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Procurement of Road Maintenance: Between Knowledge Loss and Efficiency Gains

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Abstract

Outsourcing of road maintenance activities to private contractors has become a typical practice across many National Road Agencies (NRA). Although the involvement of the private sector offers efficiency gains, the procurement of road maintenance requires from NRAs the development of a different set of skills and competences and may come with the risk of losing other knowledge that cannot be easily replaced. Thus, understanding the consequences of choosing an appropriate procurement strategy is essential for NRAs to be competent and informed clients. The procurement practices of nine NRAs are investigated to show which maintenance procurement strategies NRAs adopt, how the context can influence the procurement trajectories of NRAs, what the effects are of these strategies on maintenance outcomes, and which skills and competences are needed to follow certain strategies. The paper also discusses the lessons learnt of the investigated NRAs in terms of level of outsourcing and contractual integration of maintenance activities.

Keywords: maintenance procurement; road infrastructure; country comparison

1. Introduction

During the last decades, there has been increased political pressure in advanced industrialized countries on National Road Agencies (NRAs) to rethink and alter their service provision. NRAs are forced to achieve more value for money with fewer resources, both in terms of budget and number of staff (REF – report?). Most NRAs have responded by extending the involvement of the private sector in the provision of various road works, maintenance and management services. At the same time, both NRAs and private sector companies lost key competences due to staff retirement and an increased staff turnover rate of younger personnel. The loss of competences from both outsourcing of maintenance services and staff replacement poses a serious threat to the effectiveness and efficiency of maintenance. In finding ways of dealing with this threat NRAs are following different procurement strategies that vary in the kind of works and services integrated in maintenance contracts, the duration and management of the contracts, the criteria for tendering the maintenance work, or the payment mechanism. A main challenge for NRAs lies in the definition of procurement strategies that are able to set incentives for the contractor and allocate risks between NRA and contractor in a way that the desired level of maintenance efficiency is achieved. This also implies that NRAs need to develop new competences for the implementation of defined strategies which in the light of large staff turnover in the road maintenance sector represents an enormous challenge.

This paper reports on research conducted under the CEDR Transnational Research Program “Asset Management and Maintenance” and compares maintenance procurement practices across nine NRAs. It shows which maintenance procurement strategies NRAs follow, how the context can influence the procurement trajectories of NRAs, what the effects are of these strategies on maintenance outcomes and which skills and competences are needed to follow specific strategies. The paper also discusses the lessons learnt of the investigated NRAs in terms of level of outsourcing and contractual integration of maintenance activities.

2. Maintenance Procurement Framework

Maintenance procurement is defined as all activities and decisions necessary for a NRA to acquire maintenance services for road infrastructure from supplying contractors. Maintenance procurement goes beyond the sole purchasing function of an organization and covers the entire process from the identification of maintenance requirements to the management of maintenance contracts.

Maintenance as the procurement object involves all activities during the life cycle of road infrastructure assets intended to retain the assets in, or bring them to, a state in which they can perform the required function considered necessary to deliver a defined service. Since this may include a possible change of the required functional performance or the function itself during the life of an asset, the understanding of maintenance is not restricted to activities preserving road performance but also involves performance upgrades of road infrastructure. Moreover, maintenance is understood as a cyclical process where the actual operational work is preceded by supporting management activities such as inspecting, monitoring and predicting of road performance and, based on that, developing maintenance strategies and planning maintenance work.

In order to study and compare maintenance procurement across different countries, a comprehensive framework is required describing how maintenance activities are procured, what the drivers are for procurement practices, and what the consequences are of these practices. Based on PIARC (2003), Mattsson and Lind (2009) and Hartmann et al. (2014) a framework is proposed that consists of the following procurement components and aspects:

- **Maintenance procurement context:** relates to the drivers that can explain the development towards certain maintenance procurement practices and the appropriateness of these practices for achieving intended maintenance outcomes. The context of NRA's includes political, organizational, social and environmental factors.
- **Maintenance procurement practice:** relates to past, current and future approaches of NRAs in different countries in terms of procuring road maintenance. Aspects of procurement practices are: the maintenance contract design (e.g. geographical scope, kind and number of assets integrated, contract duration, performance specifications), the maintenance tender procedure (e.g. evaluation criteria, evaluation process), and the maintenance contract management (e.g. quality management, performance measurement).
- **Maintenance procurement outcomes:** relates to the consequences of procurement maintenance practices for the effectiveness and efficiency of road maintenance. Indicators for the maintenance effectiveness are for example road quality (e.g. condition index) and the user satisfaction or achieved level-of-service. Maintenance and user costs (e.g. cost/km of maintenance, administrative costs as percentage of total budget, changes in user cost components) give an indication for the maintenance efficiency.
- **Maintenance procurement competences:** relates to the required skills and capabilities at NRAs to procure road maintenance. Contractual competences include an understanding of the implication of contract design on incentives for and risk attitude of the contractor. Relational competences include the ability to corporately find solutions for unforeseen events and conflictual situations. Technical competences include an understanding of the function and performance-related behavior of road assets.

3. Research Method

Based on the framework introduced in the previous section, the main objective of the research is to study and compare maintenance procurement practices of NRAs and identify commonalities and differences in terms of driving factors for maintenance procurement practices, effects of maintenance procurement practices on road quality and maintenance costs, and risks experienced with current maintenance procurement practices and how they are managed. Nine countries were selected due to expected differences in the procurement practices of NRAs and the accessibility of these NRA for data collection. Data was collected for the following countries and NRAs as described:

- ***The Netherlands – Dutch Agency for Transport, Public Works and Water Management (RWS)***
10 interviews were conducted with RWS employees and market parties. At RWS top specialists in market strategy and in pavement materials and structures, as well as internal technical advisors were interviewed. The market parties interviewed included contractors, consultants and research organizations. Documents studied include annual reports, contract documents, professional presentations, and audit reports
- ***Belgium (Flanders) – Flemish Agency for Roads and Traffic (FAWV)***
In Belgium two in depth interviews were carried out with the Director of Investments and Operations, Department Planning and Coordination within the Flemish Road Administration. Documents studied include annual reports, contract documents and technical guidelines.
- ***Germany – State road authorities***
Interviews were conducted in two counties of Baden-Württemberg, in the state road authorities of Hesse and Lower Saxony, in the state enterprise of Saarland, in one county of Saxony, with the organizational consultants of the Thuringia road authority and at Via Solutions Southwest the concessionaire for a 60km section of the federal motorway A5. Documents studied include annual reports, contract documents and technical guidelines.
- ***United Kingdom – Highway England (HE)***
Interviews were conducted with employees from Highways England including senior advisor and head of asset delivery. Documents studied include, but are not limited to, annual reports, contract documents, professional presentations, and audit reports.
- ***United States (Virginia) – Virginia Department of Transportation (VDOT)***
Interviews with 13 VDOT employees from the central department in Richmond and four VDOT districts were conducted including district managers, maintenance managers, contract managers, and maintenance supervisors. Documents studied include annual reports, contract documents, professional presentations, and audit reports.
- ***Australia (Western Australia) – Main Roads Western Australia (MRWA)***
Interviews with 5 MRWA employees from the central department in Perth and the MRWA district in Bunbury were conducted including contract managers, district managers, and technical managers. Documents studied include annual reports, contract documents, professional presentations, and audit reports.
- ***Finland – Finnish Transportation Agency (FTA)***
Interviews with two FTA employees from the central department and four employees from regional Centre for Economic Development, Transport and the Environment were conducted including maintenance managers and contract managers. Documents studied include annual reports, contract documents, and professional presentations.
- ***Norway – Norwegian Public Road Authority (NPRA)***
Interviews with three NPRA employees from the central department were conducted including maintenance managers and contract managers. Documents studied include annual reports, contract documents, and professional presentations.
- ***Sweden – Swedish Transport Administration (STA)***
Interviews with four STA employees from the central department were conducted including maintenance managers and contract managers. Documents studied include annual reports, contract documents, and professional presentations.

4. Results of Comparison

4.1. Procurement context

The context of NRAs relates to the drivers that can explain the development towards certain maintenance procurement practices and the appropriateness of these practices for achieving intended maintenance outcomes. It includes political, organizational, social, and environmental factors. Although the investigated NRAs share some similarities on a general level such as type of road assets managed and organizational structure, geographical locations, administrative boundaries and historical developments show minor and major differences between the NRAs having effects on procurement practices.

