# TRiDS: Treatments for Risks in Design Science

**John R Venable**
School of Information Systems
Curtin University
Perth, WA, Australia
Email: j.venable@curtin.edu.au

**Jan vom Brocke**
Institute of Information Systems
University of Liechtenstein
Vaduz, Liechtenstein
Email: jan.vom.brocke@uni.li

**Robert Winter**
Institute of Information Management
University of St Gallen
St Gallen, Switzerland
Email: robert.winter@unisg.ch

## Abstract

Conducting Design Science Research (DSR) has many risks. Extant literature, such as the Risk Management Framework for Design Science Research (RMF4DSR), provides advice for identifying risks, but provides few suggestions for specific treatments for the kinds of risks that potentially plague DSR. This paper analyses known DSR risks from RMF4DSR, augments them with other risks identified, and develops a purposeful artefact (TRiDS: Treatments for Risks in Design Science), which provides 46 specific suggestions for treating known risks in DSR. The treatments identified are classified into 13 different categories and reference is made to relevant literature for guiding the application of each treatment. The treatment suggestions and guidance serve as a supplement to existing frameworks and methods for risk identification and management in DSR.

**Keywords** Design Science Research, Risk Management, Risk Treatment, Evaluation, Risk-aware Design Science Research.

# 1 Introduction

The literature on research methods for conducting Design Science Research (DSR, especially in the field of Information Systems) has developed substantially during the 10+ years since the publication of Hevner et al. (2004). Much has been written about methods for DSR (Bilandzic & Venable, 2011; A. Hevner & Chatterjee, 2010; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008; Pries-Heje, Venable, & Baskerville, 2014b; Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011; Vaishnavi & Kuechler, 2004, 2015), but there is little in any of these works concerning managing risk in DSR. Some literature addresses management of risk through early evaluation (Baskerville, Pries-Heje, & Venable, 2008; Sonnenberg & Vom Brocke, 2012b; Venable, Pries-Heje, & Baskerville, 2012, 2016) and other literature specifically addresses risk management in DSR (Baskerville, Pries-Heje, & Venable, 2011; Pries-Heje, Venable, & Baskerville, 2008, 2014a). However, none of this literature identifies specific treatments for preventing, overcoming, or alleviating specific DSR risks. Researchers and research students lack advice and suggestions for how to treat DSR risks to the efficiency and success of DSR projects. Funding bodies and industry partners engaged in DSR projects also have a major interest in identifying and treating risks in collaborative research projects (Vom Brocke & Lippe, 2010). What is needed is an approach to DSR that is risk-aware and treats risks in an agile and continuous way, rather than waiting for a summative evaluation at the end of a linear research process.

This paper reports on TRiDS (Treatments for Risks in Design Science) developed by the authors to overcome the above problem and gap in the DSR methodology literature. TRiDS suggests specific treatments for every specific DSR risk previously identified in the extensive DSR risk checklist by Pries-Heje et al. (2014a), as well as some other DSR risks identified in this paper. Risks that are not specific to DSR (e.g. research project not completed) are not addressed in this paper.

The rest of this paper is organised as follows. Section 2 expands on the literature identified above and details what is already in the literature about risk treatment in DSR. Section 3 describes the research method (Design Science Research). Section 4 describes the designed purposeful artefact (TRiDS). Section 5 describes an evaluation of TRiDS. Section 6 discusses the findings. Finally, section 7 draws conclusions about TRiDS and the potential for further research.

# 2 Literature Review

This literature review covers literature relating to the problem to be addressed, i.e. the lack of specific suggestions for how to treat risks encountered in DSR.

## 2.1 DSR Risk Management Literature

Pries-Heje et al. (2014a) provide a (mostly) comprehensive DSR risk checklist as part of their Risk Management Framework for DSR (RMF4DSR). Their risk checklist covers six areas (A through F) of potential risk in DSR:

A. Identifying, selecting, and developing understanding of the business needs to be addressed in the DSR project or program,
B. Grounding of the DSR in knowledge available in the body of recorded human knowledge
C. Building design artefacts
D. Evaluating design artefacts and design theories
E. Artefact dissemination and use
F. Adding knowledge to the body of human knowledge

In all, Pries-Heje et al. (2014a) identify 38 different risks specific to DSR and suggest that DSR researchers should use the checklist to identify particular risks relevant to their project as instances of each type of risk on the checklist.

Pries-Heje et al. (2014a) then go beyond their risk identification checklist to suggest that DSR researchers should first analyse and prioritise identified risks and only then determine risk treatments, especially for higher priority risks (more likely and with larger potential of negative impact). To support the identification of treatments, they propose a DSR risk treatment framework, based on the traditional risk management literature, with a generic treatment type in each of four quadrants: self-insure (for low probability, low impact risks), transfer (for low probability, but higher potential impact risks), self-protect (for higher probability, but low impact risks), and avoidance (for higher probability and high potential impact risks) (Pries-Heje et al., 2014a).

