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Brommet, O.D.; Schoenmaker, Rob; Hertogh, Marcel; Kleijn van Willigen, G.R.; Chen, Yawei

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Determining a functional responsibility allocation between public and private parties in a long-term maintenance contract for waterworks

O.D. Brommet, R. Schoenmaker, M.J.C.M. Hertogh
Faculty of Civil Engineering, TU Delft, The Netherlands

G.R. Kleijn van Willigen
Rijkswaterstaat, Utrecht, The Netherlands

Y. Chen
Faculty of Architecture, TU Delft, The Netherlands

ABSTRACT: A proper allocation of risks and responsibilities is vital for the success of long-term maintenance contracts. This paper focuses on a method to identify an adequate allocation of responsibilities for the maintenance of waterworks. The Dutch agency recently started outsourcing the maintenance of their waterworks in DBFM contracts. In order to meet the Dutch Water Act during the whole life cycle of the lock, Risk Based Asset Management is contractually required. However, how to distribute the risks and responsibilities between the public and private parties is an open question. This paper presents a functional risk allocation method, existing of a risk allocation matrix and risk allocation conditions.

1 INTRODUCTION

Early 2015 the first Design, Build, Finance and Maintenance (DBFM) contract for waterworks in the Netherlands reached its financial close (Lesterhuis, 2015). Over the next 30 years, 50 of the 83 locks in the Netherlands need to be renovated (Willems, 2015). The Dutch Government prefers the use of DBFM contracts; in this contract model the public party enters a long-term contractual agreement with the private party in which the private party is responsible for the design, construction and maintenance of public sector infrastructure facilities. Compared to road- and rail infrastructure, this type of outsourcing is relatively new for waterworks,. This gives reasons for further research: 1) the characteristics of waterworks differ from road and rail, 2) long-term outsourcing of maintenance involves uncertainty, because it is impossible to foresee all upcoming events which can influence the performance of a lock 3) the variety in functional requirements of locks. Apart from facilitating shipping, which mainly will be measured by availability; a lock prevents the hinterland against flooding, which mainly will be measured by reliability. During the long-term contractual agreement the private party is responsible of the performance of the lock, but ultimately the Dutch Government will be held accountable for the final performance related to the water safety of the lock. So it is in the interest of the public party to make sure that there is a fair risk distribution between the public and private party, not only during the construction but also during the operation and maintain phase. Long-term maintenance contracts involve uncertainty and a long-term interface between the public and private party, the question arises if and how this influence the long-term contract model.

2 PROBLEM STATEMENT

In the current DBFM contracts, the allocation of risks and responsibilities across the design, build and maintenance phase is fixed and equal, see figure 1. The payment regime is based on lump sum; this lump sum only is influenced by penalties due to non-compliance to the contractual requirements. There are no different characteristics in risk profile during the maintenance phase of DBFM contracts compared to the design and build phase. It is clear that in practice the risks during design and build differ from those in the maintenance phase. The methodology of risk-based asset management during operation and maintenance and the performance requirement is prescribed in the contracts. The risks that can lead to functional failure of a lock during the maintenance phase are supposed to be known. However, research is missing on the question how to distribute risks and responsibilities between public and private parties, where the level of outsourcing to the private party is in line with the desired degree of control of the public party during the maintenance phase. This paper provides a method to identify a balanced allocation of risks and responsibilities for the maintenance of waterworks between the public and private party, with respect to the optimisation between performance and costs.

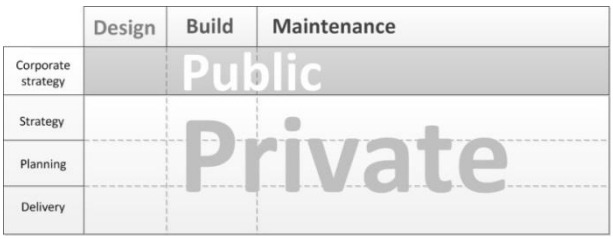

Figure 1 Allocation of responsibilities in a DBFM contract (adapted from MRWA (2015))

At first this paper will discuss the problem definition, followed by a review of literature and a research design. The results of the research are presented by a risk allocation matrix and conditions and further elaborated by the findings of case studies. In the last part the conclusion and recommendation are given how to deal with allocation of responsibilities in long-term maintenance contracts. A discussion is to be found in the closing paragraph of this paper.

