1). Subsequently, we describe the building, intervention, and evaluation that finally led to our proposed design of our prototype for information-dense IT project risk reporting (stage 2). Afterwards, we reflect on our findings (stage 3) and generalize by deriving design principles for the visualization of information for decision makers in the context of risk management (stage 4). In the last section, we summarize, point out limitations, and suggest areas for further research.

3. Related Work and Design Principles

As outlined above, stage 1 of the ADR process is based on theories and knowledge from practice related to the problem under investigation. In this section, we provide a brief overview of the related work with respect to risk management (RM) and RM in IT projects. Afterwards, we focus on prior findings from research and practice regarding the visualization of risks. Based on these two literature streams, we deduce design principles that guide the initial design of our prototype for information-dense IT project risk reporting.

3.1. Risk Management in IT Projects

In most cases, risks are defined as uncertain events, which may occur in the future. They consist of the probability that the event occurs and its consequences, which result often in a monetary loss [15]. However, a risk can generally be regarded as both, upside opportunity and downside threat [16]. For the purpose of this paper, we maintain the notion that risks exclusively refer to uncertain events with negative consequences [17], [18]. In the following, a project risk is consequently a combination of the probability of not achieving a project goal and the resulting extent of (monetary) damage [19].

To actively manage project risks, RM is needed. Thereby, RM includes "the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events" [20]. To do so, the common RM cycle is divided into four major phases [19]: In the first phase, risks are identified and documented. In the second phase, these risks are prioritized and their probability of occurrence and their consequences are analyzed. The goal during the third phase is to plan adequate responses to reduce threats caused by risks. Thereby, often counter measures are implemented. In the fourth phase, the risks and responses are monitored, tracked, and risk response plans are executed. In this phase also risk reporting to all relevant stakeholders takes place. Thereby, risks and responses need to be visualized and communicated (cf. [19], [21], [22]).

RM is particularly important for IT projects, as they are often very complex due to multiple dependencies within the project or to other projects. Furthermore, IT projects are usually per se exposed to continuous changes, for instance, due to frequently and constantly changing requirements [23]. RM in IT projects is therefore mandatory in many organizations [23]. Against this background, it is not surprising that major RM standards focus on projects and some even particularly on IT projects [24]. However, none of the nine major RM standards compared by Raz and Hillson [24] include statements about the visualization of risks, although it constitutes an important part of the RM cycle [25].

3.2. Visualization of Risks

Since the amount and the complexity of information increased tremendously over the last years, many authors stress the importance of visualizing information for decision makers (e.g., [5], [26], [27]). Feather et al. [5] further claim that decision makers need to be provided with information in such a manner that all relevant insights can be extracted. Also with respect to RM, literature emphasizes that the visualization of risks should be part of every risk analysis and risk communication [21], [22]. In this context, Eppler and Aeschimann [25] summarize two major purposes of risk visualization: First, "the use of visualization for risk analysis, discovery, and the generation of insights" and second, "the use of visualization for fast and clear communication".

However, risk reports in IT projects are often not designed in a way that enables decision makers to identify and understand the most important risks [25]. This is often due to either not sufficiently or not properly used visualization techniques [5], [21], [22]. From a practical point of view, Bissantz [28] highlights that the main mistakes when visualizing information are misleading colors, missing comparability, and invalid simplification. To improve reports, the density of information in reports needs to be high [28]. Thereby, especially advanced information technology may help to reduce complexity and provide information-dense information by IT-assisted visualization [27]. According to Eppler und Burkhard [29] visualization through graphics can be processed better than text and may help decision makers to understand information and reduce the problem of information overload. Eppler and Aeschimann [25] propose a framework that includes different purposes, contents, target groups, situations, and formats in the context of visualization to enhance information-density for improved assessing and conveying risks and decrease the potential for misleading or manipulation for decision makers. They state that for future research an evaluation of existing RM reports with newly developed suggestions for RM reports is necessary. Tufte [30] recommends using alternative techniques such as so-called sparklines, which are defined as small but high-resolution graphics embedded in text. Often time series graphs are used to allow for presenting a lot of information with minimum space requirements. Feather et al. [5] further advise that visualization techniques should be combined instead of using only a single one. This claim is also supported by Eppler and Burkhard [29].