However, Pries-Heje et al. (2014a) do *not* recommend risk treatments for the different kinds of risks. In fact, they expressly avoid doing so, stating "We could list resolution techniques for each risk item. However, we fear that this may limit the generative process of thinking through what should be done about each risk in the specific context. Hence we prefer—and believe it to be a better approach—to let the user (DSR researcher) decide the Risk Treatment within broader categories of treatments." (Pries-Heje et al., 2014a, p. 61).

Nonetheless, in explicating the different classes of risk treatments and in providing a naturalistic case study evaluation of RMF4DSR, they do identify a number of specific risk treatments, such as "Use pilots and prototypes so it becomes clear very fast what the contribution could be" and "Use many diverse problem identification techniques such as document study, observe sourcing-atwork [sic], interview at many levels, etc." (Pries-Heje et al., 2014a, p. 18). However, their examples do not cover treatments for all of the different risks and are sometimes specific to the particular case study in their evaluation of RMF4DSR.

## 2.2 DSR Evaluation Literature

Baskerville, Pries-Heje, and Venable have also published several papers suggesting that DSR risks of poor usability or of technical or organisational, feasibility might be treated through multiple, ex ante (or formative) evaluations of prototypes or partial artefacts (Venable et al., 2012, 2016).

One purpose identified for evaluation in DSR is to "evaluate a designed artifact formatively to identify weaknesses and areas of improvement for an artifact under development" (Venable et al., 2012, p. 426). They also identify that artificial, ex ante (formative) evaluation has the lowest risk to participants in the research, but naturalistic, ex post evaluation has the lowest risk of a false positive, which is especially important for safety critical systems (Venable et al., 2012, figure 2, p. 432).

In their subsequent paper on FEDS (Framework for Evaluation in Design Science, Venable et al., 2016), they suggest that different evaluation strategies (typical trajectories of evaluation episodes) can be used to reduce risks of technical or organisational feasibility or of insufficient evaluation rigour with respect to effectiveness or efficacy. Technical feasibility and/or rigorous evaluation of efficacy are better achieved with a Technical Risk & Efficacy evaluation strategy, which starts with one or more artificial formative evaluation episode(s), transitions to one or more artificial summative evaluation episode(s), and concludes with one or more naturalistic summative evaluation episode(s). Organisational feasibility, usability, and/or rigorous evaluation of effectiveness are better achieved with a Human Risk & Effectiveness evaluation strategy, which starts with one or more artificial formative evaluation episode(s), transitions to one or more naturalistic formative evaluation episode(s), and concludes with one or more naturalistic summative evaluation episode(s).

Sonnenberg and vom Brocke (2012b) present a conceptualisation for concurrent evaluation according to different aspects of design. They build on prior work describing DSR activities within the overall DSR process, and they argue that, in each of these activities, different progress towards the intended artefacts is made, which offer the potential for concurrent (or formative) evaluation. Such evaluation can mitigate risk, since early feedback on more fine-grained steps leading to the eventual artefact can be incorporated into the design process. Further, they argue that evaluation can be more specific (compared to summative evaluation), and the information to be gained can be more directed, if the evaluation is focussed on particular relevant aspects of the design at the time related decisions are made in the design process.

In order to exemplify their approach, they distinguish four evaluation types (Eval 1 to Eval 4), which are derived from typical DSR activities, and which are characterized by the input and output of each activity as wells as specific evaluation criteria and evaluation methods.

- Eval 1: Evaluating the problem identification: criteria include importance, novelty and feasibility.
- Eval 2: Evaluating the solution design: criteria include simplicity, clarity and consistency.
- Eval 3: Evaluating the solution instantiation: criteria include ease of use, fidelity with real-world phenomenon and robustness.
- Eval 4: Evaluating the solution in use: criteria include effectiveness, efficiency and external consistency.

## 2.3 Literature Gap and Problem to Be Solved

The problem addressed in this paper arises from a significant gap in the DSR literature. While the DSR literature does recommend a variety of practices, with the few exceptions above, it does not provide guidance for specific treatments for DSR risks. As noted in Pries-Heje et al. (2014a), there are a significant number of risks that are specific to DSR. For those risks, recommended practices from the general research methods and practice literature may not be adequate. Moreover, that literature has not specifically addressed those risks unique to DSR. Even within the DSR literature in particular, identification of risk treatments is far from comprehensive. Many of the risks in DSR have no specific treatments recommended for them in the literature. The very general types of treatments from the general risk management literature incorporated within Pries-Heje et al. (2014a) are difficult to apply because they are insufficiently specific and rely too much on the ingenuity of the researcher. More guidance and candidate suggestions for risk treatments are needed.

# 3 Research Method

Research methods and techniques are designed artefacts. They are designed for the purpose of conducting research efficaciously, effectively, efficiently, and ethically (cf. the five E's in Checkland and Scholes (1990)). Venable and Baskerville (2012) asserted that, as designed artefacts, research methods and techniques should be developed and evaluated using a Design Science Research approach. To fill the gap and provide guidance on risk treatment in DSR, this research developed a new purposeful artefact (TRiDS: Treatments for Risks in Design Science), an approach for identifying suitable treatments for risks potentially encountered in DSR. Therefore, we adopted a DSR approach to this research.