4.1.1. Effects of management responsibility

All involved NRAs are responsible for the main national roads including highways and primary roads. Secondary roads are also managed by VDOT (US), FAWV (Belgium) and NPRA (Norway). In other countries, the responsibility for secondary and lower roads lies with other public jurisdictions such as provinces or municipalities. In all countries, private consortia have full responsibility for operation and maintenance of some road sections and/or civil objects (e.g. bridges, tunnels) through Public-Private-Partnership (PPP) arrangements. From a network perspective, separated management responsibilities introduce additional coordination interfaces and capabilities to attain optimal maintenance planning. It can also lead to different procurement approaches and outcomes. In some countries, NRAs are larger infrastructure agencies managing other infrastructure networks as well, for example waterways (e.g. Netherlands) or railways (e.g. Sweden, Finland).

4.1.2. Effects of infrastructure peculiarities

Size and density of the road networks vary greatly between NRAs. The size of the managed road networks ranges from 7,500 km (Netherlands) to 230,000 km (Germany) and can be very dense in urban areas (e.g. Netherlands) and more wide-stretched in rural areas (e.g. Australia). This can have effects on the extent and way of bundling assets in contracts or the size of a contractual area. Urban areas also show a higher traffic intensity (e.g. 135,000 AADT in the US) than rural areas (e.g. 20 AADT in Australia). Consequences are the transfer of administrative tasks to the maintenance contractor (e.g. US) or the increased importance of traffic management in procurement and monitoring (e.g. Germany). The number of civil objects is also different between NRAs ranging for bridges from 750 (Netherlands) to 18,500 (UK). Peculiarities also exist in terms of materials used for road infrastructure and design parameters. For example, the road network in Western Australia knows a large number of timber bridges and in the Netherlands more than 90% of the highways are constructed with porous asphalt. This requires special technical knowledge and the decision of NRAs whether the knowledge can be bought in or should be developed in-house.

4.1.3. Effects of climate zones

The road networks in the different countries are exposed to different climate zones ranging from continental subarctic climate (e.g. Norway) to tropical desert climate (e.g. Australia). As a consequence, NRAs witness a variety of annual temperatures, precipitation and extreme weather events impacting the road networks such as blizzards (e.g. US), bush fires (e.g. Australia), avalanche (e.g. Norway), and flooding (e.g. Finland). The climate can foreground certain maintenance activities and has an influence of how risks related to such events are dealt with in maintenance procurement and whether private parties are regarded to bear these risks. For example, the importance and relative volume of winter maintenance are higher in Nordic countries (Sweden, Norway and Finland) than in other countries and these countries have specific risk procedures in place (e.g. weather models in Sweden) to have winter maintenance included in their integrated contracts. However, in comparison to these NRAs VDOT (US) pulled out winter maintenance from their integrated contracts and took back decision responsibility due to perceived unacceptable high risks placed at the maintenance contractor.

4.1.4. Effects of organizational policy

Despite the differences in size, all NRAs have faced a process of downsizing and (to some extent) privatization over the last 10-20 years. For most of the NRAs this meant, first of all, to hive off their operational workforce, but also engineering and research capacity. While the majority of NRAs completely outsourced operational maintenance activities (e.g. Netherlands, Finland), a few kept own staff for executing maintenance work (e.g. Germany, US). Although the downsizing process often was accompanied by an organizational restructuring, the general organizational structure at NRAs has remained similar over the years. Typically, there is a central office for strategic planning issues and support functions and several regional offices for tactical and operational planning issues taking into account the regional characteristics of the network. However, the downsizing process and the procurement changes have shown different paces between countries which can be mainly traced back to differences in organizational policy and the underlying political agendas. For example, the involved Nordic NRAs have changed from maintenance operators to transport network manager within a decade including the integration of different transportation networks in one agency.

