

Towards a Transparent Implementation of a Contractual Portfolio:

Developing design specifications for a Serious Game between public client and private contractors

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Abstract. A contractual portfolio can provide benefits by exploiting a common theme, knowledge, or resources among multiple independent projects. Therefore, it can stimulate innovation and investments to overcome the adverse effects of unique and singular projects in the Dutch construction industry. However, the absence of existing literature and practical experiences with this approach creates a barrier for public clients willing to adopt a contractual portfolio. This study aimed to develop a Serious Game between a public client and three private contractors. Literature analysis has been combined with expert interviews to find aspects associated with implementing contractual portfolios. These aspects have been translated into design specifications to establish game elements for a Serious Game that simulates the adoption of a contractual portfolio to maintain multiple objects within a fictitious area. The game allows clients to construct an ambition to maintain objects for a longer period based on the modification of different variables. These variables are: the duration of the Framework Agreement, ways of bundling, and the establishment of Key Performance Indicators. The developed game can reveal the consequences of those decisions on the client's performance management system and the contractor's intervention planning.

Keywords: Contractual portfolio, innovation, renovation and replacement intervention, Key Performance Indicators, Serious Game.

Introduction

Most bridges, tunnels, locks, and viaducts in the Netherlands were built in the 1950s and 1960s of the last centuries (Rijkswaterstaat, n.d.). These infrastructural assets will reach their required service life in the coming decades. In addition to the expected deterioration, heavier traffic and more intensive loads will significantly influence service life negatively. This situation presents a challenge for large-scale replacement and renovation in the coming decades. This challenge to the Dutch construction industry can be seen as one of the biggest challenges in the industry (BTIC, 2021). It concerns the infrastructural assets of larger public clients, such as Rijkswaterstaat, and those of provinces and municipalities.

In fact, the entire infrastructure of the Netherlands represents by far the most significant public possession and has a worth of more than 300 billion euros (Economisch Instituut voor de Bouw, 2021). To make the challenge of replacement and renovation even more problematic, the current capacity of the workforce is not sufficient, and financial resources are lacking. Furthermore, the construction industry accounts for half of the total material consumption (Dutch Ministry of Infrastructure and the Environment & Dutch Ministry of Economic Affairs, 2016). The production of primary building materials such as steel, cement, and glass results in the depletion of natural resources (World Economic Forum, 2015).

BTIC (2021) outlines that it is almost certain that a substantial part of all infrastructural assets will soon require renovation interventions to meet functional service life or will even need to be replaced. In addition, the construction industry itself is characterised as a project-based industry, and fragmentation within the sector is widely seen (Winch, 2010).

This project-based characteristic of the construction industry hinders the sharing of knowledge between projects. Adriaanse (2014) mentions that it remains a challenge to consider cohesion between all ongoing projects and further explains the three different ways of fragmentation of the construction industry;

- Horizontal fragmentation of different organisations working on one project;
- Vertical fragmentation of different process phases, and;
- Longitudinal fragmentation of multiple singular standalone projects.

It is expected that vertical and longitudinal fragmentation can be overcome by procuring and managing projects more strategically and comprehensively. Procurement is when public authorities, such as Rijkswaterstaat and provinces, purchase work, goods, or services from companies (European Commission, n.d.).

However, current practices in the Dutch construction industry do not include enough innovative solutions to cope with the anticipated renovation and replacement peak (Ministry of Infrastructure and Water Management, 2019). In addition, a recent development in the Dutch construction industry is the introduction of the 'Guideline contractual portfolio approach' (Dutch: Handreiking contractuele portfolioaanpak). As the executive division of the Dutch Ministry of Infrastructure and Environment, Rijkswaterstaat is responsible for the design, construction, management, and maintenance of the main infrastructure of The Netherlands¹. With this new guideline, Rijkswaterstaat provides guidance on how public clients can procure multiple related projects with a repeating characteristic to

¹ <https://www.rijkswaterstaat.nl/en/about-us>

the same (or a combination of) private contractors in order to achieve benefits.

Implementing the proposed contractual portfolio of Rijkswaterstaat could contribute to the replacement and renovation challenge, as mentioned above. However, since the approach has been recently introduced, it is still unknown whether the expected benefits will actually be achieved in practice. The expected benefits that the client wishes to achieve by adopting a contractual portfolio are related to increasing the learning ability, and the innovation and investments made by the private sector.

Recent studies on programme procurement show the strategic barriers and drivers that Dutch construction organisations face when shifting from project-oriented procurement to programmatic procurement (Vosman et al., 2019).

Therefore, the question that arises is how to better understand the potential implications of the new contractual portfolio if this approach will be widely used for replacement and renovation projects in the Dutch construction industry. Answering this question is not only useful for larger public clients such as Rijkswaterstaat but also for smaller organisations such as provinces and municipalities.

This research aims to expand the existing literature on bundled procurement approaches and develop design specifications for a Serious Game intended for an interplay between the client and the contractor that implements a contractual portfolio. Therefore, it focuses on the aspects that could influence the effectiveness of bundling standalone projects in a contractual portfolio. The research questions to be answered are as follows:

RQ1: Which aspects are associated with implementing a contractual portfolio by public clients used for replacement and renovation projects? RQ2: How should a Serious Game be designed to reveal the consequences of different bundling ambitions of public clients and the maintenance strategy of private contractors within a contractual portfolio?

This research builds upon the strategic barriers and drivers found by Vosman et al. (2019) to develop game specifications to construct a Serious Game. A Serious Game can be a helpful tool to create insights into the consequences of the ambitions of public clients relating to bundling projects into a contractual portfolio.

The remaining sections of this paper are organised as follows: it starts with a theoretical background of bundled approaches, different delivery methods used in the construction industry, and how Serious Gaming can provide playful experiences of real-world situations (Chapter 1). Subsequently, the overall framework used for this research is presented in the research design and the research approach that incorporates ways of data collection and data analysis (Chapter 2). Finally, the results are given in Chapter 3 and then discussed in Chapter 4 before the research is summarised and conclusions are drawn.

1. Theoretical background

This chapter serves as a basis for the consecutive research steps. To develop the theoretical background of the research, we identified and collected various available (published and unpublished) materials (Bougie et al., 2017). With the exception of Vosman et al. (2019), all sources included were published in scientific journals and found on Google Scholar². Search terms such as 'Project portfolio selection', 'Programmatic procurement approach', 'Project delivery methods construction industry', 'Policy games for strategic management', 'Serious Gaming as methodology', and 'Design science framework' were used to collect literature. The collected documents were documented per field (Table 1.) with the software Mendeley.

Table 1. Overview of the literature used per field.

Field	Number of documents
Construction industry dynamics	13
Portfolio procurement	5
Programme procurement	3
Public procurement	5
(Project) delivery methods	5
Measuring delivery method	5
Game theory (Serious gaming)	8
Conducting research	5
<i>Total</i>	<i>49</i>

In the sections below, we first present the findings of our review on the bundling approaches used in the Dutch construction industry as well as the possible delivery method of these approaches. The results of our analysis of how to measure the performance of this delivery method are then presented. This chapter will wrap up by presenting how Serious Gaming as a tool can be used to reveal the consequences of different bundling ambitions of public clients.

1.1 Program and Portfolio approach

As previously mentioned, longitudinal fragmentation in the construction sector characterises itself as managing multiple projects individually (Adriaanse, 2014). Due to this longitudinal fragmentation, the learning experiences among contractors from previous projects remain a constant point of attention (Nawi et al., 2014). Shehu and Akintoye (2009) suggested a more programmatic approach to pursue strategic goals more efficiently and effectively. Pellegrinelli (1997 p.142) defines a programme as: "A framework for grouping existing projects or defining new projects, and for focusing all the activities required to achieve a set of major benefits. These projects are managed in a coordinated way, either to achieve a common goal, or to extract benefits which would otherwise not be realized if they were managed independently". Thus, the programmatic approach manages the independence between projects and the requirements to adapt to changing circumstances associated with strategic implementation. At the same time, this

² The research of Vosman et al. (2019) was helpful because it is one of the few studies that focuses on programmatic procurement approaches in the Dutch construction industry.

programmatic approach can be part of a larger environment that is then characterised as a portfolio. In 1999, Archer and Ghasemzadeh specified a portfolio as: “A portfolio is a group of projects that are carried out under the sponsorship and/or management of a particular organisation. It is a collective group of construction projects and programmes within an organisation, with no interference to the manner in which they are organised or managed”. The similarities between these approaches are that both approaches try to enable the grouping of relatively independent projects with a common theme.

Aritua et al. (2009) point out that the terms portfolio and programme are often misused interchangeably. For example, when multiple projects are needed to accomplish an organisation’s set of goals and objectives, these projects may be grouped into a program (Project Management Institute, 2017). Grouping these projects into a program may result in benefits that cannot be obtained when managed individually. Furthermore, a portfolio may be used to effectively manage multiple programs and projects that are underway at any given time. For this research, the term ‘Contractual portfolio’ will be used and can be defined as:

- A set of projects created to exploit a common theme, knowledge, or resources among multiple independent projects, enabling greater efficiency and better performance.