Our research roughly follows the DSR lifecycle of Vaishnavi and Kuechler (2004, 2015) with its five stages: (1) Awareness of problem, (2) Suggestion, (3) Development, (4) Evaluation, and (5) Conclusion.

In conducting this research we first considered the problem to be solved and considered requirements for a new purposeful artefact (TRiDS) that could be used to solve the problem. The following three requirements for TRiDS follow directly from the identified gap and needed guidance.

1. Provide a reference of risks considered relevant in a DSR project, including those identified in Pries-Heje et al. (2014) and Venable et al. (2014), as well as any other risks identified in our analysis in this paper, with the aim to be more comprehensive in DSR risk identification than the extant literature.
2. Address all DSR risks identified (comprehensive coverage of risks).
3. Support identifying specific treatments for all known DSR risks.

In the suggestion phase, we next considered how to approach the problem. Key ideas were drawn from the extant approaches of Venable et al. (2012, 2016) and Pries-Heje et al. (2014a). Venable et al. provided the idea that risks can be reduced through early evaluation and good evaluation strategies should consider potential areas of risk. Pries-Heje et al provided the idea of DSR risk checklists and some example DSR risk treatments. Our suggested approach was to provide a list of treatments (or actions in a risk-action list (Iversen, Mathiassen, & Nielsen, 2004)), each linked to the different risk(s) that it could help reduce, alleviate, or otherwise overcome.

In the development phase, we conducted analyses and designed an artefact to include those ideas. First, we reviewed the different risks in the Pries-Heje et al. (2014a) checklists and brainstormed different treatments based on our understanding of the research literature and our collective experiences as researchers. We did this risk by risk to ensure that each DSR risk has at least one treatment. In doing so, we also identified a small number of risks not included in Pries-Heje et al. (2014a), which we discuss further below. Finally, we needed to design a way to present the outcomes of our analysis so that they are parsimonious and easily understandable. During this process, we went through a number of design iterations in which we discussed and reviewed the different treatments, as well as how to present them, then revised our artefact design accordingly.

We evaluated our purposeful artefact with a criteria-based evaluation as to whether it meets its requirements, as described further below. Further evaluation for usability, utility, etc., is still needed.

# 4 TRiDS Purposeful Artefact Description

This section describes TRiDS – what it is and how it works. TRiDS is comprised of three parts:

1. Extended DSR Risks Checklists, which make minor extensions to the DSR Risk Checklists in Pries-Heje et al. (2014a)
2. A DSR Treatment List, which describes the different treatments identified in this research that can be applied to the DSR risks in the Extended DSR Risks Checklists

3. A DSR Risk Treatments Table, which matches the treatments in the DSR Treatment List to the risks in the Extended DSR Risks Checklists, making it possible to look up candidate treatments for any risk on the Extended DSR Risks Checklists.

Some of these parts could have been combined or presented differently, but would become very wordy and repetitive. So, we split them into the above three parts, as described in more detail below.

## 4.1 TRiDS Extended DSR Risks Checklists

During the development of TRiDS, we identified several DSR risks that were not expressly included in the DSR Risk Checklists in Pries-Heje et al. (2014a). Table 1 below identifies the additional risks that we have added to the Pries-Heje et al. (2014a) DSR Risk Checklists. Pries-Heje et al. (2014a) divided risks into six different categories (A. Business needs, B. Grounding, C. Build purposeful artefacts, D. Evaluate design artefacts and justify design theories or knowledge, E. Artefact dissemination and use, F. Knowledge additions). During our review and design, we identified one other category of risk: G. Whole-of-project risks. Due to space reasons (the Pries-Heje et al. (2014a) DSR Risk Checklists include 38 items and extend over several pages), we only show the additional risks here and refer the reader to Pries-Heje et al. (2014a) for the remainder of the risks.

| Additional Risk Number | Additional Risk Description |
|---|---|
| A-9 | Inappropriate choice of meta-requirements (scoping error) |
| D-13 | Type I evaluation error (false positive) (Baskerville et al., 2011) |
| D-14 | Type II evaluation error (false negative) (Baskerville et al., 2011) |
| E-5 | Unsafe artefact released |
| F-5 | Unsafe artefact design published |

*Table 1. Additional risks in the TRiDS Extended DSR Risk Checklists*

## 4.2 TRiDS Treatment List

During our brainstorming and review and revision of different DSR risk treatments, we identified 46 different treatments, which could be used at appropriate points in a DSR project to address the risks in the Extended DSR Risks Checklists described above. Table 2 below lists and briefly describes each of the treatments, as well as listing the relevant risks to which each treatment could be applied. Treatments in Table 2 are listed in the order of the earliest risk to which they apply, e.g. a treatment that applies to risk A-1 is listed before a risk that doesn't apply to risk A-1 – and so on. Some of the treatments come from or are adapted from treatments in the DSR literature and references are provided where relevant. After listing treatments in Table 2, we briefly categorise and further explain the risk treatments listed, as well as give references to relevant literature that could guide use of the treatment.

