Effectiveness of infrastructure asset management at public agencies

Andreas Hartmann,
University of Twente, The Netherlands (email: a.hartmann@utwente.nl)
Geert Dewulf,
University of Twente, The Netherlands (email: g.p.m.r.dewulf@utwente.nl)

Abstract

For many public agencies, maintenance, renovation and reconstruction work (MR&R) represents one of the budgetary items with the largest annual expenditures. In order to spend the resources more effectively, public agencies need to implement infrastructure asset management (IAM). Using a case study approach, we investigated the effectiveness of IAM of a provincial agency in the Netherlands. One of our main findings is that the agency faces difficulties in formulating infrastructure objectives which are linked with overall goals of the agency and commonly shared within the agency. Without such objectives, it is difficult to assess the performance and condition of the infrastructure assets and judge the effect of intervention measures. For effective IAM the continuous optimization and alignment of infrastructure objectives, interventions and situation is essential.

Keywords: infrastructure asset management, public agency, case study

1. Introduction

The performance of the road networks strongly affects the distribution of resources and goods, the accessibility and economic development of regions, the mobility of the citizen and the environmental consequences of road traffic. At the same time, public agencies continually allocate large budgets for the maintenance, renovation and reconstruction (MR&R) of the road network and its components (e.g. pavements, bridges, culverts, signs) to guarantee a performance level of the entire network that contributes to the economic strength and social viability of regions. Cost-effective planning and execution of MR&R activities and projects represent essential tasks of public agencies, and therefore public agencies need to implement effective infrastructure asset management [1].

Infrastructure asset management (IAM) involves activities and decisions that reduce the expenditures over the life-cycle of an infrastructure asset while extending the period for which the asset provides its required performance [2], [3]. The decision context of IAM is characterized by three main aspects which have to be optimized and aligned:
infrastructure objectives, infrastructure interventions (MR&R), and the infrastructure situation. Public agencies implement effective IAM if:

- Infrastructure objectives are used to evaluate the situation of infrastructure assets
- Infrastructure objectives are translated into infrastructure interventions
- Infrastructure interventions take the current and future situation of infrastructure assets into account
- Infrastructure interventions result in an infrastructure situation which is conform to the infrastructure objectives
- Infrastructure objectives are evaluated based on the infrastructure interventions applied and unexpected changes of the infrastructure situation

Feedback regarding the infrastructure intervention and situation with respect to infrastructure objectives is particularly essential for the effectiveness of IAM.

This paper reports on a research project that aimed at elucidating the effectiveness of IAM at public agencies. It presents and discusses the results of case study on IAM at a provincial agency in the Netherlands and particularly shows how this agency addresses and aligns infrastructure objectives, interventions and the situation at hand.

2. Case Study

In our research, we used a case study approach to investigate the effectiveness of IAM at public agencies. Case studies are particularly appropriate if the holistic nature of real-world contexts and largely unexplored phenomena are addressed [4]. Since IAM involves three main interrelated aspects and is embedded in a specific organizational and environmental context, cases are sources of rich data which provide detailed insights into the extent to which public agencies implement an effective IAM. The case this paper reports on is a provincial agency in the Netherlands which is responsible for the management of 764 km of roads and more than 200 civil engineering objects. Interviews with employees from different organizational levels and units were conducted. In addition, policy documents, maintenance contracts, inspection reports, and planning documents were analyzed. In the following we will describe and discuss how the province addresses and interrelates the three aspects of infrastructure management.

2.1 Infrastructure objectives

Infrastructure objectives determine the criteria for the evaluation of the infrastructure intervention and situation and contribute to the overall objectives of public agencies with regard to mobility and transportation. The provincial agency under investigation
formulated an overarching policy for traffic and transport which set the framework for infrastructure objectives. An overall vision was formulated and several instruments were given through which the vision was to be put into practice. These instruments included MR&R.