According to Rijkswaterstaat (2021), examples of these common characteristics are:

- *Theme:* Circularity, innovation, or accessibility.
- *Knowledge:* Type of asset or construction method.
- *Resources:* Geographical location.

By focusing on one of the abovementioned characteristics, a contractual portfolio can achieve goals and benefits better than when executing them individually. For example, Rijkswaterstaat (2021) mentions that the client and the market can achieve the following goals when adopting the portfolio approach:

- *Market:* Spread risks over multiple works, reduce failure costs, and increase innovation.
- *Mutual:* Lower transaction costs, increase production capacity, and implement more innovation.
- *Client:* Tender work simultaneously, use more uniformity in execution, award contractors on performance, and use performance management as an incentive for more quality.

1.2 (Dis)advantages of bundled procurement

Van den Hurk et al. (2016) explored several advantages of bundled procurement within Public Private Partnerships governance and mentioned multiple points of attention when utilizing a portfolio or programme. On the other hand, Estache and Iimi (2011) discovered the disadvantages of bundling infrastructure procurement. Furthermore, Vosman et al. (2019) identified multiple barriers to transition from project to programmatic delivery methods.

Van den Hurk and Verhoest (2015) suggest that the complete body of projects (in a programme or portfolio)

should be procured at the initiation of it. In the meantime, the executing parties should also be selected in this initiation phase. Furthermore, Van den Hurk and Verhoest (2015) also mention two advantages of a bundled procurement approach: (1) a series of projects that are procured simultaneously give clients, contractors, and politicians more certainty in the realisation of upcoming projects in the foreseeable future and (2) bundled procurement (in this case for sports facilities) reduce transaction costs. Furthermore, Van den Hurk and Verhoest (2015) noticed three complexities that refer to a bundled procurement approach: (1) the political complexity plays a role in getting all heads in the same direction, and the preparedness of local government, (2) Multi-complexity that come with the involvement of many actors has been of great relevance to the performance of bundled procurement, and (3) the challenging interplay between client and contractor concerning the governance of technical requirements and competition.

Estache and Iimi (2011) claim that project bundling could potentially work. However, with a large scale and scope, this could undermine the competition effect. This effect occurs because only larger contractors can undertake large contracts. Therefore, the bidder entry is affected by the size of the contract and the division of contract packages.

Vosman et al. (2019) identified barriers inherent to a programmatic procurement approach in the Dutch construction industry. These barriers can be categorised as system, organisational, and relational, as shown in Table 2. The system-level concerns the construction industry itself and can be considered as the context in which organisations operate. The organisational level concerns the characteristics of the public client or private contractor organisation. Finally, the relational level refers to the (contractual) relationship or cooperation between the client and the contractor in the construction industry.

Table 2. Barriers to programme procurement (Vosman et al., 2019).

System barriers	level	Organisational level barriers	Relational level barriers
Tension between requirements and innovation		Governance focused on project-based operations	Low level of trust between client and contractor
Continuous competition		Lack of clear ambitions and strategy	No motive to share knowledge
Lack of continuity for innovation		Underestimation of implementation process	Different interests of client and contractor
Insufficient portfolio volume		Negative perception of regulations	
Challenging capacity allocation		Insufficiently trained employees	

The relationship of barriers to the implementation of a contractual portfolio for replacement and renovation was then analysed. Based on existing literature, we discovered that the following barriers are expected most when shifting from a project-based environment towards a bundled approach.

1.2.1 System-level barriers

- *Tension between requirements and innovation*

One of the root causes of this barrier is the project-based characteristic of the construction industry (Adriaanse, 2014). In addition, due to vague definitions of innovation requirements, private contractors experienced difficulties developing innovations. These barriers seem essential to replacements and renovation challenges, as innovations can flatten the curve and decrease primary material consumption (BTIC, 2021; World Economic Forum, 2015).

- *Lack of continuity for innovation*

When there is a short-term vision by either the client or the contractor, the continuity of the upcoming works can hamper the compensation of the initial investment (Dubois & Gadde, 2002). However, as a contractual portfolio approach suggests a similarity of some kind and assurance of the upcoming works, this barrier is overcome by implementing a contractual portfolio.

1.2.2 Organizational-level barriers

- *Governance focused on project-based operations*

Most public clients' project-based characteristics are embedded into the company's culture. However, Rijkswaterstaat wishes to transition towards a contractual portfolio approach (Rijkswaterstaat, 2021). As there are no experiences yet known for this kind of bundled approach, it is assumed that this barrier also affects smaller clients such as provinces and municipalities.

- *Lack of clear ambitions and strategy*

If ambitions are too abstract and cannot be translated into actions, organisations face a barrier in which the goals of a bundled approach will not be achieved. However, this barrier is expected to be overcome when the consequences of the ambitions and strategy can be transparent.

1.2.3 Relational-level barriers

- *No motive to share knowledge*

Learning between different projects and phases is an essential feature of a bundled approach, so sharing knowledge is hugely important. However, the learning goals are not met when there is no motivation (for both the client and the contractor) to share knowledge. This is even more urgent when approaching the replacement and renovation challenge with a bundled approach, as the lessons learned from this recently developed approach are yet unknown.

The abovementioned barriers are translated into potential aspects that could be associated with implementing a contractual portfolio used for replacement and renovation projects, as shown in Table 3. It is worth mentioning that these aspects can have either a positive or negative effect on implementation.

Table 3. Potential aspects of implementing a contractual portfolio.

	Aspect	Aspect description
System-level	Continuity innovation	To earn back investments, there needs to be a certain continuity of innovation. This can be either in the number of projects or periods of time.
	Learning ability	The learning process is based on experiences obtained during the repetitive execution of projects within a contractual portfolio.
	Prioritising and defining maintenance needs	To determine where and which kind of maintenance is needed, the process of prioritizing and defining the maintenance need is done beforehand.
Organisational-level	Client ambitions	Client ambitions can be seen as how public organisations translate their strategy and ambitions into actions.
	Market involvement	Market involvement refers to the collaboration between the client and the market. For example, this could be on how the market is involved in decisions, such as openness and participation.
	Project-transcending governance	To achieve the goals of a portfolio approach, the governance of the portfolio needs to be project-transcending rather than on single projects alone. Therefore, transcending can be seen as a long-term vision.
	Sharing knowledge	Sharing knowledge obtained by the client's contractor about maintenance needs or, for example, traffic flows could help to determine better maintenance strategies.
Relational-level	Procurement	The process of public authorities purchasing work, goods, and services from private companies. It includes the selection stage, evaluation of the selection stage, invitation to tender, and the evaluation of the tender.
	Performance monitoring	Monitoring performance during the contract period can be based on Key Performance Indicators. These indicators can be used to measure how projects are delivered in terms of quality.

1.3 Delivery methods in the construction industry

The portfolio approach suggests exploiting a complete set of programmes and projects with a common theme: knowledge of resources amongst multiple independent projects, enabling greater efficiency and better performance. In order to let the market execute the complete set of programmes and projects that the client has defined, the client needs to adopt a particular delivery method. The delivery method can be defined as a comprehensive process in determining the contractual relationships, roles, and responsibilities of the parties throughout the project life cycle (Syed Zuber et al., 2018). There are multiple delivery methods the public client can select. However, each delivery method has its characteristics, and it is worth analysing how each delivery method can be applied in the construction industry. Ahmed and El-Sayegh (2020) claim that the delivery method has a

significant impact on the extent to which efficiency and a better performance is achieved.

Through the years, the delivery methods in the construction industry have evolved, and various consumer demands have resulted in many variants and alternatives. To review the evolution of delivery methods in the construction industry, Ahmed and El-Sayegh (2020) compared traditional methods such as Design-Bid-Build (DBB) to more integrated methods such as Design-Build (DB). The DBB method can be categorised as the traditional delivery system and was dominant until the 1990s. In this conventional method, the client issues two separate contracts, one with the consultant for the design phase and one with a private construction party for the execution of the project. This delivery method is usually based on a single fixed price or lump sum, where the contractor performs a specific task for a specific amount of money. With this delivery method, the risk of any changes to the final cost is removed for the client.

Extensive literature shows that due to the increasing demand for heavy engineering projects, it became challenging to quantify the required work accurately, and a more integrated approach was desired (Ahmed & El-Sayegh, 2020; Kent & Becerik-Gerber, 2010; Syed Zuber et al., 2018). This integrated DB method encourages team collaboration and enables early involvement of contractors to give input in the design, programming, financing, constructability, and construction cost. After that, benefits such as cost and time savings can be achieved due to a faster process where part of the construction can be started while the design is still in progress (Ahmed & El-Sayegh, 2020).

Over the years, contract variants have been developed for this integrated DB method. PIANOo (n.d.) addresses different variants that are nowadays used in the Dutch construction industry; Design, Build, Finance & Maintain (DBFM), Design, Build & Maintain (DBM), Design & Construct (D&C), and Engineer & Construct (E&C). In the delivery methods that include designing elements, the contractor is responsible for the design and construction of the project. Occasionally, an E&C contract is used when the contractor has to perform projects with a minimum share of detail-engineering (PIANOo, n.d.-a). This integration of design and construction often results in a higher quality standard delivered by the contractor (Roohé, 2007).