| # | Risk Treatment | Relevant Risks |
|---|---|---|
| 1. | Literature review about the problem, existing solutions, and technological capabilities that could be used for solution | A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-8, B-1, B-2, B-3 |
| 2. | Empirical investigation of the problem (e.g. using survey, case study), *cf.* Pries-Heje et al. (2014), p. 15 | A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-8, D-1b |
| 3. | Seek co-authors or clients with expertise in and understanding of the problem area and its significance | A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-8, B-1, B-2, B-3, C-5, C-6, C-7, D-1a |
| 4. | Stakeholder analysis | A-3, A-4, A-5, A-6, A-7, A-8 |
| 5. | Causal analysis (a.k.a. root cause analysis) | A-3, A-4, A-5, A-9 |
| 6. | CATWOE/Root definition | A-6, A-7, A-8, A-9 |
| 7. | Requirements choice review | A-9 |
| 8. | Link requirements to desired outcomes (causal analysis) | A-9 |
| 9. | Update literature review, open automatic query | B-1, B-2, B-3 |
| 10. | Seek co-authors or clients with expertise in extant purposeful artefact solutions to the problem | B-2, C-4, C-5, C-6, C-7 |
| 11. | Seek co-authors or clients with expertise in technologies to be applied in new purposeful artefact | B-2, C-1, C-3 |

| | | |
|---|---|---|
| 12. | Seek co-authors with expertise in behavioural theory or other areas of potential kernel theory | B-3 |
| 13. | Review solution idea and design with technical experts | C-1 |
| 14. | Generate multiple candidate designs and contingency plans, *cf.* Pries-Heje et al. (2014), p. 14 | C-1, C-2, C-3, C-4, C-5, C-6, C-7, D-1a, D-1b, E-1 |
| 15. | Evaluate early and formatively Pries-Heje et al. 2014, p. 14) | C-1, C-2, C-3, C-4, C-5, C-6, C-7 |
| 16. | Review solution idea and design with potential users, *cf.* Pries-Heje et al. (2014), p. 15 | C-2, C-3, C-4, C-6, C-7, D-1a, D-1b |
| 17. | Review partial prototypes as early as possible with users, *cf.* Pries-Heje et al. (2014), 15 | C-5, D-1a, D-1b |
| 18. | Review solution idea and design with non-user stakeholders, especially with power and different interests | C-6, C-7 |
| 19. | Ask "Devil's Advocate" question: "How and why could use of the artefact make a situation worse rather than better?" | C-7 |
| 20. | Triangulate evaluations using different forms, *cf.* Pries-Heje et al. (2014), p. 14 | C-7, D-13, D-14, E-1, E-5, F-1, F-3 |
| 21. | Ask "Devil's Advocate" question: "How and why might the artefact fail to match the requirements?" | D-2 |
| 22. | Design and document the design carefully using template/meta-design-driven design & documentation, *cf.* Pries-Heje et al. (2014), p. 15 | D-2, D-3, D-4, D-5 |
| 23. | Design review | D-3, D-4 |
| 24. | Instantiation review | D-5 |
| 25. | Early (partial) prototype review | D-6 |
| 26. | Post-implementation review | D-6 |
| 27. | Ask naturalistic evaluation stakeholders about potential and forecast changes (when investigating the problem for naturalistic evaluation) | D-7, D-12 |
| 28. | Develop and deliver the working purposeful artefact for naturalistic evaluation quickly | D-7, D-12 |
| 29. | Seek co-authors with expertise in evaluation methods | D-7, D-9, D-10, D-11, D-13, D-14, E-1, E-5, F-1 |
| 30. | Plan a good change management practice for naturalistic evaluation | D-8 |
| 31. | Involve users early and often (a.k.a. user and stakeholder participation) for naturalistic evaluation, *cf.* Pries-Heje et al. (2014), p. 15 | D-8, D-9, D-10, D-11, D-12 |
| 32. | Identify and resolve disagreements among stakeholders (during problem formulation and/or change management) | D9, D-10, D-11, D-12 |
| 33. | Support and guide implementers (post research) to implement the purposeful artefact properly | E-1, E-2, E-3, E-4 |
| 34. | Rigorously evaluate for (unsafe) side effects, *cf.* Pries-Heje et al. (2014), p. 15 | E-1, E-5, F-1, F-3, F-5 |
| 35. | Help implementers to conduct proper change management | E-4 |
| 36. | Throughout the DSR project, actively clarify and manage (plan, review/monitor, and replan) the significance of the problem | F-1, F-2 |
| 37. | Throughout the DSR project, actively clarify and manage (plan, review/monitor, and replan) the newness/novelty of the artefact | F-1 |