4.2. Procurement practice

4.2.1. Level of outsourcing and integration

It is very common across all investigated NRAs that the outsourcing of maintenance activities started before the downsizing processes in the 1990's. Up till then discrete and framework contracts had been mainly used to buy in the actual maintenance work (doing) for single assets. Currently, most NRAs do not have any operational workforces and have outsourced all regular maintenance and rehabilitation activities to private parties. An exception is VDOT (US) that still has own operational workforces for repair and emergency responses. This is because of VDOT's historical development and organizational structure including the responsibility for the entire state system of highways and secondary roads in Virginia. Differences in the level of outsourcing exist between countries when it comes to maintenance planning and monitoring activities. Here, the level of outsourcing relates to the level of integration. The more and the longer contractors become responsible for the maintenance of different assets in a region or corridor, the more are planning and monitoring activities shifted to the contractors as well. The highest level of integration and thus outsourcing can be observed for regular maintenance. NRAs with integrated contracts for regular maintenance (e.g. Netherlands, UK, Finland) have also mainly outsourced the planning and monitoring of these activities. NRAs that do not have integrated contracts (e.g. Belgium) or only to a limited extent (e.g. US) keep planning and monitoring responsibilities in-house. Rehabilitation activities show a lower level of integration and thus planning and monitoring are less outsourced. Although inspections are often done by specialized firms, performance and risk evaluation of assets and rehabilitation planning based on inspection data often lie with NRAs. However, in some countries those monitoring and planning activities are also outsourced via discrete and framework contracts to engineering consultants (e.g. Finland, Sweden) or were also (partly) transferred to contractors via integrated contracts (e.g. Australia, UK). Although the integration of maintenance activities for multiple assets has been the main change in the procurement practices of NRAs in the last decades, three generic types of road maintenance contracts can be found at most NRAs: (i) discrete contracts, (ii) framework contracts, and (iii) integrated contracts. Design and number of each contract type differ between NRAs leading to different contract portfolios. Contracts are often set up regionally or are limited to certain areas, homogenous subnetworks or individual structures.

4.2.2. Discrete contracts: the traditional way of procuring rehabilitation

Discrete contracts have been very common among all NRAs and are mainly used for rehabilitation of road assets (e.g. pavement resurfacing). Since rehabilitation is typically site-specific and delimited in scope, the work procured by discrete contracts possesses project character. Thus, the duration of the contracts depends on the estimated duration of the work to be done. At most NRAs, the contracts have covered single assets (e.g. bridge). However, in recent years contracts have been extended combining the maintenance for multiple assets of a road section (e.g. bridge and pavement). Payment mechanisms can be lump-sum (e.g. Netherlands) unit prices (e.g. Germany) or some hybrid forms (e.g. Belgium). Some NRAs make use of penalties (e.g. US) and other NRAs apply reward schemes (e.g. Germany). Differences also exist in terms of tendering. While many NRAs still award discrete contracts mainly on lowest price (e.g. Belgium, Germany) there are also changes towards Most Economically Advantageous Tender approaches (e.g. Netherlands) that award the contract based on a certain quality/price ratio.

4.2.3. Framework contracts: the flexible way of procuring regular maintenance

Framework contracts are also very common among the studied NRAs. They are, first of all, used for regular maintenance of single assets (e.g. Germany, US), but can also include engineering and management services (e.g. Netherlands, UK). They have a duration between 1 and 5 years and use unit-price payment mechanisms. The contracts often cover larger areas for which maintenance contractors have to provide services. Between NRAs contract variations exist. In the Netherlands, this contract type was used for the rehabilitation of multiple assets in a region. A combination of regular maintenance and rehabilitation can be found in Belgium. In Finland framework contracts are used for the regular maintenance of pavements but based on a partnering approach the maintenance contractor is granted more responsibility for planning and monitoring maintenance work. All NRAs framework contracts are means of keeping some degree of flexibility and control for the decision on time and amount of road maintenance. It is the flexibility and control aspect that lead at some NRAs (e.g. US, UK) to the use of framework contracts for unbundled maintenance work from former integrated contract.

