A Strategic Asset Management Framework for Improving Transport Infrastructure: Analysis for Belgian Land Transport Modes

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Abstract. In today’s society, infrastructure asset management is a priority for multiple policymakers as it is key to guarantee high-quality transport infrastructure. While the relative quality of transport infrastructure in a number of Western European countries is deteriorating, the volumes of freight and passengers, as well as the expected service levels of all modes of transport for citizens and businesses, are increasing sharply. In response, infrastructure asset managers have developed and integrated technical and management system innovations. While short-term cost and damage control is taken better care of, a long-term asset vision and strategic principles supporting a strong future transport infrastructure network are still largely missing in many EU countries. In this paper, we analyze the strategic infrastructure asset management (SIAM) for Belgian road transport, rail and inland waterways through a cross-case analysis. Our literature study identifies strategic asset management principles, potential barriers and solutions for transport infrastructure assets in general, as well as for the different transport modes in particular. Through in-depth interviews with Belgian top administrators, the principles and SIAM frameworks for different types of mainland infrastructure are analyzed. We find, based on the studied Belgian cases, that ‘one SIAM-model does not fit all’, and that a variety of models, adapted to transport modes and the regional context, could better suit the strategic goals of different policies.

1 Introduction

Infrastructure, in Europe in particular, is ageing and is reaching the end of its lifespan [1–3]. Many of these assets date from the 1950s until the 1970s as a result of the post-World War II Marshall plan and are desperately in need of new investments [2, 4]. Contrary to the aforementioned need, expenditure in the EU has remained stable in 2016, the year that it reached its lowest point in 20 years. This while expectations from users and stakeholders regarding quality, reliability, and service are continuously increasing [5–7]. Expectations of infrastructure remain unanswered as long as investments are not forthcoming [2]. This is also the case beyond the EU, on a global scale. A report from McKinsey Global Institute indicates a yearly investment need in transport, utility and telecom infrastructure of $3.7 trillion until 2035 to be able to support the global economy [8]. The Global Infrastructure Outlook’s report [9] extends the investment time range
until 2040 instead of 2035 with a necessary investment of $4.6 trillion by 2040. Global spending on infrastructure by 2040 is estimated at $3.8 trillion, which leads to a gap of $800 billion [9]. This gap is estimated at $93.4 billion by 2040 for European transport infrastructure assets, including ports, airports, roads and railway infrastructure [9]. Even though many EU-countries have recently taken steps to increase the infrastructure investments, cf. recent Eurostat figures, the huge gap between the current assets state and the service level demands in a competitive Europe will continue to exist or even sharpen again, if in the long run the assets are not managed strategically. Porter [10] defines infrastructure, in his “Diamond of national advantage” – a seminal framework to understand competitiveness of business clusters and regions, as one of the most salient factor conditions when determining and supporting regional competitiveness. Making sure infrastructure does not become a competitive disadvantage in times of crises or serious budgetary restrictions, requires tight control as well as a long-term plan and vision. Both are at the core of asset management objectives. Sound asset management matches user’s demands with infrastructure’s supplies by setting a strategic direction and supports decision-makers with taking the right decisions at the right time when executing this strategy. Principles and possible frameworks for good asset management are discussed in the next section, and when looking at the evolution of insights on this matter, the focus of management of long-life assets evolves from a technical approach to a strategic matter [11–13]. Yet, while (case-based) research contributions on the operational approach continue to grow, insights on what a strategic approach to transport infrastructure asset management should entail, are largely absent [14, 15]. This paper defines eight key factors for a sound SIAM for managing land transportation assets by public organizations and analyzes for three modes and three regions in Belgium how their SIAM can potentially be improved to ensure a better asset quality and service level in the long run.