Even though there are single statements from science and practice that illustrate the importance of visualizing risks, an established set of design principles for the design of IT project risk reports is missing. In order to conclude stage 1 of the ADR process, we therefore derive an initial set of design principles that will guide the subsequent building, intervention, and evaluation of our prototype for information-dense IT project risk reporting (stage 2).

3.3. Initial Design Principles

The overarching objective of the risk report generated by our prototype for information-dense IT project risk reporting is to enable decision makers to unambiguously recognize "essential" information. The problem, however, is to define (1) *what* qualifies as "essential" information and (2) *how* this information should be visualized. We can already derive a number of design principles (D) from the previously presented literature, whereby section 3.1 mainly contributes to the "*what*" und section 3.2 to the "*how*". Tab. 1 shows the resulting set of initially identified design principles.

Table 1. Initial Design Principles

	Design Principles	References
What	D1 Description and categorization	[4, 24, 31, 32]
	D2 Criticality	[4, 15, 24, 31, 33]
	D3 Mitigation strategy	[4, 24, 31]
How	D4 Prioritized	[4, 24, 25, 28]
	D5 Information-dense and without forestalled assessments	[27, 28]
	D6 Visually comparable	[4, 27, 28], [30]

In order to manage risks, an identifier with a short description and a categorization of each risk is suitable [31]. This first design principle (D1) can be regarded as a necessity for communication among stakeholders and is well-established in risk reporting [4], [24], [32]. Another important aspect is a risk's criticality (D2) [15], [24], [31], [33]. This aggregate characteristic is used to prioritize risks and is comprised of probability and impact [33]. The third principle (D3) addresses that a risk report not only has to serve as documentation but also has to show how a risk is handled and what counter measures are currently underway [4], [24], [31]. Although there is often additional information available, such as persons accountable for specific risks, contingency plans, scenarios, or antecedents [25], [31], [33], these three design principles already capture the key information on risks.

With respect to visualization (the "*how*"), content wise comprehensibility has to be fostered and general visualization guidelines such as rules of proportion for item size to item importance or a consistent depiction style (cf. e.g., [25]) have to be applied [5]. Due to ubiquitous information overflow, an order prioritized by importance (D4) is required [4], [24]. This allows for the reporting of a high number of risks since decision makers can lay the focus on their own (e.g., considering the top five risks, the top twenty risks, or all risks) [28]. It also prevents invalid simplification and contributes to comparability [28]. A higher number of reported risks and the initially motivated avoidance of forestalled assessments require an increased information density (D5) (e.g., by using sparklines [30]). This does not necessarily lead to "data graveyards" but enables the detection of patterns (D6), if comparability is assured [28]. An example could be the consideration of historic developments as trends. This is a prerequisite to give decision makers the possibility to live up to their responsibilities and manage risks. Again, other requirements such as the depiction of the decision maker's influence on a risk can be found in literature, but have been omitted for sake of simplicity.

4. The Prototype for Information-Dense IT Project Risk Reporting

4.1. Research Setting

Our research has been conducted in a large German organization in the service sector with more than 100,000 employees and a nine digit IT budget per year. The starting point for this research has been a large-scale multi-year SAP ERP implementation including over 100 project members and an overall budget of more than 200 million Euros. Within this project, a team of internal staff and external researchers has been set up in order to serve as an internal and external PRM. Within this setting, a RM process similarly to the one described in section 3.1 has been implemented and established. Based on this process, information about risks has been collected (e.g., by conducting interviews with project members and experts, screening internal documents and external literature) and counter measures for identified risks have been planned and executed in cooperation with the particular responsible project members. Having the defined goals of the project and the overall organizational goals in mind, risks and corresponding mitigating measures have been regularly reported to different stakeholders in a target group specific form (e.g., only selected and less detailed risks have been reported to all project managers in the organization in comparison to the risks reported to the steering committee).

