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DOI
10.1504/IJSEAM.2013.060469

Publication date
2013

Document Version
Accepted author manuscript

Published in
International Journal of Strategic Engineering Asset Management

Citation (APA)
Volker, L., Ligtvoet, A., van den Boomen, M., Wessels, P., van der Lei, T., & Herder, P. (2013). Asset management maturity in public infrastructure: the case of Rijkswaterstaat. *International Journal of Strategic Engineering Asset Management*, *1*(4), 439-453. https://doi.org/10.1504/IJSEAM.2013.060469

Forthcoming in the International Journal of Strategic Asset Management Engineering (end of 2013)

Asset Management Maturity in Public Infrastructure: the case of Rijkswaterstaat

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Abstract

In times of restructuring governmental policies and resources, the need for strategic asset management is growing. Maturity models offer organisations a structure to assist them in improving their asset management performance. We present the results of a repeated maturity measurement based on the Infrastructure Management Maturity Matrix (IM³) in Rijkswaterstaat, a Dutch public infrastructure organisation. The IM³ distinguishes five maturity levels from ad hoc to optimised, and seven asset management dimensions: information management, internal coordination, external coordination, market approach, risk management, processes & roles, and culture & leadership. The results show significant progress on all dimensions, and continued learning and widespread awareness of asset management in the organisation. In the discussion we reflect on the findings and possible future developments for the organisation. We also discuss the potential impact of infrastructure maturity models for the professionalization of other asset intensive organisations.

Keywords
organisational growth; maturity model; road infrastructure; asset management maturity; Rijkswaterstaat; strategic asset management; public sector; quality assessment.

1. Introduction

Many public infrastructures in Europe, like roads, bridges, dams and electricity lines, were built just after World War II, which means that nowadays they require a considerable amount of maintenance. In order to keep governmental expenditures at bay, governments have to rethink their market approach (Schoenmaker, 2011). Executive public organisations such as the highway agencies and energy providers need to develop, use and control new management principles to deal with contractual and financial changes (Schraven et al., 2011). The field of asset management provides them with new perspectives on the planning and execution of large maintenance tasks. They are eager to learn from others about their asset management strategies (van der Lei et al., 2011).

Asset management is a systemic and systematic approach to building, maintaining, and decommissioning physical assets (British Standards Institute, 2004). Maximising value and minimising risks are important drivers for optimising an asset portfolio (Moon et al., 2009), requiring intensive collaboration between professionals from different departments within an organisation (Campbell et al., 2010). Understanding the whole organisation and the relations between different asset management departments can help an organisation grow towards more successful operations.

Repeated measurements of the degree to which organisations have implemented asset management principles can support organisations in identifying their strengths and weaknesses in relation to their intended goals. This enables organisations not only to find out what to do, but also how to operate more efficiently. It can support organisations in linking their strategic processes with processes on a tactical and operational level, and therefore connects the asset owner (e.g. the national government), with the asset manager (e.g. the national highway agency), the service providers (e.g. a contractor or professional service firms) and the asset users (e.g. the car owner).

In general, the initial phases of asset management implementation focus on “sticking to rules”: developing standards, processes and concepts (Campbell, Jardine and Mcglynn 2010). Later, critical evaluation, feedback, integration and collaboration are important issues that come into play when organisations are more experienced with asset management. To assist in understanding to what extent asset management processes are implemented, so-called “maturity models” can be used (Judgev and Thomas, 2002).

In this paper we first introduce the Infrastructure Management Maturity Matrix (IM³), which can be used to measure the maturity level of an asset management organisation. We then present the approach of two maturity checks with IM³ performed in 2011 and 2012 at Rijkswaterstaat (RWS), the Dutch National Highway Agency (section 3). The results in section 4 show the effects of the measures that were taken within RWS during this period. We reflect on the findings and possible future developments for RWS and discuss the potential impact of infrastructure maturity models for the professionalization of public infrastructure organisations in general (sections 5 and 6).

