Technical Report on RASTER field test at a Water Board

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Abstract

Risk assessment of unavailability of telecommunication services is an important part of an organisation's business continuity management. We developed the RASTER method to enable organisations to assess their telecommunication service unavailability risks. To validate RASTER in practice we conducted two field tests in which the RASTER method was applied at a typical target organisation. This document reports on the second field test, at a Water Board in the Netherlands. This report describes the research goals, method, and results of this field test, and compares the results to those of the first field test. This field test reconfirms the usefulness of the RASTER method, and adds some new lessons-learned.

1 Introduction

The RASTER method has been in development since 2011 [2–6]. The goal of this research is to create a risk assessment method that can be used by crisis organisations to assess their telecom service unavailability risks. We designed an initial method, and tested and improved it over a number of steps. To validate the final version we conducted a field test [6]. This report describes a second field test at a second organisation, using the same research method. In addition to further validation, this field test also allows a comparison and further conclusions based on the similarities and differences of the two tests.

This report is structured as follows. First we briefly describe relevant previous research (Section 2). Next we describe the research questions, and the research method (Section 3). Then, Section 4 summarises the results of the field test. In Section 5 these results are discussed; in Section 6 they are compared to those of the first field test. The report concludes with implications for validity of the RASTER method, and areas for further research (Section 8).

2 Background

The design of our validation follows the checklist provided by Wieringa [7]. In Wieringa's terminology, the field test described in this report is *technical action research*, an application of a still-experimental technique in the real world to help a client. In the field test described here, the author (the experimenter) participated in a project in a real operational environment. The experimenter acted as project leader, facilitating the application of the Raster method. The goal of the field test was therefore twofold: the sponsor (as the client) had an actual question that needed answering, and the experimenter wanted to validate the Raster method.

To see whether target users would want to use Raster themselves, we used the Technology Acceptance Model TAM [1]. TAM has been studied extensively and, although it has received criticism and several extensions have been proposed, its usefulness is well established in research. We use TAM because it employs a list of 12 standardised questions that accurately predict whether users would adopt new information technology. The list was integrated easily into our own post-test questionnaire (see the next section). The Raster method falls within the scope of TAM, because the use of the Raster software tool forms an essential part of the method.

TAM measures perceived usefulness and perceived ease of use as predictors for future behaviour; TAM does not (nor does it intend to) measure objective benefits or efficiency gains.

3 Setting and method

We performed a second field test at Water Board Hunze en Aa's (WHA), a water board in the north-east of the Netherlands. WHA is a public authority responsible for water management in a north-eastern region of the Netherlands. Its task is to ensure adequate water levels and to maintain water quality standards. Specifically, WHA maintains dikes and other water barriers, regulates the ground and surface water levels, maintains waterways used for shipping, and manages waste water treatment installations. Nature, agriculture, recreation and physical safety all pose their specific requirements on water management, and WHA takes the requirements of these stakeholders into account. WHA actively participates in the operational activities of the Safety Region Groningen, and to a lesser extent the Safety Region Drenthe.

A risk assessment reveals vulnerabilities and company confidential information. The full results of the assessment therefore have to remain confidential. This report can only describe the results in general terms, and does not discuss specific vulnerabilities.

Within WHA, its IT department is responsible for both information technology and communication facilities. This includes office automation, telecommunication connections to more than a dozen external locations (water treatment plants, pumping stations, locks, labs and maintenance shops), and telemetry connections to hundreds of objects. Technologies used include fiber-optic cables, DSL links, point-to-point microwave radios, and public mobile data networks based on 2G, 3G and increasingly 4G technologies.

Early in 2015 the IT department awarded a tender for telecommunication services. In the course of 2015 and 2016 services will be migrated and updated, and during this process the infrastructure will contain a complex mixture of 'old' and 'new' services. The main goal of WHA in participating in this field test is to mitigate existing availability risks in the current infrastructure, and to avoid introducing new availability risks.

The scope of the Raster project of WHA contained those telecommunication services for which WHA (specifically its IT department) had technical of functional responsibility. As always when using Raster, the first stage of the project defines precisely which telecommunication services are within scope.

3.1 Research questions

For validation three research questions need answering:

- Q1 Does Raster produce, in practice, risk evaluations that are correct? That is, are all relevant risks included (completeness), are low risks excluded (conciseness), and are risks presented with the right priorities?
- Q2 What are the costs and effort involved in execution of Raster?
- Q3 Are the target users willing to use the Raster method in their practice?

Each question is described in turn.

Q1: Correctness. Correctness of risk evaluations is a difficult concept. First, it cannot be determined objectively, because there is no available known good standard to compare against. Secondly, information is incomplete and the required amount of expert judgment is necessarily large. Lastly, risk evaluations are uncertain predictions, meaning that they state that some future impact is likely or less likely. Crises are infrequent, but even when the impact materialises the fact that the event did happen in no way validates or invalidates the risk assessment. It is only with a large set of predictions and their outcomes that statistical statements can be made about the accuracy of predictions. In that respect risk evaluations for crises are very different from other uncertain predictions, such as weather forecasts. Because of these difficulties, correctness must be determined in a subjective way. Firstly, we asked participants about their personal belief in correctness of their risk evaluations; secondly, we asked participants from an independent field test to assess the correctness of these evaluations.

Q2: Required effort. Since the parties agreed to participate without charge, only time and effort were relevant. We recorded the time spent during project meetings, and the participants reported the amount of time they spent on project matters between meetings.

Q3: Disposition to use. To see whether target users would want to use Raster themselves, we used the Technology Acceptance Model TAM described in Section 2. The standard TAM questions were translated from English into Dutch. The original TAM questions are shown in Figure 5; the versions provided to the participants are shown in Appendix A.

Role	*Domain expertise*
sponsor	crisis management
member	information technology and data communications
member	public enforcement of regulations
member	telemetry
member	water level management
experimenter	RASTER method and meeting chair

Figure 1: List of participants: their project role and their particular expertise.

3.2 Method

WHA is an active participant in the Safety Region Groningen, where the first field test was conducted. The liaison for the water board participating in this field test took the initiative to perform a similar project at WHA. The project could therefore be started on the basis of an informal, verbal agreement between experimenter and the liaison, who would act as the sponsor for the field test at WHA.

The informal plan presupposed the participation of experts from diverse backgrounds. These experts would perform the RASTER method, with the experimenter acting only as facilitator and chair. A series of project meetings was started with various professionals from WHA. The sponsor joined the project, representing the crisis management team. Three experts from the IT, telemetry, and enforcement departments participated; later a fourth expert from water level management complemented the project team (see *Figure 1*). After completing stage 1 of the RASTER method the scope of the project could be determined in more detail, and a formal written project plan was agreed upon.

At the end of the project, each participant completed a questionnaire, and a guided group discussion was held. The purpose of the questionnaire and discussion was to provide further information to answer our three research questions. The questionnaire contained 38 statements with five possible answers from 'Strongly disagree' to 'Strongly agree'. Together with the 12 TAM questions this yielded 50 questions in total; Appendix A shows the questionnaire.

Given the sensitivity of WHA's operations, all participants agreed to confidentiality. Publishing details of the risk analysis or its results could jeopardise the effective operation of emergency services, or could make them a target for malicious actions. This report therefore only describes the results in general terms and does not mention specific risks found.