2 Infrastructure Assets of a Region and Their Management

Infrastructure assets refer to assets with a physical rather than a financial nature. Uddin, Hudson and Haas [16] add the ‘public’ aspect and define them as “…all these combined facilities that provide essential public services of energy, transportation, roads, airports, … Infrastructure also provides the physical systems used to provide other services to the public through economic and social actions. These infrastructure facilities and services are provided by both public agencies and private enterprises.”. This paper researches the aspects related to public infrastructure for transport or with ‘transportation’ as main function, based on the research of Baldwin and Dixon [17]. Roads, inland waterways, railways, bridges and tunnels are particularly considered as these assets seem to have suffered heavily from underinvestment during the last decades and are still the main transport vectors in society today. According to the Global Infrastructure Hub [9], the greatest investment gap is supposed to be in road infrastructure, where the gap between spending following the current trends and investment needs will be around 31%. Policy-makers are therefore under pressure and consequently, it is important to advise them on their strategies in maintaining and if possible, improving these particular assets, beyond countering basic infrastructure concerns such as safety and availability.
Infrastructure Asset Management (IAM) may range from managing maintenance activities only in a narrow focus [18], to managing all activities related to the lifecycle [19]. The asset’s life cycle consists of the following activities: (1) needs assessment & goals identification, (2) infrastructure planning, (3) infrastructure design, (4) infrastructure construction, (5) infrastructure operations, (6) infrastructure monitoring and inspection, (7) infrastructure preservation and (8) end of life [20]. Within preservation, the following subsections can be distinguished: regular maintenance, rehabilitation, replacement and upgrade. This can range from a small-scale maintenance intervention to the replacement of the asset by a more sustainable option [16, 21]. The International Organization for Standardization [22] states that IAM can be seen as all the activities that create value from an asset. But, since the demand for infrastructure assets can be viewed as a derived demand for transport or movements, assets do not express value on themselves. They can contribute to the value-creation for its users by enabling them to travel more rapidly or easily [23]. Better road infrastructure for example can increase this contribution [23].

Many variations of IAM definitions and objectives exist, resulting in the fragmentation of the concept [24]. Definitions of IAM of roads are focusing mainly on cost-effectiveness, while the objectives for rail and inland navigation infrastructure are respectively safety and reliability and service and availability [20, 21, 25–28]. As a consequence of this variety, the management of infrastructure can be compared with the iron triangle in project management, consisting of time, performance and cost. An asset manager should always consider the trade-off between cost-effectiveness, safety and reliability and service and availability. Only one objective can be constrained, a second one needs to be optimized and a certain level of the third needs to be accepted. Based on the literature it can be stated that road IAM constrains cost-effectiveness and that inland navigation and rail IAM are constraining respectively service and availability and safety and reliability. The other strategies will be defined accordingly to the organization’s objectives. The different objectives may be rooted in current stakeholder expectations regarding a transport mode, and reflected through political priorities, but this is not the focus of our research and therefore this is taken as a basic assumption. The variance in objectives leads to the question if IAM principles and processes should be equal for each public body and each transport mode.

2.1 Developing a Strategic Infrastructure Asset Management (SIAM) Framework for Transport Infrastructure

Several frameworks have been developed to guide decision-makers with the process and implementation of IAM, mainly focusing on the technical side and optimization of IAM systems. Chen and Bai [29] analyzed 337 academic articles on optimization techniques for asset management and found that the number of articles on this subject only increased during the last years. Some do point at the lack of the strategic aspect and the connection with organizational objectives [14, 15], but few have addressed it from this lens. Some that have [12, 15, 22, 30–32], defined SIAM as “A strategic and systematic process of optimizing decision-making in resources allocation with the goal of achieving planned alignment of infrastructure asset with service demand throughout its lifecycle” by Too, Betts and Kumar [12]. After analyzing five main frameworks for
SIAM [12, 15, 30–32], eight key factors for a sound SIAM were defined: (1) the accountability of context factors’ influences on the government policy, (2) the translation of the policy into organizational objectives, (3) the possibility of non-asset solutions, (4) the development of transport mode specific goals, (5) the alignment between the government strategy and asset strategy, (6) the optimization of options, (7) the introduction of feedback loops and (8) organizational and knowledge management. First, to define a governmental policy responding to the needs of a country’s economy and society, context factors (for example user’s needs and environmental factors) need to be considered (1). Next, the defined policy should be translated into specific organizational strategic management objectives and a corresponding strategy needs to be developed (2). After that, in a stage of strategic planning, the gap between the objectives and the current supply needs to be analyzed, which can consequently be solved with asset or non-asset solutions (3). Including non-asset solutions in the SIAM framework is essential as it offers the possibility to solve existing problems without large asset interventions. Furthermore, different solutions must be translated into goals for each transport mode (4), and asset solutions consequently into asset management goals and plans on acquisition, operation, maintenance and disposal (5). The particular transport mode goals are included as silo-mentality forms one of the greatest issues in managing infrastructure at this moment [2]. The development of strategic goals for each mode can facilitate the collaboration between departments. Thereafter, the possible options need to be optimized based on the defined objectives as cost, time, risk and quality (6). Finally, feedback loops and a constant organizational and information management is required to ensure a continuous optimal service (7)(8).

