Master Thesis Research Project

Information systems with intelligent applications, user-friendly design, and digital ecosystem integration enhance performance in complex engineering projects

Arend Jan Noortman

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Title	Information systems with intelligent applications, user-friendly design, and digital ecosystem integration enhance performance in complex engineering projects
Name	ing. A.J. Noortman
Student number	2669862
Faculty	University of Twente - Faculty of Behavioral, Management and Social Sciences
Program	MSc Business Administration - Digital Business & Analytics
First supervisor	dr.ir. A.A.M. Spil
Second supervisor	dr. M. De Visser
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ABSTRACT

Project management information systems (PMIS) play a crucial role in managing complex engineering projects. By better understanding the effect of PMIS on project performance, organizations can make more informed decisions about how to implement and use these systems to improve their performance. This research investigates the application Relatics as a PMIS to enhance project performance. Through a survey involving 55 project managers, the study emphasizes key PMIS characteristics and evaluates project performance criteria, supplemented by two in-depth interviews. The outcomes provide valuable insights for project managers, researchers, subcontractors and clients of engineering firms.

Relatics users rate the PMIS with an average score of 2.9 out of 5, outperforming other information systems in automated data capturing, flexibility, and intelligence. Notably, all PMIS receive low ratings on intelligence and relatively high ratings on accessibility of information and system simplicity. Improving PMIS intelligence is achievable through the integration of advanced technologies such as artificial intelligence (AI) or virtual assistants, complemented by comprehensive training and guidelines. Relatics contributes to performance by managing complexity in large projects, where it facilitates verification processes by a clear decomposition of information. This feature suggests novel applications in asset management for maintenance projects.

The study underscores the need for a comprehensive approach to PMIS enhancements and offers practical implications for project managers, including the importance of tailored implementations for large projects, user feedback mechanisms, and external integration. The results suggest potential applicability across diverse industries, contributing to the digital engineering ecosystem's evolution. However, the study acknowledges that its focus on Relatics may limit direct applicability to other PMIS platforms, proposing a comparative analysis for a more nuanced understanding. It recommends future research to compare PMIS platforms, explore AI integration, and conduct qualitative research into project manager experiences.

Keywords: project management information system, project performance, systems engineering, complexity

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INTRODUCTION

In today's technologically-driven world, digitalization has emerged as a critical challenge for organizations (Matt, Hess, & Benlian, 2015; Romero & Alcedo, 2022; Brunetti, Bonfanti, Chiarini, & Vannucci, 2022). It gives organizations opportunities to grow, transform and reduce costs (Calderon-Monge & Ribeiro-Soriano, 2023). Within this global digitalization, information systems play a crucial role in supporting various business functions, e.g. in managing complex engineering projects (Pereira, Varajão, & Takagi, 2021; Graaf, Voordijk, & Heuvel, 2016). Engineering projects have a substantial environmental impact due to their development and implementation, as demonstrated by notable examples such as the North-South metro line in Amsterdam (Witteveen+Bos, 2023), the Oosterweel Link in Antwerp (Arcadis, 2023), and the Delta Works (Rijkswaterstaat, 2023). Engineering projects are complex and therefore needs to be managed properly and professionally. This means that they need to be planned, staffed, organized, monitored, controlled, and evaluated (Raymond & Bergeron, 2007). Trough this project management process, organizations face continual challenges in identifying, analysing, controlling, and evaluating their project performance (Bourne, Santos, Michelli, & Pavlov, 2018).

Measuring project performance helps organizations to build a more strategic approach to their projects and identify areas that can be enhanced before the next assignment (Radujkovic & Sjekavica, 2017). Besides, upper management may rely on project performance reviews to choose how the project proceeds (Berghuis, 2018) or clients may take this into account when selecting a firm for a new project (Rijkswaterstaat, 2023).

To deal with the complexity of engineering projects, project management information systems are widely used (Liu, 2015). Project management information systems (PMIS) play a crucial role in providing decision-making support to project managers during project planning, organization, and control (Caniëls & Bakens, 2012; Choi & Ha, 2022). A PMIS can be defined as an information system that encompasses various tools and techniques used to collect, integrate, and disseminate the outputs of project management processes (PMBOK Guide - The Standard for Project Management, 2021).

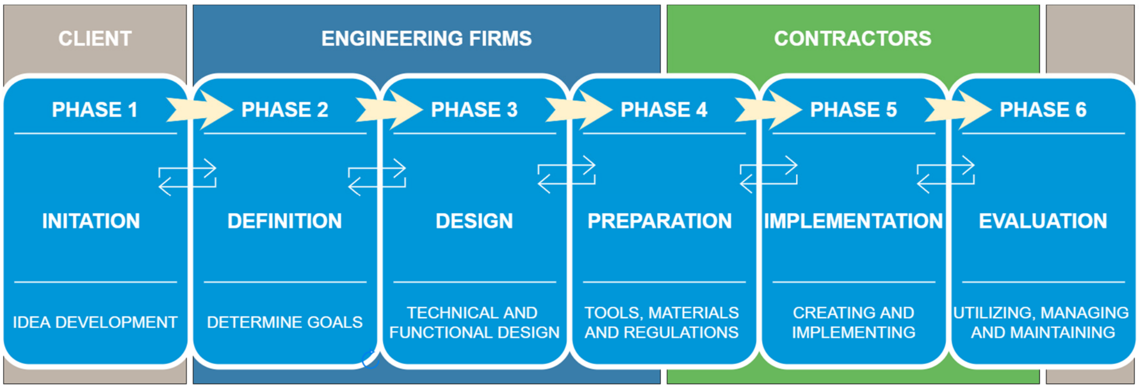
1.1 Relevance

By better understanding the effect of PMIS on project performance in specific contexts, organizations can make more informed decisions about how to implement and use these systems to improve their project management capabilities (Raymond & Bergeron, 2007). For engineering- and consultancy firms it is interesting to know the effects and limitations of PMIS on project performance, since they are constantly looking to improve its performance and effectively manage complexity (Wijnberg, 2022).

A research gap in the literature is the need for empirical evidence about the effects of PMIS within the engineering industry. Existing literature investigates the construction sector in general, not specifically in the engineering industry (Raymond & Bergeron, 2007; Stefanakis, 2019; Pavez, Gómez, Liu, & González, 2022). The construction sector as a whole encompasses activities related to building, repairing, renovating, and maintaining infrastructure (Hussain, 2022) and incorporates the entire processes as shown in figure 1.1. Engineering plays a vital role in ensuring the successful completion of construction projects, and encompasses expertise in various areas such as planning, design, and analysis of building projects (Chen, et al., 2022). This underscores the need to specifically investigate the engineering and consultancy sector rather than examining the entire construction sector, which typically focuses on the activities of (large) contractors.

This is important to notice since the activities of engineering firms often take in the first phases of projects and therefore consist of different processes, with potentially different outcomes related to project performance. In this study, engineering firms and engineering projects are defined as organizations and projects that are concerned with the definition-, design- and preparation phase as defined in figure 1.1.

Figure 1.1 Project phases and their main executors



Furthermore, little research has been conducted about the effects of PMIS on the subjective dimension of project performance in the engineering- and consultancy sector. The subjective dimension or soft side project performance is related to the ability to work in a team and the ability to control and to persuade members to work in the expected direction (Durao, Vinicius, Rafael, & Zancul, 2017; Albert, Balve, & Spang, 2017). Besides, by exploring the most important characteristics of the investigated PMIS, recommendations for improvements are developed. This can be subsequently useful for researchers, engineering firms or clients that want to implement or improve their project management information systems.

While previous literature offers a more strategic and industry-wide perspective, this study provides detailed user-centric insights for the implementation of a PMIS in engineering projects. Integrating these perspectives enriches understanding by considering both user experiences and broader technological advancements in the evolving landscape of project information management systems.

1.2 Research goal

This study aims to explore and analyse the impact of PMIS on performance within the domain of engineering projects. The outcomes provide valuable insights for project managers, researchers, subcontractors and clients of engineering firms. It provides insights in current PMIS performance, and supports decision making for project managers when considering to implement a PMIS. Besides, it points out practical improvements, and recommendations about how to improve project performance by using a PMIS. Lastly, it contributes to the growing body of knowledge on the role of PMIS in enhancing performance, specifically in engineering projects.

1.3 Research questions

By investigating the utilization of PMIS, this research seeks to uncover the potential effects it has on relevant aspects of project performance. These aspects will be investigated and further elaborated in the theory-chapter. The findings of this study will contribute to a deeper understanding of how PMIS influences performance and provide valuable insights for stakeholders involved in engineering projects. Based on this goal, the research question is:

How can project management information systems improve performance in engineering projects?

Based on the research question above, four sub-questions are formulated below and shortly explained why they are significant in order to answer the main research question.

In the construction sector, performance-related measurements have gained significance. They can serve as objectives that facilitate the effective selection of organizations based on the value they provide to stakeholders. Organizations who demonstrate the best performance on these objectives have the highest likelihood of successfully delivering the project according to stakeholders' values (Berghuis, 2018). Performance measurements are used to support optimizing organizational strategy, coordinating control and flexibility, and predicting future performance (Pavez, Gómez, Liu, & González, 2022). This question aims to answer which measurement criteria are appropriate for engineering projects. In addition to the importance of measurements criteria, the context for each measurement criterion is also meaningful to consider, because outcomes can differ based on their contexts (He, Tian, & Wang, 2022; Korhonen, Jääskeläinen, Laine, & Saukkonen, 2023). Therefore, the following sub-question is:

1 *What are the measurement criteria used in current research to capture performance, and how applicable are they in the context of engineering projects?*

Identifying the characteristics of a PMIS can help organizations to make more informed decisions about how to use the system to support its project management processes. It can also help to optimize the use of the system to improve project performance (George, 2020). Besides, the PMIS features and functionalities play an important role in enhancing the quality of information (Raymond & Bergeron, 2007). According to (Besouw & Bond-Barnard, 2021), the most important characteristics of a PMIS are: increasing efficiency and time savings, accessibility to project information, automated data capturing and validation, flexibility and adaptability, simplicity of system and intelligence. Since this study is investigating only one PMIS, measuring the degree to which it meets the most important characteristics will reveal the usefulness of this PMIS in the context of engineering projects. Therefore, the second sub-question is:

2 *To what extent does the investigated PMIS fulfil the most important characteristics of a PMIS?*

Subsequently, the data can be further analysed to determine if the investigated PMIS statistically impacts the measurement criteria, as defined in the response to the first sub-question. This provides useful insights in the effect of these characteristics on project performance. Therefore, the following sub-question is:

3 *What is the effect of the investigated PMIS on performance in engineering projects?*

After obtaining outcomes from the initial pair of sub-questions, the necessity arises to examine whether these findings can be extended to a wider framework, encompassing more than just a single PMIS and a sole engineering and consultancy firm. Hence, the following sub-question is:

4 *What is the potential applicability of the obtained results beyond the scope of a single PMIS and one engineering- and consultancy firm?*

The answers on these sub-questions provide a comprehensive framework for exploring the effects of PMIS on performance in engineering projects. This framework encompasses diverse dimensions of project performance.

2

THEORY

Saunders, Lewis, Thornhill and Jenkins (2009) proposed an iterative literature review process. This method provides guidance for conducting a literature review and answering the first sub-question (Saunders, Lewis, Thornhill, & Jenkins, 2009). This process is integrated and applied in the paragraphs below. In the context of project performance measurement, a variety of methods have been used in current research to capture and assess performance. By addressing this question, this chapter provides a comprehensive overview of the current state of knowledge on project performance measurement and context in which they can best be applied.

2.1 Measurement criteria to capture project performance

Although most organizations use metrics and perform measurements, they seem to have a poor understanding of what constitutes a proper measure for projects and how they should be used (Kerzner, 2017). Besides, current measurements are largely focused on hard criteria (Smits & Hillegersberg, 2017), while they only account for fifty percent of the overall performance (Albert, Balve, & Spang, 2017). This emphasizes the importance of further research into soft criteria when capturing project performance.

Hard criteria and soft criteria are two distinct categories used in measuring project performance. Hard criteria primarily focus on objective and measurable aspects, such as cost, time, and quality, while soft criteria encompass subjective factors, such as stakeholder satisfaction, teamwork, and communication effectiveness. Hard criteria are quantifiable and typically associated with the traditional project management dimensions as mentioned before (Kerzner, 2017). Soft criteria are subjective and relate to the people and processes involved in the project (Lamprou & Vagiona, 2022). Soft criteria have been identified as highly important for project performance (Albert, Balve, & Spang, 2017; Crawford & Pollack, 2004). By considering both hard and soft criteria, project performance assessment becomes more comprehensive, capturing both the tangible and intangible aspects that contribute to overall project performance (Albert, Balve, & Spang, 2017). This balanced approach provides a more holistic understanding of project performance and enables project managers to make informed decisions and improve future project outcomes. Therefore, they are both included in the literature review.

In literature, a multitude of measurement criteria are defined. In this literature review, project management books and scientific literature reviews and papers related to project performance are selected. To ensure actuality and relevance, the selected literature is limited to a timeframe of seven years or less (2017-2023). Another precondition is the relevance for engineering projects, which is decided based on the context where the literature is written in. This precondition is met when the literature focuses on the domain of project management, specifically within the construction sector and the IT sector, as PMIS comprise IT-related functionalities. Through an iterative process of literature analysis, the review identifies the most relevant and suitable criteria to measure project performance are listed. Subsequently, the literature was examined to assess whether the mentioned criteria play a role in measuring project performance. The findings are summarized in table 2.1.

Table 2.1 Literature review

ID	Criteria	Criteria type[1]	Source											
			(Albert, Balve, & Spang, 2017)	(Besouw & Bond-Barnard, 2021)	(He, Tian, & Wang, 2022)	(Kerzner, 2017)	(Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017)	(Lamprou & Vagiona, 2022)	(Pavez, Gómez, Liu, & González, 2022)	(Pereira, Varajão, & Takagi, 2021)	(Radujkovic & Sjekavica, 2017)	(Unegbu, Yawas, & Dan, 2020)	(Wei, Du, & Bao, 2018)	(Wijnen & Storm, 2018)
1	Time performance	Hard	x	x	x	x	x	x	x	x	x	x	x	x
2	Cost performance	Hard	x	x	x	x	x	x	x	x	x	x	x	x
3	Quality performance	Hard	x	x	x	x	x	x	x	x	x	x	x	x
4	Risk performance	Soft		x	x						x	x		
5	Stakeholder satisfaction	Soft	x	x	x	x	x	x	x	x		x	x	x
6	Image performance	Soft				x	x							
7	Scope performance	Hard		x		x				x		x		x
8	Rework rate	Hard				x						x		
9	Organisational culture	Soft				x				x	x			
10	Innovation performance	Soft	x		x		x		x	x				
		Focus area[2]	PM	CI	CI	PM	CI	PM	PM	IT	CI	CI	IT	PM
		Literature type[3]	SR	SP	SR	B	SP	SR	SR	SR	SR	SP	SP	B

Initially, an objective analysis of the top five criteria, as outlined in table 2.1, is provided. In addition to the objective analysis, an in-depth analysis is undertaken to determine interdependencies and dimensions among the performance criteria.

[1] Based on the article by Albert, Balve, & Spang (2017).

[2] Abbreviations are used to improve the legibility. The abbreviations are written out below. PM: Project Management, IT: Information Technology, CI: Construction Industry.

[3] B: Book, SR: Systematic review, SP: Scientific paper.

2.1.1 Time performance

Time performance measures the project's adherence to the planned schedule and the ability to meet established deadlines. It plays a pivotal role in project success as timely completion of milestones and deliverables is essential for achieving project objectives. Efficient time management helps minimize delays, ensures efficient resource allocation, and facilitates project progress (Wijnen & Storm, 2018; Kerzner, 2017). According to Chan (2001), time can be measured in time variation. This measure is the percentage of increase or decrease in the estimated project in days, discounting the effect of extension of time (Chan, 2001). It is also possible to measure this criterion by considering survey-questions that give an indication of the degree to which the initial project planning has been completed (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017).

2.1.2 Cost performance

Cost performance refers to the ability of a project to stay within its budget. This includes managing expenses and avoiding cost overruns (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017). Cost performance is important because it directly impacts the financial success of a project. Metrics such as cost variance (CV) and cost performance index (CPI) are commonly used to assess cost performance (PMBOK Guide - The Standard for Project Management, 2021) and (Kerzner, 2017).

2.1.3 Quality performance

Quality can be defined as meeting the legal and functional requirements of a project (Jraisat, 2016; Kerzner, 2017). Quality is realized when guidelines, which are provided by clients at the commencement of a project, are met (Chan, 2001). Quality is usually referenced to and measured by the degree of conformance to a predetermined standard of performance (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017). Another way to define quality performance is by considering rework as key factor (Wanberg, Harper, Hallowell, & Rajendran, 2013). Such additional work requires often times a Request for Adjustment (RFA)[1] since it was not included in the original project contract. RFA are proposed contractual adjustments made after the initial agreement (Graaf, 2014). Andi & Minato (2003), highlighted that low quality designs often result in poor performance indicators such as rework, delays, cost overruns and changes (Andi & Minato, 2003). These poor design process performances frequently lead to the submission of RFAs (Graaf, 2014). By adopting this definition, it becomes possible to objectively and quantifiably measure quality. However, it is important to acknowledge that the number of RFAs should not be the sole measure of quality performance. Even with a higher number of RFAs, it is still possible to achieve sufficient quality if the technical requirements are successfully met. Therefore, it is necessary to consider other quality-related metrics, such as adherence to specifications and the ability to meet project objectives. Taking a comprehensive approach by considering multiple indicators will provide a more accurate assessment of quality performance in engineering projects.