This field test therefore used the same research questions and research method as for the first field test [6].

In this field test, in addition, we performed two comparisons between the field tests: we compared and contrasted the outcomes, and also asked the participants to reflect on the outcomes of the first field test (to perform a limited peer review). The goal of this review is to validate reliability (repeatability) under practical circumstances, and to collect additional data

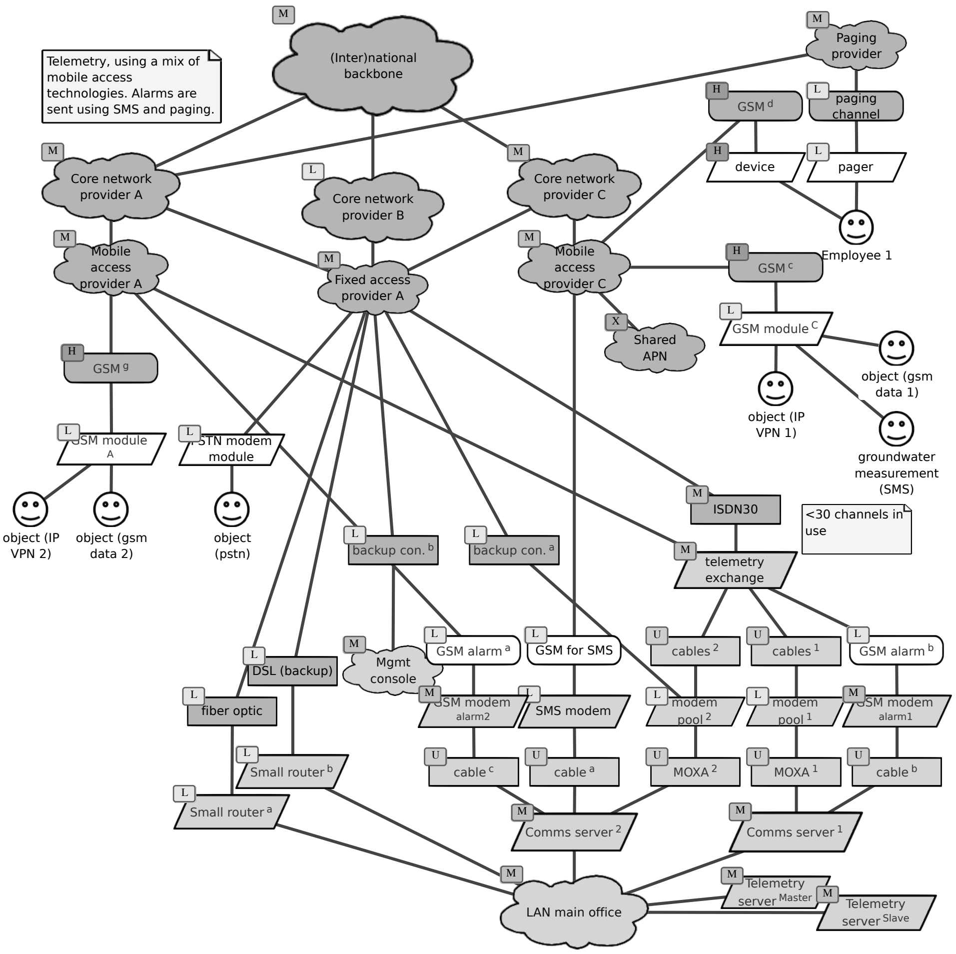


Figure 2: The project's diagram for telemetry (anonymised). Components have a shape, colour (shown in greys here) and emblem to indicating type, location and risk level respectively.

on the correctness of the results. The review is described in Section 6.

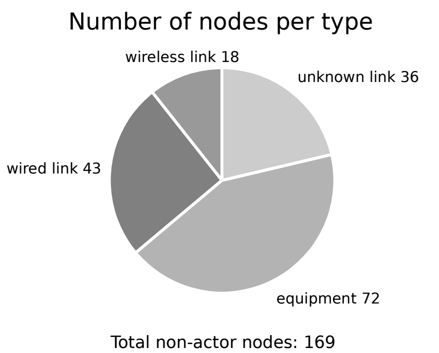
4 Results

In total ten project meetings were held (including one evaluation session), lasting three to four hours. Most project members were present during the meetings, with the exceptions of meetings six and eight, when only two experts were present. Project members convened only incidentally between meetings. Because the project took longer than planned, a three week break over the summer holidays had to be included. Towards the finalisation of the project there was also a few weeks idle time because of scheduling reasons.

The project covered seven telecommunication services: *Figure 3* provides an overview of the complexity of their diagrams and *Figure 2* shows an example of the fixed telephony service. Together, these seven services contained 204 telecom infrastructure components. In all, the project recorded just over 1,900 estimates of likelihood and impact of vulnerabilities (see *Figure 4*). The final risk list contained nine important availability risks.

Service	*Description*	*Wireless*	*Wired*	*Equip't*	*Cloud*	*Actor*	*Total*
inter-office	wired and wireless connections between various offices, work locations and objects	5	10	22	24	3	64
telemetry	remote monitoring of water levels and objects	7	12	17	11	7	54
national emergency telephony service	last resort communication	0	9	10	4	6	29
fixed telephony	external and general communications	0	8	6	5	7	26
mobile telephony	external and general communications	4	0	6	5	7	21
private mobile radios	group communication during crises	1	4	8	2	3	18
marine radio	ship-to-ship and ship-to-shore	1	0	3	0	3	7
	Total:	18	43	72	36	35	204

Figure 3: Telecom services analysed in the second field test, and the number of nodes for each node type. Not all columns add up to the provided totals because some nodes appear in more than one diagram.



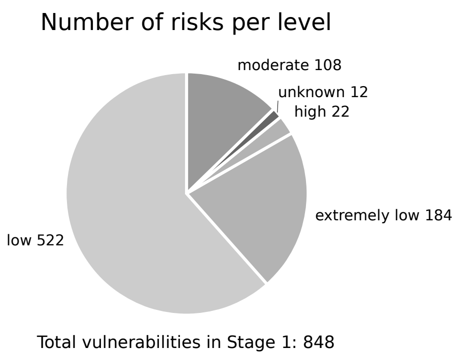


Figure 4: Summary of the second field test: number of nodes per type, and number of risks per level (single failures only).

4.1 Exit questionnaire

All five participants completed the exit questionnaire; the questionnaire was identical to the one used in the first field test. One question was left unanswered: because the Raster manual had since been translated into Dutch, the statement "I found it difficult that the Raster manual was only available in English" was no longer relevant. A summary of the questionnaire results is given below; Appendix A compares its results to those of the first field test.