2. Infrastructure Management Maturity Matrix (IM³)

The first capability maturity model (CMM) was developed by the Carnegie Mellon University (Paulk et al., 1993). It was used to assess the ability of software contractors working for the US Department of Defence in handling complex software projects. The capability maturity model has evolved from an appraisal method for software processes to other areas, such as (risk management in) water utilities , railroads (Macgillivray et al., 2007a, Busby, 2006), production firms (Ren and Yeo, 2004, Veldman and Klingenberg, 2009), and the offshore industry (Williams et al., 2003, Parkes et al., 2012). Also specifically in asset management several maturity models have been developed (Feunekes et al., 2011,

Laue et al., 2012, Winter and Fabry, 2012). Maturity models can be viewed as a set of structured guidelines that describe how different domains or expert fields of an organisation are able to contribute to a set of predetermined organisational outcomes (Volker et al., 2011).

As Malano et al. (1999) indicate, asset management includes the full range of asset planning and creation strategies, operation and maintenance, performance monitoring, accounting and economics, and audit and renewal analysis. Therefore, system-level performance measures, models, and interoperable databases should be used by asset groups to make evidence-based decisions. Based on the focal points of the implementation strategy for asset management of Rijkswaterstaat (van der Velde et al., 2010, van der Velde et al., 2012), we included seven asset management dimensions in our Infrastructure Management Maturity Matrix (IM^3):information management, internal coordination, external coordination, market approach, risk management, processes & roles, and culture & leadership. Each of these dimensions are ranked according to five maturity levels (ad hoc, repeatable, standard, managed, optimised), similar to (Paulk et al., 1993) and the examples described in Parkes et al. (2012) (see table 1).

Table 1. Infrastructure Management Maturity Matrix maturity levels (Williams et al., 2003)

Level	**Description**
1 Ad hoc	The organisation has limited experience and is at a learning and development stage.
2 Repeatable	The organisation can repeat what it has done before, but not necessarily define what it does.
3 Standard	The organisation can say what it does and how it goes about it.
4 Managed	The organisation can control what it does in the way of processes. It specifies requirements and ensures that these are met through feedback.
5 Optimised	The organisation is "best practice," capable of learning and adapting itself. It not only uses experience to correct any problems but also uses experience to change the way it operates.

Compared to other asset management maturity models, such as Winter and Fabry (2012) and Feunekes et al. (2011) the IM^3 has a stronger focus on organisational communication reflected in the columns internal and external communication, while also assessing the value and use of technical systems used for asset management activities. Furthermore, the market approach dimension was specifically added because of the high importance of the public procurement and contracting of public infrastructure. In the matrix all maturity levels are described briefly per asset management dimension. The following section includes a more detailed description of each dimension of the IM^3.

Information Management refers to sound registration of data as a basic pillar of asset management. Complete, accurate and valid data on assets and processes, stored in adequate data systems are vital for measuring and comparing network performances, agreements on service levels and budget allocation. Maturity in information management ranges from distributed and static information and data storage until fully integrated dynamic and reliable data access as part of (risk) decision processes.

At the lowest level of the *Internal Coordination* dimension we distinguish horizontal coordination within one regional division for the planning and execution of operational activities in one regional area. On the highest level we value horizontal coordination between the national agency and regional divisions in the process of system planning and budget allocation. Divisions jointly take an active role in shaping the national budget criteria and the overall system planning.

The *External Coordination* dimension measures the extent of optimising the system planning, operational planning and execution of works with third parties and the extent of communication with stakeholders. At the lowest level the asset manager informs third parties and the public about the execution of works. At the highest level the asset manager and third parties have a joint tactical system planning, operational planning and implementation in which stakeholders are involved in an early stage.

Market approach is about involving knowledge from the market and allowing service providers to be in control over parts of the network . At the lowest level, we see traditional input-based contracts on a small scale. At the highest level, contracts are performance-based and cover networks instead of asset groups. Knowledge of the market is used at the whole range of system planning, design & engineering, operational planning and execution of works.