2.1.4 Stakeholder satisfaction

Project stakeholders are individuals or entities that hold a significant interest in the project's environment, performance, and/or outcomes (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017). Relevant stakeholders in research to project performance are: the client, the project manager, the project member, the developer and the end-user (Shenhar, Dvir, Levy, & Malz, 2001; Wijnen & Storm, 2018; Albert, Balve, & Spang, 2017; Savolainen, Ahonen, & Richardson, 2011). These stakeholders might have a specific interest and they are able to promote this interest in the project (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017). Within this research, the end-user is out of scope. This stakeholder group refers to the overall project and not specifically the engineering project which is executed in phases 2, 3 and 4 by an engineering firm (Wijnen & Storm, 2018). Stakeholder satisfaction is important because project performance can mean different things

[1] In Dutch: Verzoek tot Wijziging (VTW).

to different people (Shenhar, Dvir, Levy, & Malz, 2001). An engineer for example is probably satisfied about a project with technical competence whereas a project manager is satisfied with the achievement of planning-milestones, within budget and by delivering proper quality. Measuring stakeholder satisfaction, which is a subjective criterion, can be achieved by utilizing a differentiated scale that takes into account the unique perspectives of the four distinct stakeholder groups (Chan, 2001). The three most important metrics of stakeholder satisfaction within the construction sector are communication effectiveness, stakeholder support and conflict mitigation (Oppong, Chan, & Dansoh, 2018).

2.1.5 Innovation performance

This criterion refers to the long-term benefits for the (project)organization and considers the preparation of organizational and technological infrastructure for the future (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017). It encompasses exploring new opportunities for expanding into additional markets, generating fresh ideas and innovations, developing new products, acquiring new skills and technologies, and enhancing core competencies (Shenhar, Dvir, Levy, & Malz, 2001). Katzenbach & Smith (2015), emphasize the importance of creating a supportive environment that encourages continuous learning and improvement. High-performing project teams often possess a learning orientation, meaning they actively seek new knowledge, reflect on experiences, and apply lessons learned to enhance their performance (Katzenbach & Smith, 2015). Measures that can be used to assess innovation performance are: the degree to which a project contributes to creating a new market, creating a new product/service or developing a new technology (Shenhar, Dvir, Levy, & Malz, 2001).

2.1.6 Interdependencies

The evaluation of performance criteria is complex as it involves both objective (hard) and subjective (soft) criteria. Successfully managing both aspects contribute to overall project performance (Radujkovic & Sjekavica, 2017). Therefore, both objective and subjective criteria are considered in the analysis of interdependencies.

There are interdependencies within the aspects time, costs and quality. These criteria are often closely interconnected and, in this analysis, mentioned as relevant criteria in every book, review or paper. Projects that experience delays in time performance may result in increased costs and compromised quality. Similarly, cost overruns can impact both time and quality aspects of a project (Wijnen & Storm, 2018; Kerzner, 2017). Besides, multiple competing criteria can arise, such as risk, stakeholder satisfaction and image, which may require trade-offs and adjustments to the initial criteria. The importance of criteria can vary during different project phases, and prioritization may be necessary (Kerzner, 2017). Next to that, different organizational cultures may prioritize criteria differently. For example, Dutch public project managers seem to value time and costs over quality (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017).

When it comes to interdependencies between specific criteria, quality performance has a positive influence on stakeholder satisfaction (Unegbu, Yawas, & Dan, 2020), emphasizing the importance of ensuring high-quality project deliverables. Pereira, Varajão, & Takagi (2021) underscore the limitations of focusing solely on time, cost, quality and scope as performance criteria (Pereira, Varajão, & Takagi, 2021). Acknowledging that project performance is multidimensional, there is a call for incorporating broader models that also consider stakeholder satisfaction and organizational benefits (Radujkovic & Sjekavica, 2017). While time, costs and quality are essential for immediate project performance, innovation performance looks at the long-term benefits and future-readiness of the organization (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017). The introduction of new criteria to assess performance reveals an evolution in the area of project management, showing that managers slowly start to be concerned with the overall business benefits and not just with the performance in single projects (Pereira, Varajão, & Takagi, 2021). Besides, the study of Unegbu, Yawas, & Dan (2020) identified additional relationships, such as risk management directly influencing stakeholder satisfaction, suggesting that stakeholders expect better risk management from the project organization (Unegbu, Yawas, & Dan, 2020).

This demonstrates the interconnected nature of project performance criteria. It stresses the need to expand performance evaluation beyond the traditional iron triangle criteria (time, costs and quality).

2.1.7 Dimensions

Project performance and project success are two distinct dimensions that are often used in the context of project management. While they are related, they represent different aspects and criteria by which a project is evaluated. Project performance refers to the measurement and evaluation of how well a project is meeting its defined objectives, targets, and performance criteria. It focuses on the project's execution and the extent to which it is delivering the planned outcomes (Unegbu, Yawas, & Dan, 2020). Project success, on the other hand, is a broader and more subjective concept that evaluates the overall achievement and impact of a project. It goes beyond the operational aspects of project performance and takes into account the project's strategic and organizational objectives (Wijnen & Storm, 2018; He, Tian, & Wang, 2022). In the context of engineering projects, the criteria related to time, cost, quality, risk, scope, and rework pertain to project performance. They focus on the operational aspects of the project, such as adherence to schedules, budgets, quality standards, risk mitigation, scope delivery, and rework requirements. On the other hand, stakeholder satisfaction, image performance, organizational culture, and innovation performance are more closely associated with project success. They address the broader impact and strategic objectives of the project, including stakeholder engagement, reputation, organizational values, and the project's ability to foster innovation and deliver long-term value.

Next to that, the criteria can be distinguished based on their management level. In the context of this study, the criteria are distinguished based on their management level, specifically portfolio management (project directors) and project management (project managers) (Kerzner, 2017). At the portfolio management level, these criteria are considered from a broader perspective, focusing on managing multiple projects as a portfolio. Project directors oversee multiple projects and make decisions based on their performance and success. For them, stakeholder satisfaction, image, organizational culture, and innovation performance are relevant. These criteria are relevant for project directors because they enable successful stakeholder engagement, enhance the organization's reputation and client attraction, promote efficient project management and innovation through a supportive organizational culture, and foster continuous improvement and competitiveness across projects. Project managers on the other hand are responsible for assessing and monitoring the other aspects. By effectively managing these criteria, project managers can deliver projects on time and within budget, maintain quality standards, mitigate risks, and achieve project objectives within scope and minimize the need for rework.

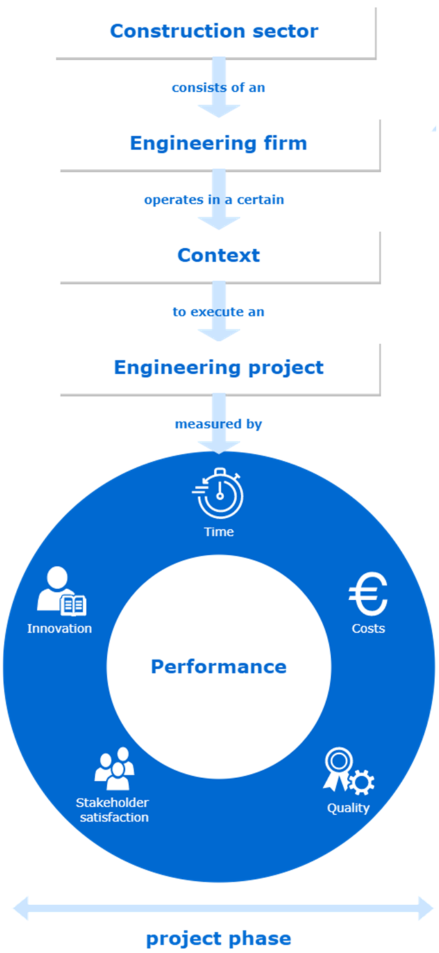
After conducting an objective literature review and taking subjective factors into account, including interdependencies, dimensions, and practical considerations such as measurability and research scope, the decision has been made to incorporate the criteria of time, cost, quality, stakeholder satisfaction, and innovation performance in this study. These five criteria have been selected for in-depth discussion and analysis in the subsequent section of the study. These aspects together provide a comprehensive overview of scientifically relevant criteria, which consists of both hard and soft dimensions. Objectively, time, costs, quality and stakeholder satisfaction are defined most relevant according to the literature review. Innovation- and scope performance are equal given the number of times that they are mentioned as relevant in the literature review. Innovation performance is chosen over scope performance in the context of this study because scope performance is closely related to the aspects time and costs (Pereira, Varajão, & Takagi, 2021; Wang, 2023). Consequently, it is anticipated that examining scope performance would not yield substantially different outcomes, whereas innovation performance has the potential to provide distinct and valuable insights. Besides, it takes into account the importance of changing priorities regarding relevant criteria over time. This means that the aspect innovation performance might not be considered as relevant as the first four aspects, while it is currently relevant for the investigated organization. Additionally, adding innovation performance to the research scope provides the literature with novel insights about a relatively underexposed aspect of project performance in relation to a PMIS and the potential for mutual amplification.

Next to that, by taking into account both project performance and project success factors, this study provides insights for both dimensions, which makes it outcomes applicable in a broader context.

2.2 Contextual application

The application of measurement criteria depends on various contextual factors, such as project size (Kaufmann & Kock, 2022), complexity (Cristóbal, Carral, Diaz, Fraguela, & Iglesias, 2018) and experience of the project manager (Salvador, Alba, Madiedo, Tenhiälä, & Bendoly, 2021). Each criterion may have different degrees of relevance and impact based on the specific project context and requirements. In the context of engineering projects, the 'iron triangle' (time, costs and quality) are still used frequently, nowadays often complemented with other aspects like stakeholder satisfaction or innovation performance (Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017). Besides, Kerzer (2017) implicates that the aforementioned criteria are applicable to all fields of project management (Kerzner, 2017). However, it is important to note that the specific outcomes of these criteria and their interrelationships may vary based on the unique characteristics and requirements of individual projects, such as its project phase or organizational culture. Due to scope restrictions, organizational culture is not taken into account in this research. The measurement criteria to capture project performance in engineering project are translated into a conceptual model and visually presented figure 2.1 below. This figure visually represents the scope of the research, gradually narrowing down from a broader perspective to a more specific focus.

Figure 2.1 Conceptual model: measurement criteria in engineering projects.



2.3 Complexity as control variable

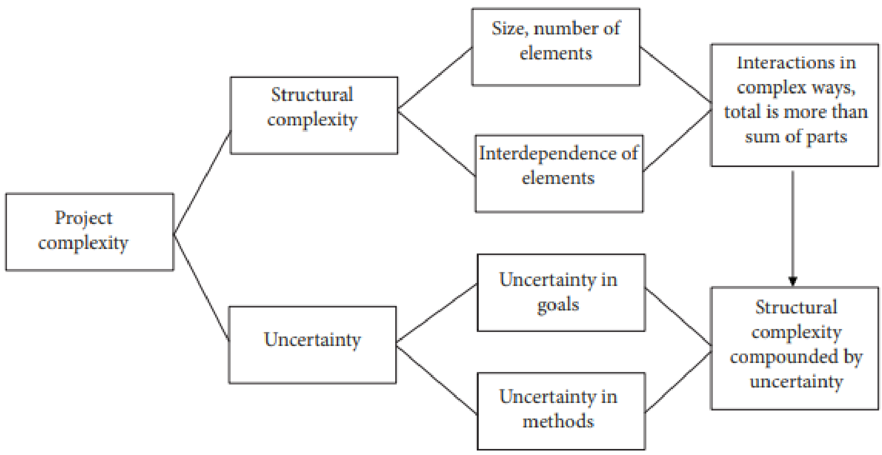
To identify the level of complexity in projects, the articles as studied in the literature review are consulted. Besouw & Bond-Barnard (2021) mention that larger projects require more advanced software capabilities to effectively manage them. Kerzner (2017) identifies three aspects of complexity in projects: design and construction complexity, technology and procedural complexity and systems methodology complexity. Pavez, Gómez, Liu, & González (2022) mention that simple projects might require monitoring only conventional (tangible) outcomes, but complex projects might require designing and monitoring a combination of processes, tangible outcomes, and perceived benefits. The other articles in the literature review do not particularly devote attention to the level of complexity. Therefore, additional sources are consulted. Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbreak (2011) identify three main categories and fourteen subcategories to capture complexity in engineering projects. The categories are presented in table 2.2.

Table 2.2 Categories of complexity in engineering projects (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbreak, 2011).

Technical	Organizational	Environment
Goals	Size	Stakeholders
Scope	Resources	Location
Tasks	Project team	Market conditions
Experience	Trust	Risk
Risk	Risk	

In addition, William's model (figure 2.2) states that complexity consists of structural complexity and uncertainty. When there is more uncertainty in goals and/or in methods, structural complexity is compounded by uncertainty, which leads to a higher overall project complexity.

Figure 2.2 William's model. Adopted from (Cristóbal, Carral, Diaz, Fraguela, & Iglesias, 2018).



All consulted scientific articles acknowledge the importance of understanding and managing complexity in projects and recognize project size as a factor influencing complexity. While Besouw & Bond-Barnard (2021), Kerzner (2017), and Pavez et al. (2022) offer a more general perspective on project complexity, Bosch-Rekveldt et al. (2011) provides a detailed categorization specific to engineering projects, encompassing technical, organizational, and environmental dimensions. Cristóbal, Carral, Diaz, Fraguela, & Iglesias (2018) view the size or the number of elements and their interrelationships as constituents of structural uncertainty which is proposed as an element of complexity. Since all these aspects can be classified roughly under the categories technical, organizational and environmental, these categories are used in the survey to assess complexity of the selected projects.

3

METHODOLOGY

3.1 Research design

This study employs a quantitative research design complemented with qualitative validation. Within this design, the treatment group consist of projects that have already implemented a PMIS, while the comparison group comprise projects that have not implemented such a system. Subsequently, the data is collected and measured by the aforementioned performance indicators (measurement criteria). The study is conducted within a Dutch engineering- and consultancy firm. It operates within the fields of infrastructure and mobility, build environment, delta's, coasts and rivers, and energy, water and environment. In 2022, the firm was involved within more than 4.000 projects worldwide and generated a revenue of 165 million euros (Witteveen+Bos, 2023). Within engineering projects, Relatics is often used by various project-teams. Relatics is a widely used PMIS in the engineering and construction sector. Relatics provides a complete picture of all project information and provides an overview of the growing number of dependencies between disciplines in projects (Relatics, 2023). This PMIS is frequently used in combination with other PMIS's. Therefore, Relatics is chosen as the PMIS for investigation in this study.

3.2 Selection and sample

When selecting projects, a number of preconditions have to be met. Only finished projects are taken into account, because only then a complete analysis of the measurement criteria can be accomplished. Projects completed before 2021 are excluded, to guarantee the novelty of the outcomes. To comprehensively account for the potential influence of project-specific contexts, the factors project size (Kaufmann & Kock, 2022), complexity (Cristóbal, Carral, Diaz, Fraguela, & Iglesias, 2018) and experience of the project manager (Salvador, Alba, Madiedo, Tenhiälä, & Bendoly, 2021) are considered as control variables to mitigate the risk of drawing incorrect conclusions regarding the effects of PMIS on project performance. Only medium and large projects are taken into account because complexity in projects mainly depends on its size (Kaufmann & Kock, 2022) and larger projects require more advanced software capabilities to effectively manage them (Besouw & Bond-Barnard, 2021), which implies that PMIS are more relevant in larger projects. A project is considered medium when it has an initial value between 100.000 and 350.000 euros and considered large when it has an initial value above 350.000 euros, in line with the proxy overview of the investigated firm. This inclusion criteria are summarized in table 3.1.

Table 3.1 Inclusion criteria

Inclusion criteria
Projects completed in 2021 or later
Medium and large projects with an initial value of 100.000 euros or more

Selection of projects for analysis

In this section, the systematic process employed for the selection of projects is described. These steps are summarized and visually presented in figure 3.1.

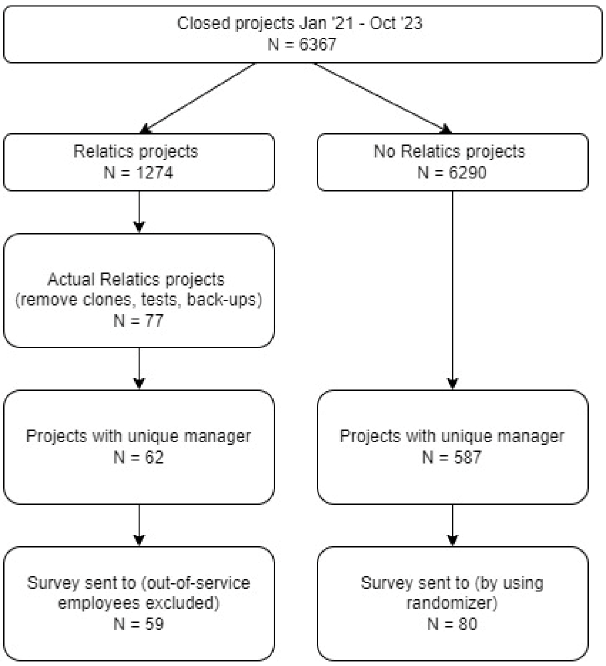
Group A. Projects using Relatics:

1 Initial pool: Closed projects from January '21 to October '23 (N = 6367).
2 Identification of Relatics projects: Identified projects where Relatics was utilized by comparing an export with Relatics project-codes with the project-codes out of the initial pool (N = 1274).
3 Filtering clones, tests, and back-ups: Removed duplicates, test projects, and back-ups, resulting in a refined dataset (N = 77)
4 Unique project managers: Identified projects with a unique project manager, narrowing down the selection (N = 62).
5 Survey distribution: Sent surveys to project managers, excluding out-of-service employees, resulting in the final sample size for analysis (N = 59).

Group B. Projects not using Relatics:

1 Initial pool: Closed projects from January '21 to October '23 (N = 6367).
2 Identification of non-Relatics projects: Identified projects where Relatics was not utilized, according to an export with Relatics project-codes (N = 6290).
3 Unique project managers: Identified projects with a unique project manager, narrowing down the selection (N = 587).
4 Survey distribution (randomized): Using a randomizer[1], surveys were sent to project managers, resulting in the final sample size for analysis (N = 80). Randomly picking projects ensures that each project has an equal chance of being included in the study. Random selection helps reduce bias and increase the generalizability of the findings (Veaux, Velleman, & Bock, 2021). This ensures that the selection of one project does not influence the selection of another, thus satisfying the independence condition. Repeating the process ensures that each project has an equal chance of being included in either group, further reinforcing the independence condition.