Participants found the instructions to be clear, but some had difficulty in applying them to their contribution in the project (questions 1–4). They

Ability to participate

1. The explanations and instructions on the RASTER method was (very unclear ... very clear).	VU	U	N	C ▲▲▲▲	VC ▲
2. The explanations and instructions on the goals of the project were (very unclear ... very clear).	VU	U	N ▲	C ▲▲▲	VC ▲
3. I knew what input was expected from me during the project.	SD	D ▲	N ▲	A ▲▲	SA ▲
4. I was able to apply the explanations and instructions on the RASTER method.	SD	D	N ▲▲	A ▲▲▲	SA

Ability to contribute

5. My technical knowledge on telecom services is (very limited ... excellent).	VL	Limtd. ▲▲	N ▲▲	Good ▲	Exc.
6. My knowledge on the use and purpose of telecom services in practice is (very limited ... excellent).	VL	Limtd.	N ▲▲▲	Good ▲▲	Exc.
7. With my knowledge I was able to contribute to the project.	SD	D	N ▲▲	A ▲▲▲	SA

Attitude to consensus

8. In the project group we agreed on the estimates for Frequency and Impact.	SD	D	N ▲	A ▲▲▲	SA ▲
9. In principle there is always one best estimate (whether we always found it or not).	SD	D	N ▲▲▲	A ▲▲	SA

Clarity of the scales

10. The scale used for Frequency was (very unclear ... very clear).	VU	U	N ▲	C ▲▲▲▲	VC
11. The scale used for Impact was (very unclear ... very clear).	VU	U	N	C ▲▲▲▲▲	VC

Applicability of the scales

12. When making estimates on Impacts I ... hesitated between two neighbouring classes (almost always ... very seldom).	AA	Often ▲▲▲▲	N ▲	Seldom	VS
13. When making estimates on Frequencies I ... hesitated between two neighbouring classes (almost always ... very seldom).	AA	Often ▲▲	N ▲▲▲	Seldom	VS
14. The scale used for Frequency was suitable for this project.	SD	D ▲▲	N	A ▲▲▲	SA
15. The scale used for Impact was suitable for this project.	SD	D ▲	N ▲	A ▲▲	SA
16. The group's estimated matched my personal estimates.	SD	D ▲	N ▲▲	A ▲▲	SA

Time required by the analysts

17. The time available for this project was (very tight ... more than ample).	VT	Tight	N ▲▲▲▲	Ample ▲	MTA
18. If we had spent more time on the project, the results would have been (much worse ... much better).	MW	W	N ▲▲▲▲	B ▲	MB

Figure 5: (continued on next page)

19. It was easy to make time available for this project.	SD	D ▲▲▲	N ▲	A ▲	SA
20. If the project had required more time, I would not have been able to participate.	SA ▲	A	N	D ▲▲▲	SD ▲
21. The project took a lot of my time.	SA	A	N ▲▲▲	D ▲▲	SD

Attitude to the project

22. Participating in this project was (very boring ... very interesting).	VB	B	N	I ▲▲	VI ▲▲▲

Need for localisation

23. I found it difficult that the Raster manual was only available in English.	SD	D	N	A	SA
24. It is important that all Raster documentation is available in Dutch.	SD	D ▲	N	A ▲▲▲	SA ▲

Accuracy and efficiency of risk identification

25. The Raster method assists in quickly determining all large risks.	SD	D	N ▲▲	A ▲▲▲	SA
26. There exist large risks for unavailability of telecom services that were not found in this project.	SA	A	N ▲	D ▲▲	SD ▲▲
27. The Raster method helps to ignore all small risks quickly.	SD	D ▲▲	N ▲▲▲	A	SA
28. The final risk list also contains risks that actually are not that important.	SA	A ▲	N ▲	D ▲▲▲	SD

Correctness of the outcome

29. I am confident that the results of the project are correct.	SD	D	N	A ▲▲▲▲	SA ▲
30. I can take responsibility for the results of the project towards my colleagues.	SD ▲	D	N	A ▲▲	SA ▲▲

Correctness of risk prioritisation

31. The Raster method helps to determine risk priorities.	SD	D	N	A ▲▲▲▲▲	SA
32. The risks on the final risk list are shown in the right order (highest priority first).	SD	D	N	A ▲▲▲▲▲	SA

Effectiveness of the project

33. I am surprised by the results of this project.	SD	D ▲▲	N ▲▲▲	A	SA
34. Altogether, the project has made [organisation] (much less secure ... much more secure).	MLS	Less S.	N ▲▲▲	More S. ▲▲	MMS

Clarity of procedures

35. For me drawing and discussing the telecom diagrams was (very unnecessary ... very useful).	VU	Somewhat Unnry.	N	Somewhat Usefl.	VU ▲▲▲▲▲
36. I found the telecom diagrams (very unclear ... very clear).	VU	U	N	C ▲▲▲▲	VC ▲
37. For me estimating and discussing Frequency and Impact was (very unnecessary ... very useful).	VU	Somewhat Unnry.	N	Somewhat Usefl. ▲	VU ▲▲▲▲
38. I found the estimates of Frequency and Impact (very unclear ... very clear).	VU	U	N ▲	C ▲▲▲▲▲	VC

Figure 5: (continued on next page)

Technology Acceptance Model – Perceived Ease of Use

Question	SD	D	N	A	SA
39. Learning to operate RASTER would be easy for me.		▲	▲▲	▲▲	
40. I would find it easy to get RASTER to do what I want it to do.		▲▲▲	▲▲		
41. My interaction with RASTER would be clear and understandable.		▲	▲▲	▲▲	
42. I would find RASTER to be flexible to interact with.			▲▲▲	▲▲	
43. It would be easy for me to become skilful at using RASTER.		▲	▲	▲▲▲	
44. I would find RASTER easy to use.		▲▲	▲▲	▲	

Technology Acceptance Model – Perceived Usefulness

Question	SD	D	N	A	SA
45. Using RASTER in my job would enable me to accomplish tasks more quickly.		▲▲	▲	▲▲	
46. Using RASTER would improve my job performance.		▲	▲▲	▲▲	
47. Using RASTER in my job would increase my productivity.		▲	▲▲	▲▲	
48. Using RASTER would enhance my effectiveness on the job.			▲▲	▲▲	▲
49. Using RASTER would make it easier to do my job.		▲	▲	▲▲▲	
50. I would find RASTER useful in my job.		▲	▲	▲▲▲	

Figure 5: Questions and answers to the exit questionnaire for the second field test. SD, D, N, A, SA stand for strongly disagree, disagree, neither agree nor disagree, agree, strongly agree respectively.

were able to contribute to its results (questions 5–7), and had little difficulty resolving disagreements and attaining consensus (questions 8–9). Although the scales for Frequency and Impact were clear (questions 10–11), participants found it difficult to assign the most suitable estimate (questions 12–13); they were not sure whether the scales are really suitable, and the consensus arrived at often differed from their own estimate (questions 14–16). The time available for the project was somewhat tight, but sufficient (questions 17–20), and participants readily made themselves available (questions 21–22). Participants agreed that RASTER helps to discover large risks, but were less certain whether it was able to weed out small risks (questions 26, 28); they doubted the efficiency of the process, especially for small risks (questions 25, 27). Still, they have confidence in the correctness of the outcome of the project (questions 29–32), but less so in its effectiveness (questions 33–34). Answers to question 30 show an outlier; we have reason to believe that this score was made in error. The process of creating diagrams and discussing vulnerabilities of components was found very useful (questions 35–38).

4.2 Group discussion

Afterwards, a one-hour discussion was held. The topics for this discussion were the same as for the first field test: 1) the RASTER methods and its strengths and weaknesses, 2) reliability of the outcome, 3) time and effort, and 4) determination of correctness. Below is a summary of the comments by the participants; unless indicated otherwise, the opinions below are the participants'. Because of time constraints, some of the issues could not be discussed in detail.