The dimension of *Risk Management* refers to the implementation of risk based methodologies for operation, maintenance and asset system management. Good risk management requires a set of predefined risk criteria and uniform methodologies for risk assessment. Risk registers of relevant assets and asset systems support the systematic selection and prioritisation of risk control measures. Good risk management on all levels is a prerequisite for effective budget allocation.

The *Processes and Roles* dimension measures the integration of the asset management system into the quality management system, job descriptions and human resources management. At the lowest level people are slightly aware of different asset management roles. At the highest level asset management is fully integrated in the organisational structure, with systematic assessments and external auditing for continuous improvement.

The area of *Culture and Leadership* refers to the collective programming employees' minds (Hofstede, 1998), which is required for uniform asset management practices. The stronger the leadership on asset management and the stronger the embedding of asset management processes, the more durable the asset management 'way of thinking' is. The extent of both culture and leadership is measured by how much people are aware of asset management, to what extend they have a positive attitude towards the changes and if people are willing to learn new methodologies and attend training.

3. Research methods and case situation

This research is based on a case study of the Dutch National Highway Agency Rijkswaterstaat. Rijkswaterstaat (RWS) operates and maintains the Dutch road network, a number of primary dikes and waterways on behalf of the Ministry of Infrastructure and the Environment. Over the years, the maintenance process has been improved within Rijkswaterstaat. In the beginning (1950's and before) maintenance was mainly based on fixing after failing. Later, the need for efficient maintenance increased and turned into maintenance management in the 1980's. The next step was the initialisation of an asset management implementation project. Since 2010, uniform standards have been developed and implemented at a national level, in close cooperation with the regional divisions (van der Velde et al., 2012). The RWS asset management approach consists of five pillars: portfolio data management, long term maintenance planning based on risk management, the use of key performance indicators, a structured market approach, and life cycle costing (van der Velde et al., 2010).

A case study is an increasingly popular research method for complex organisational and business processes in construction,. Case studies typically answer research questions that address 'how' and 'why' particularly well in empirically unexplored research areas and field work (Flyvbjerg, 2004, Edmondson and McManus, 2007). The systematic approach of analysing multiple data sources and

critical reflection among the participants enable a cross-examination (triangulation) of the data, making generalisation within the case context possible (Sameedha Mahadkar, 2012, Stake, 1995)).

We performed two maturity checks within the same organisation, one in 2011 and one in 2012, with mainly the same respondents. From the perspective of shared responsibility and implementation from floor to board room, we interviewed people from different levels in the organisation. For each department we spoke with two operational employees (data managers and team leaders) and two employees at managerial level (directors and strategic advisors) who were selected by the case organisation for their central positions. The interviews took 1-1.5 hours and were conducted by two interviewers, one from the university and one consultant. During the interviews notes were taken, that were incorporated in an interview report. The interview reports were sent to the interviewees for verification and detailed completion. In order to increase the validity of the data, all interviews were taken in a short period of time (approximately 8 weeks).

The interviews were conducted using the IM^3 structure as described in the previous section, adopted to the implementation strategy for asset management of Rijkswaterstaat (van der Velde et al., 2012). Each interviewee was asked per dimension how he or she would assess their own department on a scale from ad hoc to optimised. The interviewees were explicitly asked to mention practical examples to support their judgement on the estimated position in the IM^3 matrix by clear and concrete arguments. This strongly supported clarification of the assessment method and did justice to the complexity of certain processes and situations (Williams et al., 2003). In 2011 ten regional divisions of RWS were interviewed, resulting in 20 interviews. In 2012, these same ten regional divisions were interviewed, completed with four national departments that played a key role in the implementation process, resulting in 24 interviews in total. Since the maturity level had not been measured at the initial start of the implementation process, the level of 2011 was considered as the base line for the results in later years.