Applying these factors as management principles when managing infrastructure can contribute to a better IAM and thus, to a better service and a more cost-effective policy. These factors should be included in each SIAM framework, regardless of the mode and the objectives handled by the organization. Considering the different objectives, the focus lies on the translation of organizational objectives into asset objectives and optimization of options. In these two principles, the objective chosen to be constrained should be well incorporated as it is the key aspect that needs to be considered when deciding on an investment or a range of investments.

3 Methodology, Case Selection and Data Collection

3.1 Cross-Case Study of Land Transport Modes Managed by Belgian Regional Administrations

To identify the current and desirable future practices of transport IAM in Belgium, a case study method is used. Schramm [33] argues that “the essence of a case study, the central tendency among all types of case study, is that it tries to illuminate a decision or a set of decisions: why they were taken, how they were implemented, and with what result”. In that way the reason and the history behind principles used in the organizations can be discovered. More in detail, the study opted for a multiple case method and investigates the IAM principles of land transport modes, rail, road and inland navigation, managed by Belgian federal and regional administrations. The goal is to give an as extensive as possible overview of the current and future desirable situation, without comparison to
other modes or countries. The literature review already suggested that different modes can have different objectives, and therefore also need different frameworks and principles. The characteristics of modes, regions and countries can be various which would make a comparison inappropriate. As different organizations and transport modes are included in this research, the exact research method can be called a holistic multiple case method [34].

Belgium was chosen as country to perform the case study. First, the researchers and research chair are based in Brussels, Belgium, which leads to an extensive network of public and private contacts. Next to that, a study by Meersman and Nazamzadeh [35] states that the network of roads, rail and ports are main indicators to drive the Belgian economy. But despite its importance, it is clear that Belgium needs help with their infrastructure management, especially in the case of transport infrastructure. Comparing 2008 with 2019, the position of Belgium in the Global Competitiveness Report for the road quality index decreased, this while The Netherlands improved their position and the world’s median increased [36, 37]. Furthermore, expenses on maintenance and new investments as % of GDP have been the lowest in Belgium compared to peer-countries\(^1\) from 2007 until 2017. Belgium spent on average 0.6% of their GDP on transport infrastructure investment and maintenance between 2010 and 2017 [38–40]. This is lower than the advised 1% of GDP by the European Conference of Ministers of Transport [41]. Between 2010 and 2017, 75% of the expenditure can be related to new investments and 25% to maintenance [38, 39]. Finally, according to Mr. Debrun, senior advisor at the research department of the National Bank of Belgium, the need for public investment in infrastructure in Belgium must be recognized [42]. Although the need is clear, political obstacles are holding back investments and improvements of the transport network. Belgium forms the perfect example to indicate these potential political obstacles, given the complexity of decision making and the short duration of government terms. The country is managed by six official organizations and four different policy leaders and the duration of a government term is five years. The democratic mandate, and the changing leaders and public opinion, creates a tension field between the political leaders and the top administrators. As a consequence of the regionalization of the ministry of public works in 1989, mobility and infrastructure became regional authorities, meaning that the responsibility of transport infrastructure lies with the regions, except for rail which stayed a federal authority. Belgium is divided into three regions, Brussels, Flanders and Wallonia. The federal government includes one minister of mobility to manage the railways and to keep an overview, and each regional government includes one minister of mobility and public works responsible for roads and inland waterways. Under the responsibility of a minister, there are administrative organizations led by a chief administrator. Six different organizations are mandated with the management of transport infrastructure over the country’s three regions, Brussels, Flanders and Wallonia (see Table 1). Organizations in Flanders are managed by another overarching organization called Mobiliteit en Openbare Werken (MOW). The federal and regional governments form their own budget, based on their own incomes and expenses. Next to that, the federal government provides the regional governments with additional financial resources.