1) The participants found it difficult to create the diagrams, because diagrams show physical relations instead of logical relations, which they were more used to. They said that diagrams helped to gain insight, but tended to become complex. Diagrams allow for bundling of knowledge and expertise that would not have been possible in text-based representations. They suggested that it may be better to agree in advance on a certain depth and breadth of modelling. For example, the office network was modelled in detail, whereas provider networks were described at a high level; some IT infrastructure was modelled that extended beyond strictly telecommunication services. The more detailed the diagrams are, the more time has to be spent on their analysis. It would have been better, some participants thought, to have limited the project to a single high-level diagram, and a faster assessment without too many details.

The scales for Frequency and Impact were suitable. Having just three options forces one to make a choice; with more than three options the scores would probably cluster around the centre. Estimating the Impact was found to be easier than estimating the Frequency of vulnerabilities.

The participants were less confident about the correctness of common cause failure assessments, for both the clustering and the risk assessments.

2) Participants agreed that estimates are subjective, but saw no large issues with this, because the project team provides different views and group-discussions lead to consensus. The team composition lacked a representative from the waste water treatment department. Also, in some of the work sessions too few project members were present. Then again, the participants believed that the results of the project would not have differed.

3) The participants agreed that the time spent was sufficient; when more time had been available the results would not have been better. Had less time been available, then the analysis would have been less thorough. It is important to have an experienced project leader to guide the team through the Raster method and to monitor consistency. The participants remarked that it would have been better to shorten the lead time, and have multiple sessions per week. However, they also agreed that compressing the project into two or three consecutive full days would not have been useful: it is necessary to have time between sessions to research missing information and to "let matters sink in".

4) Participants confirmed that they believed the project results to be correct. However, there have already been changes in the infrastructure since the start of the project, and some of the diagrams are already partly outdated. The main benefit of the project was that participants gained better arguments for their risk assessments, less so the risk identification. The final risk shortlist and the priorities of the risks were mostly as expected, and unsurprising to the participants. The fact that a group of mixed experts arrived at the same conclusions based on consensus makes that the recom-

mendations carry more weight. It would be useful to repeat this project in a year's time; lead time would be shorter than for the initial project.

5 Discussion and comparison

Since this is the second field test, its results can be discussed in contrast to the first field test. Also, the research questions for the second field test are answered.

5.1 The Raster method

Although the first team had ten telecom services and the second team only seven, the total number of components in the two projects was nearly identical: 205 in the first field test versus 204 in the second. Compare Figures 6 and 3. In the second project the diagram for maritime radios was trivial: in this service, ships communicate directly using independent radio sets; there is no central infrastructure. Excluding this service, the diagrams in the second project were clearly more complex than in the first. Whereas the first project shows on average 21 components per service (median 21), in the second project this was 36 (median 28). Furthermore, in the second project the services were in the process of being redesigned, and migrated from one telecommunication provider to another. The difficulty to discover the actual status quo further complicated the creation of diagrams.

The total number of vulnerabilities assessed was nearly identical: 832 single failures and 72 common cause failures in the first field test, versus 888 and 81 respectively in the second field test (Figures 7 and 4). This is to be expected, given that the number of components was nearly identical.

There was also overlap in the telecom services employed: both projects featured fixed telephony, mobile telephony, the national emergency telephony service, and private mobile radios. As the use of these services is different for the two organisations, their diagrams in the two projects were not identical. However, the central architecture for these services was equivalent.

5.1.1 Project execution

The first field test required five work sessions; the second field test required nine. However, the total time spent on the projects is nearly identical (137 hours for the first project, versus 138 hours for the second, see *Figure 8*) and, as shown above, the size of the projects was also nearly identical. Seven experts participated in the first project versus five in the second project, meaning that the expert's average contribution in the second project was higher (20 hours per expert on average in the first field test, versus 28 hours per expert in the second).

Despite these similarities there was a large difference in lead times: 7 weeks for the first field test, but 19 weeks for the second. When the three week break over the summer holidays and other idle time are excluded, the second project still took 3 weeks longer. See *Figure 9* for an overview of the duration of the various stages. The difference in lead times does not originate

Service	*Description*	*Wireless*	*Wired*	*Equip't*	*Cloud*	*Actor*	*Total*
data services	net-centric operations	7	7	30	15	9	68
fixed telephony (over IP)	external and general communications	1	5	11	10	6	33
civil warning sirens	to warn the public about crises or disasters	8	0	11	3	5	27
vehicle automation	on-board navigation and special tools	1	1	8	11	3	24
private mobile radios	for group communication and despatch	2	2	9	4	6	23
paging	group and personnel notification	1	0	9	4	5	19
mobile telephony	external and general communications	0	0	5	6	4	15
VPN connections	inter-office communications	0	4	6	3	2	15
national emergency telephony service	last resort communications	0	2	7	4	4	17
satellite telephony	backup voice communication	1	2	5	2	4	14
	Total:	18	20	93	26	48	205

Figure 6: Telecom services analysed in the first field test, and the number of nodes for each node type. Not all columns add up to the provided totals because some nodes appear in more than one diagram.

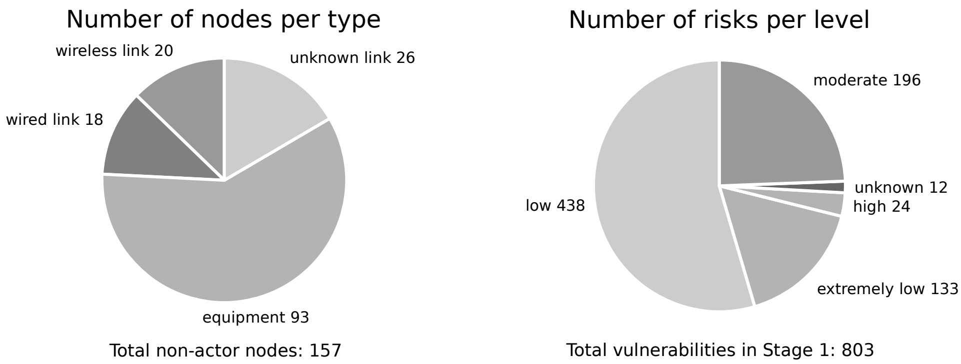


Figure 7: Summary of the first field test: number of nodes per type, and number of risks per level (Stage 2, single failures only).

from Stage 1 (initiation and preparation) or Stage 4 (evaluation); in both cases, these required one and two work sessions (and weeks) respectively. It is the risk assessment stages where a large difference is visible. In the first project the base diagrams were created in one work session, with minor revisions in the subsequent sessions. In total, Stage 2 (single failures) took three weeks. In the second project it took four work sessions before the

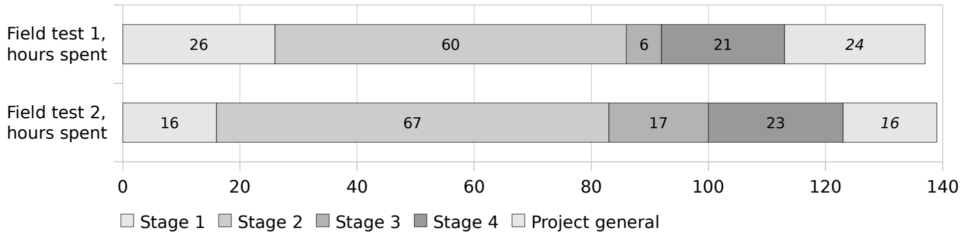


Figure 8: Time spent (in hours) by the experts, excluding the experimenter, in each of the stages of the Raster *method. "Project general" includes the kick-off session, answering the questionnaire and the final discussion.*