The results of the interviews were compared between departments, between interviews, and between the different dimensions to find differences and commonalities. Based on the results of the interviews and the documents that were available on the strategic asset management plans and activities of the organisation, the researchers discussed the findings and determined a general 'asset management maturity level' for the organisation in that specific time frame. These assessments were presented to the project sponsor RWS for a final validation. In both years a few minor details were adjusted based on these feedback activities.

4. Results

In this section we describe the 2011 baseline and 2012 progress on each of the seven axes of the Infrastructure Management Maturity Matrix. Then we reflect on the progress of RWS in implementing asset management strategies within their organisation.

Information Management

In 2011 we saw that the regional divisions had made good progress on the systematic registration of static object data for most relevant asset groups; they indicated that 90% to 95% of the quantitative data was covered. However, the systematic and accurate registration of dynamic data like the maintenance condition of assets, still lagged behind. The knowledge on asset condition was available within the regional departments but was not yet registered and stored uniformly. This hampered comparison between regional divisions and the process of budget allocation. The overall score on information management in 2011 was therefore 'repeatable'.

In 2012 significant improvement has been made on the registration of dynamic data. Static and dynamic data of relevant asset groups were registered systematically according to one standard. The completeness of the registration of dynamic data for relevant asset groups on a managerial level was now estimated at 75% to 80%. Data on performances of assets was in most cases directly available, but the validity of the dynamic data still requires attention in order to generate reliable performance indicators on a national level. The progress on the maturity matrix was judged as ‘standard’ with examples above and below. The methodologies and standards for optimised information management exist but full implementation would require additional effort and a substantial redesign of the IT architecture.

Internal Coordination

In 2011 the coordination and cooperation between regional divisions was quite common at operational level. This was shown, for example, in collective procurement and execution of works. Allocated budgets shaped the boundary constraints for the operational activities. Unforeseen budget problems were solved within the regional divisions, and more or less communicated with the national agency. There were no signs of active feedback from operational experiences with respect to the overall system planning and national budget allocation criteria. The maturity level was therefore valued at ‘standard’.

In 2012 progress was made on the coordination between the divisions, primarily through the coordinating department at a national level, supported by an integrated decision making system called RUPS. Formats and information systems were developed to program activities for the coming years. Operational experiences were used to improve the tactical system planning and budget allocation process. The maturity level was scored at the bottom of ‘managed’ which meant that processes and standards were adequate and practiced, but not yet fully implemented and optimised. Optimisation would be achieved when the current operational feedback is transformed into more dynamic and integrated processes within the whole organisation.

External Coordination

In 2011 the operational planning and execution of works with third parties, like utilities and local governments, was already considered optimised by most interviewees. The operational planning and activities were generally communicated in cooperation to the public. The operational planning was matched to public and other relevant stakeholders’ interests to prevent nuisance as much as possible. There was, however, no joint system planning with third parties yet. Therefore the maturity level was scored at ‘managed’.

Regarding external coordination some progress was measured in 2012, leading to a maturity level in the highest ranks of ‘managed’. RWS still did most of the programming by itself, but in all projects systematic coordination took place with the other infra-providers and asset users. As substantial differences exist in the planning horizon of the other infrastructure providers, it is questionable whether further optimisation and joint planning is desirable and/or realistic.

Market Approach

In 2011 the market was mainly involved in carrying out prescribed activities on the level of asset groups and, in some cases, on the network level. Internal developments towards more performance based contracting took place but were not matured yet. Examples of integrated contractual agreement,s such as Design Build Finance Maintain contracts, existed but these were exception rather than standard procedure. Knowledge of the market could have been exploited much more, both before and after contracting. Therefore the maturity level was valued at ‘repeatable’.