4.2.4. Integrated contracts: the varied way of procuring road maintenance

With discrete and framework contracts NRAs are able to cover all operational and management tasks in road maintenance. However, over the last 10-20 years the pressure to further outsource maintenance and downsize the organization has led to the introduction of integrated contracts. The level of integration and the trajectories leading to the current level largely differ between NRAs. A couple of NRAs, mainly from Anglo-Saxon countries, outsourced and integrated management and operational maintenance activities on a high level right from the beginning and remained on a high level of integration over more than two decades (e.g. UK) or as part of a learning process continuously lowered the integration level over the years (e.g. US). In contrast, other NRAs (e.g. Germany, Netherlands, Finland) started at a low level of integration and increased the level over time by integrating maintenance activities and assets in different ways and contracts. Some of them (e.g. Netherlands, Finland) also followed a learning trajectory characterized by the implementation of different contract generations whereas others did not go beyond pilot trials (e.g. Germany). Among the investigated countries is one (Belgium) that had no integrated contracts. In recent years, NRAs have started chopping up again their integrated contracts and returning back to discrete and framework contracts (e.g. US). Beside the different level of integration, integrated contracts at the investigated NRAs show a variety of combinations of maintenance activities and assets. One group of contracts integrates all regular maintenance activities for multiple road assets within a region (e.g. Netherlands, Norway) or along a corridor (e.g. US). Another group is integrating regular maintenance and rehabilitation up to a certain value for all assets in a region (e.g. Australia, UK). Also, an approach is the integration of regular maintenance and rehabilitation for a specific asset type such as pavements (e.g. Finland, Sweden). Despite the different integration approaches the underlying rationale is the same across countries. It is the attempt to move the responsibility for the monitoring of the asset condition and the planning of maintenance work to the contractor as well and, by doing so, to achieve efficiency gains and reduce the workload for the NRA. At most NRAs, the current duration of integrated contracts is up to 5 years. An exception are the integrated contracts for pavements in the Nordic countries that can have a duration between 10 to 15 years. Typically, integrated contracts make use of lump-sum payment mechanisms (e.g. Netherlands) but can also adopt hybrid forms with lump sum and unit prices (e.g. Norway, US) or even cost-plus fee reimbursements (e.g. Australia).

4.2.5. Procurement groups

If the level of outsourcing is set against the level of integration, three procurement groups can be distinguished. A first group includes the countries Belgium and Germany. This more traditional group shows a relatively low level of outsourcing and integration and use mainly discrete and framework contracts to buy in maintenance work. In this group, Germany had a couple of pilot projects that integrated maintenance work. However, not all of these pilots continued as regular maintenance procurement practice. Countries in the second group include the Netherlands, the US and Norway. This group has a more diverse contract portfolio leading to a medium/high level of outsourcing and integration. They use integrated contracts for regular maintenance of multiple assets and discrete and framework contracts for regular maintenance or rehabilitation of single or multiple assets. The Netherlands and Norway have outsourced all maintenance work whereas the US still has some own maintenance capacities. On the other hand, Norway has integrated the regular maintenance for all assets within a region including winter maintenance. In the Netherlands and the US, particularly winter maintenance is excluded from the integrated contracts. A third group is characterized by a high level of outsourcing and a medium/high level of integration. Countries in this group are the UK, Australia, Finland and Sweden. Within this group, Australia and Finland show a high level of outsourcing including the planning of rehabilitation and regular maintenance activities. Rehabilitation and regular maintenance for multiple assets are integrated in contracts in the UK and Australia. In Sweden and Finland either the contractor is responsible for the regular maintenance of multiple assets or rehabilitation and regular maintenance are integrated for single assets.

4.3. Procurement outcomes

The outcomes of different procurement approaches and contract types in terms of road quality, provided level of service and user satisfaction are hardly to be determined and compared between NRAs. A main reason is that NRAs do not have sufficient information (e.g. maintenance costs per asset/contract, performance of assets/contracts) to be able to estimate maintenance effectiveness and efficiency of different procurement strategies. This also includes the establishment and use of Key Performance Indicators (KPI) for monitoring and

evaluating procurement outcomes. The following comparison has thus a qualitative nature and is mainly based on insights gathered from experts at NRAs.

4.3.1. Discrete contracts: the quality assurance challenge

In general, discrete contracts offer NRAs a high level of flexibility and control of the maintenance work. Although the contracts are set up according to the specific needs and quality requirements of a NRA, the performance specification differs between countries. Some NRAs believe that having a strong emphasis on the task-related performance specifications keeps transaction costs of the agency and overhead costs of contractors low (e.g. Belgium, Germany) while others believe that asset-related performance specifications give the contractor more freedom to achieve better outcomes. Depending on the market situation, discrete contracts often show an intense price competition that encourages contractors to test the limits of quality tolerance rather than to offer ways to improve technical quality or work methods. There is the risk of underpriced contracts that pushes the contractor towards lower cost solutions and negotiations about the amount of payment. Incentives schemes are hardly used and not always effective. Although NRAs use warranty times, the expected material life-cycles can exceed these periods resulting in long term quality risks for the authority (e.g. Netherlands, Finland). In addition, requirements are often not enforced by appropriate monitoring systems (e.g. Germany). Discrete contracts are appropriate for well-defined maintenance activities but require some management effort to ensure the delivery of the desired quality and to coordinate the often several contracts in place.