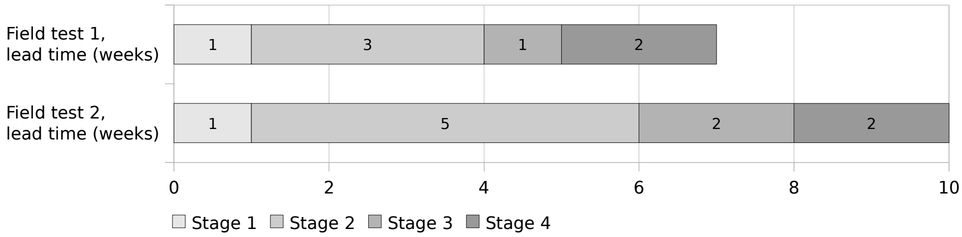


Figure 9: Duration (in weeks) of each of the stages of the Raster *method.*

diagrams were stable; overall, Stage 2 took five weeks. Stage 3 (common cause failures) took one work session and one week in the first project, and twice that much in the second project. There are three explanations for these differences.

First, the work load in the first project was shared between the core group and the plenary work sessions. The core group was able to prepare much of the output, for presentation to the entire group during the next work session. This approach was not possible in the second project, for practical reasons. As a result, most of the work had to be done during (plenary) work sessions. In Stage 2, in drawing the diagrams and assessing single failure risks, there are two kinds of activities: compiling the facts about physical components and their connections, and reflecting upon the diagrams and the risk assessments. It is more efficient to perform the first activity in a dedicated in-depth expert session, rather than during plenary sessions.

Secondly, it was far more challenging in the second project to create the telecom service diagrams, because the services were more complex. There were more locations, and more telecommunication technologies. For example, the telemetry service (Figure 2) makes use of DSL, fiber-optic, ISDN, analog telephony, 2G modems, 2G and 3G mobile data, VPN, SMS, and paging all for a single telecom service. On top of this, there was recurrent confusion about the actual situation, because services were being migrated to a new provider.

Thirdly, the second project team found it more difficult create diagrams. In the group discussion they noted that telecom service diagrams in Raster, by design, show physical components and physical connections, whereas they are more used to thinking about telecom services as abstract logical components and information flows. The Raster diagrams forced the experts on information and communication technology to think about their infrastructure in a way that they were less used to. In the group discussion one participant raised the suggestion to limit the project to a single high-level diagram. Such a simplification may work in projects where services are tightly coupled, and where most risks are low with few high-risk exceptions. If services are tightly coupled then there will be many components and functions that are shared between services. As a result it will be more difficult to separate the diagrams for these services, and a single diagram may be more efficient. However, such a single diagram tends to have many components and can therefore become complex. Complexity can be reduced by keeping details 'hidden' within Unknown links (the cloud shapes in diagrams). The disadvantage of this is that availability risks within those Unknown links are more difficult to identify. If most risks are low and high-risk exceptions can be located with reasonable accuracy, then the disadvantage of using many Unknown links is limited. However, many organisations use services that are loosely coupled, with risks cannot be located easily. Use of a single large diagram will then not be helpful for accurate risk assessment. In the project at Safety Region Groningen, for example, such an approach would not have been effective; the risks that were identified in that project would likely not have been found when only a single high-level diagram had been drawn.

In the group discussion is was said that it would have been useful to have an additional expert on waste water treatment in the project team. Team composition was addressed both at the start of the project, and later during project progress review. At those moments, the team agreed that no further participants were required, as the necessary knowledge was already present in the team. The participants believed that the project outcome would not have been different, if a waste water treatment expert had been present. It therefore appears that the participants collectively were able to supply the necessary expertise, and that an additional expert was not required.

In the group discussion it was also remarked that the common cause failure assessment may have been inaccurate and incorrect. Stage 3 (common cause failures) was carried out just before the summer break, with only a few participants present. Most project members were unable to give this stage their full attention. This will have prevented them to contribute and carefully review the assessments. However, such circumstances are a matter of project management, and are not indicative of an issue with the Raster method.

5.1.2 Project results

In addition to the higher lead time and complexity of the second project there is another notable difference. The second team's Impact assessments were less severe, and the number of high Frequency and high Impact assessments was lower than in the first field test (see *Figure 10*). The reason for this, according to the participants, is that the operations of WHA have been designed with redundancy and resilience in mind. For example, telemetry provides much of the essential information for water level management, but disruptions of a few hours can be tolerated without danger. When remote

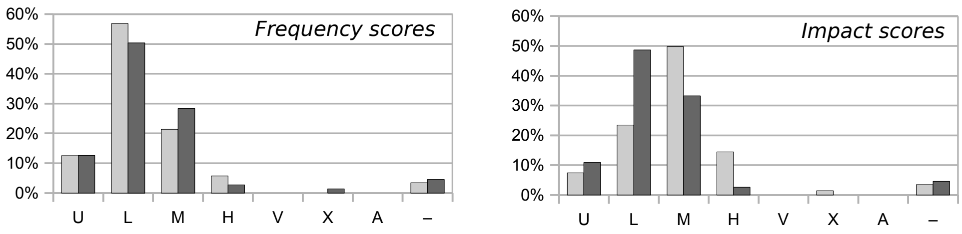


Figure 10: Distribution of Frequency and Impact assessments for single failures the in the first (light grey) and second (dark grey) field tests. Labels are: U for extremely low (Unlikely or Ultra low), L for Low, M for Moderate, H for High, V for extremely (Very) high, X for unknown, A for Ambiguous, and – for undecided.

sensors come back on-line, they will transmit all queued measurements. If disruptions are to be measured in days, then field personnel will record water levels manually, and relay this information to head office via private mobile radio or mobile phone. Even sea barriers can be closed manually in emergencies.

This lower overall risk level could also be observed during Stage 4 (evaluation). Whereas the longlist in the first field test contained 31 High risks, the second field test only contained 11.

5.1.3 Questionnaire outcome

The scores given by the two teams are often nearly identical (see Appendix A). For example, there is very little difference in their answers on ability to contribute (question 5–7), attitude to consensus (question 8–9), clarity of the scales (question 10–11) and time required (question 17–21).

A notable exception is the set of answers on applicability of the scales (questions 12 to 16). The teams from the second field test scored more negative, especially on questions 12 and 13 (hesitating between adjacent Frequency and Impact scores). Apparently, the second team had more difficulty in coming to a consensual decision when assessing Frequency and Impact, compared to the first team. The reason for their hesitation was not that the scales themselves were unclear, as indicated by the near-unanimous scores to questions 10 and 11. Where the first team was quite confident about the applicability of the scales (questions 14 and 15), the second team was somewhat less certain. A possible explanation for the difference between the two teams may be that the second team's Impact assessments were much less severe. It is possible that sifting through a seeming endless list of low risks gave the second team a sense of lack of direction. Unfortunately, it is only *after* completing the risk assessments that it becomes clear that most risks are small.