Delivery methods such as DB(F)M are generally long-term drafted contracts and try to link many uncertainties, ambiguities, and risks due to the involvement of many actors. This also can have an adverse effect (Salet et al., 2013). On the other hand, it is also possible to choose a more general contract where only specific terms and conditions such as time, quality, and delivery time are agreed (PIANOo, n.d.-c). Such a general contract is called a Framework Agreement (FA). A FA is defined by the Public Procurement Directives as *"An agreement between one or more contracting authorities and one or more economic operators, the purpose of which is to establish the terms governing contracts to be awarded during the given period, in particular about price and, where appropriate, the quantity envisaged"*³.

A FA is most applicable when there is a certain consistency in upcoming works, but there is uncertainty if the work is not relevant or needed anymore. With this kind of contract, the client can get a guarantee that the contractor can deliver a specific task or work in the maximum period of four years and that the contractor does not have to tender every single task.

Furthermore, a FA enhances the parties' positive and long-lasting relationships (Delta eSourcing, 2020). However, with this maximum of four years, the possibility of market foreclosure can occur. This market foreclosure occurs when other potential competitors do not have a fair chance to participate in profitable access to the market.

Based on the abovementioned characteristics of each delivery method, it can be noted that selecting one of the delivery methods that is used in the portfolio approach is an essential element to consider. Furthermore, each different delivery method also affects indicators that measure the performance of the project. Therefore, in the following section, the rationale behind selecting these indicators is elaborated further as to how it relates to the performance of an individual project within a portfolio.

1.4 Measuring project delivery

Through the evolution of delivery methods in the construction industry, the focus of the measurement of the delivery has not been solely on traditional aspects such as cost, time, and specifications, but also on trust, communication, and commitment (Ahmed & El-Sayegh, 2020). Therefore, the delivery measurement can be divided into measurements based on success and performance.

Takim and Adnan (2009) define that the concept of success in a construction process corresponds to efficiency and effectiveness measures. Whereas efficiency measures deal with time, budget, and specifications, effectiveness measures relate to achieving project objectives, user satisfaction, and project use. Furthermore, project success criteria can be expressed as the measure by which the success or failure of a project will be judged (De Witt, 1988; Cooke-Davies, 2002).

Furthermore, the performance measurement is done with Key Performance Indicators (KPI), which are directly affected by the decision of the delivery method (Ahmed & El-Sayegh, 2020). The performance of a construction project can be divided further into two groups, one with the use of mathematical formulas and the other with subjective opinions and personal judgement (Chan, 2001). The purpose of KPIs in the construction industry is to enable the measurement of the project and organisational performance (The KPI Working Group, 2000).

Taken together, it is of paramount importance that KPIs are properly established beforehand to ensure the interests of the alignment of different project parties in the project while providing incentives for improved performance (Molenaar & Songer, 1998). Furthermore, it is expected that adequately established KPIs make the difference if a contractual portfolio's implementation is successful.

³ Directive 2014/24/EU

Therefore, it is essential to understand the effects of each project's different KPIs in relation to the overall goals the portfolio attempts to achieve. Therefore, we adopted serious gaming as a research method to better understand those effects and reveal direct consequences.

1.5 Serious gaming as a learning tool

Organisations can face urgent organisational crises when entering uncharted territories (Duke & Geurts, 2004). Often these challenges can be seen as macro-problems. Macro-problems can be defined as policy problems characterised by unclear scope and details, connections amongst various factors, defined by focus rather than boundaries and tend to have unintended consequences, side effects, and unexpected spin-offs (Cartwright, 1987, p. 95). Macro-problems can be quite diverse, and multiple variables can differ considerably from one situation to the next. This research tries to tackle the macro-problem of how the consequences of different aspects associated with implementing a contractual portfolio can be revealed transparently. Duke and Geurts (2004) mention that defining a macro-problem is difficult. However, the implementation of a contractual portfolio contains the following macro-problem characteristics:

- *The environment of the problem:* It is situated in the construction industry that traditionally is project-based. With this contractual portfolio it is expected to increase innovation;
- *The understanding of the problem:* The relationships between ambitions, performance indicators, and the consequences are unknown;
- *The actors involved:* There are multiple actors involved (client and contractor);
- *The outcome:* Currently, the outcome (consequences) of decisions made by public clients is unknown.

Duke and Geurts (2004) suggest developing a Serious Game to deal with macro-problems. Serious Games provide playful experiences of real-world situations, meaningful in terms of learning, training, and research (Mayer et al., 2014).

In recent years, there has been an increase in the application of Serious Games for learning and behaviour change (Boyle et al., 2016). Whereas Duke and Geurts (2004) speak of policy exercises, more recent literature speaks of Serious Games (Altamirano & De Jong, 2009; Axelrod, 2003; Benitez-Avila et al., 2022; Scharpff et al., 2021). Hofstede et al. (2010) claim that the effectiveness of simulated games is evident to those who work with them (the players and facilitators). Furthermore, due to the adoption of the term *Serious Gaming*, more people took those games seriously instead of associating them with

childhood (Sutton-Smith, 1997). Serious Gaming is multifaceted, and a reasonable Serious Game effort requires attention to Knowledge, Social aspects, Emotion, and Practice in each Design-, Play- and Debrief phase (Hofstede et al., 2010). The following Serious Games have been recently developed for the (Dutch) construction industry:

- *3P Challenge:* A serious Game for reflecting on partnering in Public-Private concessions (Benitez-Avila et al., 2022);
- *Self-regulating joint service delivery:* A Serious Game between multiple contractors on road maintenance planning (Scharpff et al., 2021);
- *Road Roles 2.0:* A serious Game for future situations in road maintenance in the transition from traditional prescriptive contracts to more long-term and performance-based contracts used to provide periodic maintenance for a whole road network (CEDR, 2017).

All these games address areas of procurement or the cooperation between public clients and private contractors. However, a Serious Game that mimics the interplay between public client and private contractor implementing a contractual portfolio for inquiring replacement and renovation interventions has not yet been developed. In order to develop a Serious Game in a structured and holistic manner, Duke and Geurts (2004) suggest integrating the game elements 'Content', 'Structure' and 'Process'.

2. Research design

In the previous chapter, the foundations of bundled approaches, including measuring its performance and Serious Gaming as a research methodology, have been presented along with the possible contributions for this research. This chapter addresses the research design, including the framework that has been adopted to conduct this research and the research approach that incorporated various tools, procedures, and processes to collect and review data.

To construct the research design for this study (Figure 1), the Information Systems (IS) framework of Hevner et al. (2004) has been used. The IS framework combines behavioural science and design science research. Whereas behavioural science addresses research through the development and justification of theories (*Phase 1*), design science addresses building and evaluating artefacts (*Phases 2 and 3*). This research combined the implications of the foundations concerning delivery methods and bundled approaches during the implementation of a contractual portfolio approach with the building and evaluation of a Serious Game to reveal the consequences of those implications.

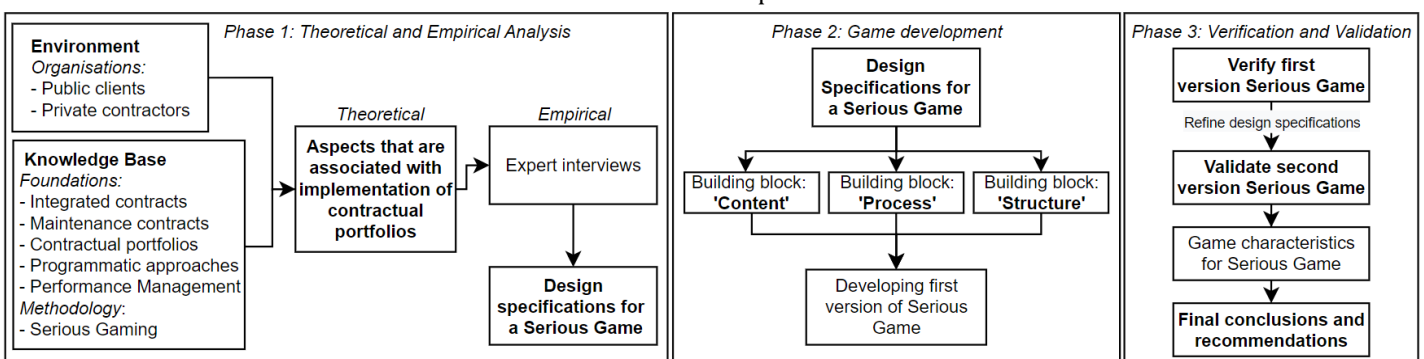


Figure 1. Research design. Based on the IS framework of Hevner et al. (2004).

2.1 Phase 1

The first phase served as the research foundation and involved the theoretical and empirical analysis of the research topic. In this first phase, the Environment and the Knowledge Base are central. The Environment can be considered as the problem space in which the research takes place and involved the organisations of public clients and private contractors. Each organisation's goals, problems, and opportunities define its business needs as people perceive them within the organisation. For this research, the public client's unknown implementation process of a contractual portfolio can be seen as the origin of this research in the Environment. Understanding the perception of this Environment assures the relevance of the research.