4.3.2. Framework contracts: the work estimation challenge

Framework contracts allow flexibility in the planning of maintenance work or quick responses to unplanned circumstances. Particularly for the latter they are suitable vehicles to absorb risks (e.g. winter maintenance) that contractors are not able to take by providing extra resources (e.g. Germany, US). In combination with a partnering approach they appear to lead to satisfying maintenance outcomes (e.g. Finland) and represent a possible way of stimulating local economy. However, for some maintenance activities, there has to be a local industry, otherwise it might be impossible to find suitable contractors (e.g. Germany). In addition, if contractors regard the amount of actual work to be executed as very uncertain, bid prices can go up and the number of bidders can drop (e.g. US). In recent years, framework contracts have gained more relevance for the procurement of road maintenance due to the flexibility they brought back to NRAs. However, the estimation of the expected work load during a contract period is a challenge and has to be compensated with a sound relationship with the contractors. For the contractors, this type of contract introduces more uncertainties about the actual work load and requires some flexibility in capacity planning.

4.3.3. Integrated contracts: the value for money challenge

The outcome of integrated contracts depends on the extent to which cost savings through the reduction of management effort can outweigh a loss of flexibility and control. The experiences with this contract type are rather mixed across the investigated countries. Although integrated maintenance contracts can be cost effective (e.g. Finland, Sweden, UK), they can also lead to quality issues, particularly if public and market parties have not (yet) the technical, contractual and relational competences needed for working under these contracts. This became prevalent in countries that implemented comprehensively integrated contracts right from the beginning (e.g. UK, US, Australia). Besides the necessary competences for ensuring a certain quality level, it appears essential to be able to clearly demarcate assets belonging to the contract, have sufficient data on asset condition at the beginning of the contract, and effective monitoring systems and penalty/reward schemes. In addition, the formulation and use of performance requirements is still a challenge for NRAs and often lead to misinterpretations and disputes between NRAs and contractors. Another critical issue for the outcomes of integrated contracts concerns the combination of contract duration, performance description and payment mechanism. In most countries, the first generations of integrated contracts had a long contract duration, were based on asset-performance specifications, and relied on pure lump-sum payment. A main intention was to stimulate innovative behavior and life-cycle oriented investments of the contractors. However, even durations up to 10 years seemed to be insufficient to create enough incentives for contractors to make more long-term capital investments (e.g. US, Australia) and can create lock-in effects, which make it difficult to introduce any task or asset related changes during the contract period. NRAs dealt differently with these unwanted effects. Some agencies that had contracts with a high integration level (e.g. US) unbundled the contracts to put some maintenance activities under discrete and framework contracts. Other agencies introduced partnering approaches

(e.g. Finland, Sweden) and included a change in payment mechanism from lump-sum to cost-plus fee (e.g. Australia) or changed to hybrid payment forms of lump-sum/unit price (e.g. US). All these changes had the aim to bring back flexibility and control for the NRAs. Since integrated contracts offer many design varieties, they should be deliberately set up, monitored and evaluated to ensure the desired outcomes. This also includes the possibility for NRA and contractor to develop the required competences and skills to work under these contracts.

4.4. Procurement competences

4.4.1. Contractual competences

Contractual competences play an important role for all NRAs, but their development can differ between countries and have mainly to do with the different procurement strategies and trajectories followed when implementing these strategies. Typical contractual competences include monitoring and surveillance skills (e.g. US), contract coordination skills (e.g. Sweden), understanding contract documents (e.g. Finland), and commercial knowledge (e.g. Australia). Although contractual competences are relevant for all contract types, their importance can be different between contracts. Particularly integrated contracts seem to ask for competences to set up the appropriate incentives (bonuses and deductions) for contractors (e.g. UK, Netherlands). This also includes the formulation and implementation of the appropriate performance requirements (e.g. Finland). Integrated contracts also require more commercial competences to indicate the value for money of this contract type. This includes the ability to capture and analyze the cost of maintenance activities and the establishment of cost performance regimes to achieve commercial targets (e.g. UK, Australia). Another contractual competence is the selection of the appropriate contract type or the adjustment of existing template contracts to the specific circumstance of road networks and their stakeholders (e.g. Sweden, Germany).