This conjecture may then also explain the results of another pair of differences. Question 26 asks whether there exist large risks that were not identified during the project. The second team, with hardly any High risks and overall lower assessments, was more confident that this was *not* the case (a more positive outcome). However, that same team was more negative on the question whether small risks were quickly ignored; they had to assess many more Low-impact risks.

5.2 Research questions

Recall that there are three research questions:

- Q1 Does Raster produce, in practice, risk evaluations that are correct? That is, are all relevant risks included (completeness), are low risks excluded (conciseness), and are risks presented with the right priorities?
- Q2 What are the costs and effort involved in execution of Raster?
- Q3 Are the target users willing to use the Raster method?

5.2.1 Q1: Correctness

The participants' answers to the questionnaire (questions 29–32) show that they have confidence in the correctness of the project results. As for the aspect of completeness, the participants were certain that no large risks have been overlooked, but less certain about the efficiency of this activity. They were divided on the conciseness of the outcome: some participants indicated that the final risk list might contain too many unimportant risks. The activity of eliminating small risks was perceived to be slow. Despite these reservations, the participants were positive about having found the right risk priorities. Overall, it can be concluded that the participants believe the results to be correct, but somewhat inefficient, especially for small risks.

5.2.2 Q2: Required effort

The five participants spent on average 28 hours on the project (see *Figure 8*). The questionnaire results and group discussion both indicate that the time for the project was sufficient. The participants were aware that the project required a significant portion of their time, but were able to make themselves available for the project without too much difficulty. Overall, it can be concluded that the time required is acceptable.

5.2.3 Q3: Disposition to use

As in the first field test, we used the original Technology Acceptance Model to assess the participants' disposition to using the method in other projects. Answers to the questions on perceived ease of use were inconclusive (*Figure 11*). This topic was also remarked upon in the group discussion; participants said that an experienced project leader is essential and that they would not have been able to employ the Raster method without help. This opinion will have been influenced by the large lead time of the project, as discussed in the previous subsection. It was not uncommon for participants not to work on the project for three weeks between work sessions. A more compact project planning may have resulted in more positive answers in the ease-of-use section.

The answers for perceived usefulness (*Figure 12*) were slightly more positive but still somewhat inconclusive, and markedly different from the scores

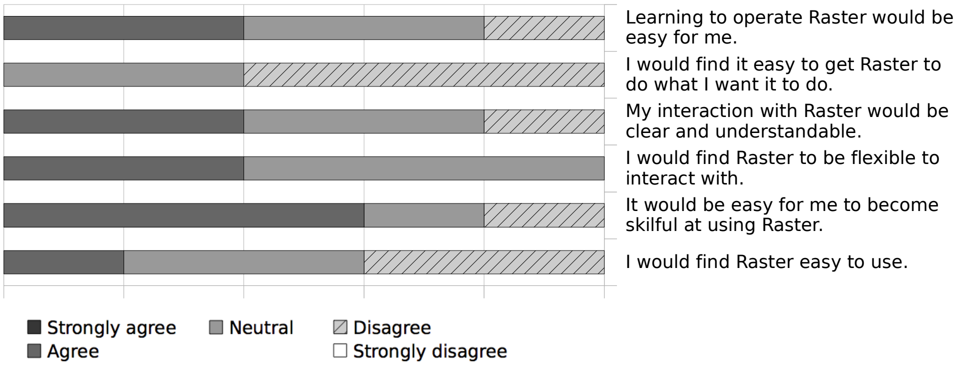


Figure 11: Scores on the TAM questions on Perceived Ease of Use.

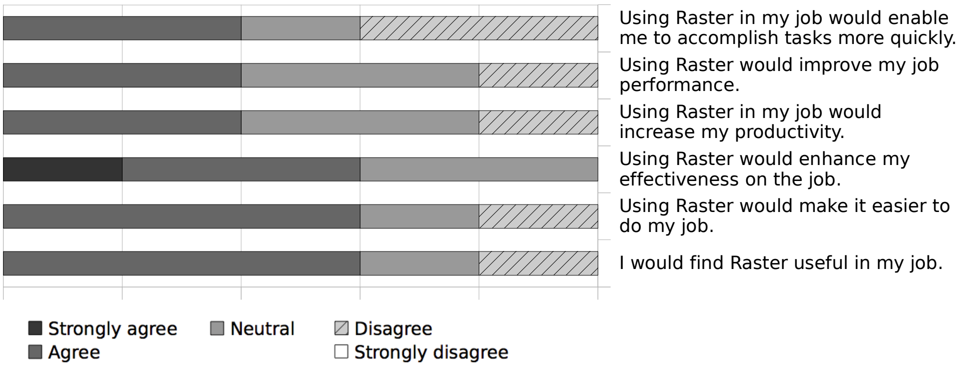


Figure 12: Scores on the TAM questions on Perceived Usefulness.

from the first field test. These opinions are probably influenced by the large number of Low risks, and by the fact that there were few High risks, as discussed in the previous subsection.

6 Peer review

We asked the project team members to participate in a limited peer review. The goal of the review was twofold:

- to validate reliability of the Raster method, and
- to validate the correctness of its outcomes.

In previous research we called a method reliable if it can be repeated with the same results [5]. In this publication we proposed a method for experimental validation of reliability, and indicated that for practical reasons it cannot be applied using professionals. Therefore, we used peer review instead. Participants from the second field test were asked to review the products of the first project. In the context of peer review, 'correctness' means that results are based on accurate input data, consistent with existing knowledge, and derived according to the Raster procedures.

A peer review has two main disadvantages. First, a full review takes a lot of time; given the already long lead time of the project we were only able to dedicate a part of the final project meeting to the review. Secondly, a

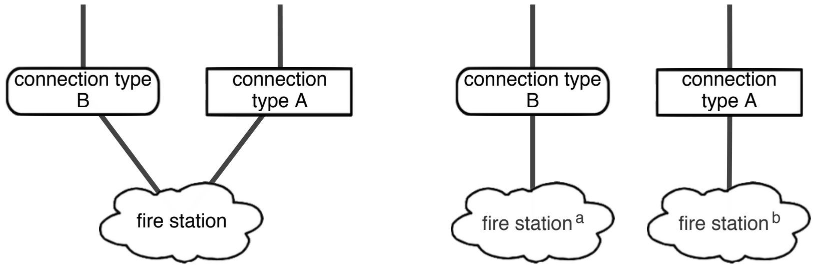


Figure 13: Two equivalent representations of component instances with alternative connections. The representation on the right was found to be more clear.

full review requires domain knowledge about the target organisation. The first project team included specialists from emergency medical care, police, civil support, and fire services; the second project team did not possess this expertise. This restricted the possible scope of the review.

To minimise our capacity claim on the participants and to limit our questions on areas of shared expertise, we carefully selected partial results from the first project. This selection excluded the results of Stage 1 (identifying services, actors, etc.), the drawing of telecom service diagrams, treatment recommendations, and any other area that requires domain knowledge about Safety Region Groningen that was not available in the second project team. We selected the following four topics: understanding the diagrams, correctness of single failure assessments, clustering and assessments for common cause failures, and assessment of social risk factors. For each topic we selected parts of the first project's results (e.g. a diagram, two or three single failure assessments) and asked specific questions about these parts. The results are described and discussed below.