3 LITERATURE REVIEW

A proper allocation of risks and responsibilities is vital for the success of long-term maintenance contracts (Ward, Chapman, & Curtis, 1991). Risk and responsibility allocation is a broadly discussed item in scientific research, including the issue of a proper allocation of the technical risks. Xioa-Hua Jin (2009)investigated how different kinds of risks and responsibilities are allocated in different countries in combination with the opinion of the public and private parties. The Transaction Costs Economics of Williamson (1981) provides concepts for an efficient governance structure of a project, based on the frequency, uncertainty and asset specificity of a transaction. In this paper a transaction is defined as the contents of the DBFM contract.

The theory of complex projects related to dynamic contracting by Hertogh and Westerveld (2009, pp. 109, 120) state that a governance structure needs to be adaptive, because not everything can be known in advance. But a further elaboration of this contract during the maintenance period is missing. Schoenmaker (2011) defined a six stage model of maintenance that can be used to investigate maintenance and the outsourced level of activities in different contract models. Examples of governance structures using this six stage model are given in Schoenmaker and Verlaan (2013). In a standard DBFM contract model, the maintenance activities work identification, planning & design, work scheduling, analysis, data management, work execution and measurement inspections are all outsourced to the private party.

A methodology to verify the performance (regarding the reliability and availability) is available, known as Risk Based Asset Management (RBAM) (Bogaard & Akkeren, 2011). The Dutch Water Act requires the use of this probabilistic methodology in the DBFM contracts. In order to verify the performance of the asset, the LPAM methodology requires translation of the Water Act into performance requirements expressed in failure rates of the asset. The performance requirements are the set of criteria regarding the main functions of the lock that must be met all times during its lifecycle. The RBAM methodology indicates respective risks of the lock divided in hardware, software, human failure and external risks. Seen from this methodology, the risks of the maintenance phase are asset-related elements, which can lead to a functional failure.

4 RESEARCH DESIGN

In order to establish a suitable allocation of risk and responsibilities between the public and private party, at first a functional responsibility allocation method is developed. This method, consisting of an allocation matrix and conditions, is based on the theories of DBFM, Life Cycle Costing, uncertainty of failure probabilities and suitable management structures according to the Transaction Costs Economics. Secondly the method is validated and improved by applying the risk allocation method on three Dutch waterworks cases. These cases have the requirement to use the RBAM methodology of the Dutch Government: the Volkerak complex (lift locks), Safety Lock Heumen and Safety Lock Limmel. The Volkerak complex and Safety Lock Heumen are both in the operation and maintenance phase. Safety Lock Limmel is during the research (2015) in the design phase. The observations of the first two cases are used in the last case to define the current culture of risk allocation and validate the results of the first two cases. On the one hand the functional risk allocation is analysed and on the other hand the organisation regarding the maintenance phase is scrutinised. Case studies are based on desk research (contracts, reports), active participation and on interviews with the critical stakeholders: the operator, the public party (contract and technical managers) and the private party (project leaders).

5 RISK ALLOCATION MATRIX AND CONDITIONS

The functional responsibility allocation method derived from literature consists of an allocation matrix and conditions. The allocation matrix, see figure 2, provides a management structure for long-term contracting based on the degree of two uncertain variables. The matrix is based on the risk formula: multiplying the probability of failure by the consequences

(Turner, 2014, p. 295). During long-term maintenance the formula is translated to multiplying the frequency of failure during the contract period by the repair time. Applying this principle provides management structures based on theoretical perspectives.

The first uncertain variable is the frequency of failure. This variable is determined by translating the failure rate into the expected frequency of failure of a critical element during the contract period. The frequency of failure (f) during the contract is apportioned between often (>3), likely (>3 f > 1.05), probable (1.05 > f > 0.95), possible (0.95 > f > 0.6) and rare (<.6). Note, achievement of Life Cycle Cost optimisation by the public party are contradictory to such a optimisation by the private party: optimisation is achieved when the responsibility is transferred to the other party at the moment of failure. The strategy of the 'Value for Money' philosophy is outsourcing elements for life cycle optimisation (Eversdijk & Korsten, 2009). The Transaction Costs Economics of Williamson (Williamson, 1985, p. 29) provides management structures how to deal with uncertainty and asset specificity. Depending on the frequency and uncertainty of the event, it can be more efficient to postpone decisions until there is more certainty of the actual occurrence of the event. Asset specificity requires efficient management of the elements, the manage effectively is indicated by the risk allocation criteria.

The second variable is the repair time of an element. Repair time can have negative influence on the Reliability and Availability of the lock. Since the payment regime is based on compliance to the reliability and availability requirements, long repair time will be priced into the costs as risk premium. The degree of uncertainty of the variables influences the risk premium costs involved (Zou, Zhang, & Wang, 2006, p. 65). Efficient management positively influences the repair time and thus performance of the element, but due to high risk premium costs the consideration of outsourcing must be accepted politically.