| | | |
|---|---|---|
| 38. | Throughout the DSR project, actively clarify and manage (plan, review/monitor, and replan) the rigour of the evaluation | F-1, F-3 |
| 39. | Throughout the DSR project, actively clarify and manage (plan, review/monitor, and replan) the relationship of the problem and the extant artefact to extant theory and the literature | F-1 |
| 40. | Seek co-authors to distribute the workload and the risk, *cf.* Pries-Heje et al. (2014), p. 15 | F-1, F-2 |
| 41. | Change the scope of the research to something less risky, *cf.* Pries-Heje et al. (2014), p. 15 | F-1, F-2 |
| 42. | Abandon the research if too risky, *cf.* Pries-Heje et al. (2014), p. 14 | F-1, F-2 |
| 43. | Enter into contract/agreement clarifying IP rights and right to publish, *cf.* Pries-Heje et al. (2014), p. 18 | F-1 |
| 44. | Ask “Devil’s Advocate” question: “How and why might this research produce incorrect results?” | F-3 |
| 45. | Ask “Devil’s Advocate” question (during design and design review): “How and why could the artefact be (or become) too unique to disseminate?” | F-4 |
| 46. | Ask experts whether the design is too unique to be used in other contexts (during design review) | F-4 |

*Table 2. TRiDS Treatment List (with relevant risks)*

## 4.3 TRiDS DSR Risk Treatments Classification and Guidance

The DSR risk treatments in Table 2 are listed in order of risks and similar types of treatments are not grouped together. In this section, we classify different treatments, provide further explanation about them where needed, and provide references to literature for further explanation and guidance for how to conduct the treatments.

Within the list of DSR risk treatments above, some treatments are similar to others and can be grouped into classes. We identified 13 generic classes of DSR risk treatments, including (1) Literature Reviews, (2) conducting Empirical Studies, (3) applying Problem Analysis Techniques, (4) encouraging Participation, (5) conducting Reviews, (6) following established Design Practices, (7) following established DSR Evaluation Guidance, (8) applying Change Management practices, (9) using Project Management techniques, (10) seeking Expert Advice, (11) seeking Co-Authorship, (12) asking (and answering) Devil’s Advocate Questions, and (13) Managing Critical DSR Quality Guidelines. Some treatments fall into more than one category. We introduce each of these risk treatment categories next.

**Literature Reviews (treatments 1 and 9):** Much has been written in the IS field about rigorous literature reviews, including work by Jennex (2015) and vom Brocke et al. (2015). Effective search queries and tracking how the literature search was conducted are essential. Modern search systems also provide the feature of open queries or alerts, which notify the user when new publications meeting search criteria become available. See, e.g., Google Scholar.

**Empirical Studies (treatments 2 and 20):** Relying solely on the literature may not be appropriate, particularly for understanding problems (which may change over time). Empirically evaluating purposeful artefacts and design theories needs to be carefully designed, using tried and true approaches such as triangulation rather than relying solely on one evaluation approach or episode.

**Problem Analysis Techniques (treatments 4, 5, 6, 7, 27, and 32):** Understanding problems, which are always perceived, and agreeing about them are important in a problem solving paradigm like DSR. Much has been written about analysing and achieving shared understanding of problems, including work by Checkland and colleagues on Soft Systems Methodology (Checkland, 1981; Checkland & Scholes, 1990), other work about problem analysis and solving methods (e.g. Flood & Jackson, 1991; Rosenhead & Mingers, 2001), and work on causal analysis for DSR (Venable, 2014).

**Participation (treatments 3, 10, 11, 16, 17, 18, 27, 31 and 32):** Participation by stakeholders, including users, beneficiaries, and decision makers is useful (if not essential) throughout all phases of DSR. The literature on problem analysis and solving above stresses participation. Various DSR methods have also been developed that stress participation, including and Action Design Research (ADR - Sein et al., 2011), Participatory Action Design Research (PADR - Bilandzic & Venable, 2011), Soft Design Science Methodology (SDSM - Pries-Heje et al., 2014b), and a different version of Participatory Action Design Research (PADRE - Haj-Bolouri, Bernhardsson, & Rossi, 2016).

**Reviews (treatments 8, 13, 16, 17, 18, 23, 24, 25, 26, 36, 37, 38, 39, 45, and 46):** Formal (or semi-formal) reviews can be conducted at any stage of a DSR project on any of the artefacts developed along the way. The Software Engineering literature describes practices and standards for the conduct of reviews. E.g., see (Pressman & Maxim, 2015; Sommerville, 2015).

**Design Practices (treatments 14, 20, 23, and 28):** There is a rich literature on how to design quality into software and other artefacts. See the software engineering books listed above for reviews as well as journals such as *Design Research*.

**Evaluation Guidance (treatments 15, 16, 17, 20, 25, 27, 28, and 34):** As described earlier, the DSR literature provides substantial guidance for evaluation in DSR. See Venable et al. (2012, 2016), Sonnenberg and vom Brocke (2012a, 2012b), or Prat et al. (2015).

**Change Management (treatments 30, 33, and 35):** The fields of management and information systems have both studied change management extensively and provide guidance for how to accomplish it successfully. See, e.g., the paper by By (2005).

**Project Management (28, 41, 42, and 43):** In many important ways, a DSR project is just like any other project, and basic project management practices can be very useful to help ensure successful DSR projects and avoid common DSR project pitfalls. See, e.g., vom Brocke and Lippe (2010, 2013) and Lippe and vom Brocke (2016).