Understanding the diagrams. We wanted to know whether participants could explain key elements of a telecom service diagram, such as the path of communication between two actors, and the intended meaning of multiple paths. Participants were able to explain the flow of communication and the purpose of components, and correctly identified built-in redundancy in parallel connections.

When a diagram component represents not a single instance but a collection of instances (for example 'all fire stations') than the meaning of multiple connections to this component can have two meanings. Either it means that every instance has all connections, or that each instance has one of these connections (see *Figure 13*). Participants were of the opinion that only the first meaning is correct; if the second meaning is intended, an alternative diagram should be used. This disambiguation is not more than a diagram technique; the risk assessments will be identical in both cases.

Recall that several telecom services occurred in both the first and the second field test. This allowed us to compare the two variant diagrams developed by the teams. We selected mobile telephony for this comparison. The participants found no substantial differences between the two diagrams. The WHA-version showed somewhat more detail, e.g. to explicitly show the wireless connection between smart phones and the mobile network, but participants disagreed on whether this added useful information to the analysis or not.

The participants suggested that, in order to make diagrams more understandable, additional information could be recorded. For example, a small note could indicate the starting point of communication. It would also help understanding if a concise explanation of key points was included in the diagrams. Both suggestions are already supported by the current version of the Raster tool; it is possible to insert coloured notes containing arbitrary text.

Single failure assessments. Another service appearing in both projects is private mobile radio. The participants were hesitant to review the assessments made by the first project team, indicating that they lacked the required domain knowledge, especially for impact assessments. Respect for the professional integrity of the first project's team members may play a role here. When pressed, they were able to compare the assessments against their own situation, noting similarities and differences in their organisations that would explain the difference in assessments. They also pointed out risk assessments that, in their opinion, were unjustifiably high. In addition to domain knowledge, participants also indicated subjectivity as a factor in differences between assessments. They reiterated the importance of a balanced group composition in order to moderate the effects of subjectivity.

Common cause failures. We selected the general vulnerabilities of malfunction and configuration errors by end-users and maintenance staff. The participants found it difficult to comment on the clustering criteria and on the cluster composition. As explained in the previous section, analysis of common cause failures did not receive sufficient attention in their project. This will also explain their incapacity to critically discuss the common cause failure assessments of the first project.

In addition to the two vulnerabilities above we also selected flooding. Flooding is, of course, of special interest to the staff of the water board. Here participants were able to make useful suggestions on alternative clustering properties (height above sea level instead of physical proximity), and on additional clusters. For example, additional clusters could have been created for flooding of river banks, or flooding after heavy rainfall.

Evaluation. We asked participants to reflect on the assessment of social risk factors, as performed by the first team. Participants saw no omissions nor unnecessary items. They were struck by the emphasis on public accountability and danger of media attention, issues that were less important in their own project.

When asked, the participants were unable to name large risks that were not mentioned and addressed in the first project. Again, they stressed the need to have representatives from all disciplines on the project team, to prevent such omissions.

Participants observed that both organisations are dependent on external partners and suppliers. They also speculated that the RASTER method could be adapted to a wider range of risk assessments. For example, they suggested that RASTER or a modified method could be applied to business processes in general. Also, cyber security risks could be explored using the RASTER method and tool. The project team would in this case have to be extended with a cyber security expert.

6.1 Conclusion

Using a limited peer review we gathered additional data on the reliability and correctness of the RASTER method. The participants were able to correctly interpret selected diagrams from the first project, even when they lacked domain knowledge.

As for reliability, the second project team did not indicate steps in the RASTER method where their approach would have obtained different results. Diagrams for services that appeared in both project were similar, with differences based on the particular needs of both organisations. Participants indicated a preference for a particular diagram technique, but this difference would only improve the understandability, and not lead to different risk assessments. In the few examples presented during the review, single failures and common cause failures would not have been assessed differently. However, when presented with an area where the participants' domain knowledge exceeded the knowledge of the first project team, several enhancements and additions were suggested. These findings support the statements in previous research about generally low reliability of expert assessments, and the need for good justifications for assessments and risk treatment decisions [5].

Correctness means that results are based on accurate input data, consistent with existing knowledge, and derived according to the RASTER procedures. The participants had questions on some of the assessments of the first project team, but did not find reasons to label any of their results as incorrect. The review does not provide arguments to change previous statements on the correctness of RASTER.

7 Lessons learned

The findings in the field test at the Water Board Hunze en Aa's teach us a lot about managing a RASTER project, but do not lead to improvements in the method or tool themselves. There are, however, a number of lessons to learn.

Project lead time. The project results would have been more accurate and perhaps more complete if the lead time had been shorter. The total time spent was sufficient, but spread out over too many weeks. Although it was noted during project review meetings that the planned deadlines had to be extended, the author underestimated the negative impact thereof. Participants did not gain the exposure necessary to become fluent in the RASTER method. In future, it is necessary to stay close to a 5 to 6 week lead time.

Also, it is necessary to obtain commitment from the project sponsor on the availability of project members, to ensure that all project members are present during plenary meetings.

Organising work sessions. The first project made use of a core team as part of the full project team. The core team could collect the facts about telecom service components and their composition. This is an activity in which, in general, the full project team cannot make a useful contribution. An in-depth experts-only session will be more effective and efficient in creating the initial diagrams. The full project team is necessary to reflect upon the diagrams and risk assessments. Based on these reflections the assessments can then be completed in a smaller expert team, possibly a different team than the one creating the initial diagrams. This two-tier organisation of work sessions would have made better use of the scarce time of participants, and will have a beneficial effect on lead time.

Small risk projects. The second project was carried out in an organisation characterised by high redundancy, high resilience, and low availability risks. The RASTER method will perform equally well for such organisations as for organisations exposed to higher risks. However, it is important for the project leader to realise that project members may become somewhat annoyed or frustrated with perceived lack of progress. In such situations, it will be better to spend less time on single failure analysis, and more on common cause failures. For example, instead of assessing every single vulnerability the team may decide to assess only those vulnerabilities that may result in a High risk score, and leave all others unassessed, thus saving time and effort. As it may not be apparent at the start of the project for this to be the case, the project leader should be aware of this possibility, and prepared to switch to a different approach if necessary.

8 Conclusion

Some general conclusions can be drawn from the results of both field tests.

Assessment of risks with high uncertainties requires a large amount of expert knowledge. Facing such risks, decision makers depend on a team of risk assessment and domain experts. Different assessment teams will arrive at assessments that are similar but not identical. If the assessments are both correct, as can be expected from well-motivated experts, the differences in assessments will be supported by the difference in arguments for the assessments as provided by both teams. In either case, decision makers can use the risk assessment as their justification for making risk treatment choices that are both scientifically well-grounded and supported by most stakeholders. In general it will be impossible to state whether one team's assessment was incorrect, or the other team's assessment was more correct. Given limited resources, decision makers are confined to the best possible assessment and justifications available at the time.