Against this background, particularly the existing risk report for the steering committee has been found to inherit several characteristics (e.g., traffic light colors) that were not in line with the current state of the art on the visualization of risks (cf. sections 3.2 and 3.3). Therefore, the RM team has been concerned that the existing report might lead to similar problems as the ones exemplarily outlined within the introduction, that is, major risks might not be recognized early enough by decision makers and necessary decisions might be not or wrongly made. Hence, we aimed at designing an Excel-based prototype for information-dense IT project risk reporting that allows for generating reports which enable decision makers to better recognize and address risks. Another goal was that the prototype should be easy to use in different projects without major trainings for project members. Therefore, a graphical user interface and an integrated third-party application for generating sparklines have been used.

Over the duration of the project, mutual learning and the exchange of different perspectives among both internal and external project members resulted in numerous alterations until our final prototype for information-dense IT project risk reporting emerged. Overall, there have been four major cycles. In each cycle, risk reports generated by our prototype for information-dense IT project risk reporting were used within the actual RM process. Additionally, we drew on feedback from interviews with different stakeholders, (e.g., steering committee, project management, internal PRM) about our risk reports in each cycle. Since most of the stakeholders had been involved in multiple past projects, they were able to provide valuable feedback based on their rich experiences in PRM.

4.2. Initial Risk Reporting (1st Cycle)

A key principle of ADR is the "reciprocal shaping" [6] of both the artifact, in our case the prototype for information-dense IT project risk reporting, and the organizational context. In our case, the organizational context has been characterized by time-constraints and a severely strained project management challenging both, content and form of each risk report, openness to experimenting with new reporting formats, and aspiration for continuous improvements of RM capabilities.

The process of reciprocal shaping is characterized as "authentic and concurrent evaluation" [6] ensuring a continuous evaluation against both research gap and real-world, as for instance demanded by Riege et al. [34]. The initial design of the IT project risk reporting has been primarily based on the organizational standards and RM software, which have already been in place to support the RM process. A number of organization-internal guidelines such as rules for the formulation of risks' short titles ("risk cause" causes "damage") have been adopted. In cooperation with the internal PRM, we introduced evolutionary improvements during the first cycle, such as the requirement that newly defined counter measures have to be specific, measurable, attainable, relevant, and time-bounded (cf. e.g., [30]). The initial risk report uses a 10 x 10 matrix as depicted in Fig. 1.

The organization initially insisted on using color coding for risk severity. The matrix served as an executive summary of the current risk situation and is reported to both steering committee and project management. During the first cycle, the one page summary has been complemented by two to three backup pages containing additional information, such as a more detailed risk description, the development of the risks' severity compared to the previous report, and a list of started or planned counter measures.