**Expert Advice (treatments 3, 10, 11, 12, 13, 29, and 46):** For researchers who are not themselves experts in one or more areas relevant to a DSR project, seeking and obtaining expert advice can be a very useful way to minimise key risks. Key areas of expertise might be in the problem to be solved, known extant approaches to the problem, technologies that might be employed, and DSR research and change management methods.

**Co-Authorship (treatments 3, 10, 11, 12, 29, and 40):** A common practice used to obtain expertise is to invite an expert to join the project as a co-author. This also has the advantage of distributing the risk (and workload) across multiple individuals. Adding co-authors may complicate working arrangements, but is often well worth it.

**Devil's Advocate Questions (treatments 19, 21, 44, and 45):** The Devil’s Advocate (Latin: Advocatus Diaboli) was a formal position within the Roman Catholic church, whose task was to argue against canonization of people under consideration for sainthood (Wikipedia, 2017). The idea is extended to mean “someone who pretends, in an argument or discussion, to be against an idea or plan that a lot of people support, in order to make people discuss and consider it in more detail” (Cambridge Dictionary, 2017). A popular corollary expression to that is to seriously (as opposed to flippantly) ask “What could possibly go wrong?” James A. Senn (Senn, 1981), when considering a system development project, would ask and consider “Under what circumstances would implementing the system actually make things worse rather than better?” In our list, we suggest asking similar “Devil’s Advocate” questions about different parts of a DSR project.

**Manage Critical DSR Quality Guidelines (treatments 36, 37, 38, 39):** The DSR literature suggests a number of guidelines and recommendations for what makes criteria for quality (or satisfactory) DSR. The most commonly advocated are the seven guidelines in Hevner et al. (2004). Managing the achievement of critical guidelines is a good way to help overcome risks and ensure DSR project success. Of the seven Hevner et al. guidelines, we chose guidelines 2, 3, and 4 as critical, but also add a fourth one: ensuring that the artefact is clearly related to the literature and relevant theory.

## 4.4 TRiDS Risks and Treatments Table

Having introduced all the DSR risk treatments that we identified, we invert table 2 so that it is easily searchable by risk to look up candidate risk treatments for any particular risk. Table 3 provides that capability. Unfortunately, space limitations prevent providing explanations of the risks in Table 3.

| DSR Risk | Risk Treatments | DSR Risk | Risk Treatments |
|---|---|---|---|
| A-1 | 1, 2, 3 | D-3 | 22, 23 |
| A-2 | 1, 2, 3 | D-4 | 22, 23 |
| A-3 | 1, 2, 3, 4, 5 | D-5 | 22, 24 |

| | | | |
|---|---|---|---|
| A-4 | 1, 2, 3, 4, 5 | D-6 | 25, 26 |
| A-5 | 1, 2, 3, 4, 5 | D-7 | 27, 28, 29 |
| A-6 | 1, 2, 3, 4, 6 | D-8 | 30, 31 |
| A-7 | 1, 2, 3, 4, 6 | D-9 | 29, 31, 32 |
| A-8 | 1, 2, 3, 4, 6 | D-10 | 29, 31, 32 |
| A-9 | 1, 2, 3, 5, 6, 7, 8 | D-11 | 29, 31, 32 |
| B-1 | 1, 3, 9 | D-12 | 27, 28, 31, 32 |
| B-2 | 1, 3, 9, 10, 11 | D-13 | 20, 29 |
| B-3 | 1, 3, 9, 12 | D-14 | 20, 29 |
| C-1 | 11, 13, 14, 15 | E-1 | 14, 20, 29, 33, 34 |
| C-2 | 14, 15, 16 | E-2 | 33 |
| C-3 | 11, 14, 15, 16 | E-3 | 33 |
| C-4 | 10, 14, 15, 16 | E-4 | 33, 35 |
| C-5 | 3, 10, 14, 15, 17 | E-5 | 20, 29, 34 |
| C-6 | 3, 10, 14, 15, 16, 18 | F-1 | 20, 29, 34, 36, 37, 38, 39, 40, 41, 42, 43 |
| C-7 | 3, 10, 14, 15, 16, 18, 19, 20 | F-2 | 36, 40, 41, 42 |
| D-1a | 3, 14, 16, 17 | F-3 | 20, 34, 38, 44 |
| D-1b | 2, 14, 16, 17 | F-4 | 45, 46 |
| D-2 | 21, 22 | F-5 | 20, 29, 34 |

*Table 3. TRiDS Risks and Treatments*

# 5 Evaluation

This paper identified three requirements for TRiDS in section 2.4. The first requirement is to provide a comprehensive list of threats, including extra risks identified in this paper. The list of extra risks is provided in table 1 and all risk numbers are provided in Table 3. However, space limitations prevent listing descriptions of all risks. Instead, the reader is referred to Pries-Heje et al. (2014a).

The second requirement is that all risks must have a treatment that applies to that risk. Table 3 above facilitates confirming this, as all risks are listed. Every risk in Table 3 has at least one treatment.

The third requirement for TRiDS is that it must support identifying treatments for each risk. Table 3 is sorted by DSR risk, allowing easy look-up of relevant treatments. The only thing needed then is to use the treatment number to look up the treatment description in Table 2.