Figure 3.1 Participant diagram flow



[1] The tool 'Random Lists' was used by inserting anonymous project manager ID's into the tool and subsequently let the tool select 80 random ID's (Random Lists, 2023).

3.3 Data collection and measurement instruments

After selecting projects, data is collected using a survey to collect information about the control variables, time- and cost performance, quality level, stakeholder satisfaction level and innovation performance. The survey is administered using Qualtrics and the data is measured on a five-point Likert scale. Since this study is organized within an engineering firm, the survey is sent to project managers. Project members are excluded from the survey because they might have specialization-related interests in the project, which could influence their responses. Besides, standardizing the survey approach by focusing on project managers ensures consistency in data collection. Project members may vary widely in their roles and responsibilities, potentially leading to heterogeneous responses that are challenging to compare. Project directors are excluded from this survey because they need to oversee multiple projects simultaneously, which may limit their familiarity with the specific details and challenges of each project. By focusing on project managers who oversee multiple aspects of the project, the research aims for a more objective assessment of project performance. Next to project managers, clients and developers are also important stakeholders to consider (Shenhar, Dvir, Levy, & Malz, 2001; Wijnen & Storm, 2018; Albert, Balve, & Spang, 2017; Savolainen, Ahonen, & Richardson, 2011). However, due to practical uncertainties and the scope of the research, conducting the survey with them is not possible. Therefore, two interviews are organized to elaborate on the findings. For the client, this will be with Rijkswaterstaat, the largest client of the investigated engineering- and consultancy firm. For the developer, this will be Relatics, since this firm is the developer of the investigated PMIS.

The first sub-question is answered by the literature review in chapter two. To answer the second sub-question, questions about specific PMIS characteristics will be included in the survey. These questions are based on the most important characteristics of a PMIS found by (Besouw & Bond-Barnard, 2021) and presented in table 3.2.

Table 3.2 Most important characteristics of PMIS (Besouw & Bond-Barnard, 2021) and survey-questions

Characteristic	Description	Question
Increasing efficiency and time savings	The system should save the user time in managing tasks.	To what extent does the system save you time in managing tasks? (1 = Not at all, 2 = Very little, 3 = Neutral, 4 = Quite a bit, 5 = Significant time savings).
Accessibility of project information	The system should provide easy access to project information.	How easy is it for you to access the project information you need from the system? (1 = Very difficult, 2 = Difficult, 3 = Neutral, 4 = Easy, 5 = Very easy).
Automated data capturing and validation	The system should automate data capturing and validate data entries.	To what extent does the system automate data capture and validation processes? (1 = Not at all, 2 = Very little, 3 = Neutral, 4 = Quite a bit, 5 = Fully automated).
Flexibility and adaptability	The system should be flexible and adaptable to different stakeholder needs and project requirements.	How well does the system allow you to customize and present project information to meet stakeholders' needs? (1 = Very limited, 2 = Limited, 3 = Neutral, 4 = Adequate, 5 = Highly flexible).
Simplicity of system	The system should be easy to use and user-friendly for all users.	How would you rate the ease of use and user-friendliness of the system? (1 = Very complex and difficult, 2 = Complex, 3 = Neutral, 4 = Easy, 5 = Very easy and intuitive).

Characteristic	Description	Question
Intelligence	The system should demonstrate intelligence in managing project complexities.	To what extent does the system demonstrate intelligence in understanding and managing project complexities? (1 = Not at all, 2 = Very little, 3 = Neutral, 4 = Moderately intelligent, 5 = Highly intelligent).

To increase the validity and applicability of these characteristics, project management literature as mentioned in table 2.1 is consulted. By examining multiple sources, a robust foundation for these PMIS characteristics is established through a review of multiple sources (Albert, Balve, & Spang, 2017; Kerzner, 2017; Lamprou & Vagiona, 2022; Pavez, Gómez, Liu, & González, 2022; Wijnen & Storm, 2018). These sources confirm the PMIS characteristics suggested by Besouw & Bond-Barnard (2021) as shown in table 3.3. Further elaboration on this analysis can be found in appendix I.

Table 3.3 Confirmation of PMIS characteristics

Characteristic suggested by (Besouw & Bond-Barnard, 2021)	**Confirmed by source**
Increasing efficiency and time savings	"Effective and efficient use of project management methods is necessary" (Albert, Balve, & Spang, 2017). "Satisfying the information needs for the various stakeholders in a timely manner" (Kerzner, 2017). "Lowering the cost of collecting the right information" (Kerzner, 2017).
Accessibility of project information	"It should be highlighted that the proper and accurate project monitoring and control give the opportunity to the project manager and each stakeholder to get informed about the progress of project execution" (Lamprou & Vagiona, 2022).
Automated data capturing and validation	"In information management, productive use can be made of automation. Automation can be employed for storing and retrieving information" (Wijnen & Storm, 2018).
Flexibility and adaptability	"Providing information on how the project interacts with various initiatives that are part of the ongoing business" (Kerzner, 2017). "Communication and alignment with other systems, procedures are defined as one of the most important success factors" (Lamprou & Vagiona, 2022).
Simplicity of system	"Having the correct amount of information, rather than too much or too little" (Kerzner, 2017).
Intelligence	"Providing the correct information for informed decision making" (Kerzner, 2017).

To answer the third sub-question, a survey is developed for the criteria time, quality, stakeholder satisfaction and innovation performance, based on the literature review. The survey-questions are presented in table 3.4. The answer-possibilities are 1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree. A higher score indicates better performance on these criteria. In the most-right column, the source of the survey-question is provided.

Table 3.4 Survey-questions regarding sub-question 3

Criteria	Sub-criteria	Statement	Based on source
Time	Time management	Time management is effectively conducted.	(Lee & Yu, 2012)
	Time variation	The total duration of the project did not exceed the planned duration.	(Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017)
	Schedule performance	The project is finished within the time frame required by contract.	(Wei, Du, & Bao, 2018)
Cost	Adherence to budget	The total costs did not exceed the original budget.	(Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017; Pavez, Gómez, Liu, & González, 2022)
	Development costs	The project was developed and launched at the pre-determined cost.	(Pavez, Gómez, Liu, & González, 2022)
	Cost control	The project was effectively managed within budget.	(Wei, Du, & Bao, 2018)
Quality	Degree of RFA	The project required no frequent adjustments or modifications during its execution.	(Andi & Minato, 2003; Graaf, 2014)
	Adherence to specifications	The project deliverables met the specified requirements and specifications.	(Koops, Loenhout, Bosch, Hertogh, & Bakker, 2017)
	Ability to meet objectives	The project successfully achieved its predefined objectives.	(Chan, 2001)
Stakeholder satisfaction	Communication effectiveness	Stakeholders were regularly informed about project progress and updates in a clear and timely manner.	(Oppong, Chan, & Dansoh, 2018)
	Stakeholder support	Stakeholders expressed strong support for the project's goals and objectives.	
	Conflict mitigation	Any conflicts or issues that arose during the project were successfully addressed and resolved.	
Innovation	Creating a new market	The project has successfully created a new market opportunity.	(Shenhar, Dvir, Levy, & Malz, 2001)
	Creating a new product/service	The project has successfully created a new product/service offering.	
	Developing a new technology	The project has successfully developed a new technology or solution.	

Next to these questions an open question is added to gain qualitative information that might be useful in the further analysis. This question is: "Do you have any comments or additional insights that you want to share?"

3.4 Data analysis

Subsequently, a multivariate analysis of variance (MANOVA) is conducted in SPSS 28.0.1.0 to analyse the effect of the specific PMIS (Relatics) on project performance, which answers sub-question 3. Next to that, it aims to answer the main research question by analysing differences in means of the dependent variables (time, costs, quality, stakeholder satisfaction and innovation performance) and assessing the overall effect of the independent variable (Relatics usage) on the set of dependent variables. MANOVA examines the impact of the independent variable (PMIS) on multiple dependent variables simultaneously (Veaux, Velleman, & Bock, 2021). This statistical test is used to control for other factors that might influence project performance. Control variables in this study are size, complexity and experience of the project manager. Besides, MANOVA helps to determine whether there is a significant difference in the means of the dependent variables (time, cost, quality, stakeholder satisfaction and innovation) across different levels of the independent variable (Relatics usage). It also takes into account the interaction among the dependent variables. In the context of project performance, the metrics may be correlated with each other (e.g., projects with longer durations might have higher costs). MANOVA considers these interdependencies, providing a more comprehensive analysis. It is important to note that MANOVA assumes certain assumptions, which are independence, equal variance and normal distribution. If the F-value corresponding to an alpha level of 0.05 is reached, then the difference between groups is considered statistically significant (Veaux, Velleman, & Bock, 2021). The outcomes of this analysis are discussed within the interviews with a client of an engineering- and consultancy firm (Rijkswaterstaat) and a PMIS developer (Relatics).

Finally, addressing the fourth sub-question entails conducting a subjective analysis to determine the extent to which the study's findings correlate with established theory, as clarified in the theory chapter. This analysis aims to highlight the potential broader theoretical implications of the findings. Additionally, the research findings are incorporated into the interviews, enabling the researcher to inquire about the generalizability of the conclusions. This inclusion enhances the overall reliability of the analytical process.

4

RESULTS

4.1 Stages in MANOVA

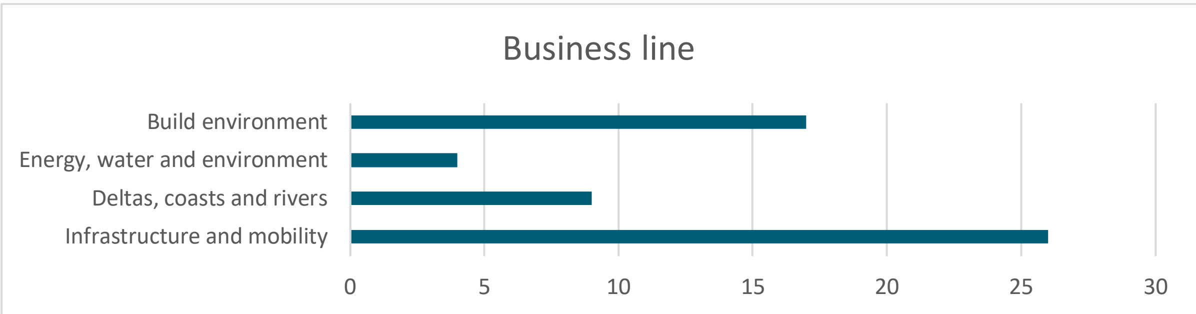
Stages as proposed by Hair, Black, Babin, & Anderson (2022) are followed to ensure a qualitatively proper data analysis. The implementation of these steps is elaborated in appendix II. In the final paragraph, the interview results are presented.

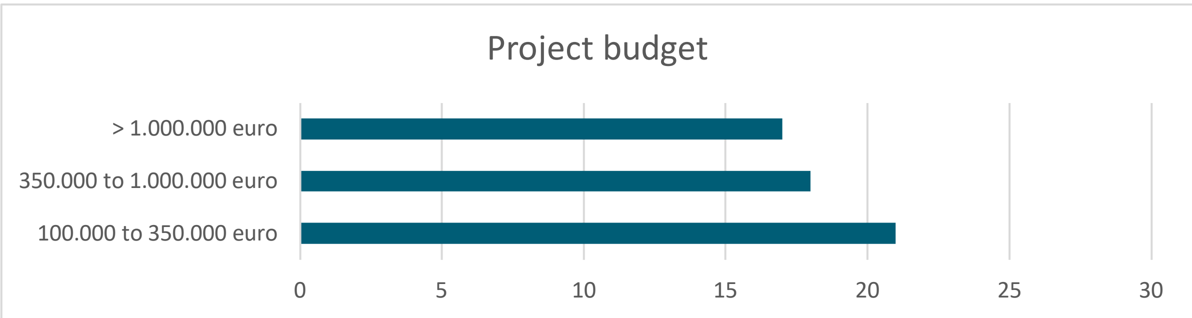
4.2 Descriptives

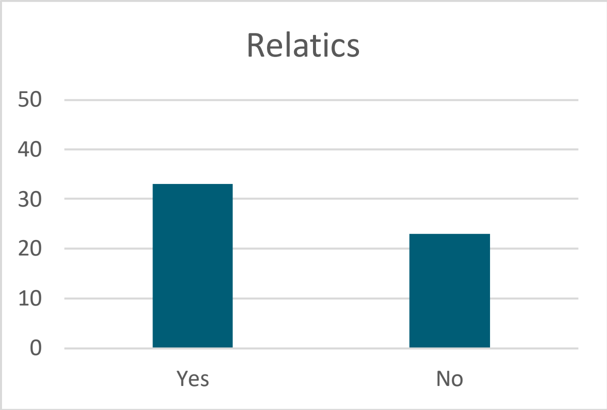
The original dataset comprised responses from 64 project managers who participated in the survey. Hair et al. (2022) suggests that in MANOVA, a minimum group size of 20 is recommended. After excluding 8 observations due to their lower than 100.000 project size, and 1 outlier there are 55 observations left, with 32 using Relatics and 23 not using Relatics. Descriptive statistics regarding the business line, budget (size), gender, utilization of Relatics, project manager experience, and client type are presented below in figure 4.1.

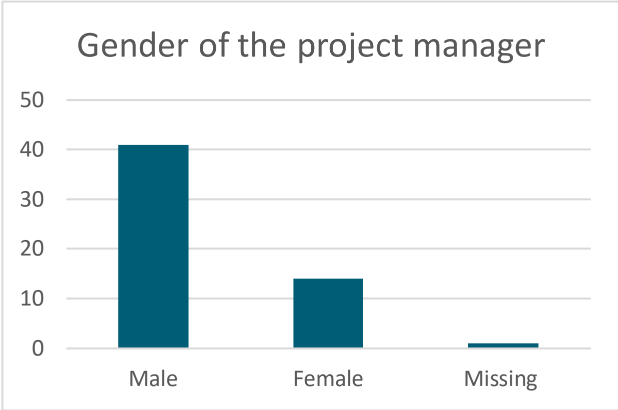
It is noticeable that most project managers have 15+ years of experience, which makes the insights particularly valuable and reflective since their extensive expertise in the field of project management. Another noticeable descriptive are the client types local authorities, and waterways and public works, which together constitute over half of the respondents. Furthermore, the use of Relatics is evenly distributed, which enables to continue with the analysis.