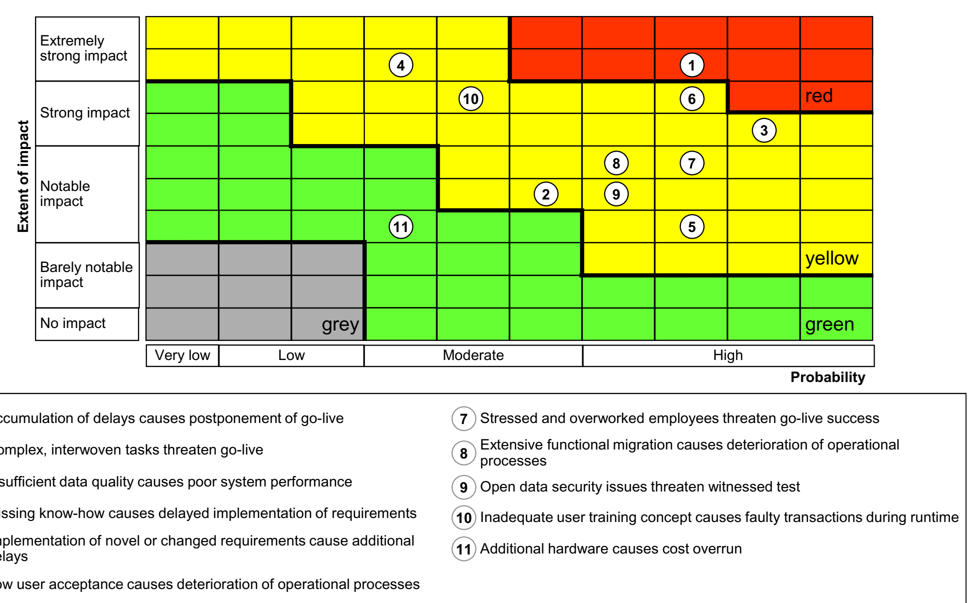

Figure 1. Initial Risk Reporting (Anonymized Data)

4.3. Final Information-Dense Risk Reporting (2nd, 3rd, and 4th Cycle)

During the following cycles, the prototype for information-dense IT project risk reporting has been tailored to avoid identified shortcomings of the initial risk reporting:

1. Avoidance of colors that anticipate decisions (2nd and 3rd Cycle). There were recurring time-wasting discussions focusing on risk colors instead of more important areas such as impact or mitigation strategy and a diverging interpretation of colors (Are green risks positive risks? Do red risks imply a failure of project management?). Along with the initially described overconfidence of decision makers and lack of involvement attributed to the use of traffic light systems, we recognized the need to avoid colors that anticipate decisions and therefore switched to the use of grey shades in the second cycle. In the third cycle, all colors have been omitted (cf. Fig. 2).

2. Single-dimension order based on potential impact (2nd Cycle). The used matrix has been based on the implicit assumption that probability and impact are equally important for risk prioritization. However, the fear for so-called black swans, that is, the underestimation of rare but substantial risks [35], led to a clear order on the impact dimension. Probability serves as second order criterion.

3. Development of probability over multiple periods (2nd Cycle). The increased number of substantial risks due to a consideration of low probability risks requires the support of visually intuitive identification fostered by comparability and standardization [28]. Based on patterns such as a "positive" trend of increasing probabilities or eye-catching correlations between risks, decision makers are provided with richer information that allows for predicting rare events with a higher probability.

4. One page executive summary including counter measures (2nd Cycle). Decision makers wish to focus on the most important set of risks. We found throughout the project that the risk situation has been typically only discussed based on a single page, namely the executive summary (although a more detailed appendix has been readily available). During this discussion, all aspects including mitigation strategy and counter measures have been discussed. Hence, we identified the need to incorporate an overview of the top counter measures as well as their effectiveness in an information-dense way.

5. Transparent communication of the degree of confidence (4th Cycle). Another observation has been that decision makers tended to challenge data quality when being confronted with unpleasant news, such as risks. This causes the inherent problem that risk reports only stated risks once they were well-understood and thus rather had already turned to problems. Furthermore, novel and often severe risks that were solely based on first indications were jeopardized to be neglected, as nobody wanted to be claimed as being not well-informed. Making the level of confidence transparent finally proved to be a useful way to foster the discussion on how to approach a certain risk instead of denying it.

Risk ID	Risks	Impact	Probability	Main counter measures	Degree of confidence
01	Accumulation of delays causes postponement of go-live	8	7	Raise awareness at top management	
04	Missing know-how in causes delayed implementation of requirements	8	5	Increase share of external programmers	
03	Insufficient data quality causes poor system performance	7	8	Data cleansing	
06	Low user acceptance causes deterioration of operational processes	7	7	Advertising of new benefits	
10	Inadequate user training concept causes faulty transactions during runtime	7	5	Continuous evaluaton of training measures	
07	Stressed and overworked employees threaten go-live success	6	7	Focus on essental requirements and raise awareness	
08	Extensive functional migration causes deterioration of operational processes	6	6	Observe success of training results	
09	Open data security issues threaten witnessed test	6	5	Development of work-around solutions	
02	Complex, interwoven tasks threaten go-live	6	4	Detailed cut-over plan	
05	Implementation of novel or changed requirements cause additional delays	4	7	Raise awareness at top managemet	
11	Additional hardware causes cost overrun	3	3	Observe	