Although in the policy the direction for infrastructure management is given, infrastructure objectives are not directly specified. With the policy for maintenance quality, the provincial agency indirectly defines infrastructure objectives for the daily maintenance. The agency applies a calculation method for maintenance costs compiled by a nationwide institution for infrastructure. The starting points of this method are four quality levels for infrastructure objects such as roads and waterways: optimal, good, average, fair. The quality level average is defined as what is prevalent in the Netherlands. The quality levels are linked with 6 infrastructure objectives: safety, accessibility, convenience, appearance, quality of life, and environment. By choosing a specific quality level, a statement is made about the objectives to be achieved. The relationship between quality level and infrastructure objective for roads is depicted in Table 1.

<table>
<thead>
<tr>
<th>Quality level</th>
<th>Optimal</th>
<th>Good</th>
<th>Average</th>
<th>Fair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Minimal risk of accidents</td>
<td>Low risk of accidents</td>
<td>Low risk of accidents</td>
<td>Low risk of accidents</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Accessibility not at risk</td>
<td>Accessibility not at risk</td>
<td>Accessibility partly restricted</td>
<td>Accessibility restricted</td>
</tr>
<tr>
<td>Convenience</td>
<td>Very convenient</td>
<td>Convenient</td>
<td>Convenient</td>
<td>Somewhat convenient</td>
</tr>
<tr>
<td>Appearance</td>
<td>Very good appearance</td>
<td>Good appearance</td>
<td>Sufficient appearance</td>
<td>Moderate appearance</td>
</tr>
<tr>
<td>Quality of life</td>
<td>Quality of life not at risk</td>
<td>Quality of life not at risk</td>
<td>Quality of life partly at risk</td>
<td>Quality of life partly at risk</td>
</tr>
<tr>
<td>Environment</td>
<td>Environmental danger as low as possible</td>
<td>Environmental danger lower than law</td>
<td>Environmental danger according to law</td>
<td>Environmental danger according to law</td>
</tr>
</tbody>
</table>

Table 1. Quality level and infrastructure objectives for roads.

In its policy for maintenance quality, the provincial agency formulated a quality vision for roads which aims at an average quality level for all road maintenance work except for winter maintenance (good quality). This quality vision is further specified in the policy for daily road maintenance which translates the infrastructure objectives into sub-objectives, provides indicators and maintenance norms to achieve these sub-objectives, and calculates maintenance cost based on the norms. However, the policy does not include renovation and reconstruction work, nor does it include a maintenance policy for civil engineering objects and waterways.

Besides incompleteness, the policy for maintenance quality and the policy for road maintenance are not consistent and concerted. Since the provincial agency uses a
general method for formulating infrastructure objectives, both policies are not directly based on the overall policy for traffic and transport. Some of the infrastructure objectives such as safety and accessibility are not deduced from the traffic and transport policy, although the policy gives guidance for these objectives. For example, in the traffic and transport policy the safety objective is stated as having “not more than 32 traffic deaths and not more than 300 injured who need a hospital”, whereas the safety objective in the maintenance policy is formulated as “low risk of accidents”. For other objectives such as appearance and quality of life it remains completely unclear which relationship they have to the overall mobility policy of the provincial agency. The same holds true for the infrastructure objectives to be achieved (Table 1), which are also taken over from the general method. Most striking is the way of determining the objectives. First, a quality level is chosen which leads to a specific objective. In other words, the means define the objectives. Since the objectives of the general method are non-specific, the provincial agency couched additional sub-objectives and indicators to allow for measuring and monitoring. For example, the general safety objective “low risk of accidents” is transformed into the sub-objective “no accidents caused by pending maintenance”, and road roughness and levelness are chosen as indicators. However, given the definition of safety – extent to which accidents are prevented – road roughness and levelness do not represent indicators but rather means to achieve the safety objective. The objective itself is measurable (no accidents) and does not need any indicators. There are also objectives which are not directly measurable such as a convenient infrastructure for which indicators are required to determine whether the objective is achieved. If for example convenience is defined as the extent to which road users experience the infrastructure as comfortable, the number of road user complaints may serve as indicator. The provincial agency, however, identified signage and drainage as indicator for convenience, which in fact are again means to ensure a certain level of convenience.