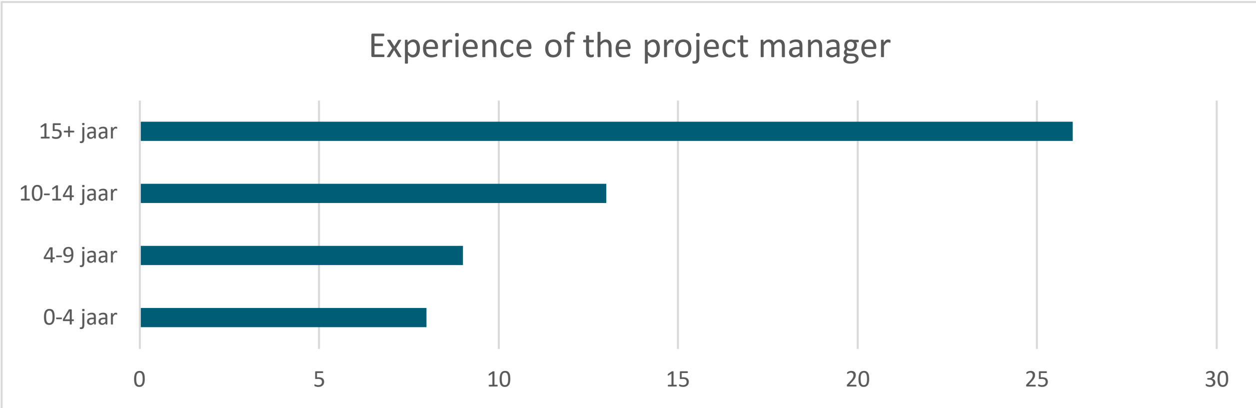
Figure 4.1 Descriptive statistics

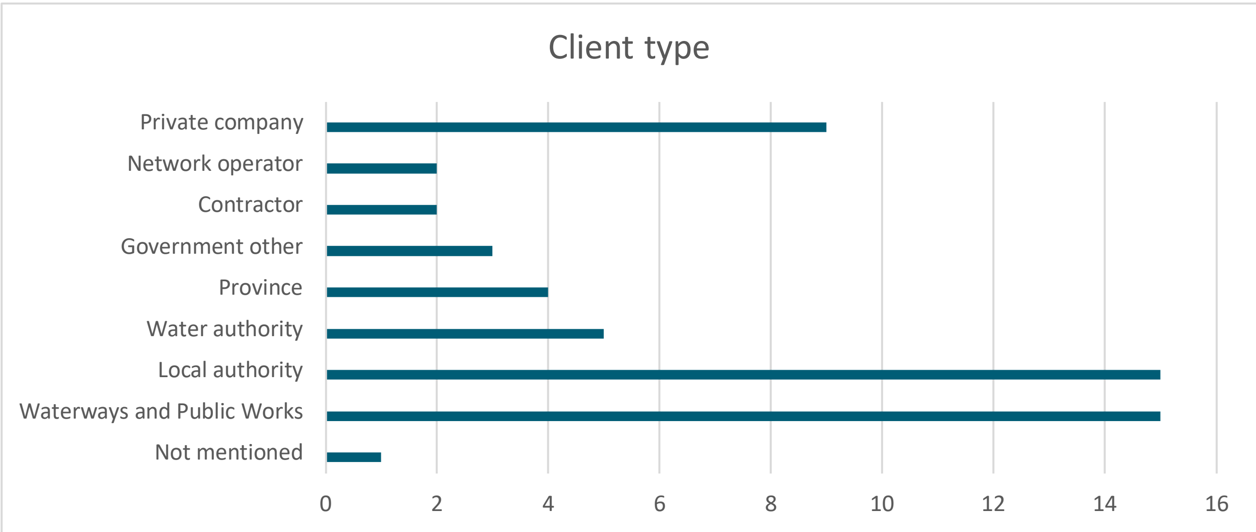








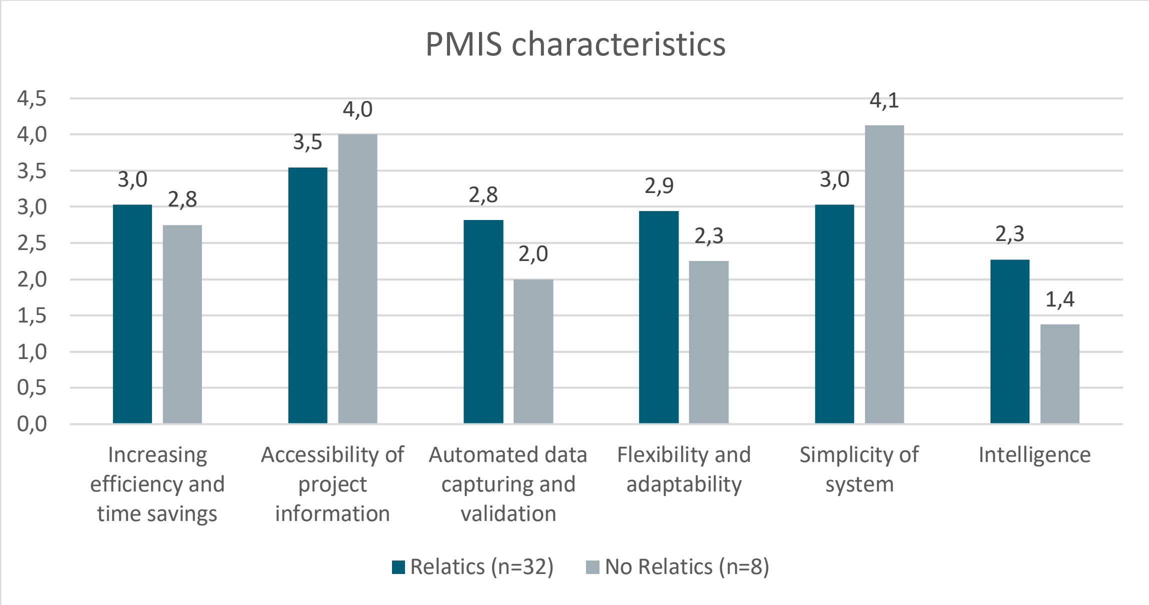




4.3 PMIS characteristics

Users rate Relatics with an average score of 2.9 out of 5. Other information systems achieve a score of 2.8 out of 5. Relatics scores higher than other systems on efficiency and time saving (3.0 vs. 2.8), automated data capturing and validation (2.8 vs. 2.0), flexibility and adaptability (2.9 vs. 2.3), and intelligence (2.3 vs. 1.4). On the contrary, other systems score higher than Relatics on accessibility of project information (4.0 vs. 3.5), and simplicity of the system (4.1 vs. 3.0). Since the sample sizes of Relatics (n=32) and the other systems (n=8) differ considerably, the results have to be interpreted with caution. Nevertheless, it is noticeable that all PMIS have low ratings on intelligence (2.3 and 1.4) and relatively high on accessibility of information (3.5 and 4.0) and simplicity of the system (3.0 and 4.1). The results can be found in appendix III (PMIS ranking). For more information, boxplots are included in appendix III (Boxplots PMIS characteristics).

Figure 4.2 PMIS characteristics scores



4.4 Correlations

4.4.1 Correlation between PMIS characteristics

The correlation table, which can be found in appendix III (Correlation between PMIS characteristics), provides useful insights into the relationships between different aspects of the system's performance, each measured by a specific question. There are three significant correlations between the PMIS characteristics found:

- Users who perceive the system to save time are more likely to find a connection with its automation capabilities. Correlation: 0.338* (significant at the 0.05 level);
- Users who find it easy to access project information are more likely to perceive the system as supportive in customizing and presenting information for stakeholders. Correlation: 0.403** (significant at the 0.01 level);
- Users who perceive the system to be effective in automating data processes are more likely to see it as intelligent in handling complex project aspects. Correlation: 0.420** (significant at the 0.01 level).

These correlations highlight the interconnectedness of user perceptions across different aspects of the system's functionality. This is an interesting finding for project managers because successful improvements in the PMIS regarding time and efficiency, accessibility, and automated data capturing and validation are correlated with improvements in the associated factors.

4.4.2 Correlation between aspects of project performance

The level of correlation between most of the variable combinations are between the recommended inter-correlation level of 0.4 and 0.6. However, some combinations have a lower correlation than 0.3, which is considered low. These are described in appendix II. Significant correlations are found between the following aspects:

- Time with cost. Correlation: 0.494** (significant at the 0.01 level);
- Time with quality. Correlation: 0.486** (significant at the 0.01 level);
- Time with stakeholder satisfaction. Correlation: 0.302* (significant at the 0.05 level);
- Cost with quality. Correlation: 0.426** (significant at the 0.01 level).

4.5 MANOVA assumptions

For the multivariate test procedures of MANOVA to be valid, the following assumptions must be met:

- Observations must be independent. This condition is satisfied by using random sampling in selecting projects. Random sampling helps reduce selection bias and ensures that the sample is more likely to generalize (Hair, Black, Babin, & Anderson, 2022).
- Variance-covariance matrices must be equal for all treatment groups. This is tested by executing the Box's test of equality of covariance matrices. The significance level in this case is 0.421 (has to be higher than 0.05) and not be significant. Also, other equality tests (Pillai's Trace, Wilk's Lambda, Hotelling's Trace and Roy's Largest Root are statistically not significant and therefore equality between the groups can be assumed.
- The set of dependent variables must follow a multivariate normal distribution. The variable project performance is normally distributed (0.182 significance level in the Shapiro-Wilk test). However, the dependent variables time, costs and quality have lower significance-levels than 0.05 (0.006, 0.002 and 0.014). This means that the data in these variables are not normally distributed. To handle this issue, these variables are grouped into one variable 'TCQ'. Considering the correlation among these variables and the theoretical justification for their strong interconnection, opting for this choice is logically sound. After grouping the variable, the normality is still not accomplished. Therefore, an logarithmic transformation has been conducted. A transformation is also done for the variable stakeholder satisfaction, in order to improve the normality score, which makes the variables better to compare. For this variable, the square root is calculated. The square root method is chosen this leads to the most normal distribution of the data in comparison to the original- and logarithmic data. After applying these transformations to the data, all three the variables are assumed normal, since they are not significant at the Shapiro-Wilk test.
- Outliers: outliers are identified by calculating the standardized z-values of the dependent variables. When a value has a z-value of + or - 2.5, the value is eliminated from the dataset, which is recommended by Hair et al. (2022). In this analysis, this means that one value is eliminated.
- In addition, the linearity of the relationships between the dependent variables is considered. The analysis, as illustrated in appendix III (Scatterplot matrix dependent variables), demonstrates a noticeable tendency towards linearity. In combination with the correlation matrices, this provides reasonable grounds for assuming a predominantly linear relationship among the variables under consideration. Nevertheless, it is important to exercise caution in interpreting the results, particularly due to the low correlations observed between time, cost, and quality with innovation, as well as the modest correlation between innovation and stakeholder satisfaction.

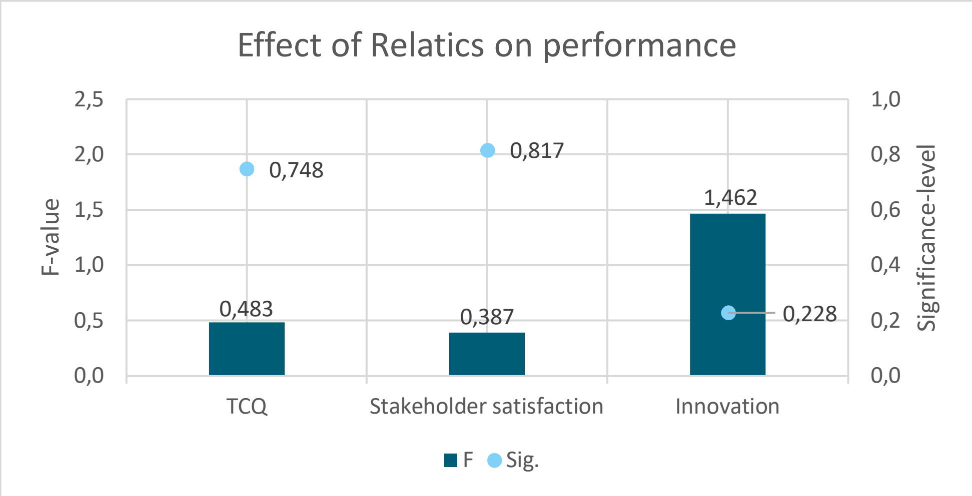
4.6 MANOVA results

The results of the MANOVA are shown in appendix III (Multivariate tests and Test of Between-Subjects Effects). All multivariate tests show non-significant results ($p > 0.05$), indicating that the use of Relatics does not have a significant multivariate effect on the different aspects of project performance. The effect size (Partial Eta Squared) for the use of Relatics is small (0.012), suggesting a small proportion of variance explained by Relatics usage. The between subjects effect-table provides information on the significance of the effects of Relatics usage on the dependent variables separately. Here also, no noticeable significant effects are observed.

When applying the control variables project size, experience of the project manager, and complexity to the MANOVA, several changes occur. Also here, the corrected model, which includes all the control variables, is not statistically significant for TCQ ($p = 0.748$), stakeholder satisfaction ($p = 0.817$), and innovation ($p = 0.228$). However, there is still a mentionable effect of the use of Relatics on the three different performance aspects, as shown in figure 4.3. Particularly, Relatics has a considerable effect on innovation performance compared to the other performance aspects, which gives project managers of large projects a relevant argument to implement Relatics, in order to improve innovation performance. The effect size for innovation ($R_2 = 0.105$) is approximately three times as large as it is for TCQ ($R_2 = 0.037$) and stakeholder satisfaction ($R_2 = 0.030$). This indicates the proportion of variance in innovation performance that can be explained by

Relatics usage is noticeable higher than for TCQ and stakeholder satisfaction. The complete analysis can be found in appendix III (Multivariate tests without control variables and Test of Between-Subjects Effects with control variables).

Figure 4.3 Effect of Relatics on performance aspects



When considering the effects of the control variables on performance, there can be seen in figure 4.4 that size seriously contributes to differences in performance between Relatics and non-Relatics users. This suggests that as projects increase in size, the role of PMIS becomes more critical. Upon closer examination of the performance aspects, as shown in table 4.1, it is clear that size has a significant impact on innovation performance, aligning with the overall findings.

Figure 4.4 Magnitude of the F-statistic

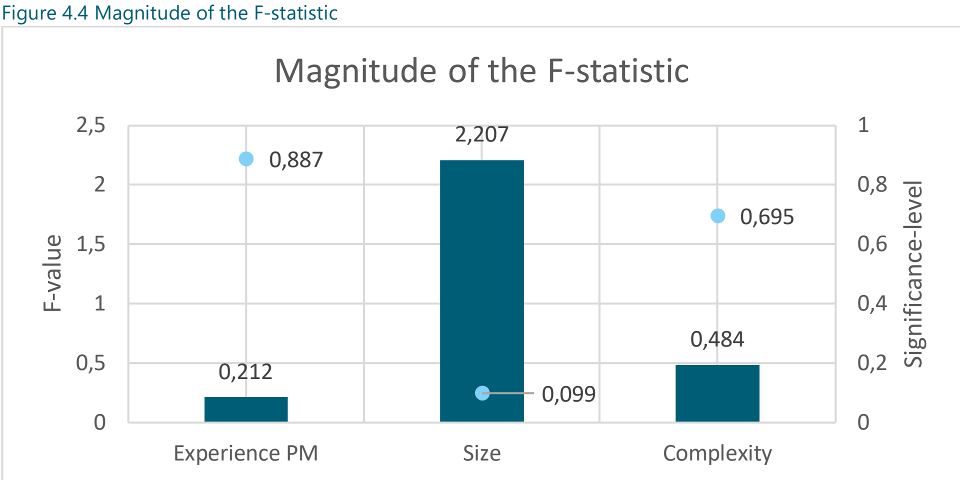


Table 4.1. Significance-levels of the control variables

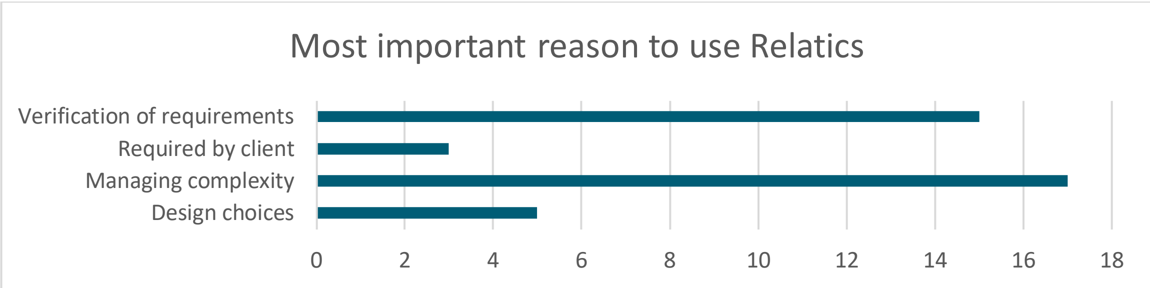
Control variable	TCQ	Stakeholder satisfaction	Innovation
Project manager experience	0.857	0.558	0.683
Size	0.633	0.344	0.024*
Complexity	0.277	0.894	0.911

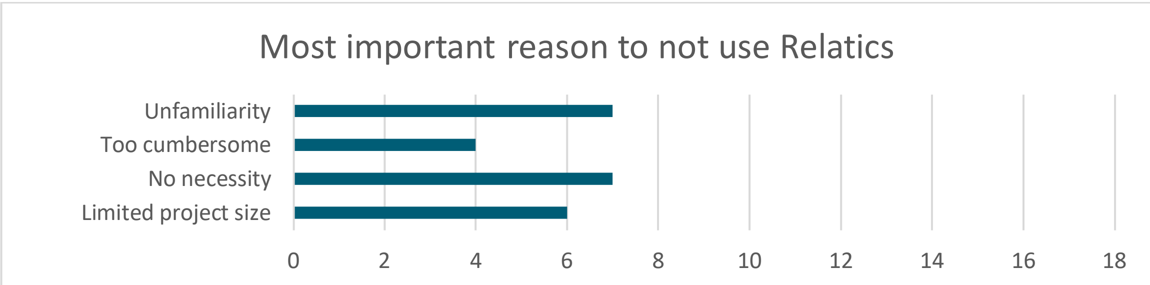
* significant at the 0.05 level

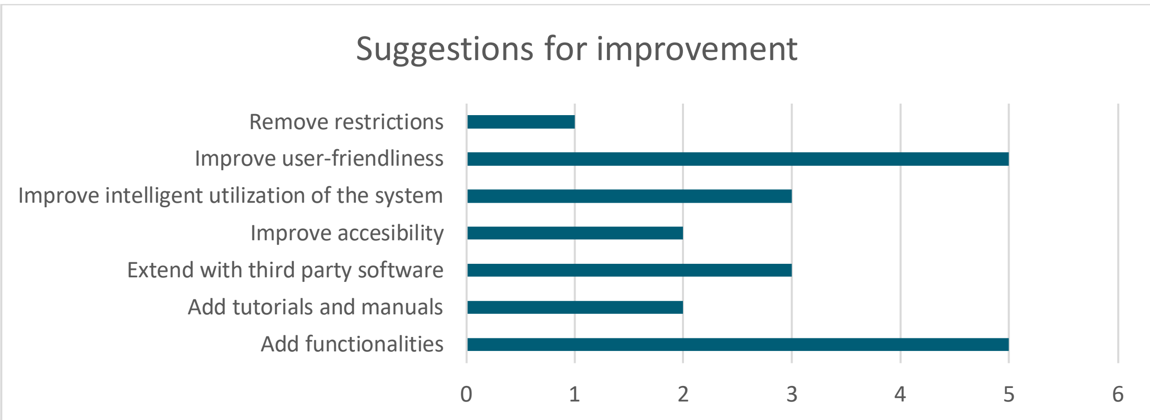
4.7 Open question results

The open questions are analysed and categorized to gain insight in underlying reasons. The open questions are about the main reasons to use or not use Relatics as a PMIS, and suggestions for improvement. The results are presented in figure 4.5 below. Verification of (client- or system-) requirements and managing complexity are consistently mentioned as crucial reasons to use Relatics. Factors such as unfamiliarity with the system, perceived limited necessity, or limited project size continue to be common reasons for not opting for Relatics. The feedback emphasizes the need for improving user-friendliness. Users express their current desire for additional functionalities, including dashboards, notifications, and workflows. There is a present call for emphasizing the intelligent utilization of the system. Users currently suggest extending capabilities through the integration of third-party software.

Figure 4.5 Answers to open questions in survey







4.8 Interview results

As an addition to the quantitative results, the interviews give a more nuanced explanation of the effect of Relatics on project performance. Besides, they provide potential improvements for the system and how to generalize them to a broader scope, beyond one engineering- and consultancy firm. In the next two paragraphs, the most important findings from the interviews are reported. Full interview transcripts are available in Dutch and can be found in appendix IV.