Impact: scale1 (low) to10 (serious); probability: scale 1 (very low) to 10 (very high);
counter measures: efficacy of the initiated measures, rises with degree of filling; degree of confidence: assessment by external risk management, rises with degree of filling

Figure 2. Excerpt of Information-Dense Risk Reporting Generated by the Prototype (Anonymized Data)

Besides these evolutionary improvements, we adopted new findings from visualization research that have been well-accepted and quickly understood by executives. Especially new graphical elements such as graphical tables, sparklines, and harvey balls (that is, small ideograms used for comparing the degree to which a feature meets a specific criterion [36]) were appreciated, as they support basic principles of visualization such as priority of interpretation, lossless aggregation, high data density, and comparability (cf. [28]). The final information-dense risk reporting generated by the prototype is depicted in Fig. 2.

In accordance with the initial risk reporting (cf. section 4.2), the final information-dense risk reporting generated by the prototype has also been complemented by a more detailed description containing a short title, cause, potential damage, potential positive effect, indicators of occurrence, substantiation/examples from the past, and the mitigation strategy (“accept and observe”, “reduce probability of occurrence”, “soften potential damage”).

4.4. Summative Evaluation

While the formative evaluation cycles led to the refined artifact, that is, the prototype for information-dense IT project risk reporting, the summative evaluation aims at “assessing value and utility outcomes” [6]. We first apply feature comparison [37] by evaluating the information-dense risk reporting generated by our prototype presented in section 4.3 against the design principles derived from literature (cf. section 3.3). Thus, we evaluate the artifact against our stated research question [34]. Second, we evaluate the prototype for information-dense IT project risk reporting by using it in a large reorganization project within the organization described in section 4.1. Hence, we evaluate our artifact once more against our research question and in a real-world context [34].

Tab. 2 summarizes the extent to which the prototype for information-dense IT project risk reporting fulfills the design principles derived from literature. In order to compare the design proposal with common designs, we also take a look at an established RM tool called Risk2Chance (R2C). We chose this particular tool for two reasons: First, it is implemented in over 350 companies in Germany, Austria, and Switzerland including major (e.g., DAX) listed companies [38]. Second, a large share of professionally used RM tools is designed in a similar fashion and inherits the same characteristics [4]. Taken together, R2C can be considered as sufficiently representative for many companies. Fig. 3 gives an impression of an exemplary risk report generated by R2C.

Risks:	
1	Accumulation of delays causes postponement of go-live
2	Complex, interwoven tasks threaten go-live
3	Insufficient data quality causes poor system performance
4	Missing know-how causes delayed implementation of requirements
5	Implementation of novel or changed requirements cause additional delays
6	Low user acceptance causes deterioration of operational processes
7	Stressed and overworked employees threaten go-live success
8	Extensive functional migration causes deterioration of operational processes
9	Open data security issues threaten witnessed test
10	Inadequate user training concept causes faulty transactions during runtime
11	Additional hardware causes cost overrun

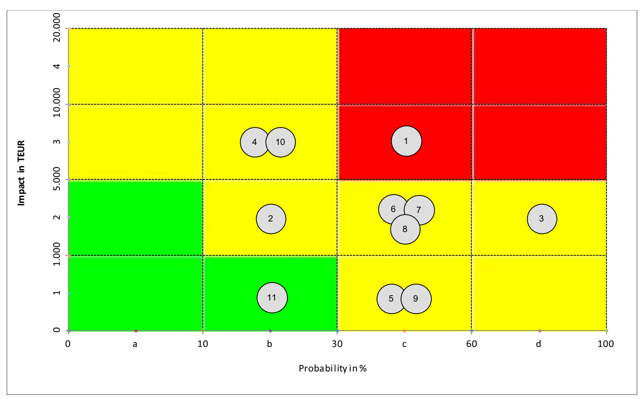

Figure 3. Exemplary Risk Reporting Generated by R2C (Anonymized Data)