Furthermore, the Knowledge Base provides raw materials from and through which IS research is practised. For this research, the Knowledge Base addresses the foundations of different project delivery methods, bundled approaches and Serious Gaming as a research methodology. Formulating this applicable knowledge appropriately determines the rigour of this research. Therefore, we performed a literature analysis and conducted expert interviews to answer our first research question.

We interviewed five experts to better understand how different public clients experience the possible future barriers they foresee when implementing a contractual portfolio and how they would use KPIs to measure its performance. These experts were from public clients who work with traditional and integrated project delivery methods. The interviews were semi-structured to allow the researcher to deviate from the predefined questions and probe more into a subject (Bougie et al., 2017). Each interviewee had worked for a considerable time in the construction industry at the time of interviewing. Due to the qualitative nature of the interview, a predefined topic list was sent to the interviewees. This topic list was based on the analysed literature and included the following topics that reflected essential areas in the implementation of a contractual portfolio:

- *Measurement of performance and success in replacement and renovation projects;*
- *Ambitions and foreseeable barriers during bundling replacement and renovation projects;*
- *Influence of delivery methods;*
- *Learning ability (client and contractor) and prioritizing the replacement and renovation challenge.*

All interviews were recorded and the collected data was transcribed before analysis. The interview transcripts were sent to the interviewees to provide them with the opportunity to correct factual inaccuracies. After that, the ATLAS.ti software was used as a tool to analyse the interviews qualitatively. Because we aimed to build upon the work of Vosman et al. (2019), the analysis involved deductive coding (Boeije & Bleijenbergh, 2019). The analysis involved assigning categories and groups to text

elements in the transcripts. This coding process transformed the collected data into meaningful and cohesive categories (Sun, 2017). The first coding step involved deriving of, central *concepts* from the research of Vosman et al. (2019): Organisational-level, Relational-level and System-level. After that, the *concepts* were divided into different lower-level *aspects*. After the division of *concepts* into the *aspects*, these *aspects* were then subdivided into lower-level codes (*indicators*). These *indicators* have been developed by determining what kind of indicator suited a specific fragment (inductive coding). Then, the second round of coding was conducted. First, the indicators were checked for overlap. Second, the indicators were recategorized into *aspects*.

2.2 Phase 2

Insights from the first phase were then used to develop a Serious Game in the second phase. As mentioned, a Serious Game can explore, explain, and assess complex interactions between ecosystems and human actions. The building blocks of Duke and Geurts (2004), 'Content', 'Structure' and 'Process', were used to construct the game elements.

In order to get familiar with the dynamic setting of Serious Gaming, the researcher joined a gaming session of the game Road Roles 2.0 on 15 June 2022, held at the University of Twente, with students of the course Asset Management. During this session, the researcher assisted the lecturer as *Game Facilitator*. Road Roles 2.0 is a Serious Game that focuses on the impact of knowledge and competences on the agency's ability (public client) to maintain control and ensure the optimal long-term performance of the road network in the most cost-effective way (CEDR, 2017). The game was developed to gain insight into the strategic behaviour of private contractors and the effects on maintenance efficiency it has as a result.

2.3 Phase 3

After the Serious Game development in Phase 2, the first version of the game was tested by playing it with eight master students on 30 September 2022. All students who participated had knowledge of either (programmatic) procurement processes or asset management. As the students were all familiar with the subject, it was *assessed* if the developed Serious Game was built correctly and if it addresses the purpose of this research. After playing multiple game rounds, the session ended with an evaluation. This evaluation was based on the game itself and its playability. Subsequently, with the output of the game session and the feedback of the students, a second version of the game was developed (see Appendix C – Table A). Subsequently, the game was *refined*, and the second version was played and evaluated by experts with knowledge of procurement and asset management at Witteveen+Bos⁴ on 20 October 2022. Again, the game results were evaluated

⁴ Witteveen+Bos is an engineering and consultancy firm that possesses expertise in construction cost and financing, contracting, and tendering, and project and contract management.

with the participants and the feedback was considered to adjust the Serious Game again resulting in the final version .

Eventually, the third phase of the research supports us in answering our second research question. This third phase is also focusing on the applicability of the game in the Environment and Knowledge Base. It is determined if and how the game could be played within organisations and the theoretical contributions the research tries to deliver.

3. Results

3.1 Design Specifications

Through analysing existing literature and collecting the experiences of experts, aspects were identified that could

influence the implementation of a contractual portfolio used for the replacement and renovation projects (Table 4). The results from the interviews served as a pragmatic list of concerns that were translated into design specifications for a Serious Game. Each identified aspect will be discussed separately, together with its *Design Specification (DS)*.

3.1.1 Client ambitions

All interviewed experts of the public clients were familiar with the bundled procurement approaches. However, different Client ambitions were observed. Where two experts tried to change the processes, attitudes, and behaviour of the people working in the organisation, the other experts preferably stuck to traditional work

Table 4. Overview of design specifications used for the development of the Serious Game.

Aspect	Results interview	Design Specification (DS)
Client ambitions	Public clients have the ambition to bundle replacement and renovation interventions on 'Type of work', 'Geographical location', or 'Condition' to achieve contractual portfolio goals.	(1.0) Let the participants that play the client choose between three different ways of bundling: 'Type of work', 'Geographical location' or 'Condition'.
	The consequences the way of bundling have on the planned replacement and renovation interventions are yet unknown.	(1.1) It should be possible to reveal different consequences based on the way of bundling that has been chosen: Type of work', 'Geographical location' or 'Condition'.
Procurement	Due to the opportunity to tender for multiple objects instead of each individual object, a Framework Agreement suits best for a contractual portfolio to inquire replacement and renovation interventions.	(2.0) The game should contain multiple objects that needs replacement or renovation interventions.
	It is expected that the competition effect of multiple contractors within a FA can result in higher quality and/or efficiency (see also: Performance Monitoring)	(2.1) It should be possible in the game to inquire multiple objects in one Framework Agreement with multiple contractors.
	It is expected that the efficiency and quality of the interventions will increase by a longer duration of the agreement. However, the relationship between duration, quality, and effectiveness is unknown.	(2.2) The game should incorporate flexibilities in the duration of the Framework Agreement.
	By inquiring multiple objects over a long time, the risk emerges that one of those objects does not have to undergo any interventions anymore.	(2.3) It should be possible that the game incorporates a random risk that a part of the contractual portfolio no longer needs any intervention after a certain period.
Continuity innovation & Project-transcending governance	A constant flow of projects is tremendously crucial for the continuity of innovation. However, unfortunately, experience in governing these projects in a project-transcending way is lacking.	(3.1) The game should address the governance of multiple objects over a long period and, by doing so, create the possibility for the continuity of innovation.
Learning ability	It is expected that by executing replacement and/or renovation interventions in a particular order, learning effects between different objects can be obtained.	(4.1) It should be possible in the game that the contractor can plan their replacement and renovation interventions in a (logical) order and that a distinction is made between replacement and renovation interventions.
	Learning effects are expected to result in an increased impact or decreased cost of the replacement and renovation interventions.	(4.2) It should be possible to incorporate learning effects in such a way that this has a consequence on the impact and cost of the replacement or renovation intervention.
Prioritising and defining maintenance needs & Market Involvement	Contractors can help clients in the prioritising and defining process of maintenance needs. Investing in his working processes or methods allows the contractor to show 'Ownership'.	(5.0) The game should incorporate an incentive for the contractor to make investments that increases the effectiveness and efficiency of the replacement and renovation interventions.
Sharing knowledge	Sharing knowledge can be between project teams and singular objects or between the organisation of the client and contractor. Expectations are that gained knowledge is lost during the transition between objects or project teams.	(6.0) The game should incorporate a situation in which an emerging event hinders knowledge sharing, or in which that knowledge is lost. This situation should start a dialogue between the client and contractor to come to an arrangement.
Performance monitoring	Performance monitoring can increase the competition effect within a contractual portfolio. Furthermore, formulating Key Performance Indicators possibly incentivises the contractor to increase 'Client Value'.	(7.0) It should be possible for the client to use a mechanism whereby Key Performance Indicators can be measured in such a way that this can be used when awarding successive works to the best scoring contractor(s).

procedures. Public clients understand the benefits that bundled procurement approaches can offer (for example, the more efficient and more effective execution of projects due to the repetitive characteristic). Nonetheless, translating long-term ambitions into actual projects that could be part of a contractual portfolio is experienced as complicated. An interviewee who works at a province states that this results from *"The insufficient consistency and stability of the project teams that work with these bundled procurement approaches"*. The origin of this bottleneck can be found in the scarcity of personnel, a common fact in the construction industry. Furthermore, the clients have the ambition to bundle different projects into work-packages based on the following ways of bundling (DS - 1.0):

- *Type of work*: Where the objects have similarities in the construction method or market segment;
- *Geographical location*: Where the objects are situated with a geographical relation to each other;
- *Condition*: The objects have the same condition as the other related objects.

All interviewees mentioned that these ways of bundling can increase the efficiency and/or effectiveness of the replacement and renovation interventions. However, at this point, it is unclear what the precise consequence is of each way of bundling (DS - 1.1).