In 2012 we noticed that the developments towards performance based contracting had progressed. Most of the former activity based maintenance contracts were transposed into performance based maintenance contracts. The concept of performance based contracting was understood reasonably well by the regional divisions and contract types were planned to be continued with minor adjustments. Therefore the score at the IM^3 progressed towards the 'standard' level, with some examples of initiatives on a managed level. Future growth can be found in increased early market involvement in the design and planning phase. This could positively affect the early use and benefit of innovations and life cycle costing, but also decrease the inflexibility of financial means.

Risk Management

In 2011 most regional divisions had some kind of risk register for the most relevant assets. However, risk criteria and methodologies within and between regional divisions were not uniform which made comparison of risks difficult. At national level a start had been made for a generic risk-standard (RAMS-standard: Risk, Availability, Maintainability, Safety). Therefore the level on the Infrastructure Maturity Matrix was set at 'repeatable to standard'.

In 2012 the risk management level was valued at 'standard'. This indicated that a uniform set of risk and performance criteria were applied to most of the objects and critical network nodes, supported by a special risk management system. This greatly supported the national budget allocation process. Also Failure Mode Effect & Criticality Analyses (FMECA's) had been carried out for the most relevant asset groups. This resulted into sound risk registers and a systematic prioritisation of risk control measures. Yet, a lot of work still needs to be done for full implementation of risk management within the organisation.

Processes and roles

In 2011 the regional divisions had distinguished different asset management roles. However, these were not linked to specific functions and job descriptions. Asset management was carried out implicitly rather than explicitly. Respondents reckoned the need for more explicit role descriptions and pointed at a national program being in progress. The maturity level was scaled at 'repeatable'.

In 2012 most of the regional divisions had uniform job descriptions that were linked with specific asset management roles. People were assigned to the new functions, but these changes were not always made official within the organisational structure. Some employees tend to fall back on old habits easily, so there was still a discrepancy between what is on paper and the operational way of working. The maturity level was set 'between repeatable and standard'. Further growth could be found in continuous improvement through internal audits and function evaluations.

Culture and Leadership

In 2011 we noticed that knowledge on asset management was available to only a limited number of ambassadors in the regional divisions. Asset management had not reached down to the work floor nor the board room yet. Some asset management training was available, but not everybody was aware of the existence of this training. The maturity level was valued at 'repeatable'.

In 2012 we concluded that asset management had reached both the work floor and the board room. In general the asset management principles had been positively received and people generally supported the overall asset management objectives as being sound and logical. In fact, it helped them to explain what funds were required to deliver a certain performance and risk level. An asset management training program is now broadly available and specific courses are provided on reliability centred

maintenance, risk management, systems engineering and life cycle costing. The IM^3 level of culture and leadership was set at the bottom of 'standard'. Although organisational change and trainings were well received, these processes take time to anchor.

Overall progress

The results of both maturity measurements have led to an overview of the implementation of strategic asset management for Rijkswaterstaat. The levels of each dimension are shown in the following radar chart (see Figure 1). Generally, asset management has matured in the period 2011-2012. The largest progress in this period was measured in Information Management and Market Approach. Further analysis has shown that the management of RWS initially focused on developing precisely those dimensions of asset management (Van Der Velde, Hooimeijer and Meima 2010): improve portfolio data on a managerial level, contracting long-term maintenance planning, monitoring on key performance indicators, and optimising the market approach. Both measurements also revealed a challenge in the further growth of the organisation: maturity levels in the areas of Processes & Roles and Culture & Leadership are lagging behind. This is possibly related by a substantial decrease of governmental funds within the national government and a drastic reorganisation process that was announced at the end of 2011.