Regarding the first design principle on *what* to visualize, D1 (“description and categorization”), both the risk reports generated by the prototype for IT risk reporting and R2C provide a meaningful short title for each risk. Furthermore, both risk reports allow for categorizing risks by either grouping them (information-dense reporting, cf. Fig. 2) or assigning colors that correspond to specific categories (R2C, cf. Fig. 3). Hence, D1 can be fulfilled by both our prototype and R2C. D2 (“criticality”) asks for the possibility to assess a risk’s criticality based on probability and impact. Both risk reports include information on the probability and impact of a risk either by stating the corresponding numbers and their visual representation (information-dense report, cf. Fig. 2) or by a risk’s position within the matrix (R2C, cf. Fig. 3). D3 (“mitigation strategy”) is fulfilled by the information-dense risk reporting provided by our prototype, as each risk’s corresponding counter measures and the extent of implemented measures is displayed (cf. Fig. 2). In the case of R2C, the design principle is only fulfilled, if the attachments to the risk report are taken into account. Thus, we consider D3 to be partly fulfilled by risk reporting generated by R2C.

With respect to the design principles on *how* to visualize, D4 ("prioritized") is fulfilled by the information-dense risk reporting, as the risks within each category are primarily ordered by descending impact (cf. section 4.3). Taking a look on the risk reporting generated by R2C, a clear prioritization is not always possible (cf. e.g., risks 4 and 7 in the upper and lower yellow area in Fig. 3) and the prioritization by the product of probability and impact can be dangerous in case of extremely rare events. Hence, D4 is considered to be only partly fulfilled by R2C. D5 ("information-dense and without forestalled assessments") is strongly supported by the information-dense risk reporting provided by our prototype, as we used for instance sparklines in order to highlight developments over time and avoided color coding that already assesses the criticality of risks. However, since both impact and probability inevitably require some degree of assessment, we consider D5 to be only partly fulfilled. In the case of R2C, only aggregated information about risks' importance is reported and supported by color-coding. Therefore, D5 is not fulfilled by R2C. Finally, D6 ("visually comparable") is partly fulfilled by the information-dense risk reporting, as for instance developments over time, counter measures, or the degree of confidence can be compared due to the structured visualization using identical scales (cf. Fig. 2). Since the risk reporting generated by R2C only allows for a comparison with respect to a risk's position in the matrix, we consider D6 as marginally fulfilled. Although both D5 and D6 still bear some potential for improvement, the prototype for information-dense IT project risk reporting constitutes a significant step towards higher information density in risk reporting. Tab. 2 provides an overview of the evaluation by feature comparison.

Besides the evaluation based on feature comparison, the prototype for information-dense IT project risk reporting is currently evaluated in a second large-scale project. The report informs the steering committee about the project's risks on a monthly basis. In contrast to the widely, especially in lower and middle management, held belief that executives cannot cope with detailed and dense information, the alternative form of presentation was highly appreciated by the executives. Particularly the possibility to gain insights on the development of the risks over time, the initiated counter measures, and the degree of confidence at first sight, have been considered to be very useful. It was observable that prior to the introduction of the information-dense report, risk reports were mainly taken note of. The new design triggered more discussions among the steering committee members that revealed new points for improvement within the project.