Given the need for an assessment team composed of experts from various backgrounds, information sharing and discourse within the team will be difficult but important. Rich graphical models can facilitate shared understanding and discussion about architectures, not only within one team but also between teams. This shared understanding is limited however by the need for specific domain knowledge. In general, peer review of risk assessments is therefore restricted to aspects of the assessment that are general or do not require domain expertise.

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A Questionnaire

The next four pages show the original questionnaire. Note that this questionnaire was used within Dutch crisis organisations; participants strongly preferred to receive all materials in Dutch. A translation of the questions and their possible answers was already provided in the report.

Deelnemer: ___________

Afsluitende vragenlijst

Deze vragenlijst neemt ongeveer 20 minuten in beslag.

Het onderwerp van deze vragenlijst is het gehele project dat bij de Veiligheidsregio Groningen is uitgevoerd: de introductie, werkwijze, uitvoering en resultaten. In het project hebben we gebruik gemaakt van Raster, een methode om een risicobeoordeling voor uitval van telecomdiensten te maken.

De vragenlijst bevat 50 stellingen. Voor elke stelling omcirkelt u het antwoord dat het beste overeenkomt met uw persoonlijke mening, of het antwoord dat de zin naar uw mening het beste afmaakt.

Voorbeelden

Er was in voldoende mate koffie aanwezig tijdens de bijeenkomsten.	Helemaal mee oneens	Mee oneens	Neutraal	Mee eens	Helemaal mee eens
De koffie was …	veel te heet	iets te heet	precies goed	iets te koud	veel te koud

Met deze vragenlijst kunnen wij beter begrijpen wat in de praktijk de voor- en nadelen zijn van de Raster methode.

De vragenlijst start op de volgende bladzijde.

Ik heb vertrouwen in de juistheid van de uitkomsten van het project.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Als ik zelf een telecom-risicoanalyse moest doen, dan zou de Raster methode mijn uitvoering verbeteren.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Er is in principe altijd één beste schatting (of we die nu altijd vonden of niet).	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
De beschikbare tijd om dit project uit te voeren was …	meer dan genoeg	ruim	voldoende	krap	veel te krap
Mijn technische kennis van telecomdiensten is …	zeer beperkt	beperkt	goed noch beperkt	goed	uitstekend
Het zou voor mij helder en begrijpelijk zijn om zelf met de Raster methode te werken.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
In de projectgroep waren wij het eens over de schattingen voor Waarschijnlijkheid en Impact.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
De gebruikte schaal voor Waarschijnlijkheid was …	zeer helder	helder	helder noch onduidelijk	onduidelijk	zeer onduidelijk
Als ik zelf een telecom-risicoanalyse moest doen, dan zou de Raster methode mijn productiviteit verhogen.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
De gebruikte schaal voor Waarschijnlijkheid was geschikt voor dit project.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik vond de schattingen van Waarschijnlijkheid en impact …	zeer duidelijk	duidelijk	duidelijk noch onduidelijk	onduidelijk	zeer onduidelijk
Ik zou de Raster methode eenvoudig vinden om zelf te gebruiken.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
De Raster methode helpt om alle grote risico's snel te vinden.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Als ik zelf een telecom-risicoanalyse moest doen, dan zou de Raster methode mij in staat stellen om taken sneller uit te voeren.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Bij het schatten van Impact twijfelde ik … tussen twee naastgelegen waarden.	bijna altijd	vaak	vaak noch zelden	zelden	zeer zelden
Deelnemen aan dit project was …	zeer interessant	interessant	interessant noch saai	enigszins saai	zeer saai
Ik durf verantwoording te nemen voor de resultaten van het project tegenover mijn collega's.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Al met al heeft dit project ertoe geleid dat de VRG … is geworden.	veel onveiliger	onveiliger	veiliger noch onveiliger	veiliger	veel veiliger
Als wij meer tijd aan het project hadden besteed, dan zouden de resultaten … zijn geweest.	veel slechter	minder goed	hetzelfde	beter	veel beter
Bij het schatten van Waarschijnlijkheid twijfelde ik … tussen twee naastgelegen waarden.	bijna altijd	vaak	vaak noch zelden	zelden	zeer zelden

Naar volgende pagina →

Ik zou het eenvoudig vinden om zelf de Raster methode te laten doen wat ik wil doen.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik vond de telecomdiagrammen …	zeer duidelijk	duidelijk	duidelijk noch onduidelijk	onduidelijk	zeer onduidelijk
Ik zou zelf de Raster methode flexibel vinden in het gebruik.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Mijn kennis over het gebruik en nut van telecomdiensten in de praktijk is …	zeer beperkt	beperkt	noch goed noch beperkt	goed	uitstekend
Ik wist welke inbreng er tijdens het project van mij verwacht werd.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
De uitleg en instructies over de Raster methode was …	zeer duidelijk	duidelijk	duidelijk noch onduidelijk	onduidelijk	zeer onduidelijk
De gebruikte schaal voor Impact was geschikt voor dit project.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Het zou voor mij eenvoudig zijn om de Raster methode zelf te leren gebruiken.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik vond het lastig dat het Raster boekje alleen in het Engels beschikbaar was.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik vond het maken en bespreken van schattingen van Waarschijnlijkheid en Impact …	zeer nuttig	een beetje nuttig	nuttig noch overbodig	een beetje overbodig	zeer overbodig
De schattingen van de groep kwamen overeen met mijn persoonlijke schatting.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik vond het tekenen en bespreken van de telecomdiagrammen …	zeer nuttig	een beetje nuttig	nuttig noch overbodig	een beetje overbodig	zeer overbodig
Er bestaan grote risico's voor de uitval van telecomdiensten die in dit project niet gevonden zijn.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik ben varrast door de uitkomsten van dit project.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
De uitleg over de opzet en doelen van het project was …	zeer duidelijk	duidelijk	duidelijk noch onduidelijk	onduidelijk	zeer onduidelijk
De Raster methode helpt om de prioriteit van risico's te bepalen.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik heb de uitleg en instructies over de Raster methode kunnen toepassen.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Het is belangrijk dat alle Raster documentatie in het Nederlands is gesteld.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Als ik zelf een telecom-risicoanalyse moest doen, dan zou de Raster methode mijn effectiviteit verhogen.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Het was eenvoudig om tijd vrij te maken voor dit project.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens

Naar volgende pagina →

De gebruikte schaal voor Impact was …	zeer helder	helder	helder noch onduidelijk	onduidelijk	zeer onduidelijk
Ik kon met mijn kennis bijdragen aan het project.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
In de uiteindelijke risicolijst staan alle risico's in de juiste volgorde (hoogste prioriteit bovenaan).	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Op de uiteindelijke risicolijst staan ook risico's die eigenlijk niet zo belangrijk zijn.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Als het project meer tijd gevraagd zou hebben, dan zou ik niet mee hebben kunnen doen.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik zou de Raster methode nuttig vinden in mijn werk.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Het zou voor mij eenvoudig zijn om vaardigheid te verkrijgen in de Raster methode.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Als ik zelf een telecom-risicoanalyse moest doen, dan zou de Raster methode dat vergemakkelijken.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
De Raster methode helpt om alle kleine risico's snel te negeren.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens
Ik was veel tijd kwijt aan de uitvoering van dit project.	helemaal mee oneens	mee oneens	neutraal	mee eens	helemaal mee eens

Hartelijk dank voor uw medewerking.