4.8.1 Interview Rijkswaterstaat

Relatics is primarily used in Rijkswaterstaat for construction, replacement and renovation projects, where Systems Engineering (SE)[1] is often a requirement. SE elements like requirements, interface analysis, functional analysis, and specification are crucial features of Relatics. The system is not used in the daily work of regional managers or asset managers who do not work on project-based tasks. The ability to establish relationships between different pieces of information is a crucial feature of Relatics, providing a centralized source of information. Relatics helps in managing complexity by providing a clear decomposition of information, distinguishing between standard and specific elements in projects. Relatics significantly contributes to improving project performance by streamlining information, standardizing processes, and focusing on essential and risky aspects of a project. It aids in efficient handling of requirements and enhances the ability to manage information and project data. There is potential for Relatics to contribute more to asset management and maintenance aspects, which are becoming more critical in the shift from construction-focused projects to maintenance. Challenges include varying levels of software proficiency among Rijkswaterstaat employees, emphasizing the importance of simplicity and accessibility. Suggestions for improvement include enhancing user-friendliness, automatic data saving, and potential integration with external environments like those of engineering firms or contractors. Product management and specification features of Relatics, such as product desks[2], can be applied beyond the infrastructure sector in areas involving contractor-client relationships. There is a need for comprehensive information systems in the infrastructure sector to manage data centrally and prevent the loss of knowledge when employees leave. Communication about the level of expertise and needs of users is crucial for successful implementation of systems like Relatics. Information systems like Relatics can help align expectations between stakeholders and contribute to smoother project execution.

"In addressing complexity in projects, Relatics plays a pivotal role by assisting in the creation of a clear decomposition of information. This aids in distinguishing between standard and specific elements, a challenge encountered not only at Rijkswaterstaat but also in engineering firms dealing with both general and project-specific requirements." (Interview Rijkswaterstaat, 2023)

4.8.2 Interview Relatics

Relatics is described as model-based tooling for construction projects, flexible, and capable of meeting project-specific requirements. Clients include government institutions, engineering firms, contractors, and consulting firms. Relatics contributes to managing complexity by translating projects into a Systems Engineering model, providing an overview without removing complexity. Verifications of requirements, integration of third-party software, and flexibility are considered by the interviewee as the key features contributing to the success of engineering projects. In terms of PMIS characteristics, user-friendliness and time savings are essential features of Relatics as an integral project information management system. Innovative solutions arising from the use of Relatics include setting up project management tools more efficiently and enabling connections with external software packages. There are opportunities to improve performance by increasing user acceptance and familiarity with the software, with a focus on large projects and handling significant amounts of data. Suggestions for enhancing user-friendliness include integration with external systems, tutorials, workflows, and notifications, as well as reducing the threshold for occasional users. Relatics is more broadly applicable than it is applied at the moment, but the focus remains on engineering- and construction projects where Systems Engineering is indispensable.

[1] Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. The methodology considers both the business and the technical needs of all customers and is aimed at providing a quality product that meets the users' needs (International Council on Systems Engineering, 2024).

[2] Product desks are modules in Relatics that can be used for product inquiries of the client. Its purpose is to maintain an overview within a project or program.

4.8.3 Differences and similarities

Rijkswaterstaat and Relatics both emphasize that the most suitable application of the software lies within engineering- and construction projects with a focus on Systems Engineering (SE). This is expressed in Relatics' contribution to project performance by streamlining information, facilitate verification-processes and managing complexity. Rijkswaterstaat addresses challenges like varying software proficiency and suggests simplicity improvements. Relatics sees opportunities in improving user acceptance and suggests enhancements for large projects. Key similarities that are found are that both interviews highlight a key improvement: integration with third-party software. This enables organisations to integrate information into one general source of information: a single source of truth. Besides, both recognize the need to enhance user-friendliness and performance, suggesting improvements like tutorials, workflows, and reducing user thresholds. Finally, both interviews attach Relatics' innovative solutions and contributions to the success of engineering projects, by focusing on verifications, third-party software integration, and flexibility.

4.9 Applicability beyond the research scope

The insights gained from the interviews offer valuable information regarding the potential applicability beyond the research scope. Rijkswaterstaat emphasizes Relatics' primary use in construction, replacement, and renovation projects where SE elements are crucial. However, the system's potential might go beyond the infrastructure sector. Relatics acknowledges that its applicability extends beyond its current usage in engineering- and construction projects, indicating the adaptability of Relatics to various industries. After all, the emphasis on managing complexity and providing a clear decomposition of information is a feature that can be relevant in different contexts and industries. Despite that, Relatics emphasizes that the software is developed aiming for managing complexity in specifically engineering- and construction projects. This specific focus is the strength of the software. Next to that, the integration of Relatics with third-party software is identified as a key improvement, providing autonomy for end-users and utilizing diverse software packages according to their strengths. This feature can be valuable in diverse organizational settings. Rijkswaterstaat sees potential for Relatics to contribute more to asset management and maintenance aspects, indicating a broader relevance beyond the initial new-build construction projects. Both organizations recognize the importance of information systems and the utilization of SE, for which Relatics is designed. Through the implementation of these tools and methods, a transition is underway towards a dynamic digital engineering ecosystem. This digital engineering transformation is necessary to meet new threats, sustain competitive advantage, and leverage technology advancements (Vaneman & Carlson, 2019). This development offers opportunities for SE and Relatics to enhance its target group. In conclusion, the information from the interviews suggests that the obtained results have potential applicability across diverse industries. This indicates that the insights gained from the study on Relatics and the interviewed firms can inform and benefit project management practices beyond the immediate context of a singular PMIS and one engineering- and consultancy firm.

5

DISCUSSION AND CONCLUSION

This chapter provides a summary of the key findings, addresses the answers on the research questions, and outlines contributions to existing theories. Additionally, it delves into the identified limitations, explores opportunities for future research, and discusses implications derived from the study.

5.1 Key findings

In the following paragraphs, the key findings in relation to the sub-questions are described. These answers together form the answer to the main research question.

The measurement criteria used in current research to capture performance in engineering projects are diverse and categorized into hard criteria (objective and measurable aspects) and soft criteria (subjective factors). The literature review identifies a multitude of criteria, and a selection of the most relevant ones is presented in table 2.1. The top five criteria selected for this research are time performance, cost performance, quality performance, stakeholder satisfaction, and innovation performance. The analysis also explores the interdependencies and dimensions among the chosen criteria, acknowledging the interconnected nature of project performance criteria (Kerzner, 2017; Wijnen & Storm, 2018). This is confirmed by the intercorrelation matrix where time correlates significantly with cost, quality and stakeholder satisfaction, and cost with quality. However, there are also some low correlations found, e.g. innovation has a low correlation with all the other four criteria. This might be due to the relative novelty of innovation as measurement criteria (Huff, 2016; Hu, Zhao, & Tang, 2023) and the possible unawareness of the impact of innovation on the other criteria. Additionally, the contextual application of measurement criteria is highlighted, taking into account factors such as project size, complexity, and the experience of the project manager. The factor size demonstrates a statistically non-significant yet still relevant impact on project performance factors. Complexity, although exhibiting a smaller effect, is closely connected to size (Bosch-Rekveldt et al., 2011; Cristóbal et al., 2018), indicating an indirect influence on project performance. This suggests that the greater the size or complexity of a project, the more influence a PMIS has on project performance.

Based on the PMIS characteristics analysis, Relatics demonstrates several notable characteristics according to user perceptions. Relatics users generally have higher perceptions of automated data capturing and validation, flexibility and adaptability, and intelligence, compared to non-Relatics users. Despite the higher score of Relatics than non Relatics-users in the perceived intelligence of the system, there is still room for improvement because this characteristic scores generally lower than the other characteristics. A concrete recommendation in this matter is to integrate artificial intelligence (AI) in the PMIS. AI can enhance traditional project management tasks, by taking over administrative tasks like reminders, day-to-day updates, freeing up project managers to focus on higher-level and complex activities. AI can also help keep projects on schedule and on budget. Besides, AI integration can facilitate decision information based on which can guide project managers through difficult decisions (Project Management Institute, 2024; (Nieto-Rodriguez & Vargas, 2023). Other ways to improve intelligence of the PMIS are implementing evaluation processes (Pereira, Varajão, & Takagi, 2021), people preparation (e.g. by training and guidelines), and implementing a virtual assistant, which can help project managers to focus more on coaching and stakeholder management than on administration and manual tasks (Nieto-Rodriguez & Vargas, 2023).

Relatics does have a mentionable effect on performance in engineering projects. Particularly, the control variable size, in combination with the other variables, has a serious effect on project performance. The relatively high F-value for size is due to the high effect on innovation performance, which gives project managers of large projects a relevant argument to implement a PMIS, in order to improve innovation performance. This finding is confirmed in the interviews, where Relatics and Rijkswaterstaat recognize that Relatics is valuable for managing large and complex projects. This is particularly evident in engineering- and construction projects, with potential applications in asset management for maintenance projects. The strength of the PMIS lies in streamlining requirements and specifications, capturing information unambiguously, and facilitating systems engineering in large and complex projects. Opportunities for improvement lies in enhancing its functionalities by e.g. adding dashboarding, notifications, workflows or adding tutorials and manuals, user-friendliness, and integration with third-party software.

At its core, Relatics' is designed for managing complexity in engineering and construction. However, the software's proficiency in clearly breaking down information, Relatics exhibits potential adaptability in various contexts. For instance, Rijkswaterstaat envisions Relatics playing a more significant role in asset management and maintenance, aligning with recent policy developments in the Netherlands (Rijkswaterstaat, 2024; Rijksoverheid, 2022). The interviews underscore the importance of information systems and SE in a growing digital engineering ecosystem, which is supported by (Mordecai, Weck, & Crawley, 2020). This increasing importance points towards broader implementation, beyond the scope of a single PMIS and a specific engineering and consultancy firm. However, it's essential to recognize that Relatics was initially designed and validated within the engineering- and construction sector. Hence, careful consideration and context-specific assessments are necessary before implementing the PMIS.

To conclude and answer the main research question, Relatics enhances performance trough facilitating systems engineering in large and complex projects. While the PMIS outperforms other systems in data capturing, flexibility, and intelligence, there is room for improvement in implementing intelligent applications, user-friendly design, and external integration. Consequently, it can be stated that information systems with intelligent applications, user-friendly design, and digital ecosystem integration enhance performance in complex engineering projects.

5.2 Limitations

The study is based on a relatively small sample size of 64 project managers, with 55 observations remaining after exclusions. Despite the appropriate sample size to execute a MANOVA and to draw conclusions in the context of an engineering- and consultancy firm, this may limit the generalizability of the findings to a broader population of project managers. Besides, the study relies on subjective perceptions of the interviewed persons. These perceptions may be influenced by personal biases or experiences. Finally, because this study focuses on Relatics as the PMIS, the findings may not be directly applicable to other PMIS platforms. A comparative analysis with other systems could provide a more nuanced understanding. This is therefore also a suggestion for further research.

5.3 Future research

Suggestions for further research include comparing the performance and user perceptions of Relatics directly with other PMIS to identify strengths, weaknesses, and unique features that contribute to project performance. Next to that, it is recommended to investigate the possibilities of integrating AI into project management information systems and delve into the associated opportunities and challenges. Further investigation into the feasibility and obstacles of implementing Relatics or another PMIS in maintenance oriented projects is advised. Lastly, conducting in-depth qualitative research is suggested to delve into the nuanced facets of project manager experiences with PMIS, offering deeper insights into their challenges, needs, and recommendations.

5.4 Practical implications

Practical implications for Witteveen+Bos, as well as other engineering and consultancy firms, their clients, and software developers, involve enhancing intelligence of the software and try to integrate innovation performance more within the other performance aspects: time, cost, quality, and stakeholder satisfaction. Innovation performance is the only aspect which is not correlated to any of the other measurement criteria. Integrating AI into the PMIS offers the advantage to improve both the intelligence of the system and increase the level of innovation performance, which contributes to the overall project performance. Besides, project managers should consider a comprehensive approach to PMIS enhancements. Rather than focusing on isolated improvements, address the aspects time and efficiency, accessibility, automated data capturing, flexibility, simplicity, and intelligence collectively. This ensures a comprehensive and interconnected system upgrade. Establish feedback mechanisms to gather insights from users regarding their experiences with the enhanced PMIS features. User feedback is valuable for identifying specific pain points and opportunities for continuous improvement. Currently, users express their desire for additional functionalities, including dashboards, notifications, and workflows. It is advised to offer comprehensive training and add manuals and tutorials for all users involved in the project to maximize the performance of the information systems. Next to that, information systems have a greater effect on project performance if they are implemented in complex and large projects. Therefore, tailor the features and functionalities of the PMIS to align with the specific needs and difficulties of complex projects. Users currently suggest extending capabilities through the integration of third-party software. Therefore, encourage cross-environment integration by connecting Relatics with entities such as other engineering firms, clients, or contractors, as well as with specialized software that excels in specific areas of expertise, such as SharePoint, Power BI, Tableau and ArcGIS. Finally, highlight the potential for information systems to enhance asset management in maintenance projects, aligning with the industry's shift towards maintenance-focused activities.

5.5 Theoretical implications

The results emphasize the interdependencies among selected performance criteria, confirming the existing literature about the interconnected nature of project performance criteria. The findings indicate that size and complexity of a project influence the impact of a PMIS on project performance. This highlights the potential of PMIS, such as Relatics, in enhancing project performance, by facilitating systems engineering and managing complex projects. Opportunities regarding further improvement of PMIS are developing additional and intelligent functionalities, improving user friendliness, and external integration. This aligns with evolving trends in a growing digital engineering ecosystem.

6

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Appendices

APPENDIX: PROJECT MANAGEMENT LITERATURE ANALYSIS ABOUT PMIS CHARACTERISTICS

(Albert, Balve, & Spang, 2017)

The authors mention that effective and efficient use of project management methods is necessary in terms of customer satisfaction and the customer should be satisfied with the execution of the project. During planning and execution of a project, the assessment focus is more on management efficiency. PMIS can be seen as a management method and therefore needs to be efficient, in line with (Besouw & Bond-Barnard, 2021).

(Kerzner, 2017)

Kerzer highlights several characteristics of PMIS in his book 'Project Management - A Systems Approach to Planning, Scheduling and Controlling'. A PMIS contains all of the essential and supporting information for project approval, initiation, planning, scheduling, execution, monitoring and control, and closure. While an earned-value measurement system (EVMS) is a critical component of the PMIS, today's PMIS contains significantly more metrics than just time and cost. The PMIS can provide significant benefits if designed properly, such as:

1 Satisfying the information needs for the various stakeholders in a timely manner;
2 Providing the correct information for informed decision making;
3 Having the correct amount of information, rather than too much or too little;
4 Lowering the cost of collecting the right information;
5 Providing information on how the project interacts with various initiatives that are part of the ongoing business;
6 Providing information on how one project interacts with other projects being supported by line managers;
7 Providing value to the company.

A good PMIS can prevent projects from failing because of the derailment in project communications. PMIS also makes it easy for team members and functional managers to input the information necessary for effective status reporting.

(Lamprou & Vagiona, 2022)

This article mentions the importance of communication and alignment with other systems, procedures as one of the most important success factors. These success factors are associated with basic processes of a project and can play an important role in its evolution route. It should be highlighted that the proper and accurate project monitoring and control give the opportunity to the project manager and each stakeholder to get informed about the progress of project execution so as to be ready to intervene in case of potential deficiencies or omissions.

(Pavez, Gómez, Liu, & González, 2022)

This article does not explicitly highlight aspects of PMIS, but has focus on performance measurement. The authors define the purpose of project performance measurement as providing information that helps a project team make timely decisions related to planning, budgeting, monitoring, controlling, and improving the execution of a project, as well as assessing the project's overall success.

(Wijnen & Storm, 2018)

The authors highlight the significance of information management within projects, as it influences a wide range of management practices including categorization of components and documentation, formulation of verification and validation processes, and overseeing workflows. They also underscore the pressing need for structured information management. This necessitates precise identification of the information assigned for management, a task that can be facilitated by a PMIS.

II

APPENDIX: STAGES IN MANOVA

Stages as proposed by Hair, Black, Babin, & Anderson (2022) are followed to ensure a qualitatively proper data analysis.

Stage 1 Research objectives

The research question is intrinsically multivariate due to the consideration of multiple dependent variables, potential correlations among variables, and the fact that MANOVA provides more statistical power than ANOVA when the number of dependent variables is five or lower (Hair, Black, Babin, & Anderson, 2022).

The level of correlation between most of the variable combinations are between the recommended inter-correlation level of 0.4 and 0.6. However, the following combinations have a lower correlation than 0.3, which is considered low:

- Time and innovation
- Cost and stakeholder satisfaction
- Cost and innovation
- Quality and stakeholder satisfaction
- Quality and innovation
- Stakeholder satisfaction and innovation

Stage 2 Research design

The research design is discussed in paragraph 3.1.

Stage 3 Assumptions of MANOVA

For the multivariate test procedures of MANOVA to be valid, the following assumptions must be met:

- Observations must be independent. This condition is satisfied by using random sampling in selecting projects. Random sampling helps reduce selection bias and ensures that the sample is more likely to generalize (Hair, Black, Babin, & Anderson, 2022).
- Variance-covariance matrices must be equal for all treatment groups. This is tested by executing the Box's test of equality of covariance matrices. The significance level in this case is 0.421 (has to be higher than 0.05) and not be significant. Also, other equality tests (Pillai's Trace, Wilk's Lambda, Hotelling's Trace and Roy's Largest Root are statistically not significant and therefore equality between the groups can be assumed.
- The set of dependent variables must follow a multivariate normal distribution. The variable project performance is normally distributed (0.182 significance level in the Shapiro-Wilk test). However, the dependent variables time, costs and quality have lower significance-levels than 0.05 (0.006, 0.002 and 0.014). This means that the data in these variables are not normally distributed. To handle this issue, these variables are grouped into one variable 'TCQ'. Considering the correlation among these variables and the theoretical justification for their strong interconnection, opting for this choice is logically sound. After grouping the variable, the normality is still not accomplished. Therefore, an logarithmic transformation has been conducted. A transformation is also done for the variable stakeholder satisfaction, in order to improve the normality score, which makes the variables better to compare. For this variable, the square root is calculated. The square root method is chosen this leads to the most normal distribution of the data in comparison to the original- and logarithmic data. After applying these transformations to the data, all three the variables are assumed normal, since they are not significant at the Shapiro-Wilk test.
- Outliers: outliers are identified by calculating the standardized z-values of the dependent variables. When a value has a z-value of + or - 2.5, the value is eliminated from the dataset, which is recommended by Hair et al. (2022). In this analysis, this means that one value is eliminated.
- In addition, the linearity of the relationships between the dependent variables is considered. The analysis, as illustrated in appendix III (Scatterplot matrix dependent variables), demonstrates a noticeable tendency towards linearity. In combination with the correlation matrices, this provides reasonable grounds for assuming a predominantly linear relationship among the variables under consideration. Nevertheless, it is important to exercise caution in interpreting the results, particularly due to the low correlations observed between time, cost, and quality with innovation, as well as the modest correlation between innovation and stakeholder satisfaction.