Postponing the decision of allocation of risks gives the public party more control on the maintenance strategy, and thus the consideration of the costs versus performance during the life cycle of the lock. In this way, the public party can adapt the maintenance strategy on the prospective requirements and developments. The allocation matrix gives for each element a management structure for the public party to keep control on the asset and the related performance and costs.

5.1 *Conditions*

The allocation conditions are imperative to ensure a reasonable and fair allocation. The conditions are related to the assessment and effective management of the responsibilities and risks. The desired risk as-

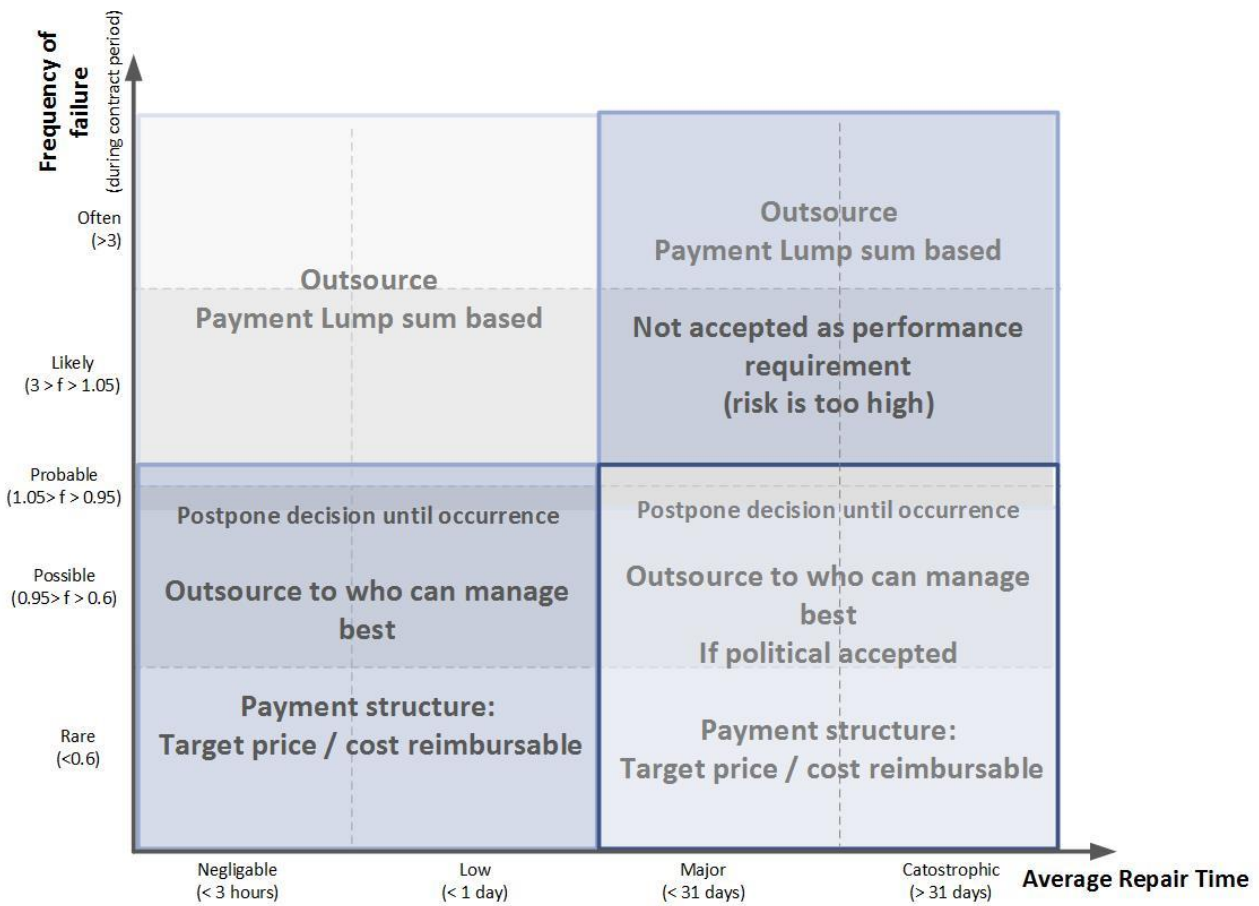

Figure 2 Risk allocation matrix

Table 1 Risk allocation criteria

	Risk allocation criteria	Operator	Public Party	Contractor
1	Whether the party is able to foresee the risk / Has been made fully aware of the risks they are taking	✓	✓	✓
2	Whether the party is able to assess the possible magnitude of consequences of the risk	✓	✓	✓
3	Whether the party is able to control the risk chance of occurring	✓		✓
4	Whether the party is able to sustain the consequences if the risk occurs			
5	Whether the party will benefit from bearing the risk		✓	✓
6	Whether the premium charged by the risk receiving party is considered reasonable and acceptable for the owner	✓	✓	✓
7	The party is able to manage the associated uncertainty, and thereby mitigate risks	✓	✓	✓
8	The party has the necessary risk appetite to want to take the risk			✓
9	Whether the party is able to make use of the prescribed LPAM methodology.	✓	✓	✓

sessment of the critical stakeholders is risk averse for the operator and contractor, so that a good performance of the respective lock is most likely (Brommet, 2015). On the other hand, the desired risk assessment of the public party is risk avoidance combined with risk neutrality to keep control of the optimisation of performance and costs. The compliance to the nine risk allocation criteria by the critical stakeholders (see table 1) indicates the risks can be managed effectively. Creating incentives for critical stakeholders can result in a desired risk assessment.

5.2 *Results by case studies*

All three case studies proved that the functional responsibility allocation matrix is suitable to allocate the hardware and software related risks. In case 1, the hardware and software risks are outsourced in line with the risk allocation matrix, project problems which came up were related to the organisation and contractual requirements. Case 2 involved a short-term maintenance period for a fixed price, whereby the management suggestion for hardware and software risks of the risk allocation matrix is applicable. In the last case, which is used as validation, every hardware and software risk is outsourced under several functional contractual requirements in DBFM. This disagrees with the risk allocation matrix which suggests that outsourcing the risks which will possibly, likely or often occur is the best way to control the performance of the object compared to the respective costs. It can be stated that the risk allocation matrix provides a suitable management structure for long term contracting to keep in control of the performance versus the costs. In practice, the application of the matrix shows that the political acceptance of risk premium costs with respect to the performance and the degree of control by the public party have various considerations.