3.1.2 Procurement

According to the experts interviewed, the procurement of a contractual portfolio is a necessary process that deserves considerable attention when adopting a contractual portfolio. Integrated project delivery methods with contract variants such as Engineering & Construct (E&C), Design & Construct (D&C), and Framework Agreement (FA) have been addressed during the interviews. It can be concluded that a FA as a legal relationship has the highest potential to engage in the replacement and renovation challenge and can act as a basis for the contractual portfolio. An interviewee mentioned: *"The advantage of a FA is that series of works can be awarded to contractors without tendering for each individual work. It is expected to do this faster and cheaper when tendering a complete set of works rather than individual ones"* (DS - 2.0). In addition to this monetary advantage, a FA can guarantee the continuity and predictability of upcoming objects for contractors in the agreement. Furthermore, it is possible to include multiple contractors within the same agreement. A competition effect between contractors is expected to emerge by including multiple contractors in one agreement. When the performance monitoring of a contractual portfolio is well structured, this competition effect may increase quality and/or efficiency (DS - 2.1).

Besides the abovementioned advantages of a FA, experts also foresee points of attention when adopting such an agreement. First, the scope of the FA needs to be sufficiently broad enough to include all possible tasks. Meanwhile, *"You only get what you ask"* said an interviewee regarding the broad task definition. This is even more important when deviating from the standard duration of 4 years. However, one interviewee referred to an example where a FA was

adopted by a public client that had a duration of 10 years. The client deviated from the standard duration as the learning effects were only expected to be achieved by lengthening the agreement's duration. However, deviating from the standard duration, clients need clear motivation.

During the interviews, it became clear that the experts see possibilities in extending the duration of a FA up to a maximum of 10 years and thereby aim to increase the quality and efficiency of replacement or renovation interventions. Nonetheless, it is unknown what the relationship is between different long-term durations of a FA and the effect on the quality and efficiency (DS - 2.2).

Furthermore, it is a fact that a risk emerges when inquiring interventions for a long period with the same agreement. This risk relates to the uncertainty that one of the objects does not have to undergo any interventions anymore (DS - 2.3).

3.1.3 Continuity of innovation & Project-transcending governance

The continuity of innovation seems important, as all interviewees mentioned this during the interviews. Organisations could earn investments back when there is an assurance for future works. This can only be achieved when there is a clearly defined scope of upcoming work. Furthermore, one interviewee mentioned: *"When you invest a considerable amount of money, you could earn this investment back after completing all projects"*. Also, one interviewee foresaw a point of attention if there were *"hiccups"* in the flow of projects. This negatively influenced the continuity of innovation and, thus, the efficiency and effectiveness of the overall goals. It is expected that the governance of the objects within the contractual portfolio in a project-transcending way can result in the continuity of innovation.

Experts indicated that project teams, in the way they are now organised, cannot manage the projects in a bundled way due to a lack of experience and sometimes a short vision of the teams. In order to create those experiences, a Serious Game can help to get familiar with revealing the consequences of different ambitions while constructing and governing of a long-term contractual portfolio (DS - 3.1).

3.1.4 Learning ability

Learning ability can be defined as learning from the experiences of projects within a contractual portfolio. These experiences can be applied in successive replacement or renovation interventions. To achieve such learning effects, the interviewees expect that the contractors need to plan their interventions in some logical way (DS - 4.1).

Furthermore, at this point, it is unknown what the relationship is between different ways of bundling ('Type of work', 'Geographical location', and 'Condition') and the learning effects that can be deployed in successive interventions. Nevertheless, the interviewees expected that when these learning effects are achieved, this may increase the impact or decrease the cost of the successive intervention(s) (DS - 4.2).

3.1.5 *Prioritising and defining maintenance needs & Market involvement*

Often, the client has already identified the type of intervention specific objects need. However, in a more extensive contractual portfolio, it is expected that the practical knowledge and experience of the contractor can help to support the actual definition and planning of those interventions. This involvement of the contractors can be exploited more during a contractual portfolio. The interviewees expected that when the contractors feel the need to make investments (and thereby get more involved in the contractual portfolio), this may result in a beneficial situation for both the client and the contractor. By making such investments during the portfolio, the contractor, on the one hand, can improve his working processes and/or effectiveness and efficiency. On the other hand, the client may get improvements regarding quality or faster turnaround times. In order to achieve such market involvement, the interviewees argued that the duration of the contractual portfolio creates an incentive or limits the contractor to make such investments (DS - 5.0).

It is expected that the longer the duration of the contractual portfolio, the more investments are made by the contractor. In this way, the contractors can create 'Ownership' Furthermore, to increase this incentive, the interviewees mention that this 'Ownership' can be used in the awarding process of eventual successive projects during the extension period of the contractual portfolio (see: 3.1.7 Performance monitoring).

3.1.6 *Sharing Knowledge*

During a contractual portfolio, sharing knowledge between the client and contractor is a vital aspect to consider. After a project within the contractual portfolio is finished, a risk emerges that knowledge is being lost. The interviewees were concerned that the gained knowledge stays at one party and will not be shared. To overcome this, the experts suggested using a KPI that covers collaboration and/or sharing of knowledge. Worth mentioning is that a KPI based on collaboration also entails a point of attention, as one of the interviewees stated: "*What will you do if it turns out that after the realisation of a product the product works properly, meets the users' expectations, but the collaboration between client and contractor was undesirable*". Therefore, using KPIs is beneficial but should be constructed with care.

Another interesting point to consider is the distinction between sharing knowledge among persons of the project team and the overall organisation. During the interview, a respondent asked himself: "*Who is actually the one who learns?*" When the project teams share their knowledge only amongst the project team, it could be that the organisation itself does gain this knowledge. Therefore, it should be prevented that knowledge is lost after completing singular objects or when shifting teams within the contractual portfolio (DS - 6.0).

3.1.7 *Performance monitoring*

Performance monitoring seems essential, as all interviewees mentioned this as an aspect that should be carefully considered in a contractual portfolio. The interviewees stated that KPIs could aid clients in monitoring the performance. The contractor's performance is even more critical in a long-term contractual portfolio when a FA is used. This is because performance monitoring can be used to distribute potential successive objects within the contractual portfolio (DS - 7.0). If the client uses this in the awarding process, it is expected to increase the competition effect between the contractors. Furthermore, the quality is expected to increase due to this competition effect. Therefore, it is beneficial to create an incentive for the contractor in which the contractor tries to achieve the most 'Client Value' during the contractual portfolio.

3.2 *Design and development process of Serious Game*

3.2.1 *Problem definition for Serious Game*

All experts interviewed for this research work at larger public clients in the Dutch construction industry. According to those experts, the potential aspects identified in the literature were all expected to be present while implementing a contractual portfolio used for replacement and renovation interventions. However, all respondents agreed that these aspects' precise influence is unknown. Multiple variables such as the way of bundling, contract type, and duration could have consequences on the performance of a contractual portfolio, either positive or negative.

3.2.2 *Goal definition for Serious Game*

Based on the clarification of the problem in the previous section, the purpose of a Serious Game is to create insights into the issues emerge during the implementation of a contractual portfolio. Furthermore, a developed game should intend contributions to the decision-making of public clients when considering a bundled approach. The game should therefore have at least the following functions: negotiating, building consensus, and reaching decisions. Taken this together, the goal of the Serious game is as follows:

- Identifying consequences of duration, ambition, and ways of bundling on planning and implementation of replacement and renovation interventions in a contractual portfolio.

The previously constructed game design specifications in Table 4 can be transformed into game elements that are the blueprint for the Serious Game. Table 5 holds the developed game characteristics of the building block 'Content' and highlights related design specifications. Hereafter, the developed game characteristics of the 'Structure' and 'Process' are presented.

3.2.3 Content of the Serious Game

- **Scenario**

The scenario describes the storyline and is given to all participants as the game begins. The Serious Game scenario has been set in the future to address different ways of bundling within a contractual portfolio. The designed Serious Game's storyline mimics the execution of a contractual portfolio that can be played with public clients and private contractors. To create the possibility to incorporate different ways of bundling, the scenario describes a waterway that holds 6 objects (see Appendix B – Figure A for an illustration).

Where the different types of objects (A, B, and C) are developed because these can be bundled on 'Type of Work', the waterway creates the possibility to bundle on 'Geographical location'. Furthermore, the objects have different initial conditions that will decrease yearly.

Therefore, different initial conditions of the objects create the possibility to bundle the objects based on 'Condition'.

Furthermore, in this scenario, the client is responsible for inquiring replacement and renovation interventions using a FA with three contractors. The scope of the scenario (number of objects) is clearly defined. Nonetheless, the duration of the FA is flexible and can vary between a standard duration of 6 years, 6 years plus 2 years extension, and 6 years plus two times 2 years extension. By performing replacement or renovation interventions, the contractors can increase the condition of the objects. Replacement interventions replace parts of the object and increase the condition more than renovation interventions. The contractors have the freedom to plan their interventions so that learning effects might emerge within (or between) objects.

Table 5. Overview of developed game characteristics based on building block 'Content'.