Stage 4 Select multivariate test

All four multivariate tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root) are selected. Within these test, the dependent variables TCQ_Log, Stakeholder_Satisfaction and Innovation are selected. Use_of_Relatics is used as independent variable.

Stage 5 Interpret the results

The results of the MANOVA are shown in appendix III. The intercept refers to the constant term in the analysis, representing the mean values of the dependent variables when all other factors are zero. In this analysis, this does not say anything meaningful, as the factors involved are categorical and not quantitative. Therefore, the interpretation of the intercept lacks practical significance. The variable Use_of_Relatics represents whether Relatics is used (coded as 1) or not used (coded as 0). All multivariate tests for Use_of_Relatics show non-significant results ($p > 0.05$), indicating that the use of Relatics does not have a significant multivariate effect on the dependent variables. The effect size (Partial Eta Squared) for Use_of_Relatics is very small (0.012), suggesting a small proportion of variance explained by Relatics usage. The between subjects effect-table provides information on the significance of the effects of Relatics usage on the dependent variables separately. Here also, no noticeable significant effects are observed.

Stage 6 Validating the results

The validation of the results is done by interviewing Relatics and Rijkswaterstaat.

MANOVA for PMIS characteristics

In addition to the regular MANOVA there was also investigated if the MANOVA also could be used to analyse differences between the PMIS characteristics. Due to assumption and feasibility issues this analysis has been aborted. Below, the arguments are described. However, there is still useful information available. Therefore, the descriptives of PMIS characteristics and their correlations are analysed.

Assumptions for PMIS characteristics:

For the multivariate test procedures of MANOVA to be valid, the following assumptions must be met:

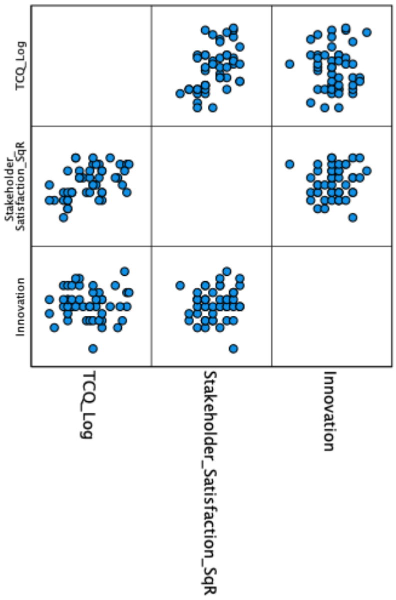
- Observations must be independent. This condition is satisfied by using random sampling in selecting projects. Random sampling helps reduce selection bias and ensures that the sample is more likely to generalize (Hair, Black, Babin, & Anderson, 2022).
- Variance-covariance matrices must be equal for all treatment groups. This is tested by executing the Box's test of equality of covariance matrices. The significance level in this case is 0.406 (has to be higher than 0.05) and not be significant. However, other equality tests (Pillai's Trace, Wilk's Lambda, Hotelling's Trace and Roy's Largest Root are statistically significant and therefore equality between the groups can not be assumed.
- The set of dependent variables must follow a multivariate normal distribution. All the PMIS characteristics variables are not normally distributed ($p = < 0.05$) in the Shapiro-Wilk test and Kolmogorov-Smirnov test).
- In addition, the linearity of the relationships between the dependent variables is considered. The analysis shows no linearity at all.
- Outliers: outliers are identified by calculating the standardized z-values of the dependent variables. When a value has a z-value of + or - 2.5, the value is eliminated from the dataset, which is recommended by Hair et al. (2022). In this analysis of the PMIS characteristics, this means that no values are eliminated.

Therefore, the PMIS characteristics are not suitable for the MANOVA-test. However, the correlation table provides useful insights into the relationships between different aspects of the system's performance, each measured by a specific question. There are three significant correlations between the PMIS characteristics found.

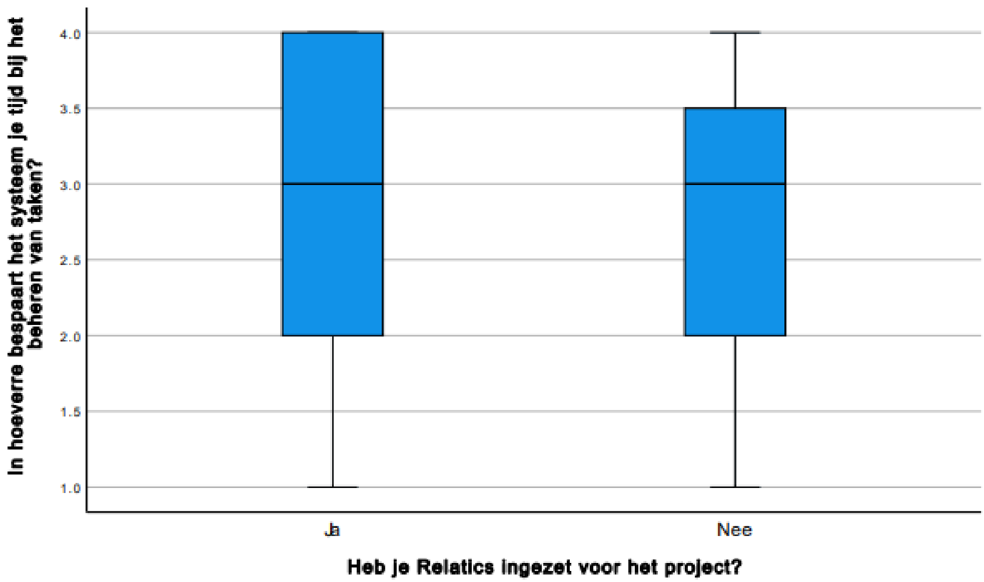
III

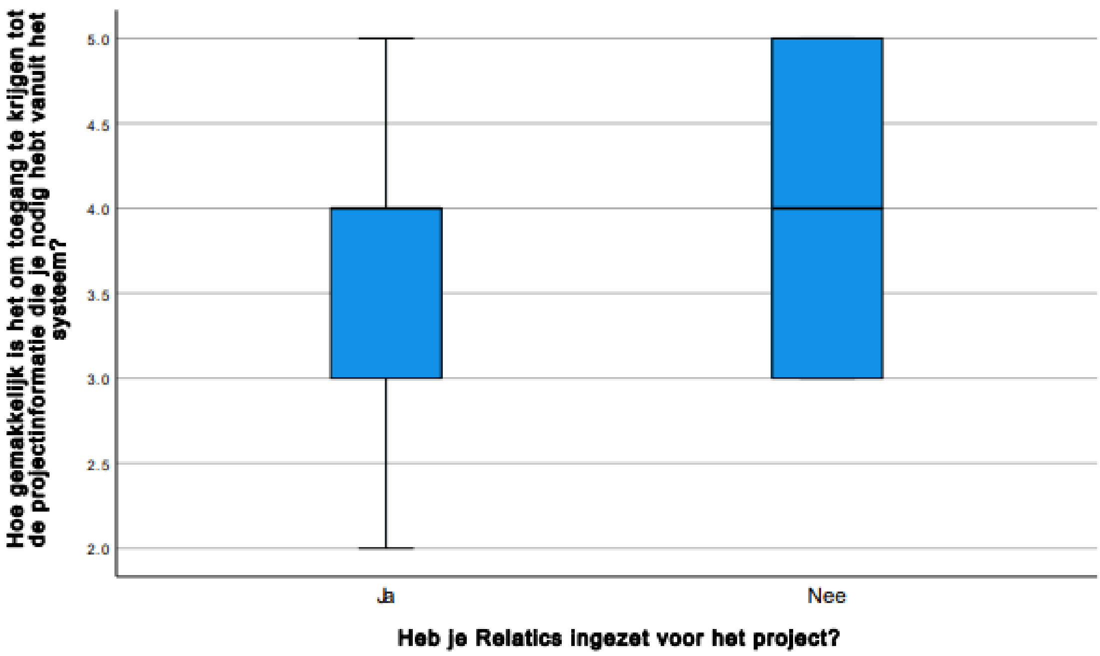
APPENDIX: SPSS OUTPUT

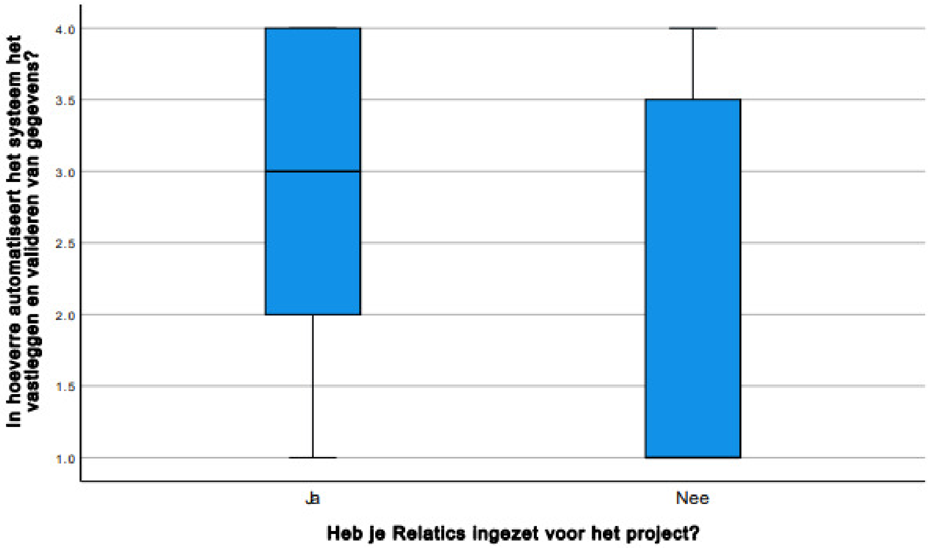
1. Scatterplot matrix dependent variables

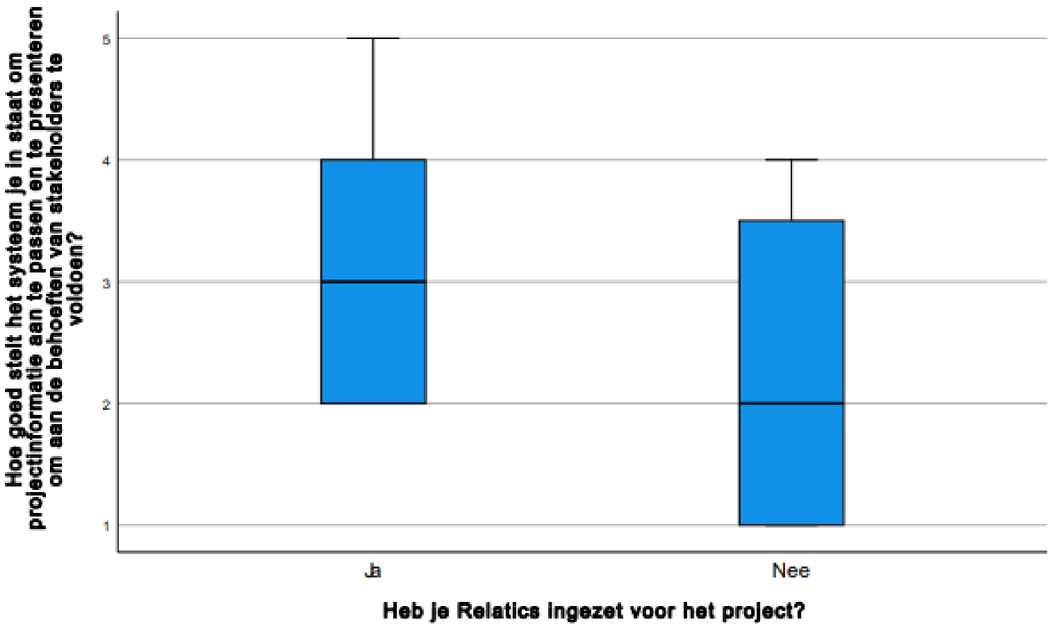


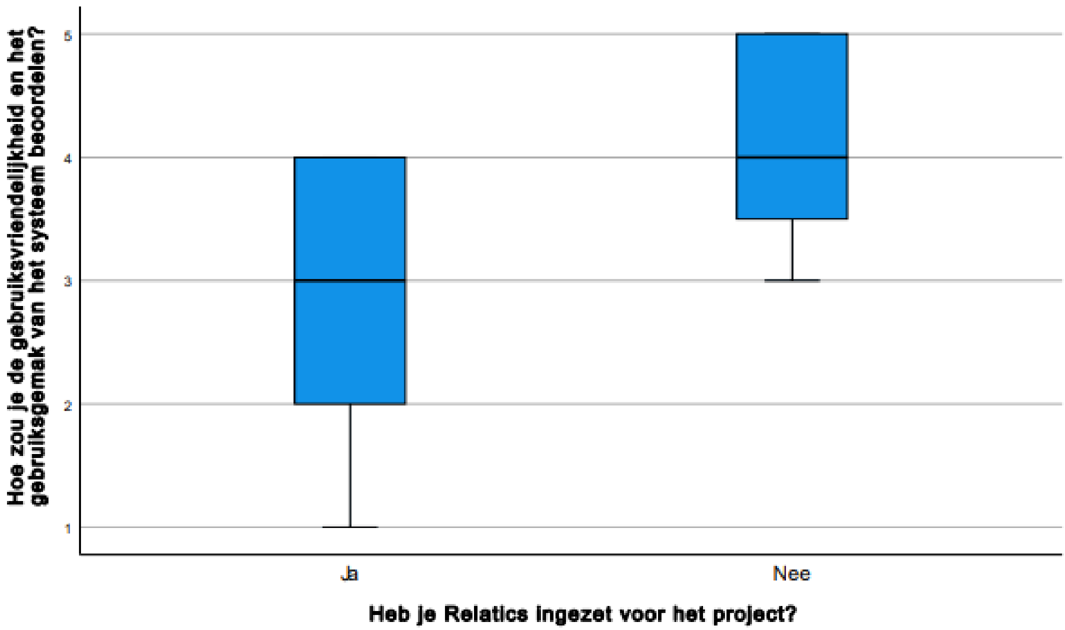
2. Boxplots PMIS Characteristics

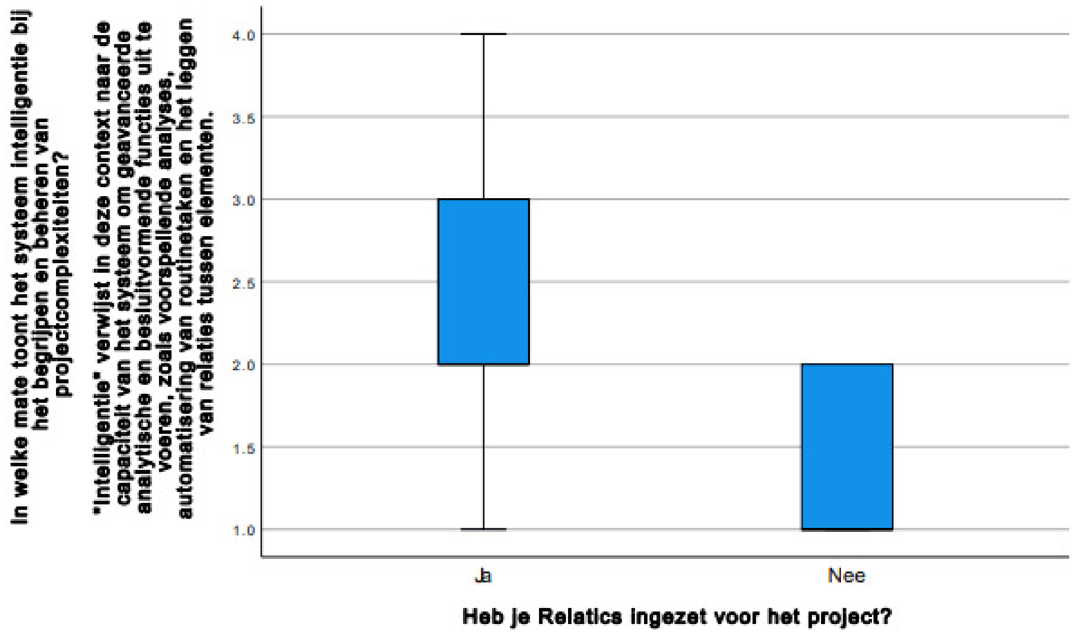





In hoeverre automatiseert het systeem het vastleggen en valideren van gegevens?
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Ja
Nee
Heb je Relatics ingezet voor het project?


Hoe goed stelt het systeem je in staat om projectinformatie aan te passen en te presenteren om aan de behoeften van stakeholders te voldoen?
5
4
3
2
1
Ja
Nee
Heb je Relatics ingezet voor het project?


Hoe zou je de gebruiksvriendelijkheid en het gebruiksgemak van het systeem beoordelen?
5
4
3
2
1
Ja
Nee
Heb je Relatics ingezet voor het project?


In welke mate toont het systeem intelligentie bij het begrijpen en beheren van projectcomplexiteiten?
"Intelligentie" verwijst in deze context naar de capaciteit van het systeem om geavanceerde analytische en besluitvormende functies uit te voeren, zoals voorspellende analyses, automatisering van routinetaken en het leggen van relaties tussen elementen.
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Ja
Nee
Heb je Relatics ingezet voor het project?