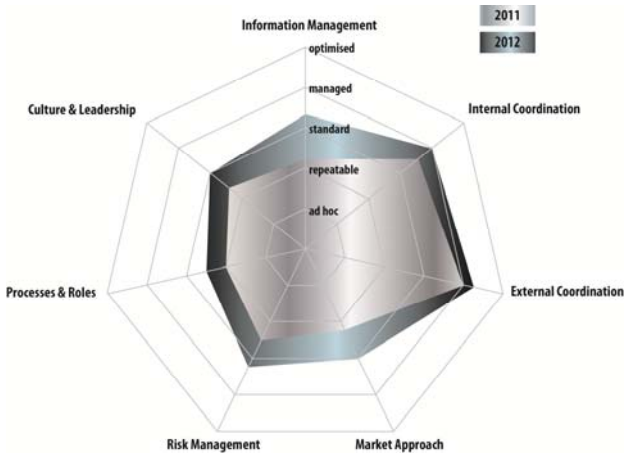

Figure 2: Results of the 2011 and 2012 measurements with the Infrastructure Management Maturity Matrix at Rijkswaterstaat

The relatively low number of interviews do not allow for further statistical analysis on differences between the groups of interviewees. However, in this sample managers appeared to be slightly more positive on the development of asset management compared to asset managers and operational personnel. This could be addressed to the overall perspective from the managers, compared to the detailed and day-to-day focus of the operators and information managers. We also found little differences in the estimated maturity levels between different regional divisions. This indicates a centralised organisational culture, also reflected in the maturity levels that were not extremely far apart. In the interviews many collaborative initiatives and joint projects were mentioned, pointing out that regional divisions were not afraid to learn from each other. These national meetings were organised on a regular basis and the divisions were aware of their weaknesses and strengths. An example of collaborative learning is the fact that the management of dry infrastructure (roads, bridges, etc.) and wet infrastructure (floodgates, locks, etc.) is increasingly integrated. Where a number of years ago, dry and wet infrastructure departments lived separate lives, nowadays dry and wet infrastructure is combined in one department, using similar structures and systems.

5. Discussion

The results of this case study give reason to further develop the Infrastructure Management Maturity Matrix. The IM^3 provides a structure to measure the maturity level of asset intensive organisations on seven dimensions. Yet, a few methodological reflections need to be made.

Firstly, we noticed that the perception of the levels within this matrix structure is subject to change. Not only the perception of the interviewees changed as their awareness of the concepts increased, but the context in which the levels were defined also altered. The optimised level of the desired market approach is, for example, defined as 'being a professional commissioner, directing and inspecting the network, while leaving most of the maintenance activities to the service providers'. In combination with the recent trends towards public-private partnerships, this led to a preference of long term integrated performance-based contracts. The experiences in the past few years have learned that long term contracts are not suitable for every type of asset activity as some require specific expertise of responsibilities (Rufín and Rivera-Santos, 2012). It also requires a different type of relational governance. Furthermore, experiences of other (international) asset managers showed that especially in time of limited budgets, the financial inflexibility of long term agreements can be bothersome for the executive organisation (National Audit Office, 2011). These combined developments caused a change in the perception of the need for further outsourcing of the activities to the service providers, and this also for the desired market approach. Furthermore, the influence of role, background, age, and experience on the perception of maturity levels is definitely an interesting area for further research.

Secondly, we noticed that respondents in some cases have difficulty interpreting the different dimensions and maturity levels in a holistic way. Regarding external communication the respondents distinguish, for example, between design and construction activities and general operation and maintenance. Hence, they tend to score these aspects separately while they are part of the same dimension. The same holds for the elements of processes and roles. In these cases the researchers assessed the overall maturity level based on the descriptions of the respondents as the tool is meant for learning and not for judging. We therefore think it is crucial to determine the maturity levels collaboratively (researchers and interviewees), taking enough time to discuss the meaning behind the levels. This also enables a broader interpretation of the scores than single numbers (MacGillivray et al., 2007b). In our interviews practical examples and discussions appeared to be the key for realistic estimations of maturity levels and interpretation of the results on a general level. This means that the structure as developed is not suitable for (online) surveys.