Game element	Developed game characteristics	Design specification
Scenario	A waterway that holds 6 objects decreases in condition yearly. The scope of the scenario is clearly defined, and the objects are divided into 3 work-packages, each with 2 objects. One party is responsible for the governance of the contractual portfolio for a long time, and multiple other parties are responsible for planning and executing replacement and/or renovation interventions.	(3.1)
	Work-packages can be composed by combining 2 single objects. The way of bundling of these objects can be on: 'Type of work', 'Geographical location' or 'Condition'.	(1.0)
	The conditions of the objects decrease yearly with a random factor (between -0.2 and -0.8). By adopting one Framework Agreement, three different contractors plan and execute replacement and/or renovation interventions that increase the objects' condition.	(2.0) (2.1)
	Due to the flexibilities of the Framework Agreement, the client can choose between a duration of 6, 8 or 10 years. Where the last two are (6 years + 2 years extension) or (6 years + 2 times 2 years extension).	(2.2)
Events	At a predefined moment in the game, the event that influences the impact or costs of planned replacement or renovation interventions can be brought in. It should be decided by chance (rolling of dice) which work-package is affected by this event.	(1.1)
	During the extension periods of the agreement (8 and 10 years), an event can be brought in that involves a risk that a particular work-package no longer needs any intervention. It should be decided by chance (rolling of dice) which work-package is affected by this event.	(2.3)
	If a critical expert leaves the organisation, this results in the event that knowledge could be lost. To express this risk under the participants, this event negatively influences the impact or costs of the replacement or renovation interventions.	(6.0)
Participants and their decisions	The stakeholders consist out of a public client and three different private contractors. It is advised to fulfil both roles with at least 2 players, which result in a total of at least 8 players. The public client and the private contractor have the freedom to make the following decisions:	
	Client: Determine the duration of the Framework Agreement (6, 8 or 10 years)	(2.2)
	Client: Determine the way of bundling of the work-packages 'Type of work', 'Geographical location or 'Condition'.	(1.0)
	Client: Determine the ambition of the 'end'-condition of the work-packages (constant, increased or decreased);	(1.0)
	Client: If there is chosen for 8 or 10 years, how successive work is awarded to the contractors. In here, there can be made use of a KPI to measure the performance of the contractors.	(7.0)
	Contractor: Prepare and hand-in intervention strategy for 2 work-packages. This is done for 3 years (and for 2 years in the extension period). This can be either a larger replacement or smaller renovation intervention.	(4.1)
	Contractor: Plan their interventions in such way that learning effects could emerge. The successive replacement or renovation intervention in the planning of the contractor possibly can result in lowering the cost and/or higher impact. The game makes a distinction in the following characteristic of the successive intervention: <ul style="list-style-type: none"> - Same size within same work-package; - Same size in another work-package; - Other size in another work-package; - Other size in within the same work-package. 	(4.2)
Contractor: Buy 'Invest cards' to increase the efficiency or effectiveness of the replacement or renovation interventions, thereby increasing their 'Client Value' and show 'Ownership'.	(5.0)	

- *Events*

To get the attention of one player or group during the game, there can be made use of events. These events can be brought in during predefined or random moments of the game. It results in an updated scenario as the game progresses. Events can be used to make the game more dynamic, and it forces players to make decisions.

The first event developed for the Serious Game is that the expected learning effects of the planned interventions will not materialize in practice. This event should be brought in at a predefined moment of the game, and to which work-package this affects should be randomly determined. Creating this event creates uncertainty if actual learning effects occur that could be obtained by planning interventions in a particular order.

The second developed event relates to a risk that could emerge during the extension periods of the agreement. Long-term agreements entail the risk that one of the objects initially thought to be replaced or renovated no longer needs any intervention. According to the interviewees, the most important reason this risk might occur is that a particular object will be demolished or become part of another agreement. The chance that this event occurs during the game correlates with the duration of the agreement. So, the longer the duration, the higher chance of occurrence. The rationale behind this event is that the participants of the client and the contractor jointly have to devise a solution, and it can start a dialogue.

The third developed event for the Serious Game affects the sharing of knowledge. This event creates a consensus that the gained knowledge should not leave the organisation when an expert does. When this event occurs, it affects the impact or cost of the planned replacement of renovation interventions. As this event occurs randomly and addresses a contractor determined by chance, the participants do not have the opportunity to act on this.

- *Participants and their decisions*

Characteristics of the stakeholders of the Serious Game are important to understand when developing a Serious Game. These characteristics can be translated into role descriptions for participants. When correctly constructed, every participant can play each role in the game. The game elements developed for the Serious Game intend to identify consequences of duration, ambition, and ways of bundling in a contractual portfolio. In this contractual portfolio, two different stakeholders are present and have the following characteristics:

Public client:

- Is an asset owner and responsible for the governance of the asset;
- Inquires replacement and/or renovation interventions to maintain the assets at a required condition;
- Has a limited budget.

Contractor:

- Is a private party motivated to make profits;
- Is responsible for the execution of replacement and/or renovation interventions;

- Is willing to invest in the portfolio to increase impact or decrease the cost of interventions.

The extent of the role description of both client and contractor minimizes the personalities but still gives freedom to make decisions during the game. The client has the freedom to decide how the fictitious waterway, including 6 objects, will be governed. In this ambition, the duration of the FA is decided, together with the way of bundling the objects. If chosen for extension periods, KPIs can be developed to structure the performance monitoring of the contractors. This ambition that the client establishes is expected to be different each time the game is played. Due to this difference, the contractor also has a different starting point each time the game is played.

The contractor is responsible for planning and executing replacement and/or renovation interventions based on the established ambition of the client. The contractor has the freedom to plan the interventions, consisting of larger and smaller interventions, in 3 years. These 3 years are proposed as it is a reasonable period in which the contractor can obtain the following possible effects due to planning the interventions in a particular order.

Interventions of the same size within the same work-package possibly decrease the cost and increase the impact of successive interventions regardless of the way of bundling (Table 6.A). It is expected that when bundled on 'Type of work', the highest increase of the impact can be realised due to the knowledge the contractor obtains of a specific object together with the experiences of the intervention. The other effects are expected to be realised as the same intervention is repetitively executed.

Table 6.A Overview effects on cost and impact of intervention.

Same size within the same work-package		
Bundled by client on	Effect on cost of intervention	Effect on impact of intervention
Type of work	(-)	(+)(+)(+)
Geographical location	(-)	(+)
Condition	(-)	(+)

Successive interventions of the same size in another work-package possibly decrease the cost when bundled on 'Geographical location' and increase the impact when bundled on 'Type of Work' (Table 6.B). It is expected that this decrease in cost can be realised by, for example, optimising the movement of equipment. Furthermore, an increase in impact may be realised due to lessons learned from the intervention executed to the same object type in another work-package. However, at this point, no other effects are expected to be realised when executing similar interventions in other work-packages.

Table 6.B Overview effects on cost and impact of intervention.

Same size in another work-package		
Bundled by client on	Effect on cost of intervention	Effect on impact of intervention
Type of work	n/a	(+)(+)
Geographical location	(-)(-)	n/a
Condition	n/a	n/a

It is expected that executing successive interventions of another size in another work-package only decreases costs when bundled on 'Type of work' and 'Geographical location' (Table 6.C). Where in the former way of bundling, characteristics of the object can be obtained, and in the latter way of bundling, the movement of equipment may be optimised.

Table 6.C Overview effects on cost and impact of intervention.

Another size in another work-package		
Bundled by client on	Effect on cost of intervention	Effect on impact of intervention
Type of work	(-)	n/a
Geographical location	(-)	n/a
Condition	n/a	n/a

The highest effect on the impact of the successive interventions of another size within the same work-package is expected to be realised when bundled on 'Type of Work' (Table 6.D). This impact increase may be realised due to lessons learned on the object type during a prior intervention.

Table 6.D Overview effects on cost and impact of intervention.

Another size within the same work-package		
Bundled by client on	Effect on cost of intervention	Effect on impact of intervention
Type of work	(-)	(+)(+)
Geographical location	(-)	(+)
Condition	(-)	n/a

Lastly, the contractor has the freedom to make one more decision during the game. This decision relates to the investments that can be made to increase the efficiency and/or effectiveness of the interventions. The possibility of positive return on investments during the contractual portfolio creates an incentive for the contractor. The following return on investments are thought of during the game:

- Extra monitoring of objects (decrease cost of interventions);
- A new way of conditioning the objects (decrease cost or increase the impact of interventions);
- Improving personnel allocation (decrease cost of interventions);
- No usable return on investments.

The first three returns on investments have a positive effect on the interventions that the contractor executes. However, there remains a risk for the contractor that there is no positive return on investment. By creating this incentive for the contractor to invest in the contractual portfolio, it is expected that the contractor will be challenged to show Ownership and increase its 'Client Value'.

3.2.4 Structure of the Serious Game

- *Format*

The format of a Serious Game is the physical configuration of documents, visuals, and artefacts. It creates an environment that the players will experience. Appendix B – Figure A visualises the game board on which the scenario is presented and acts as a central point in the experienced

environment. At the start of the game, the game board also holds the initial condition of each object situated in the waterway. After the completion of each round, the new condition scores of the objects can be made public on this board.

- *Procedures of play*

The procedures of play are the policies, rules, and steps of play of the game. A Serious Game should consist of multiple game cycles to challenge participants to make (other) decisions. Within these cycles, a predefined sequence of activities recurs every cycle. The duration of the agreement of the contractual portfolio determines the number of game cycles. For example, if the client chooses 6 years, the game has two cycles. If the client chooses for 8 or 10 years, the game has 3 or 4 cycles.