For risks related to human failure and external factors the risk allocation conditions must be considered first. In practice, the allocations of these risks in long-term contracts are highly influenced by the criteria related to the ability to control and mitigate the risk. It is not reasonable and fair to hold the public party responsible for a fault of the private party and vice versa. Both parties are not able to control the probability of occurrence of external risks, but the risk can be mitigated by control measurements. Those measures are hardware and software related and therefore it is possible to outsource the control measurements according to the risk allocation matrix. In every case study the control measurements were outsourced to the private parties.

A long-term contract including lump sum payment, like DBFM, includes a financial reward for the Private party to optimise the maintainability, reliability and availability in the design. The optimisation is enhanced by the private party in case 1 and case 2 by hiring a specialised private party to ensure effective management of the mechanical, electrical, operational and control installations.

The RBAM methodology prescribes optimising maintenance activities during the first years as an incentive, to decrease the maintenance costs. In practice optimisation of the maintenance requires sufficient solution space (due to uncertainty) in order to find an optimal maintenance strategy which leads to long-term benefits. The solution space is determined by the performance requirements and the periodical inspections, both indicators for the periodical payment (lump sum). Currently, these limitations are present from the beginning, while optimising maintenance according the RBAM methodology requires time. The current solution is unable to bear disappointing results of the uncertainty of maintenance optimisation.

The last result is related to the role of the lenders in construction projects. The lenders are interested in a future cash flow which is certain, resulting in con-

tracts whereby risks are directly contracted back to back to smaller and specialised private parties.

6 DISCUSSION

In order to derive a functional responsibility allocation method, assumptions are made during this research. The following assumptions are limitations of this research and require further research.

The first limitation is the determination of the variables of the functional responsibility allocation matrix; frequency and repair time/costs. To be able to validate the functional responsibility allocation matrix, knowledge of the repair time of the different critical elements of the case studies is necessary. . The repair time is determined qualitatively by the use of expert judgement for each case study individually. Hereby, the dependency of the repair time on the specific kind of failure is not included. The frequency of failure is based on the failure data of components: so redundancies in subsystems are not included.