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1 France, Italy, Luxembourg, The Netherlands, Finland and Austria. There was no complete data available for other countries.
Besides other motives, this complexity, and by consequence possible silo mentality, shows the research interest for a Belgian case study.

**Table 1.** Organizations mandated with the management of transport infrastructure in Belgium

<table>
<thead>
<tr>
<th>Region</th>
<th>Road</th>
<th>Inland waterways</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brussels</td>
<td>Bruxelles Mobilité/Brussel Mobiliteit</td>
<td>Port of Brussels</td>
<td>Infrabel</td>
</tr>
<tr>
<td>Flanders</td>
<td>Agentschap Wegen &amp; Verkeer</td>
<td>De Vlaamse Waterweg</td>
<td></td>
</tr>
<tr>
<td>Wallonia</td>
<td>Service Public de Wallonie Mobilité et Infrastructures (&amp; SOFICO)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.2 Data Collection Methods

Scientific literature, desktop secondary data in the form of reports from organizations in the same field and policy documents, in-depth face-to-face interviews with top administrators and a focus group with top administrators and experts were used as data collection methods. The interviews covered nearly all regions and all transport modes in Belgium (except for the Port of Brussels). In total seven interviews took place. Based on scientific literature and our developed framework, a semi-structured qualitative survey, including some open-ended questions, was drawn up. After executing seven intensive two-hour interviews in the period October 2019 - November 2020, remaining questions, confirmation of the preliminary findings and potential solutions or ways ahead were discussed in the format of a focus group with all six top administrators responsible for the IAM at their regional level. After carrying out the interviews and gathering the data, the method for cross-case analysis of qualitative data described by Miles and Huberman [43] was followed. The information was first reduced and synthesized, then it was displayed using visuals in the form of matrices and finally, based on these matrices, relevant conclusions were drawn and validated [43].

### 4 Results

In this section, results of the cross-case study will be discussed per transport mode. For each Belgian organization mandated with the management of road, rail or inland navigation infrastructure, their management is compared against the identified key success factors of the framework for SIAM.

**4.1 Road Infrastructure**

At this moment, Brussels and Wallonia are considering user’s needs before drawing up a long-term vision plan, using workshops or user surveys. Brussels followed this method for the first time during this government term, while Wallonia repeats it regularly. Flanders, on the other side, does not yet include methods to define the demand for
Table 2. Application of the key-success factors of IAM for road infrastructure in Belgium

<table>
<thead>
<tr>
<th>Factor</th>
<th>Brussels</th>
<th>Flanders</th>
<th>Wallonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) the accountability of context factors’ influences on the government policy</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>(2) the translation of the policy into organizational objectives</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>(3) the possibility of non-asset solutions</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(4) the development of transport mode specific goals</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>(5) the alignment between the government strategy and asset strategy</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>(6) the optimization of options</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>(7) the introduction of feedback loops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) organizational and knowledge management</td>
<td>●</td>
<td>●</td>
<td></td>
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</tbody>
</table>

infrastructure. Each organization uses their long-term vision plan to translate policy objectives into organizational objectives. However, while focusing on infrastructure to solve the needs identified from the gap between supply and demand, non-asset solutions are not yet considered in the regions. In Wallonia, policy objectives are introduced in the Gestion des Projets routierS (GPS) system, which automatically results in candidate asset projects. Brussels and Flanders translate policy objectives into asset objectives. All regions set transport mode specific goals, in Flanders this is done under the supervision of MOW. SPW in Wallonia also manages inland waterways next to roads, in Brussels only roads are managed by Brussels Mobility. Depending on the scope of activities of each organization in Brussels, general policy goals are being implemented as transport mode specific goals. Railroads are never part of it as this is the responsibility of another organization named Infrabel. Whereas Flanders and Wallonia are already implementing organizational and information processes dedicated to IAM, Brussels is still setting up an asset management direction and collecting information and creating a database. Based on the available information, only Flanders (Pavement Management System - PMS) and Wallonia (GPS) are trying to optimize their interventions. Since road agencies have budget as their main constraint, a strongly embedded budget optimization would be expected in their IAM practices. In contradiction, budget optimization is only done for highways in Flanders. It can be noticed that none of the regions uses feedback loops (Table 2).