In the first 6 years of the agreement, the interventions are inquired by planning the interventions for 3 years. In the extension period (during 8 and 10 years), the interventions are planned for 2 years. In general, the designed Serious Game has the following game cycles:

A. Introduction cycle

Presents the meaning of the game, the game board, and how the intervention planning can be filled in. Also, the different roles are explained, and the yearly deterioration of the objects. Lastly, a practice round can help the participants to get familiar with the game.

B. Playing cycle (Round 1)

1. *Client*: Developing ambition and bundling of work-packages + presenting it to the contractors;
2. *Contractors*: Prepare intervention planning for 3 years + make investments + submit planning to the client;
3. *Client*: Assess planning of contractors and pay out for planned interventions;
4. Occurrence of an event;
5. *Contractor*: Based on the event, pay for the performed interventions to the bank;
6. Simulating the condition of the objects;
7. *Client*: Present the new conditions to the contractor and change it on the game board.

C. Playing cycle (Round 2)

8. Repeat steps 2-7.

D. Playing cycle (Round 3 – if the duration is set at 8 years)

9. *Client*: Based on the new conditions, determine to which contractor(s) the objects are awarded for the remaining part of the agreement;
10. Repeat steps 2 (2 - years) – 7.

E. Playing cycle (Round 4 – if the duration is set at 10 years)

11. Repeat steps 2 (2 - years) – 7.

F. Evaluation cycle

- *Simulation*

Every game cycle consists of a quantitative simulation representing a model and accounting system. The model determines the yearly deterioration of the condition of each object, as can be seen in the visualisation in Appendix B – Figure B. The condition has a maximum value of 5 and minimum value of 1, and the model randomly decreases the initial condition between -0,2 and 0,8. The accounting system can be used to fill in the interventions that the contractors plan. Subsequently, the replacement and/or renovation interventions increase the condition of the objects. Lastly, this simulation allows registering the increased condition per object per contractor. This can be used as input for determining the ‘Client Value’ (CV). The formula to determine this CV per object is as follows:

$$1) \quad CV = \left(\frac{\text{increased condition}}{\text{planned costs}} \right) * 1000 + \# \text{ invest cards}$$

The formula shows that the number of investment cards is included in the determination of the *Client Value*. This creates an incentive for the contractor to make investments during the contractual portfolio.

3.2.5 Process of the Serious Game

- *Presentation of the game*

The game's presentation is often done by a central figure (game facilitator) who leads the game. This presentation is structured concerning the three game cycles mentioned above: the introduction, the play, and the final briefing of the game. The facilitator presents the game's overall goal during the introduction and initiates a practice round with the participants. During the play of the game, the facilitator keeps track of the time. The developed Serious Game for this research can be played in approximately 2 hours. After the game, the game facilitator starts the evaluation.

- *Game artefacts*

Game artefacts are those physical materials that are needed to play the game. In general, the game artefacts for the developed Serious Game are the role descriptions, the simulation, and the game board. Appendix A holds a comprehensive list of all game artefacts developed for this Serious Game.

- *Evaluation*

The evaluation of a Serious Game can be divided into two concepts: the evaluation of the game elements and the evaluation of the decisions made during the game. The evaluation of the game elements is considered more important during the game's development phase and can also be seen as *Verification* and *Validation*. After the game is developed, the evaluation that the facilitator initiates relate to the decisions made during the game. Therefore, holding this session directly after playing the game is advised, as the reasoning behind the decisions is still memorialised. Furthermore, evaluating the results and decisions creates a consensus between the participants that played the client and contractor.

3.3 Verification session

After the development of the game characteristics of each game element, the next step in our research was to build the first version of the Serious Game. After that, the game was tested with eight master students to see whether the developed game and, mainly, if the game elements addressed its intended purpose (*Verification*). The first version of the Serious Game was composed of rudimentary game elements. In this first version, the participants who played the public client experienced great freedom, and in combination with the predefined time for this step, this resulted in inclusive decisions. For example, as the game tries to create insights into the consequences of ways of bundling, the ways of bundling are given instead of giving this choice to the participants.

After the game, the game elements and results were evaluated together with the participants. Each game element was discussed to determine whether it addresses its purpose and where improvements of the element could be implemented. Table A of Appendix C holds all the improvements based on each game session.

Also, the game intended to incorporate a performance monitoring mechanism that helps to decide which contractor performs best based on a predefined KPI. However, during this first session, it became clear that this performance monitoring mechanism was not used to its full extent due to the lack of precise threshold specifications. Therefore, this has been adjusted so that the client should also think of a minimum value that all contractors should meet.

Taken together, the first version of the game addressed all design specifications and game characteristics. However, adjustments in the ‘Procedures of play’ were needed to increase the game's playability. Therefore, together with the other adjustments to the game elements, the second version was developed and played once again.

3.4 Validation session

After the adjustment of the first version, a second version was played with five experts of Witteveen+Bos (*Validation*). These experts had knowledge of procurement processes and/or asset management. All participants understood the background and problem in which the Serious Game was situated.

Similar to the first session, the evaluation of the second version was immediately held after the game session. Together with the participants, the playability and the content of the game were discussed. According to multiple participants, it took considerable time to understand each game artefact's exact purpose. It was assumed that a mutual test round at the beginning of the game will eliminate these ambiguities and therefore this element was added to the current version.

Furthermore, the game also had the incentive to let the contractors invest in ‘Invest cards’ to increase the efficiency or effectiveness of their planned interventions. However, the first version did not include the percentage of each return on investment. The players mentioned that it was

desirable to add this, as this helps to make a more substantiated decision to invest or not.

Generally, the developed second version of the Serious Game addressed the game's intended purpose. The experts who participated in the validation session recognized and confirmed that a Serious Game that reveals the consequences of those aspects that come along with implementing a contractual portfolio (Table 4) is usable in the Dutch construction industry.

4. Discussion

The results of this research have provided insight into the relation of multiple aspects associated with implementing a contractual portfolio and the design process of a Serious Game intended to reveal the consequences of different bundling ambitions.

4.1 Theoretical and practical contributions

This study offers a contribution to the literature on bundled procurement approaches. The developed game characteristics attempt to overcome some of the barriers identified by Vosman et al. (2019). Additionally, the empirical analysis confirmed the benefits of long-term positive relationships between parties that Delta eSourcing (2020) imply about Framework Agreements.

Furthermore, this study contributes to recently developed Serious Games intended for the Dutch construction industry. In the experiment conducted by Sharpff et al. (2021), it was found that a monetary incentive influences the decision making, but the effect may be opposite to their intended aim subsequently leading to a competitive network. In this study the contractors do not self-regulate their service delivery but there emerges a competitive network when awarding successive works. It is expected that this competition effect within the contractual portfolio creates an incentive to achieve greater efficiency and effectiveness of replacement and renovation interventions. Another contribution is that the Serious Game developed in this study adds the possibility to create 'Ownership' in the contractual portfolio. However, during the game it became clear that an unclear ambition does not fully exploit the possibilities 'Ownership' as a mechanism can have. Further research could, for instance, investigate how different public clients translated their ambition and strategy into those elements that can be used in constructing the 'Ownership'-mechanism.

Road Roles 2.0 focuses on a long-term optimal performance of the road network in the most cost-effective way possible (CEDR, 2017). In this Serious Game, the contract duration of the agreement is fixed to four years. In the game that has been developed for this research, the client has more freedom to decide on the duration of the agreement to gather insights into the consequences of it. Worth mentioning, the participants of the verification and validation session noticed the undermining competition effect that comes along when bundling projects for a long time, as this is in line with the points of attention claimed by Estache and Iimi (2011).

4.2 Limitations and further research

The results should be interpreted with caution due to some limitations of the current research and the developed game. The interviews were structured based on existing literature about bundled procurement approaches. According to the experts, the potential aspects associated with the implementation seem essential and need to be considered. However, other possible aspects have not been discovered by confirming the potential aspects and by probing into foreseeable points of attention. Next, more respondents would have increased the reliability of the public clients' concerns in the Dutch construction industry.

The Serious Game that has been developed for this study, is expected to increase a consensus and to create insights in the decision-making of the client and contractor. By adopting a contractual portfolio for the Serious Game, both client and contractor are challenged to make decisions that have long-term effects.

During the development of the 'Content', the assumption is made that private contractors can achieve learning effects by planning their interventions in a 'logical' way. It is uncertain if these learning effects actually emerge in practice. It was beyond the scope of this study to make these learning effects explicit. Nonetheless, during the interviews and the validation session, all experts agreed that the intervention planning could have considerable influence on the learning ability of the contractor within a contractual portfolio. Future research could further test if these learning effects are realistic.

Furthermore, the developed game characteristics focus on adopting a long-term contractual agreement. It is assumed that the longer duration of the agreement will materialize the desired benefits despite excluding other possible contractors for that period. One of these benefits is that the contractors make investments to increase their efficiency and/or effectiveness. If this materializes in future replacement and renovation projects that are part of a contractual portfolio remain a point of attention.