In order to find a proper risk and responsibility allocation, the application of the risk allocation and organisation of the present critical stakeholders is evaluated. These stakeholders are already involved in the design, build and maintenance. The statements and objectives of the private parties that were not selected in the procurement phase are neglected, similar as the private Parties who did not enter the procurement phase at all. Entering the procurement process requires high commitment of the involved parties, because of the high tendering costs. Their decision not the enter the competition may be influenced by the allocation of risks. This mechanism of the public party is to assure quality and ambition of the private party, but the tendering costs may have been the reason that only a few private parties participated in the procurement process (interview RWS, 2015d).

The last limitation is the non-involvement of the lenders during the research. Afterwards the financial position on an adaptive long-term maintenance contract is checked. The lenders are interested in a future cash flow which is certain, achieved by contractual agreements; this is in contrast to achieve an adaptive contract.

7 FINAL RESULT

The application of the functional responsibility allocation method in a DBFM contract implies an increasing responsibility and control mechanism for the public party during the maintenance phase, see figure 3. By this mechanism the public party can achieve their desired result. Besides enforcing the contract, the public party becomes able to steer the maintenance strategy on the long term, with respect to performance and costs. In addition, this control mechanism requires some organisational changes and collaboration between the critical stakeholders. Every case study confirms that collaboration between the critical stakeholders is crucial in order to achieve an adequate functioning lock.

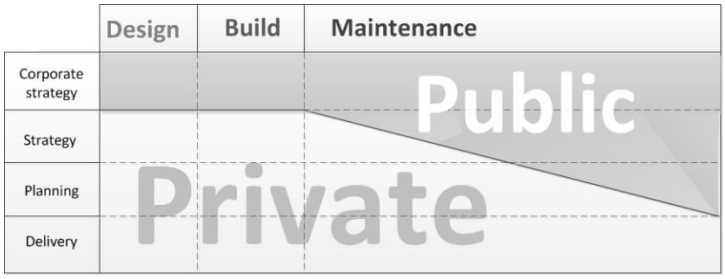

Figure 3 Allocation of responsibility by a balanced risk allocation

Postponing the decision of allocation until there is increased certainty of the probable occurrence of the risk is a control mechanism for the public party on the management strategy of the risk. This is in line with Williamson (1985, p. 20), who states: *Rather, therefore, than contemplate all conceivable bridge crossings in advance, which is a very ambitious undertaking, only actual bridge crossings choices areaddressed as events unfold.* To realise this method, an adequate management strategy for uncertainty during the maintenance phase is necessary. An appropriate strategy is discussed in the six stage model by (Schoenmaker, 2011, p. 364). This management strategy will provide first of all knowledge for the public party of the condition of the lock and the elements which can lead to non-functioning. Secondly, it provides control of an adequate response strategy seen from the performance versus costs. The findings in this paper are in line with that description.

Overall, the presented functional responsibility allocation method provides a sound basis for the discussion of the degree of outsourcing from a technical point of view, how to maintain control form the client's point of view and how to assure optimal performance versus costs during the life cycle of the asset.

7.1 *Recommendations*

In order to achieve a balanced risk and responsibility allocation, with respect to the performance and the costs, the following recommendations are done:

- The risk allocation conditions should be considered at first by the allocation of human

failure and external risks. In this way the risk allocation will be feasible, reasonable and fair.

- Early involvement of and collaboration between the critical stakeholders and lenders during the whole life cycle enhances the risk allocation support and provides the opportunity for the public party to keep being involved closely to the functioning of the object and to influence decisions in the maintenance strategy.
- Define an adaptive lump sum mechanism, in which the public party is able to control and steer the private party and the lenders have sufficient assurance of the repayment the loans they granted. The private party has the opportunity to optimise the maintenance strategy according the RBAM methodology.
- Sufficient technical knowledge, experience and skills of the public party is required to be able to test the provided reports and risk analysis made by the private party. In this way, the current condition of the lock can be assessed and an appropriate decision making regarding life cycle costs optimisation can be reached. In other words, the public party has to be *knowledgeable*.

The first two recommendations are discussed in previous research: the recommendation related to the allocation of external risk is discussed for project risks. The early involvement of all dependent stakeholders in order to achieve the desired result is part of the network approach, which is related to process management (Bruijn, Heuvelhof, & Veld, 2010). The last recommendation is in line with Schoenmaker (2011), in which he states that the client (public party) should not only be informed but also knowledgeable.

7.2 *Further research*

Based on the earlier discussed limitations of this research, the following topics require further research:

- The quantification of the classification of the repair time and frequency distribution, in such a way that the different kind of failure modes with their related repair time are taken into account.
- The influence of the non-selected parties of the procurement phase and other private parties that did not enter the procurement process.
- The achievement of financial support of the lenders in an adaptive long-term maintenance contract.

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