The above criteria-based, artificial evaluation (meeting requirements) does not yet consider issues of usability, practicality, completeness of potential treatments, and other potential issues. Further naturalistic evaluation is needed with DSR researchers (student or practicing) on actual DSR projects.

# 6 Discussion

This research has developed an approach for identifying risk treatments in DSR (TRiDS), which extends prior research on DSR evaluation and risk management with additional identified risks and recommendations for risk treatments. As discussed in section 5, TRiDS meets the three requirements identified for how to fill the identified literature gap of how to provide more detailed guidance for how to effectively and efficiently treat risks in DSR projects.

This paper identifies new risks in DSR, identifies and classifies treatments for DSR risks into 13 categories, and fills an important gap in the literature.

From a Design Theory perspective, TRiDS provides a *general design* (Baskerville & Pries-Heje, 2010; Venable, 2013) of an artefact for matching DSR risks to candidate DSR treatments, which can later be expanded with additional risks and treatments. The artefact's *general design* meets the *general requirements* (Baskerville & Pries-Heje, 2010; Venable, 2013) to match risks and treatments through a *utility relationship between them for improved effectiveness and efficiency* (Venable, 2006, 2013). Moreover, the approach could be generalised for use for risk management in other domains than in DSR. Finally, the risks and risk treatments identified could be generalised to other research paradigms than DSR. The design theory includes new constructs of the artefact and increased utility (compared to extant approaches) for meeting the requirements of providing better guidance for how to treat DSR risks.

Appropriate use of TRiDS, as described in this paper, should enhance DSR and help make it more efficacious, effective, efficient, and ethical. DSR, in turn, should better serve society by delivering contributions to the solution of real-world problems.

While helpful, no checklist is complete (so risks may be missed) and no treatment is guaranteed to work 100% of the time. Users of RMF4DSR and TRiDS must be diligent in their application and consider how their DSR project's context might reduce the effectiveness of risk management approaches.

Another limitation of this work is that, while extending the risk list (Iversen et al., 2004) provided by Pries-Heje et al (2014a) into a more specific risk-action list (Iversen et al., 2004), it does not provide the strategic oversight offered by a risk-strategy model or a risk-strategy analysis (Iversen et al., 2004). Future work might further extend RMF4DSR and TRiDS to provide such strategic oversight.

# 7 Conclusions

The research in this paper has filled an important gap in the DSR literature by identifying 46 potential treatments for known risks in DSR. It also provides a straightforward way to work from a relevant risk – the augmented risk checklists – to identify candidate treatments for a particular risk. It has further classified the risk treatments into 13 categories and made reference to relevant literature to guide and support their enactment. Overall, it has extended the existing literature in DSR risk management with some very practical ideas for how to address and treat risks, which should assist DSR researchers to better manage risks in their DSR projects and programs, and thus to better conduct DSR in terms of efficacy, effectiveness, efficiency, and ethics.

However, further research would be useful. TRiDS could still use a more complete, naturalistic evaluation. It could also benefit by supplementing it with better guidance on how to decide among the treatments identifies and how and when to apply the treatments identified for best results.

Furthermore, TRiDS could be extended further. Ultimately, what we envision is an approach to DSR that is risk-aware and identifies and treats risks in an agile and continuous way, developing and evaluating intermediate artefacts rather than waiting for a summative evaluation at the end of a linear research process. Such an approach should lead to DSR that is both more effective (higher quality and more needed outcomes) and more efficient (less wasted effort and rework).

# 8 References

Baskerville, R., & Pries-Heje, J. (2010). Explanatory Design Theory. *Business & Information Systems Engineering, 2010*(5), 271-282.

Baskerville, R., Pries-Heje, J., & Venable, J. R. (2008). *Evaluation Risks in Design Science Research: A Framework*. Paper presented at the Third International Conference on Design Science Research in Information Systems and Technology (DESRIST 2008), Atalanta, USA.

Baskerville, R., Pries-Heje, J., & Venable, J. R. (2011). *A Risk Management Framework for Design Science Research*. Paper presented at the 44th Hawaii International Conference on System Science (HICSS 2011), Kauai, Hawaii, USA.

Bilandzic, M., & Venable, J. R. (2011). Towards Participatory Action Design Research: Adapting action research and design science research methods for urban informatics. *Journal of Community Informatics, 7*(3).

By, R. T. (2005). Organisational Change Management: A Critical Review. *Journal of Change Management, 54*(4), 369-380. doi:10.1080/14697010500359250

Checkland, P. (1981). *Systems Thinking, Systems Practice*. Chichester, UK: Wiley.

Checkland, P., & Scholes, J. (1990). *Soft Systems Methodology in Action*. Chichester: J. Wiley.

Flood, R. L., & Jackson, M. C. (1991). *Creative Problem Solving: Total Systems Intervention*. Chichester, UK: Wiley.

Haj-Bolouri, A., Bernhardsson, L., & Rossi, M. (2016). *PADRE: A Method for Participatory Action Design Research*. Paper presented at the 11th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2016), St John's, NL, Canada.