4.4.2. Relational competences

With integrated contracts, the importance of relational competences is increasing. This can be observed for all NRAs using integrated contracts for a longer time (e.g. UK, Australia, Finland). Trustworthiness is an essential ingredient of integrated contracts and forms the basis of a cooperative relationship. However, trustworthiness needs to emerge between individuals through regular interactions and work meetings. If contract teams experience a frequent turnover of employees, the development of trustworthiness might be hampered (e.g. Australia, Finland). It also depends on the right persons at both sides of the table. They need to be able to understand the principles underlying the cooperation, openly discuss contract issues and share information, and accept deviating opinions of the other party. Some NRAs have also set up third party forums for the communication with contractors (e.g. Finland). In general, relational competences include communication skills (e.g. UK, Finland), negotiation skills (e.g. US), stakeholder management skills (e.g. Netherlands) and the understanding of role and responsibilities (e.g. Australia)

4.4.3. Technical competences

For all NRAs, technical competences are important for the procurement of road maintenance. Particularly those NRAs that outsourced maintenance activities to a large extent have experienced the (partly) loss of technical competences and the consequences for their role as informed client and being a competent partner for the market (e.g. UK, Netherlands, Australia, US). Technical competences are seen essential for establishing realistic cost and time estimations for maintenance activities and developing functional requirements and technical maintenance specifications. In other words, they help in setting contracts up in the right way, knowing what to ask from contractors, being competent during discussions and negotiations with contractors, and assessing the risks involved in maintenance activities and projects (e.g. Netherlands, US). They allow NRAs to keep in control and steer contracts to meet the required quality targets (e.g. Belgium, UK). Similar to other competences, technical competences have been developed over years and are mainly based on the experiences of employees (e.g. Germany). If competences are lost, it will take time to get them back in the organization (e.g. US, Australia). Technical competences that are seen to be essential for NRAs are the understanding of asset conditions (e.g. Norway), the understanding of asset performance and behavior (e.g. UK, Netherlands), the understanding of maintenance cost and duration (e.g. US, Netherlands), the understanding of technical peculiarities of local networks (e.g. Sweden), and engineering knowledge of unique structures (e.g. Australia). Operational technical competences are no longer present at most NRAs. An exception is VDOT in the US, where this knowledge is also seen as being beneficial to realistically estimate costs and manage and evaluate the work

of contractors. In order to ensure that contractors possess the required technical competences, NRAs specify the training employees of contractors need to have or the amount of work that contractors have to deliver with own staff (e.g. US, Sweden, Norway). The competence level of contractors can be different in regions. Particularly in regions with low population density and far distances less contractors are capable to do the required maintenance (e.g. Sweden, Australia). Here, framework contracts can help in building up competences through the assurance of future work (e.g. Germany, Australia).

4.5. Lessons learned

Due to different contextual characteristics and different outsourcing / integration trajectories of NRAs, the lessons learned by NRAs differ as well. However, the identified lessons learned relate to six larger themes.

4.5.1. Contractual incentives

For many NRAs, it remains a challenge to find appropriate contractual incentives. The experiences with financial incentives are very similar. Financial incentives alone do not work properly, since even bonuses might be priced in by contractors and then lose their stimulating effect (e.g. Netherlands, US, Sweden). Therefore, NRAs try to complement financial incentives with other types of incentives. This might be a better balance between bonuses and penalties (e.g. Netherlands) or high-quality levels in combination with a representative quality assessment scheme and high penalties to increase the contractor's compliance with contractual requirements (e.g. US). Particularly with penalties some NRAs experienced very little freedom of action in case the contractor does not meet the required outcomes (e.g. Norway, Netherlands). With the first generation of integrated contracts there was also the expectation that a long contract duration would stimulate the contractor to make cost-effective life-cycle oriented decisions such as applying preventive maintenance strategies. However, experiences suggest that even long-term contracts up to 10 years do not result in contractors' decisions that drive value-for money (e.g. UK, Australia, US). NRAs need oversight, a strong supervisory role and own investments to improve maintenance outcomes. The interest of contractors is more on efficiency rather than effectiveness gains (e.g. Norway, Sweden).