Table 2. Evaluation by Feature Comparison

Design Principles	Information-Dense Risk Reporting Generated by the Prototype	Risk Reporting Generated by R2C
D1 Description and categorization	Fulfilled ●	Fulfilled ●
D2 Criticality	Fulfilled ●	Fulfilled ●
D3 Mitigation strategy	Fulfilled ●	Partly fulfilled ◕
D4 Prioritized	Fulfilled ●	Partly fulfilled ◕
D5 Information-dense and without forestalled assessments	Partly fulfilled ◕	Not fulfilled ○
D6 Visually comparable	Partly fulfilled ◕	Marginally fulfilled ◔

5. Reflection and Formalization of Learning

During the building, intervention, and evaluation of our artifact (stage 2), we gained insights that help to refine the initial design principles derived in stage 1 of the ADR process (cf. Tab. 1). According to Sein et al. [6], "[t]he design principles define the [design research] contribution and represent design knowledge emerging from the application of ADR". Our final set of design principles consists of revised initial as well as new design principles is displayed in Tab. 3 (changes in bold italics) and represents the formalized learning (stage 4). Particularly through the ADR principles "reciprocal shaping", "mutually influential roles", and "concurrent formative evaluation", we found that the developments of risks' criticality over time needs to be included in order to allow for pattern recognition (e.g., correlated behavior of certain risks) (D2). Furthermore, the mitigation strategy (e.g., counter measures) needs to be visualized in a way, that the information can be gained together with all relevant information regarding the corresponding risk at a glance (cf. D4). Besides these two refined design principles, we found that also the degree of confidence regarding the provided information should be stated. Therefore, we propose a new design principle D4. Thus, we found that the habit of presenting rather common knowledge instead of relevant first insights based on more vague indicators can be overcome (cf. section 4.3).

The proposed prototype for information-dense IT project risk reporting can be regarded as an instance of the design principles summarized in Tab. 3. In accordance with Raz and Hillson [24], we believe that the visual presentation of risks is a class of problems that is not only relevant for RM in IT projects or project management in general but also for operational risk reporting in a much wider area of applications (e.g., within the financial services industry). Therefore, we hope that our findings and the final set of design principles help to improve the visualization of risks also in a broader context.

Table 3. Final Set of Design Principles

	Design Principles
What	D1 Description and categorization
	D2 Criticality *including its development over time*
	D3 Mitigation strategy *visualized related to each risk at a glance*
	D4 *Degree of confidence*
How	D5 In prioritized order by probability and impact *but no simple multiplication of both*
	D6 Information-dense and without forestalled assessments
	D7 Visually comparable

6. Summary, Limitations, and Future Research

This paper presents the design of an Excel-based prototype for information-dense IT project risk reporting following an ADR approach to address problems of risk visualization in RM (such as popular misinterpretations of "traffic light" reports). By closely working in collaboration with an organization allowing for reciprocal shaping of the artifact, we derived and refined seven design principles that can also be used in the broader context of risk visualization. However, there are also limitations. First, for instance Fang and Marle [33] show that risks are usually in a risk network and influence each other. However, even though correlations can be detected by optical pattern recognition, we neglect the visualization of interdependencies between risks to a large extent. Visualizing risk networks themselves might also be a fruitful future area for future research. In this case, however, the complexity would probably increase to an extent that requires the use of automated pattern recognition using data mining techniques. Second, we stated that decision makers need to understand the suggested information-dense risk reporting easily and within a short period of time. This can be assumed as a trade-off to the fact, that we also claim that decision makers need to recognize patterns and therefore take some time to understand and to think-through the report. Third, in the ADR process „evaluation is *not* a separate stage of the research process, that follows building" [6]. Together with the generalization of outcomes aspired by ADR, this raises the question on validity of findings based on a single organization. In order to both substantiate our results, we started evaluating the prototype for information-dense IT project risk reporting by more rigorous methods. Thereby, we aim at conducting surveys and laboratory experiments to analyze the actual cognition of visualized risks by different stakeholders. However, despite its limitations, the proposed prototype is a first step towards a more information-dense risk reporting in IT projects that may help decision makers to identify, analyze, and mitigate risks more efficiently and effectively by applying proper visualization techniques.

7. References

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