2.2 Infrastructure interventions

Infrastructure interventions aim at changing the situation (function and performance) of an infrastructure asset in such a way that formulated infrastructure objectives can be met. The provincial agency conducting this study distinguishes between three major types of intervention which are separated as to organization and to budget: daily maintenance, renovation and reconstruction. Daily maintenance includes short-term maintenance work (< 1 year), which can be both corrective and preventive. It primarily aims at maintaining the performance of the infrastructure asset and removing unsafe traffic situations which occur unexpectedly. Renovation also includes corrective or preventive activities but is planned and carried out in a medium-term period (1 – 5 years) with the aim of maintaining or improving the performance of the infrastructure. For most civil engineering objects the annual budget is the basis for the work planning. If there are no unsafe situations expected, the budget which has remained stable over the years determines the amount of work to be done. The starting point for the annual
renovation planning of roads is the deterioration and based on that, the remaining lifetime of single road sections. By combining several sections, an attempt is made to find the technically and economically optimal renovation planning. The annual budget represents the major constraint in this regard. Reconstruction work has a long-term orientation (> 5 years) with again a corrective or preventive nature. Often the aim is to improve the performance or change the function of the infrastructure. The planning of reconstruction projects is a continuous process which often takes several years due to the major impact the project has on the infrastructure environment.

Although the three interventions suggest a logical delimitation, each intervention option is characterized by a process starting with the collection of information about the infrastructure situation, followed by the planning of the work to be done and the determination of the required budget. Each work process shows uncertainties which cause changes in the extent of work or the time planning. As a consequence, all three interventions show some overlap with each other. A clear separation of budgetary and organizational responsibility appears to be difficult. For example, the policy for daily road maintenance applies a long-term perspective through which actually renovation or reconstruction work is described.

2.3 Infrastructure situation

In order to apply an effective infrastructure management, a public agency needs to know the situation of the infrastructure. That includes the current and future technical condition and performance of the infrastructure, the public and economic value, the cost and risks. The situation determines the interventions that are required to attain the infrastructure objectives and is the starting point for evaluating the attainment of these objectives. The provincial agency uses different ways of measuring and monitoring the conditions of their infrastructure assets. Besides daily inspections through which unexpected occurrences are detected and kept in weekly reports, roads and civil engineering objects are annually inspected. Civil engineering objects are visually inspected, whereas for roads specific measuring methods and tools are available and used. For both roads and civil engineering objects the inspection data are stored in databases. The database for civil engineering objects only indirectly reveals the development of the infrastructure condition by listing the observations made during the visual inspections. The data of the road inspections on the other hand are used to calculate the remaining lifetime of road sections and to determine the moment when maintenance work is necessary. For this calculation the provincial agency can make use of specific deterioration models provided by the aforementioned nationwide institute for infrastructure. The calculation methods also allows for linking the condition development to the four quality levels (see Table 1). For civil engineering objects the quality is evaluated by employees and is based on their knowledge and experience. This knowledge also plays a role in assessing the uncertainties connected with the deterioration and performance development of infrastructure. For many, component
deterioration is an ongoing process which does not immediately lead to an unsafe situation. Although the provincial agency is conscious of possible political, social and technical changes and their impact on performance and condition of the infrastructure assets, a risk analysis of these factors is not conducted.