4.2 Inland Navigation Infrastructure

Focusing on inland navigation infrastructure, both Flanders and Wallonia are considering context factors and user’s needs by having regular conversations with the users of the waterways. Using their long-term vision plans, they attempt to translate policy objectives resulting from the input on these context factors into organizational objectives, and eventually into asset objectives. For the same reason as for road infrastructure, common
Table 3. Application of the key-success factors of IAM for inland navigation infrastructure in Belgium

<table>
<thead>
<tr>
<th>Factor</th>
<th>Brussels</th>
<th>Flanders</th>
<th>Wallonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) the accountability of context factors’ influences on the government policy</td>
<td>No data</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>(2) the translation of the policy into organizational objectives</td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>(3) the possibility of non-asset solutions</td>
<td></td>
<td></td>
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<tr>
<td>(4) the development of transport mode specific goals</td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>(5) the alignment between the government strategy and asset strategy</td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>(6) the optimization of options</td>
<td></td>
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<tr>
<td>(7) the introduction of feedback loops</td>
<td></td>
<td></td>
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<tr>
<td>(8) organizational and knowledge management</td>
<td>●</td>
<td>(●)</td>
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</table>

Transport mode goals are defined by the overarching organizations. Both regions already have a system in place to collect inspection data from bridges and to link quality indicators to it. While Flanders already has a database of their other assets, Wallonia is still creating one. The organizations are focusing on the development of an extensive database of all their assets to define the assets that are the most critical in delivering an optimal service and that need an intervention. The optimization of options is not yet done in Flanders, nor in Wallonia and an integration of budget is still work in progress. Equal to road infrastructure, the possibility of non-asset solutions and the introduction of feedback loops are also missing in the SIAM frameworks of inland navigation infrastructure (Table 3).

4.3 Rail Infrastructure

In collaboration with the Belgian railways, responsible for delivering rail service in Belgium, Infrabel defines the user’s needs, to draw up the document ‘Strategy GO’ and to define its objectives. Afterwards, these specific objectives are being translated into asset objectives. Years ago, Infrabel implemented an information system. But, while a large quantity of data is available, the quality of the data is still lacking. Together with the optimization of options, the possibility of non-asset solutions and feedback loops are at this moment non-existing (Table 4).

5 Conclusion

Based on the results and the findings of this study it can be concluded that each transport mode and each region have its own objectives, good practices and challenges. A variety of asset management principles and processes exists, is possible and is potentially
Table 4. Application of the key-success factors of IAM for rail infrastructure in Belgium

<table>
<thead>
<tr>
<th>Factor</th>
<th>Federal</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) the accountability of context factors’ influences on the government policy</td>
<td>●</td>
</tr>
<tr>
<td>(2) the translation of the policy into organizational objectives</td>
<td>●</td>
</tr>
<tr>
<td>(3) the possibility of non-asset solutions</td>
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</tr>
<tr>
<td>(4) the development of transport mode specific goals</td>
<td>●</td>
</tr>
<tr>
<td>(5) the alignment between the government strategy and asset strategy</td>
<td>●</td>
</tr>
<tr>
<td>(6) the optimization of options</td>
<td></td>
</tr>
<tr>
<td>(7) the introduction of feedback loops</td>
<td></td>
</tr>
<tr>
<td>(8) organizational and knowledge management</td>
<td>●</td>
</tr>
</tbody>
</table>

even required based on the differences. A ‘one fits all strategy’ implementation does not exist, nor in theory, nor in practice. The framework provides general guidelines, retrieved from best practices abroad and scientific literature, that can be applied on each mode and each region and that can help policy makers and top administrators with the introduction and development of their custom asset management process. In this way, tension fields between policy makers and top administrators resulting from the short government terms can be reduced or even solved as clear principles are available. It is however necessary to include all these principles to achieve a sound SIAM. None of the studied organizations are considering non-asset options as possible solutions and are introducing feedback loops. Moreover, while option optimization and supporting databases should be well developed to focus on the chosen objective, this is only the case in respectively two and three out of the six organizations included in the research. Given the raising complexity in launching, budgeting and executing infrastructure assets, a strategic, and following operational asset management (including data management), would provide more resilient asset management and thus, a more stable and stronger infrastructure factor for competitiveness in a centrally located country in the European Union.

6 Research Financing

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