4.5.2. Contract complexity

Some NRAs experience maintenance contracts as too complex, which makes them cumbersome to manage. Particularly the gap in language and understanding between people writing the contracts and technical groups working with the contracts needs to be reduced (e.g. Sweden, UK, Netherlands).

4.5.3. Contract flexibility

Although many NRAs use standardized contract templates, it should be possible to adapt contracts to the maintenance work required and the regional peculiarities. This may include the combination of hybrid performance specifications (task-related/asset-related) and mixed payment mechanisms (unit price/lump sum) (e.g. US, Sweden, Finland). It can also mean to apply different contract types depending on the local situation. Integrated contracts might be more suitable for urban areas with high traffic intensity, since they can reduce coordination of maintenance activities and third parties. Discrete and framework contracts might be more appropriate for rural areas with low traffic intensity allowing the NRA to coordinate maintenance activities in a way that preventive maintenance strategies can be followed (e.g. US).

4.5.4. Risk transfer

Outsourcing maintenance activities should always be accompanied with a careful evaluation of the risks that are transferred to the market and whether contractors are able to bear the risks. In general, risk should not be transferred if the receiving party is not capable of handling it, and the management responsibility for uncertain events but with a high impact on service provision and user should remain at the NRA (e.g. US, Sweden).

4.5.5. Relationship building

Across a number of NRAs, the building of strong relationships with contractors is seen as a way to realize joint cost minimization and drive value for money considerations (e.g. UK, Australia, Finland, Norway). However,

this requires more emphasis on creating effective integrated project teams and the communication practices between NRA and contractor on personal level to further align each other's expectations, get to know each other's roles and responsibilities, and share knowledge (e.g. UK, Norway). Then, relationship-based contracts can offer flexibility in decision-making and the use of resources (e.g. Australia, Finland).

4.5.6. Knowledge development and retention

Outsourcing and integration of maintenance activities has always consequences for the knowledge to be developed and retained for both NRA and contractor. In general, there is the shared view across NRAs that technical knowledge is required to properly manage and control maintenance contracts. This particularly includes asset management knowledge that needs to be developed with the help of centrally-coordinated maintenance management systems, which also allow the comparison of outcomes of different contracts (e.g. Australia, Netherlands, Belgium). This brings back ownership of investment decisions to NRAs and increases intelligence on local factors that influence where work is most needed (e.g. UK). For some NRAs, operational and hands-on technical knowledge and experience is also an essential basis for managing maintenance contracts (e.g. US, Belgium). Road networks can consist of unique engineering structures that require specialized knowledge. Due to small markets contractors might not be interested in providing this knowledge. Here, the NRA should develop and retain it (e.g. Australia). Expertise often rests only on single employees. Thus, more emphasize is needed to keep knowledge at NRAs, otherwise the knowledge is lost if people leave the organization and it can take time to get it back (e.g. Germany, US). Particularly integrated contracts require time for the contractor to settle in, in order to create a new organization, develop local network knowledge, use unfamiliar systems and processes, and build effective working relationships with the NRA (e.g. UK, Australia).

5. Conclusion

The practices of procuring road maintenance in the investigated countries differ. Due to historical and organizational developments and peculiarities of their infrastructure networks NRAs have followed different procurement trajectories. These trajectories are characterized by a different level of outsourcing and integration of operational and management tasks. Despite these differences there are a number of commonalities between NRAs on a more general level. This includes the types of contract used and their effects on the procurement outcomes, but also the consequences for the competences of NRAs. In this sense, it can be concluded that establishing procurement practices is first and foremost a learning process of each NRA, in which experiences and lessons learnt by other NRAs can provide some guidance. However, it is important to note that each NRA has its own organizational history, structure and working culture. Whether and how procurement strategies should be changed depends on a number of organizational factors such as the available technical and managerial knowledge and skills, the existence of careful asset inventories, sound history and trend data on asset conditions and maintenance cost. Often the effects of changed practices on working procedures, competencies of employees and relational behavior of contract partners are insufficiently assessed. Forced to quickly present a changed situation, the dynamic and complex character of a change in procurement is often neglected. That also means that much effort is employed to find adequate answers to problems in the management processes, but less effort is spent to find ways how these answers could become part of the operational practice. Changing practices require additional effort and resources to adjust them to the peculiarities of the network, the organization and the market situation.

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6. References

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