Since clearly defined quality levels for civil engineering objects and their components do not exist, the provincial agency cannot objectively state whether maintenance is deferred. Deferred maintenance is a judgment made by single employees. There are several deviating meanings and consequently discussions about the necessity, extent and time of maintenance. For roads quality levels are defined by the nationwide institute for infrastructure. Moreover, discussions arise about the kind of intervention activities to be applied. The quality levels can be achieved by different intervention means that have different consequences for future interventions and finally for the MR&R costs. For example, the safety of a road section can be attained by preserving means. Over the short-term such means are less expensive than more constructive interventions. Over the long-term they may have a stronger budgetary effect since they need to be applied more often. Furthermore, by choosing preserving, this means the actual damage is likely to remain, and it will become worse and require much more extensive and costly interventions. Without agreement on the quality levels and the time in which the required interventions are done, the extent to which maintenance is deferred is hard to determine.

2.4 Alignment of IAM aspects

Infrastructure objectives, interventions and the situation cannot be considered separately. For effective infrastructure asset management all three aspects need to be optimized and aligned to each other. For the provincial agency the relationship between the three aspects is not clear. Particularly the relationship between infrastructure objectives and the other two aspects is weak. The reason is that there are insufficiently formulated objectives for the management of infrastructure assets. Thus, an assessment of infrastructure condition and performance is hardly possible, and decisions on intervention options are difficult to support. For example, the budget for road renovations has been increased in the last years in order to cope with the accelerated deterioration. However, without a comprehensive set of infrastructure objectives the increased budget cannot be vindicated and the effect of its usage on road performance cannot be determined. It remains unclear what the current road performance is and which future quality level the province is striving for. Since there are no objectives defined, employees have different perceptions of whether maintenance is deferred and to which extent.

The policy for road maintenance is intended to translate infrastructure objectives into interventions for daily maintenance. The frequency of interventions to achieve a certain quality level is provided. Most of these frequencies, however, have a medium-term or
long-term perspective. That makes it difficult for employees monitoring and maintaining the infrastructure on a daily basis to implement the interventions. It becomes much more difficult without a clear picture of the current infrastructure situation.

Infrastructure objectives can change and can also alter the way of doing MR&R. For instance, there are hardly any discussions about the effects of an altered mobility policy on the intervention options. In addition, objectives can show conflicts with each other. For example, noise reducing asphalt has to be replaced more often than traditional asphalt with the consequence of much more traffic disturbance. Again, discussions about the prioritization of objectives are lacking. Discussions only take place if the reserved budget is seen to be insufficient.

To some extent, the relationship between infrastructure situation and intervention is clearly addressed. The reason is that many employees have been working for the provincial agency for a longer time. They have much knowledge and experiences about inspection, maintenance planning and intervention implementation. This knowledge and experience, which is mostly implicit, determines the employees' picture of what good maintenance is. Based on this picture, employees make decisions and choices. For example, although infrastructure objectives and their importance are not explicitly formulated, several criteria are used to prioritize MR&R work due to the restricted budget. Safety has the highest priority and MR&R work which resolves unsafe situations is carried out first. Moreover, employees try to combine MR&R work to minimize traffic disturbance. However, these prioritizations tend to be more implicitly assumed than explicitly determined.

3. Conclusions

Effective infrastructure asset management aligns infrastructure objectives, interventions and the situation. The case of a Dutch provincial public agency revealed that in particular, missing objectives for MR&R cause divergent and conflicting views within the agency on the position of MR&R and its consequences for the MR&R budget and provision. There is a missing link between the overall strategic objectives of the agency and the importance of MR&R to achieve these objectives. Moreover, the provincial agency faces difficulties to set these objectives in such a way that they are conclusive, measurable and linked with the overall mobility strategy. That can be traced back to the implicit knowledge and experience employees have on performance and the technical condition of the infrastructure assets. There is no common and explicitly shared vision on the quality of infrastructure and the consequences different quality levels have for infrastructure performance. We conclude that within road agencies, a common understanding needs to be developed on the road performance to be achieved, the technical conditions and the infrastructure interventions to ensure the desired performance. Furthermore, performance measurements systems need to be
installed which continually monitor the achievement of objectives and the impact of interventions measures.

References