Thirdly, we would like to draw some attention to the limits of the maturity model. On a generic level the model prescribes the know-what of an organisation for the different levels (Judgev and Thomas, 2002) . It supports an organisation in improving its processes according to a vision on organisational maturity. In previous research we have found that Dutch organisations that have an active attitude towards the standardisation of asset management purposes, score higher regarding asset management maturity (van der Lei et al., 2011). However, one should be careful with a too strong focus on structures and know-what alone. The long term challenge of a public infrastructure organisation is to make sure its asset management system is sufficient for generations to come. As (Judgev and Thomas, 2002) argue, organisations that are sustainable, are also capable of sustaining the know-how of an organisation. This requires that an organisation continuously investigates and develops its perspective on asset management and the tools to support the implementation of these processes. A dynamic approach of maturity models is therefore needed.

Finally, we noticed that the respondents were very interested in the progress of their own organisation. During our new measurement in 2012 the matrix was recognised by many respondents and several interviewees had prepared themselves by reading the report of the previous measurement. In some cases the different levels and dimensions even provided strategic goals for the future. It would, therefore, be very interesting to compare these goals and the results of this case to professionalization processes in other asset intensive sectors. As our matrix is in line with current asset management standards, we expect that our IM^3 matrix can be applied with minor adjustments for other infrastructure companies pursuing asset management strategies. Several electricity grid operators, water companies and other transport agencies in the Netherlands have already shown interest. In this way continued learning in strategic asset management will not only take place within the organisation but also between them.

6. Conclusion

Since the introduction of strategic asset management in 2008 within Rijkswaterstaat organisation, the concept has developed significantly. The baseline measurement with the IM^3 in 2011 showed that asset management principles were present, but practiced only implicitly within the regional divisions. The major bottleneck for RWS was that each division had its own approach to asset utilisation and optimisation strategies. As a result, differences in data definitions existed and data was mainly stored in local data bases. Uniform standards for data management and performance indicators were being developed on a national level in close cooperation with the regional divisions.

We have found a considerable learning curve among the divisions and its employees. While in 2011 discussions were mainly focused on definitions of data management, the majority of the discussions in 2012 dealt with qualitative data aspects. Most of the quantitative data was included in the system and people started to realise the benefits of reliable and integrated data management systems. The 2012 measurements showed that the service level agreements with the regional divisions for regular maintenance activities were successful. A set of predefined risk management criteria and risk based methodologies were widely used to prioritise budget proposals.

The results indicate that the new roles and processes have started to take shape but have not yet been fully enrolled within the asset organisation. In public organisations politics play an important role in allocating budgets for managing the assets. Sometimes day-to-day issues appear to be more important than long term strategic goals. On the other hand, public organisations operate in a historical context with substantial stakeholder responsibility, reflected in bureaucratic structures. This means that further implementation of asset management processes could take time, especially since Rijkswaterstaat is forced to further reduce its manpower in the coming years.

Most of the interviewees were positive about further implementation of the asset management strategy. A positive attitude towards change and improvement fosters discussion and organisational growth. Achievements should be celebrated, especially in a time of limited budgets. Yet, a critical voice underlines the need for substantial investments in, for example, ICT infrastructure, knowledge management and training. The first priority for Rijkswaterstaat could be to translate the external stakeholder needs and life cycle asset performances into functional asset systems (networks) and asset objectives. This would require increased budget flexibility and improved uniformity of risk management processes. The databases and uniform data systems also need to be kept updated and to be connected further. Furthermore, the employees that were not involved in asset management before, need to learn and understand how to proactively use the asset management principles. This requires an extensive educational program, regular performance measurement and external audits. We believe the

Infrastructure Management Maturity Matrix provides an excellent basis to monitor these kinds of developments.

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Acknowledgements

This paper is a revised and expanded version of a paper entitled *Continued Learning in Asset Management for the Dutch Transport Network* presented at the Third International Engineering Systems Symposium CESUN 2012, Delft University of Technology, Delft, the Netherlands, 18-20 June 2012.

We would like to thank the reviewers for the valuable comments on capability models literature. We also acknowledge the support of Rijkswaterstaat in opening up their organisation and financially supporting this research.