Hevner, A., & Chatterjee, S. (2010). *Design Research in Information Systems: Theory and Practice*. New York, NY, USA: Springer.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly, 28*(1), 75-105.

Iversen, J. H., Mathiassen, L., & Nielsen, P. A. (2004). Managing Risk in Software Process Improvement: An Action Research Approach. *MIS Quarterly, 28*(3), 395-433.

Jennex, M. E. (2015). Literature Reviews and the Review Process: An Editor-in-Chief's Perspective. *Communications of AIS, 36*(8).

Lippe, S., & vom Brocke, J. (2016). Situational Project Management for Collaborative Research Projects. *Project Management Journal, 47*(1), 76-96.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2008). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems, 24*(3), 45-77.

Prat, N., Comyn-Wattiau, I., & Akoka, J. (2015). A Taxonomy of Evaluation Methods for Information Systems Artifacts. *Journal of Management Information Systems, 32*(3), 229-267.

Pressman, R. S., & Maxim, B. R. (2015). *Softward Engineering: A Practitioner's Approach*. New York, NY, USA: McGraw-Hill.

Pries-Heje, J., Venable, J. R., & Baskerville, R. (2008). *A Risk Management Framework for Design Science Research*. Paper presented at the 31st Information Systems Research Seminar in Scandinavia (IRIS 2008), Åre, Sweden.

Pries-Heje, J., Venable, J. R., & Baskerville, R. (2014a). RMF4DSR: A Risk Management Framework for Design Science Research. *Scandinavian Journal of Information Systems, 26*(1), Article 3.

Pries-Heje, J., Venable, J. R., & Baskerville, R. (2014b). Soft Design Science Methodology. In O. E. Hansen, J. Simonsen, C. Svabo, S. M. Strandvad, K. Samson, & M. Hertzum (Eds.), *Situated Design Methods*. Cambridge, MA, USA: MIT Press.

Rosenhead, J., & Mingers, J. (Eds.). (2001). *Rational Analysis for a Problematic World: Problem Structuring Methods for Complexity, Uncertainty and Conflict*. Chichester, UK: Wiley.

Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action Design Research. *MIS Quarterly, 35*(1), 37-56.

Senn, J. A. (1981). [personal communication].

Sommerville, I. (2015). *Software Engineering* (10th ed.). Harlow, Essex, UK: Perason.

Sonnenberg, C., & Vom Brocke, J. (2012a). *Evaluation Patterns for Design Science Research Artefacts*. Paper presented at the European Design Science Symposium (EDSS) 2011, Dublin, Ireland.

Sonnenberg, C., & Vom Brocke, J. (2012b). *Evaluations in the Science of the Artificial – Reconsidering the Build-Evaluate Pattern in Design Science Research*. Paper presented at the 7th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2012), Las Vegas, Nevada, USA.

Vaishnavi, V., & Kuechler, W. J. (2004, 23 October 2013). Design Science Research in Information Systems. Retrieved from http://desrist.org/design-research-in-information-systems/

Vaishnavi, V., & Kuechler, W. J. (2015). *Design Science Research Methods and Patterns: Innovating Information and Communication Technology* (2nd ed.). Boca Raton, FL, USA: CRC Press.

Venable, J. R. (2006, 24-26 February 2006). *The Role of Theory and Theorising in Design Science Research*. Paper presented at the First International Conference on Design Science Research in Information Systems and Technology (DESRIST 2006), Claremont, CA, USA.

Venable, J. R. (2013). *Rethinking Design Theory in Information Systems*. Paper presented at the 8th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2013), Helsinki, Finland.

Venable, J. R. (2014). *Using Coloured Cognitive Mapping (CCM) for Design Science Research*. Paper presented at the 9th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2014), Miami, FL, USA.

Venable, J. R., & Baskerville, R. (2012). Eating Our Own Cooking: Toward a More Rigorous Design Science of Research Methods. *Electronic Journal of Business Research Methods, 10*(2), 141-153.

Venable, J. R., Pries-Heje, J., & Baskerville, R. (2012). *A Comprehensive Framework for Evaluation in Design Science Research*. Paper presented at the 7th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2012), Las Vegas, Nevada, USA.

Venable, J. R., Pries-Heje, J., & Baskerville, R. (2016). FEDS: A Framework for Evaluation in Design Science Research. *European Journal of Information Systems, 25*(1), 77-89. doi:10.1057/ejis.2014.36

Vom Brocke, J., & Lippe, S. (2010). *Taking a Project Management Perspective on Design Science Research*. Paper presented at the 5th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2010), St Gallen, Switzerland.

Vom Brocke, J., & Lippe, S. (2013). Identifying and Managing Creative Tasks in Collaborative IS Research Projects. *Project Management Journal, 44*(6), 94-113.

Vom Brocke, J., Simons, A., Riemer, K., Niehaves, B., Plattfault, R., & Cleven, A. (2015). Standing on the shoulders of giants: Challenges and recommendations of literature search in Information Systems research. *Communications of ACM, 37*(1), 205-224.