3. Correlations between PMIS characteristics

Correlations

		Increasing efficiency and time savings	Accessibility of project information	Automated data capturing and validation	Flexibility and adaptability	Simplicity of system	Intelligence
Increasing efficiency and time savings	Pearson Correlation	1	0,061	.338*	0,079	-0,204	0,036
	Sig. (2-tailed)		0,707	0,031	0,622	0,202	0,822
	N	41	41	41	41	41	41
Accessibility of project information	Pearson Correlation	0,061	1	-0,065	0,132	.403**	-0,134
	Sig. (2-tailed)	0,707		0,686	0,410	0,009	0,403
	N	41	41	41	41	41	41
Automated data capturing and validation	Pearson Correlation	.338*	-0,065	1	0,100	-0,114	.420**
	Sig. (2-tailed)	0,031	0,686		0,535	0,477	0,006
	N	41	41	41	41	41	41
Flexibility and adaptability	Pearson Correlation	0,079	0,132	0,100	1	0,210	0,196
	Sig. (2-tailed)	0,622	0,410	0,535		0,188	0,220
	N	41	41	41	41	41	41
Simplicity of system	Pearson Correlation	-0,204	.403**	-0,114	0,210	1	-0,092
	Sig. (2-tailed)	0,202	0,009	0,477	0,188		0,569
	N	41	41	41	41	41	41
Intelligence	Pearson Correlation	0,036	-0,134	.420**	0,196	-0,092	1
	Sig. (2-tailed)	0,822	0,403	0,006	0,220	0,569	
	N	41	41	41	41	41	41

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4. Correlations between aspects of project performance

Correlations

		Time	Cost	Quality	Stakeholder Satisfaction	Innovation
Time	Pearson Correlation	1	.494**	.486**	.302*	0,114
	Sig. (2-tailed)		0,000	0,000	0,025	0,407
	N	55	55	55	55	55
Cost	Pearson Correlation	.494**	1	.426**	0,216	0,111
	Sig. (2-tailed)	0,000		0,001	0,113	0,418
	N	55	55	55	55	55
Quality	Pearson Correlation	.486**	.426**	1	0,091	-0,041
	Sig. (2-tailed)	0,000	0,001		0,507	0,764
	N	55	55	55	55	55
Stakeholder_Satisfaction	Pearson Correlation	.302*	0,216	0,091	1	0,014
	Sig. (2-tailed)	0,025	0,113	0,507		0,917
	N	55	55	55	55	55
Innovation	Pearson Correlation	0,114	0,111	-0,041	0,014	1
	Sig. (2-tailed)	0,407	0,418	0,764	0,917	
	N	55	55	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5. Multivariate tests

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Intercept	Pillai's Trace	0,990	1706.712[b]	3,000	51,000	0,000	0,990	5120,135	1,000
	Wilks' Lambda	0,010	1706.712[b]	3,000	51,000	0,000	0,990	5120,135	1,000
	Hotelling's Trace	100,395	1706.712[b]	3,000	51,000	0,000	0,990	5120,135	1,000
	Roy's Largest Root	100,395	1706.712[b]	3,000	51,000	0,000	0,990	5120,135	1,000
Use_of_Relatics	Pillai's Trace	0,012	.199[b]	3,000	51,000	0,897	0,012	0,597	0,085
	Wilks' Lambda	0,988	.199[b]	3,000	51,000	0,897	0,012	0,597	0,085
	Hotelling's Trace	0,012	.199[b]	3,000	51,000	0,897	0,012	0,597	0,085
	Roy's Largest Root	0,012	.199[b]	3,000	51,000	0,897	0,012	0,597	0,085

a. Design: Intercept + Use_of_Relatics

b. Exact statistic

c. Computed using alpha = .05

6. Tests of Between-Subjects Effects[1]

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[d]
Corrected Model	TCQ_Log	.002[a]	1	0,002	0,239	0,627	0,004	0,239	0,077
	Stakeholder_Satisfaction_SqR	.018[b]	1	0,018	0,355	0,554	0,007	0,355	0,090
	Innovation	.072[c]	1	0,072	0,128	0,722	0,002	0,128	0,064
Intercept	TCQ_Log	12,744	1	12,744	1253,822	0,000	0,959	1253,822	1,000
	Stakeholder_Satisfaction_SqR	212,496	1	212,496	4295,657	0,000	0,988	4295,657	1,000
	Innovation	517,438	1	517,438	921,691	0,000	0,946	921,691	1,000
Use_of_Relatics	TCQ_Log	0,002	1	0,002	0,239	0,627	0,004	0,239	0,077
	Stakeholder_Satisfaction_SqR	0,018	1	0,018	0,355	0,554	0,007	0,355	0,090
	Innovation	0,072	1	0,072	0,128	0,722	0,002	0,128	0,064
Error	TCQ_Log	0,539	53	0,010					
	Stakeholder_Satisfaction_SqR	2,622	53	0,049					
	Innovation	29,754	53	0,561					
Total	TCQ_Log	13,577	55						
	Stakeholder_Satisfaction_SqR	220,333	55						
	Innovation	563,556	55						
Corrected Total	TCQ_Log	0,541	54						
	Stakeholder_Satisfaction_SqR	2,639	54						
	Innovation	29,826	54						

a. R Squared = .004 (Adjusted R Squared = -.014)
b. R Squared = .007 (Adjusted R Squared = -.012)
c. R Squared = .002 (Adjusted R Squared = -.016)
d. Computed using alpha = .05

[1] The intercept refers to the constant term in the analysis, representing the mean values of the dependent variables when all other factors are zero. In this analysis, this does not say anything meaningful, as the factors involved are categorical and not quantitative. Therefore, the interpretation of the intercept lacks practical significance

7. Multivariate tests with control variables

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Intercept	Pillai's Trace	0,636	27.985[b]	3,000	48,000	0,000	0,636	83,954	1,000
	Wilks' Lambda	0,364	27.985[b]	3,000	48,000	0,000	0,636	83,954	1,000
	Hotelling's Trace	1,749	27.985[b]	3,000	48,000	0,000	0,636	83,954	1,000
	Roy's Largest Root	1,749	27.985[b]	3,000	48,000	0,000	0,636	83,954	1,000
Q03	Pillai's Trace	0,013	.212[b]	3,000	48,000	0,887	0,013	0,637	0,087
	Wilks' Lambda	0,987	.212[b]	3,000	48,000	0,887	0,013	0,637	0,087
	Hotelling's Trace	0,013	.212[b]	3,000	48,000	0,887	0,013	0,637	0,087
	Roy's Largest Root	0,013	.212[b]	3,000	48,000	0,887	0,013	0,637	0,087
Q06	Pillai's Trace	0,121	2.207[b]	3,000	48,000	0,099	0,121	6,622	0,526
	Wilks' Lambda	0,879	2.207[b]	3,000	48,000	0,099	0,121	6,622	0,526
	Hotelling's Trace	0,138	2.207[b]	3,000	48,000	0,099	0,121	6,622	0,526
	Roy's Largest Root	0,138	2.207[b]	3,000	48,000	0,099	0,121	6,622	0,526
Complexity	Pillai's Trace	0,029	.484[b]	3,000	48,000	0,695	0,029	1,451	0,141
	Wilks' Lambda	0,971	.484[b]	3,000	48,000	0,695	0,029	1,451	0,141
	Hotelling's Trace	0,030	.484[b]	3,000	48,000	0,695	0,029	1,451	0,141
	Roy's Largest Root	0,030	.484[b]	3,000	48,000	0,695	0,029	1,451	0,141
Use_of_Relatics	Pillai's Trace	0,006	.089[b]	3,000	48,000	0,966	0,006	0,267	0,065
	Wilks' Lambda	0,994	.089[b]	3,000	48,000	0,966	0,006	0,267	0,065
	Hotelling's Trace	0,006	.089[b]	3,000	48,000	0,966	0,006	0,267	0,065
	Roy's Largest Root	0,006	.089[b]	3,000	48,000	0,966	0,006	0,267	0,065

a. Design: Intercept + Q03 + Q06 + Complexity + Use_of_Relatics

b. Exact statistic

c. Computed using alpha = .05

8. Test of Between-Subjects Effects with control variables

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[d]
Corrected Model	TCQ_Log	.020[a]	4	0,005	0,483	0,748	0,037	1,934	0,155
	Stakeholder_Satisfaction_SqR	.079[b]	4	0,020	0,387	0,817	0,030	1,549	0,132
	Innovation	3.123[c]	4	0,781	1,462	0,228	0,105	5,847	0,421
Intercept	TCQ_Log	0,345	1	0,345	33,129	0,000	0,399	33,129	1,000
	Stakeholder_Satisfaction_SqR	3,801	1	3,801	74,230	0,000	0,598	74,230	1,000
	Innovation	3,456	1	3,456	6,472	0,014	0,115	6,472	0,704
Q03	TCQ_Log	0,000	1	0,000	0,033	0,857	0,001	0,033	0,054
	Stakeholder_Satisfaction_SqR	0,018	1	0,018	0,349	0,558	0,007	0,349	0,089
	Innovation	0,090	1	0,090	0,168	0,683	0,003	0,168	0,069
Q06	TCQ_Log	0,002	1	0,002	0,231	0,633	0,005	0,231	0,076
	Stakeholder_Satisfaction_SqR	0,047	1	0,047	0,914	0,344	0,018	0,914	0,155
	Innovation	2,888	1	2,888	5,408	0,024	0,098	5,408	0,626
Complexity	TCQ_Log	0,013	1	0,013	1,209	0,277	0,024	1,209	0,190
	Stakeholder_Satisfaction_SqR	0,001	1	0,001	0,018	0,894	0,000	0,018	0,052
	Innovation	0,007	1	0,007	0,013	0,911	0,000	0,013	0,051
Use_of_Relatics	TCQ_Log	0,000	1	0,000	0,011	0,919	0,000	0,011	0,051
	Stakeholder_Satisfaction_SqR	0,003	1	0,003	0,061	0,807	0,001	0,061	0,057
	Innovation	0,124	1	0,124	0,233	0,631	0,005	0,233	0,076
Error	TCQ_Log	0,521	50	0,010					
	Stakeholder_Satisfaction_SqR	2,560	50	0,051					
	Innovation	26,704	50	0,534					
Total	TCQ_Log	13,577	55						
	Stakeholder_Satisfaction_SqR	220,333	55						
	Innovation	563,556	55						
Corrected Total	TCQ_Log	0,541	54						
	Stakeholder_Satisfaction_SqR	2,639	54						
	Innovation	29,826	54						

a. R Squared = .037 (Adjusted R Squared = -.040)
b. R Squared = .030 (Adjusted R Squared = -.048)
c. R Squared = .105 (Adjusted R Squared = .033)
d. Computed using alpha = .05

9. PMIS ranking

PMIS	Overall	Increasing efficiency and time savings	Accessibility of project information	Automated data capturing and validation	Flexibility and adaptability	Simplicity of system	Intelligence
Relatics (n=32)	2,9	3,0	3,5	2,8	2,9	3,0	2,3
Other (n=8)	2,8	2,8	4,0	2,0	2,3	4,1	1,4

IV

APPENDIX: INTERVIEW TRANSCRIPTS

Interview Relatics

Datum: 08-12-2023

Introductie (5 min)

- Doel van het interview
- Audio-opname
- Informed consent

Relatics (10 min)

1. Kun je jezelf kort voorstellen en uitleggen wat je rol is bij Relatics?

   Wegens anonimiteit is deze functiebeschrijving weggelaten uit de interview-uitwerking. Deze vraag was relevant voor de onderzoeker om een beeld te vormen over de werkzaamheden van de geïnterviewde persoon.

2. Wat zijn de belangrijkste kenmerken en functionaliteiten van Relatics?

   Relatics is een model-based tooling voor bouwprojecten. Het systeem is in staat om mee te groeien met het project. Het systeem is flexibel, dit maakt het mogelijk om aan de project-specifieke eisen en wensen te voldoen. Het systems-engineering (SE)-model moet eerst goed staan vanuit waar vervolgens het systeem gebouwd kan worden. Klanten van ons zijn overheidsinstellingen, ingenieursbureaus, aannemers en adviesbureaus.

3. Hoe draagt Relatics bij aan het beheersbaar maken van complexiteit in projecten?

   Met Relatics zorgen we dat de vertaalslag wordt gemaakt van het project naar een SE model. Deze vertaalslag zorgt er niet voor dat complexiteit in projecten minder wordt, maar dat klanten overzicht krijgen. Het is daarin niet onze bedoeling om de complexiteit weg te nemen. Daar zijn genoeg slimme koppen voor in de markt, maar wij zijn eigenlijk de handreiking in de vorm van tooling, zodat eigenlijk iedereen die betrokken is bij het project het antwoord op zijn vragen kan krijgen. Deze kunnen bijvoorbeeld gaan over afhankelijkheden er verbanden tussen objecten en eisen. We zien dat als Relatics niet wordt gebruikt op het moment dat de grootte van het project toeneemt, de complexiteit zodanig toeneemt dat op een gegeven moment antwoorden krijgen die bepaalde verbanden hebben met verschillende disciplines erg lastig worden. Als je 'document-gedreven' blijft werken en je past ergens wat aan zonder dat de documenten in een systeem gekoppeld zijn aan elkaar wordt het al snel tijdrovend en foutgevoelig. Het leidt dus tot tijdsbesparing, maar het draagt ook bij aan het tegengaan van faalkosten en het verhogen van de efficiëntie.

4. Wat zijn de belangrijkste verbeteringen die vanaf de lancering van Relatics versie 5 tot en met nu zijn doorgevoerd? Hoe zijn jullie hier op gekomen?

   Het eerste is dat vandaag de dag de eindgebruiker meer in staat wordt gesteld om antwoorden te kunnen krijgen op de vragen die ze hebben. Er is minder afhankelijkheid van de technische kant van de software, die uitgevoerd wordt door functioneel beheerder, wat ook tijd bespaart en het systeem intuïtiever maakt. Inmiddels is de software uitgebreid met de integratie van third-party software, zoals SharePoint, Power BI en ArcGIS.

   <u>Interviewer</u>
   Zo'n koppeling met externe software heb ik ook gezien bij een project vanuit Witteveen+Bos. Een collega had een aanpasbare Gantt-planning gebouwd met behulp van een Javascript koppeling met Relatics. Maar ik begrijp dat bij de nieuwe versie van Relatics de mogelijkheid om te kunnen koppelen met third-party software afneemt?

Interviewee
Ja, dat is ook in de nieuwe versie de focus. We hebben ons zodanig op dit moment gepositioneerd dat we zeggen: Wij kunnen heel goed inzicht creëren in complexe projecten, maar we zijn niet de beste in het bouwen van een DMS systeem of in het creëren van een planning. Om Relatics optimaal op je project te kunnen gebruiken, willen we wel alle informatie kunnen ontsluiten. Dus we hebben echt op integratie ingezet zodat deze DMS lekker goed kan doen waar hij goed in is, een planningssysteem kan doen waar hij goed in is en CAD-systeem kan doen waar hij goed in is. Maar door deze software te integreren in Relatics hebben we het in ieder geval inzichtelijk in één centraal systeem. Dat is denk ik een van de belangrijkste verschuivingen. In het verleden wilden we nog wel eens die krachten naar ons toe trekken om te zeggen van nou ja, doe alles in Relatics en laat de andere tooling maar zitten. Nu leggen wij de focus op het inzichtelijk maken van de totale projectcomplexiteit waarbij je informatie uit andere systemen kunt ontsluiten en die in hun kracht laat.

5. Hoe is de verhouding in gebruikers, kijkend naar type gebruiker (ingenieursbureau, aannemer, Rijkswaterstaat, ministeries, gemeentes, waterschappen)?

We zien dat de opdrachtgevers een kleine klantengroep zijn. Wij werken voornamelijk voor aannemers, ingenieurs- en adviesbureaus. Zaken die in Relatics vastgelegd worden, zoals eisenbeheer, risico's, keuringen en verificaties worden gedaan door uitvoerende partijen, dus bijvoorbeeld in de vorm van de aannemerij of ingenieursbureaus. Qua verdeling aan klanten staat de aannemerij op één, daarna opdrachtgevers en ingenieursbureaus. Daaronder vind je dan de adviesbureaus.

Kenmerken van Relatics als PMIS (10 min)

6. Welke specifieke functies van Relatics dragen volgens jou het meest bij aan het succes van engineeringprojecten?

Dat is in mijn optiek verificaties. Zonder verificaties kun je wat gaan ontwerpen of bouwen, maar dan weet je uiteindelijk helemaal niet wat en hoe iets gebouwd is. Daarnaast denk ik dat de integratie van third-party software een belangrijke functie is. Ook draagt een stukje maatwerk en flexibiliteit naar klanten bij aan het succes van projecten. Ten slotte denk ik dat we over de 20 jaar ervaring die we nu hebben ook hebben kunnen leren van processen die vaak op elkaar lijken. Ook al blijft onderscheid en maatwerk altijd belangrijk. Zo kun je bijvoorbeeld als functioneel beheerder een eigen template bouwen.

7. In hoeverre voldoet Relatics aan de belangrijkste kenmerken van een integraal project informatie management systeem?

Een van de onderwerpen waar we op kunnen winnen is gebruikersvriendelijkheid. Een deel daarvan ligt in ieder geval bij de klanten zelf. Een inrichting kunnen zij namelijk zelf bepalen. Dit is een van de aspecten die we ook hebben aangepakt met de introductie van Relatics 6. Daarnaast is tijdsbesparing een belangrijk aspect waar Relatics zeker aan kan bijdragen.

Interviewer
Wat betreft de scores uit de enquête, zou je een idee hebben waar dat door komt?

Interviewee
Als je kijkt naar gebruiksvriendelijkheid kan ik dat uitleggen met een voorbeeld. Het kan zo zijn dat er 10 organisaties zijn die allemaal Relatics gebruiken maar alle 10 verschillende werkwijzen en inrichtingen hebben daardoor het erg lastig is om daar een eenduidige werkwijze voor eindgebruikers in de vinden. Een voorbeeld is Excel: iedereen weet dat als je het bestand wil opslaan je linksboven moet zijn. Ook al weet je het niet precies, klik je gewoon ergens linksboven omdat je weet dat het daar ergens moet staan. Wil je in Relatics een document zoeken in project A, B of C? Dan kan dat bij project A links boven staan, bij project B rechtsonder en bij project C door middel van het uitschuiven van een balkje. Ik denk dat daar nog echt de pijn zit qua gebruiksvriendelijkheid. De recente ontwikkelingen in Relatics 6 hebben ervoor gezorgd dat bepaalde aspecten, zoals het zoeken van documenten of het openen van verificatieoverzichten altijd aan de linkerkant van het scherm te vinden zijn.