The 'Structure' of the Serious Game of the contractual portfolio has been divided into four game cycles. These game cycles have been developed to incorporate a point of reflection on the decisions made by the contractor. After each game cycle the new condition scores of the portfolio are made public. By playing all four game cycles, it is expected that the contractor creates the highest learning effect and the client achieves most insights on their constructed ambition. On the other hand, the developed game in its contemporary form, holds the possibility to play only two rounds. This may hinder the overall decision making and can be considered as a limitation of the developed game.

During the verification and validation sessions, the focus was not on collecting the game results, but rather on the playability and constructability of the game characteristics. Presenting, playing, and evaluating the Serious Game that has been developed until now consumes considerable time. Duke and Geurts (2004) propose a 'rule of ten' practice runs before a designed Serious Game can be considered valid. Therefore, the Serious Game in its contemporary version is

a step in the right direction but needs to be carefully considered as it still requires improvements.

Also, the current version of the game is experienced as complex and requires considerable time to play (2+ hours). Further research could investigate how to reduce the number of artefacts to increase the game's playability. Also, the current version of the game uses a simulation that needs to be filled in by the Game Facilitator during the game. We recommend doing further research into the distinct advantages of bundling projects on a particular element, such as using pilot contractual portfolios or interviewing experts who can make more substantiated assumptions. Furthermore, the room for evaluation and discussion about the game's results is one of the most important elements of a Serious Game. Therefore, to develop the subsequent versions of the Serious Game, it is recommended to remain focused on this element. Moreover, it is undesirable to develop the next version of the Serious Game in a full digital version for remote play.

Conclusions

Although the new guideline for contractual portfolios has been developed to achieve advantages by exploiting a common theme, knowledge, or resources among multiple independent projects, public clients have few experiences in implementing these portfolios for replacement and renovation projects effectively. This research translated the potential aspects that could have consequences on implementing such a contractual portfolio into characteristics to develop a Serious Game. The approach of developing a Serious Game to mimic the interplay between public client and private contractors, together with two gaming sessions, proved fruitful. By negotiating and reaching for decisions during the Serious Game, consensus is created between stakeholders. This consensus can increase even more by fulfilling opposite roles of actual client and contractors.

To better understand the implications of the characteristics of the developed game, future studies should focus on the actual advantages that emerge when integrating projects into a contractual portfolio. With the Serious Game developed in this research, public clients can more transparently identify the consequences of bundling, contract duration, and performance monitoring.

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Appendix A – Game Folder (Dutch)

- A.1 – Spelhandleiding
- A.2 – Spelbord
- A.3 – Overzichtstabel voor keuzes Opdrachtgever
- A.4 – Randvoorwaarden bundelingen en effecten
- A.5 – Communicatie Kaarten
- A.6 – Event Kaarten
- A.7 – Rol omschrijving Opdrachtgever
- A.8 – Rol omschrijving Opdrachtnemer
- A.9 – Ontwikkel Kaarten
- A.10 – Rol omschrijving Spelleider
- A.11 – Introductie (PowerPoint)
- A.12 – Simulatie verslechtering areaal (Excel)
- A.13 – Vragenlijst evaluatie
- A.14 – Aanbieding formulier A
- A.15 – Interne onderhoudsstrategie opdrachtgever
- A.16 – Conditie sterren

Appendix B – Illustrations developed Serious Game

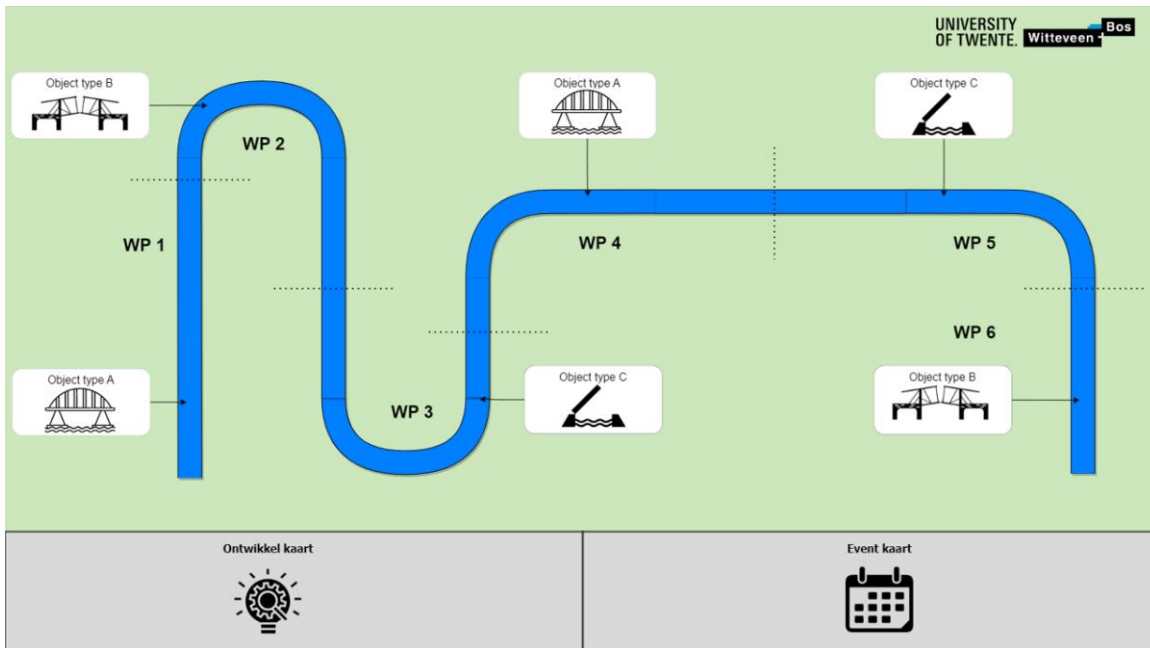


Figure A. Physical game board of developed Serious Game (Size: A3)

		Werkpakket								
		1 _A	2 _B	3 _C	4 _A	5 _C	6 _B			
Initiele overeenkomst	Jaar	Nr. ON	3	2	3	1	2	1		
	1	STAAT	4	2	4	3	2	3	2023	
	2			GO			GO		2024	
	3		KO	KO	KO				2025	
		BUNDELING					A-3.0			
	4	STAAT	3	4	4	3	2	2	2026	
	5				KO	GO	GO	GO	2027	
	6				KO				2028	
		BUNDELING			A-1.0					
		STAAT	2	3	4	4	2	2		
	VL	7								2029
		8		GO	KO	GO	KO	GO		2030
		BUNDELING					A-1.0			
		STAAT	3	3	5	5	3	3		
9								KO	2031	
10			KO	GO			KO		2032	
	BUNDELING									
	STAAT	3	4	4	4	3	3			

Figure B. Interpretation of the simulation that used for planning interventions in the Serious Game (Format: Excel)

Appendix C – Development process of game elements

Table A. Improvements made during the development of the Serious Game after each version

Game element	Improvements after the first version	Improvements after the second version
Process	<ul style="list-style-type: none"> • Adding a general introduction (PowerPoint), as the players did not understand the game's overall goal. • Adding requirements to the room where the game will be played; the players must get the room to prepare the intervention strategy individually. Otherwise, the possibility of cheating emerges. • If the contractor hand in an invalid intervention strategy, the contractor should still have to pay some fixed costs. 	<ul style="list-style-type: none"> • The players did not directly understand the game's overall goal, even with a general introduction. To get more familiar with this, a practice round is suggested.
Boundary conditions bundling effects		<ul style="list-style-type: none"> • The second version introduced the boundary conditions after completing the first round. However, to let the contractor plan their intervention strategy better, it is proposed to give the conditions directly in the beginning.
Scenario	<ul style="list-style-type: none"> • Add the option for the public client to choose 'geographical location.' • The budget of the client has been fixed based on the chosen ambition. 	
Role description Public Client	<ul style="list-style-type: none"> • Limit the degree of freedom. The public clients had too much freedom, and due to this freedom, players made choices that were too broad. To give more clarity, bandwidths were included in the second version of the game (budget, duration of agreement) 	<ul style="list-style-type: none"> • Include a matrix in which the public client can divide their budget over the agreed period.
Invest card	<ul style="list-style-type: none"> • Change the moment when an 'Invest card' could be purchased. The respondents mentioned that this was only possible after playing the first round. This has been adjusted so that the 'Invest card' can be purchased before each round to increase the incentive for the contractor to invest. 	<ul style="list-style-type: none"> • The chance of a positive return on investment (%) has been added to the player description to make a more substantiated choice.
Internal intervention strategy	<ul style="list-style-type: none"> • The intervention strategy form has been divided into an 'internal' intervention strategy and an 'Offer form A' that can be used externally for the client. The client does not know precisely where this division executes the intervention. 	
Event card	<ul style="list-style-type: none"> • Initially, the 'Event card' related to external events that had no relation to the intervention planning of the contractors. However, this has been adjusted so that it relates to the learning effects the contractor could achieve by planning. 	
Condition starts	<ul style="list-style-type: none"> • Visualising the number of stars was considered unnecessary. Only the number of stars is sufficient 	
Simulation	<ul style="list-style-type: none"> • The Excel file that holds the simulation has been expanded with a graph in which the development of condition scores is visualised. This graph can be used in the evaluation part. 	