Daarnaast houden we ook AI-ontwikkelingen nauw in de gaten, maar zijn daar erg voorzichtig mee omdat informatie in Relatics zeer vertrouwelijk is en we dit nooit openbaar kunnen maken in open source software.

Relatics en project performance (10 min)

8. In welke mate draagt Relatics bij aan het verbeteren van projectprestaties op het gebied van tijd, geld, kwaliteit, stakeholder tevredenheid, en innovatie-prestaties?

Eerlijk gezegd is dit het lijstje met argumenten waarom klanten Relatics zouden moeten gebruiken. Ik begrijp dat hier een gradatie in zit. Relatics is na 20 jaar relatief de standaard geworden in de markt, dus als je vandaag de dag Relatics gebruikt is het vanzelfsprekender dat je tijd bespaart, terwijl je een aantal jaren geleden dit niet voor mogelijk had gehouden. Mensen raken er dus steeds meer gewend aan.

9. Kun je voorbeelden geven van innovatieve oplossingen die zijn voortgekomen uit het gebruik van Relatics?

Dat is third party-software. Aanbestedingstooling korter op Relatics aan het zetten, zodat voorinformatie van projecten in kaart worden gebracht. Daarnaast ook de externe pakketten in hun kracht laten en koppeling met Relatics mogelijk maken, en niet zelf als losse tooling in Relatics proberen te bouwen.

Verbetermogelijkheden (10 min)

15. Zijn er specifieke gebieden waarop je denkt dat Relatics kan worden verbeterd?

Gebruiksvriendelijkheid en performance. We hebben vaak te maken met grote projecten met gigantisch veel data. Deze data moet in ieder geval toegankelijk blijven tot jaren na oplevering. Volgens mij gaan we nu richting de 70.000 workspaces, dit kan nogal impact hebben op de laadsnelheid van Relatics. Vandaag de dag willen mensen niet meer wachten, het moet snel zijn omdat mensen daar aan gewend zijn geraakt. Je moet mee gaan met de verwachting van de eindgebruikers. Om de prestaties te verbeteren is archivering van workspaces een onderdeel wat besproken wordt in de ontwikkeling van Relatics 6, dit zou kunnen zorgen voor meer overzicht voor de functioneel- beheerder en betere prestaties van Relatics omdat er minder data opgehaald hoeft te worden.

16. Welke suggesties heb je om het gebruiksgemak van Relatics te verbeteren?

Bij de nieuwe Relatics hebben we een help-button. Eerder hadden we een knowledge base, die best wel technisch was. Nu hopen we met een beknopte hulp-beschrijving vragen te kunnen beantwoorden. Binnen Relatics geloven we dat je ook kunt werken met incomplete datasets. Als je in een project bepaalde informatie al weet, zonder dat je het eindresultaat al kunt vastleggen, kun je deze eerste informatie al vastleggen in het systeem. Dit voorkomt dat je het zelf moet onthouden met het risico dat het vergeten wordt of naar verloop van tijd anders geïnterpreteerd wordt. Het onderwerp workflow is dus een belangrijk agendapunt voor ons, wat we ook van onze klanten te horen krijgen.

Wat we daarnaast zien is dat Relatics best een specialistische tooling is waardoor wij eigenlijk altijd adviseren om ons te laten meekijken in de eerste implementatie. Laten we in ieder geval inzichtelijk krijgen wat de behoeften zijn en ook welke data uitwisselingen op termijn nodig zijn, om de klant in ieder geval de juiste kant op te duwen.

Toepasbaarheid buiten de scope (10 min)

12. Zijn er bepaalde aspecten van Relatics die volgens jou breder toepasbaar zijn in de sector of daarbuiten?

Qua strategie trekken we ons weer terug in een bepaalde hoek. We zijn eerst in de bouwsector gestart, vervolgens zijn we gegroeid en ook in andere sectoren gestapt, zo hebben we bijvoorbeeld een CRM-systeem gebouwd voor een werving- en selectiebureau. Wij hebben gezien dat de inzetbaarheid erg breed is. Maar toen hebben we ons gerealiseerd dat we ons willen focussen op waar we echt goed in zijn:

bouwprojecten waar de toepassing van SE onmisbaar is. Het systeem is in theorie dus breder inzetbaar, maar gezien onze focus op bouwprojecten ligt daar onze kracht.

13. Welke kansen zie je voor informatiesystemen (breder dan alleen Relatics) om projecten te verbeteren?

Dan moet ik denken aan laagdrempeligere koppelingen. We zien dat de koppelingen met verschillende koppelingen lastiger gaat dan andere. Als hier een uniformere werkwijze in komt zou dit veel betekenen. Het bij elkaar brengen van een CAD- of risicosysteem is een uitdaging maar zie ik zeker als een kans. Ook blijft er altijd een mogelijkheid tot koppelen van 'custom-made' koppelingen, zodat we het systeem niet teveel beperken en we weten dat elk project andere behoeften heeft. We hebben wel een inventarisatie gemaakt dat de top-20 applicaties in de markt altijd plug- and-play geïntegreerd moeten worden. Hiermee proberen we het beheer sneller, efficiënter en makkelijker te maken. Ook maken deze constructies het proces herleidbaarder, bij bijvoorbeeld vertrek van kennisdragers.

Afsluiting (5 min)

14. Zijn er nog andere opmerkingen of inzichten die je zou willen delen met betrekking tot het gebruik van Relatics en projectprestaties?

Met Relatics worden èchte projecten gebouwd. Er worden echt kunstwerken opgeleverd, dus dat dat dat dat vind ik in ieder geval een hele mooie motivatie om aan mee te werken. Wij maken het kunstwerk niet zelf, maar leveren wel een indirecte contributie en dat vind ik echt tof.

Interview Rijkswaterstaat

Datum: 20-12-2023

Introductie (5 min)

- Doel van het interview
- Audio-opname
- Informed consent

Rijkswaterstaat en Relatics (10 min)

1. Kun je kort uitleggen wat je rol is bij Rijkswaterstaat?

Wegens anonimiteit is deze beschrijving weggelaten uit de interview-uitwerking. Deze vraag was relevant voor de onderzoeker om een beeld te vormen over de werkzaamheden van de geïnterviewde persoon.

2. Kun je uitleggen hoe Relatics wordt ingezet binnen Rijkswaterstaat en specifiek binnen jouw rol als netwerkcoördinator?

Relatics wordt binnen RWS met name ingezet voor aanleg- en Vervanging en Renovatie (V&R) projecten. Bij de aanlegprojecten is Systems Engineering (SE) vaak een vereiste. Dan is Relatics natuurlijk een passend systeem. Bij V&R projecten is dit ook het geval. Dit is echter anders bij werkzaamheden van bv. de beheerders in de regio of assetsmanagers. Zij werken niet op projectbasis en dus ook niet met Relatics. Dus daar wordt het niet gebruikt. Het ironische is dat we nu bezig zijn met het opstellen van generieke prestatie-eisen aan de netwerken (hoofdweggennet, hoofdvaarwegen en hoofdwatersysteem). Ik heb voorgesteld om dat in Relatics te doen. Maar de organisatie wil dit toch in het bekende Excel blijven doen. Relatics wordt dus met name binnen de aanleg en V&R projecten ingezet.

3. Wat zijn volgens jou de belangrijkste kenmerken en functionaliteiten van Relatics?

Dat je overal relaties tussen kunt leggen. Dit houdt in dat je informatie makkelijk en efficiënt op één plek invoeren en op meerdere manieren weer kunt geven en gebruiken waardoor je niet met schaduwversies werkt maar met een duidelijke centrale bron hebt. SE is ook erg kenmerkend voor veel projecten. Ik denk dat binnen bv. de aanlegprojecten de SE-elementen zoals eisen, raakvlakkenanalyse, functionele analyse, vraagspecificatie die je eruit kunt halen wel erg kenmerkend is voor het systeem.

4. Hoe draagt Relatics volgens jou bij aan het beheersbaar maken van complexiteit in projecten?

Omdat Relatics helpt om een duidelijke decompositie te hebben: het helpt de gebruiker inzichtelijk te maken op welk niveau je zit. Dit helpt om onderscheid te maken tussen standaard en specifiek. Bijvoorbeeld het onderscheid tussen een objecttype die je aan alle vaste bruggen kunt koppelen en een object die alleen geldt voor een specifieke brug. Dat vinden mensen lastig om te begrijpen. Dit komt in veel gevallen terug: bij RWS maar ook bij ingenieursbureaus waarbij je algemene en project specifieke eisen hebt. De bijdrage van Relatics is dat het deze informatiestructuur op een logische manier ondersteunt.

Kenmerken van Relatics als PMIS (10 min)

5. Welke specifieke functies van Relatics dragen volgens jou het meest bij aan het succes van projecten/programma's?

Dat je het specifiek voor één project kunt inrichten, zodat het past bij de specifieke opgave zonder dat dit heel ingewikkeld is en je de boel helemaal opnieuw moet gaan programmeren. De meerwaarde vanuit de SE-systematiek zit in de eisenopbouw en hoe je dit vervolgens volgens het SE- template kunt inzetten en gebruiken.

6. In hoeverre voldoet Relatics aan de belangrijkste kenmerken van een integraal project informatie management systeem?

Dit hangt er sterk vanaf aan wie je het vraagt binnen Rijkswaterstaat. Bij RWS werken veel mensen die niet handig zijn met softwareprogramma's. In de praktijk is de simpliciteit dus erg belangrijk. Maar als je ervan uit gaat dat iedereen dit basisniveau hebt denk ik dat flexibiliteit zeker belangrijk is. Binnen RWS is er behoefte aan één bron en dat je die op verschillende manieren kunt benaderen. Ik denk ook dat automatisering ook een ambitie is waar stappen op gezet moeten worden (slimmer met data omgaan en te kunnen inzetten). Dit raakt aan intelligentie. De focus ligt niet op het zelf denken van een system maar om de mens te ondersteunen in zijn werkzaamheden. Daar valt wel een slag te in maken. Toegankelijkheid en simpliciteit zijn denk ik rand voorwaardelijk. Op tijdsbesparing en efficiency ligt minder focus. Hier zie ik sterk een verschil tussen een ingenieursbureau als winst gedreven organisatie en RWS als overheidsorganisatie. Het is belangrijker dat er een gedegen product ligt met minder oog voor tijd en geld. Soms is er wel tijdsdruk bij bv. Kamervragen die snel een antwoord nodig hebben. Een robuust systeem zou dan helpen bij het snel en eenduidig benaderen van de informatie die je nodig hebt.

Relatics en project performance (10 min)

7. In welke mate draagt Relatics bij aan het verbeteren van projectprestaties op het gebied van tijd, geld, kwaliteit, stakeholder tevredenheid, en innovatie-prestaties?

Heel veel. Ik denk dat Relatics kan helpen bij het niet continue zelf het wiel opnieuw uit vinden. Bij eisen-specificaties en stroomlijnen van informatie kan het zeker goed helpen. Het biedt ondersteuning bij het standaard doen wat standaard kan en het leggen van de focus op de belangrijke en risicovolle aspecten van een project.

Ik denk dat Relatics indirect bijdraagt aan het verhogen de tevredenheid van stakeholders omdat het je helpt om snel de juiste informatie eenduidig boven tafel te krijgen. Ik denk ook dat ieder systeem wat informatie eenduidig bij elkaar brengt wel helpt. We zijn betrokken bij verschillende programma's m.b.t. bereikbaarheid. Dan is het wel belang dat iedereen de goede informatie kan delen op verschillende projecten. Daarnaast is het ook van belang dat je de meest actuele informatie gebruikt wat waarvan je honderd procent zeker weet dat dat de juiste en meest actuele informatie is, wat vaak bij bv. Excel of Word bestanden nog wel eens mis gaat. De bijdrage van het systeem is wel indirect, als in: dat Rijkswaterstaat de informatie kan tonen maar dat stakeholders niet direct zelf inzicht in krijgen.

8. Kun je voorbeelden geven van innovatieve oplossingen die zijn voortgekomen uit het gebruik van Relatics?

Het draagt bij aan het beheersen van SE in projecten. Een andere innovatieve oplossing is het ontwikkelen van productenloketten geweest. Hiermee kun je het systeem dus ook gebruiken voor de beheersing van je project. Ook draagt het bij aan automatisering zoals het standaard uitdraaien van voortgangsrapportages op basis van informatie die is vastgelegd in Relatics.

Verbetermogelijkheden (10 min)

9. Zijn er specifieke gebieden waarop je denkt dat Relatics kan worden verbeterd om projecten en/of programma's binnen Rijkswaterstaat verder te optimaliseren?

Ik denk dat dit niet per se in Relatics zit maar meer met hoe er door mensen mee omgegaan wordt. Bij mijn weten wordt het nu niet gebruikt voor onderhouds-zaken of andere werkzaamheden van RWS buiten V&R en aanlegprojecten. Vanuit de politiek wordt nu de keuze gemaakt om de verschuiving te maken van aanleg naar onderhoud. Hierbij kun je denken aan verlichting of stormvloedkeringen. Daar zitten allemaal projectteams op en er lopen onderhoudscontracten. Dit is een hele andere wereld dan de projecten wereld. Nu is dat nog erg gescheiden. Je ziet in de praktijk dat Relatics en SE niet voor de onderhoudswereld gebruikt wordt terwijl dit juist hetgeen is waar de infra-sector juist op in gaat zetten. Een kans voor Relatics zit denk ik in het ondersteunen in het assetmanagement. Ik denk dus niet dat het zit in dat het technisch niet mogelijk is, maar dat bepaalde groepen niet weten hoe het werkt, de mogelijkheden niet zien of onbekendheid met het systeem. Het is ergens ook wel begrijpelijk omdat er al zoveel systemen zijn waar een assetmanager in moet werken en dan is altijd de vraag: wat is de toegevoegde waarde van dit specifieke systeem?

10. Welke suggesties heb je om het gebruiksgemak van Relatics te verbeteren?

Dat is denk ik meer een organisatie specifieke keuze. Per project is het altijd lastig om specifieke instructies op te stellen. We moeten er misschien naar toe dat we een randvoorwaarde stellen dat iedereen een bepaalde basiskennis heeft. In de tutorial hoef je dan alleen maar uit te leggen wat de project-specifieke onderdelen zijn. Een andere verbetering is het automatisch opslaan van data tijdens het typen in een veld. Nu wordt dit niet opgeslagen bij het typen van een lang stuk tekst. Ook een CTR+Z knop (terug-navigeerknop) zou een handige toevoeging zijn die het systeem gebruiksvriendelijker maakt. Rijkswaterstaat staat ook open voor het koppelen van Relatics-omgevingen van bijvoorbeeld een ingenieursbureau of een aannemer zodat informatie eenduidig vastligt.

Toepasbaarheid buiten de scope (10 min)

11. Zijn er bepaalde aspecten van Relatics die volgens jou breder toepasbaar zijn in de sector van infrastructuur, bouw, milieu of daarbuiten?

Ik kan me voorstellen dat productenloketten breder inzetbaar zijn omdat dit gaat over opdrachtnemer/opdrachtgever en hoe je afspraken kunt maken over welke werkzaamheden uitgevoerd worden, door wie en wanneer. Als we het hebben over eisenspecificaties is dit relevant voor iedereen die met SE werkt, dus niet alleen de bouw- en infrasector. Daarbij is het belangrijk om te noemen dat er nog veel te behalen valt in de infrasector. Er is momenteel veel aandacht voor de aanleg en renovatie van infrastructuur, maar het is ook belangrijk om te kijken naar de werkzaamheden die vallen onder asset management en wat er nodig is om deze uit te voeren. Nu er minder focus zal zijn op aanleg en meer nadruk op onderhoud, kan het nuttig zijn om te overwegen hoe de kennis die is opgedaan bij aanleg en renovatie projecten kan worden toegepast bij het beoordelen en aanpakken van problemen met bestaande infrastructuur.

12. Welke kansen zie je voor informatiesystemen (breder dan alleen Relatics) om projecten/programma's te verbeteren?

Dat er vooral behoefte is aan één systeem waar je uit een bron alle informatie uit kunt putten. Dat je goed op de hoogte bent van je areaal en dat je daar inspectiegegevens inlaadt, maar ook wanneer een aanlegproject is afgerond dit allemaal in een systeem gebeurt zodat je dit voor een V&R project nogmaals kunt gebruiken. Er lopen nu ook programma's om dit slimmer te gaan doen. Ik denk dat informatiesystemen in het algemeen essentieel zijn voor de ondersteuning hiervan. Het helpt bij het beheren van informatie op één centrale plek, wat voorkomt dat iedereen zijn eigen gang gaat en kennis verloren gaat op het moment dat iemand met pensioen of uit dienst gaat.

Afsluiting (5 min)

13. Zijn er nog andere opmerkingen of inzichten die je zou willen delen met betrekking tot het gebruik van Relatics binnen Rijkswaterstaat?

Dat het vooral van belang is met elkaar te bespreken op welk niveau mensen zitten en waar ze dan behoefte aan hebben. Wat ik zelf opvallend vind is dat er ingewikkelde zaken aangeboden worden door opdrachtnemers zonder dat die vraag er is. Soms liggen de verwachtingen erg ver uit elkaar en hebben opdrachtnemers andere ambities dan het niveau van de vraag van de opdrachtgever. Binnen de RWS-projectorganisatie speelt ditzelfde probleem. Ik denk dat het goed is om met z'n allen te streven naar iets wat van een iets lager niveau is niveau heeft maar dat je wel op één lijn zit. Als je dit niet doet heb je denk ik veel onvrede en onbegrip. Daar ligt denk ik een belangrijke kans voor informatiesystemen zoals Relatics.