

Contradictions in Infrastructure Management – The Introduction of Performance-Based Contracts at the Dutch Highways and Waterways Agency

A. Hartmann and G. Dewulf

Abstract — Increasingly, public organizations are being compelled to improve the efficiency and effectiveness of their service provision. A key approach of public organizations for achieving these objectives is to extend private sector involvement. In infrastructure management, integrated, performance-based contracts are a concrete expression of this involvement. From an activity-theoretical perspective, this paper explores infrastructure management as activity system and elucidates the contradictions which the introduction of integrated, performance-based contracts at the Dutch Highways and Waterways Agency provokes within this activity system. Due to the mediating role maintenance contracts play in the interaction of public and private parties with regard to maintenance objectives, this paper shows that changes in the contract form and in contract controlling lead to the aggravation of already existing contradictions and the emergence of new contradictions within the infrastructure management system.

I. INTRODUCTION

DURING the last decades there has been increased political pressure in advanced industrialized countries on public agencies to rethink and alter their service provision. Public agencies face high expectations in terms of greater cost-effectiveness and customer-orientation of their primary production and service processes. They are forced to achieve more public value with fewer resources by optimizing their decision-making on when, where and how to build, maintain and renovate infrastructure assets. Not surprisingly, more and more public agencies have developed and implemented integrated approaches of managing their infrastructure portfolio. At their core, these asset management approaches involve all those activities and decisions that reduce the expenditures over the life-cycle of infrastructure assets while extending the period for which the assets provide the required performance.

A main decision many public agencies have taken to increase the effectiveness of infrastructure investments is to successively extend the involvement of the private sector in the provision of various public goods and services. Not only are private sector suppliers contracted to construct large-scale

infrastructure projects, they are also assigned the financing, development, operation and maintenance of these facilities. Instead of prescribing detailed tasks to be fulfilled, new forms of long-term integrated contracts describe the functional specifications as well as the performance requirements of the final product and services. Central to this ongoing reorientation is the transition from procuring single goods and services – as was done in the past – to procuring integrated service packages. With the extension of public sector involvement and the implementation of integrated, performance-based contracts, public agencies are confronted with contradictions, tensions and conflicts stemming from changed activities, roles, responsibilities and competencies. Recognizing and addressing these contradictions appropriately will be essential for attaining the intended optimization potential and preventing suboptimal infrastructure performance.

The paper seeks to analyze the contradictions that are related to the introduction of integrated, performance-based contracts for the maintenance of infrastructure networks from an activity-theoretical perspective. It uses a case study on the introduction of performance-based contracts at the Dutch Highways and Waterways Agency to elucidate the interdependency of these contradictions. Based on this analysis, it seeks to better understand the complexity and dynamic character of the decisions public agencies have to make while implementing new asset management practices in general and new procurement strategies in particular.

II. THEORETICAL BACKGROUND

A. Activity Theory

Activity theory has its roots in the work of the Soviet psychologists L. Vygotsky and A.N. Leont'ev. Vygotsky [1] introduced the concept of mediation, which suggests that individuals do not directly interact with their environment but that their interactions are mediated by technical and psychological tools. Leont'ev [2] extended the idea of Vygotsky by viewing human activity as socially created and historically embedded. In this sense activities are socio-cultural interpretations of individuals which put meaning onto the object of activity. These interpretations are developed through involvement and are imposed by individuals on particular circumstances [3]. Activities incorporate the specific objectives and motives of individuals in a particular context. Activity theory neither understands

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individuals in isolation from the context of their practice nor is the context seen as independently existing from individuals. Activities emerge through social practice within a culturally and historically formed setting, and at the same time the interpretations about the nature of these activities may change [3]. Contradictions between and within activities caused by deviating interpretations subsequently provide the opportunity for change and further development.

Based on the work of Vygotsky and Leont'ev, Engeström [4] developed the structure of a human activity system which includes individual and group actions and reflects the social and cultural aspects of human activity. His general activity system consists of six components:

- 1) *Subject*: refers to persons involved in human activity.
- 2) *Object*: is seen as the societal motive of activities which defines them and separates them from other activities [5].
- 3) *Tool*: is the physical or conceptual artifact through which an individual's interaction is mediated.
- 4) *Community*: emphasizes the social nature of human activity. Individual action is embedded in communities.
- 5) *Rule*: mediates the interaction of the individual with the community.
- 6) *Division of labor*: is the mediating aspect of the relationship between the community and the object of an activity.

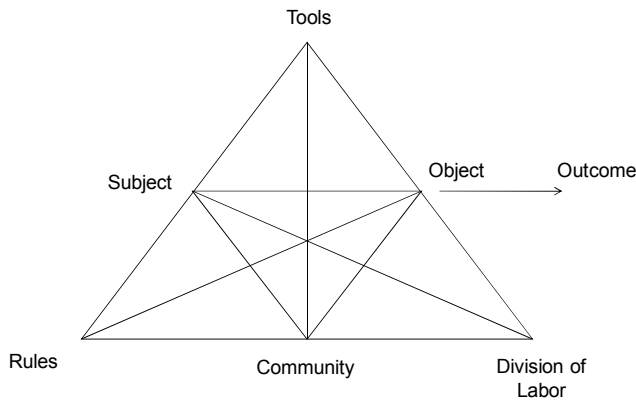


Fig. 1. System of human activity [4]

According to activity theory, dynamic forces of change are contradictions and misalignments within and between activity systems which are manifest in the performance of the system [5] (Virkkunen and Kutti, 2000). Such contradiction may occur when people interpret situations differently or single components of the system change due to external developments.

B. Infrastructure Management as Activity System

Activity theory provides a useful explanatory framework for the managerial challenges of public agencies when implementing new procurement strategies for the maintenance of infrastructure. It allows the understanding of infrastructure management as a socially constructed practice in which new contractual arrangements represent the tools mediating the interaction of individuals and organizations

with regard to the maintenance object (e.g. the infrastructure performance). Moreover, from the perspective of activity theory the shift of maintenance activities and responsibilities from public agencies to private parties depicts a change in the division of labor and consequently a disturbance of the existing maintenance regime. This may lead to different interpretations of public and private organizations on how to maintain the infrastructure assets. Contradictions occur that reduce the efficiency goals envisaged with the new procurement strategy. According to activity theory, removing these contradictions means developing a new maintenance regime over time. This development process, however, will show its own dynamics and follow its own trajectory due the interdependency of the several components of the maintenance system with their particular cultural and historical background.

III. CASE STUDY

The aim of this research was to uncover the contradictions in infrastructure management that are related to the introduction of integrated, performance-based contracts. The context-bound, history-laden nature of activity systems suggests a case study approach to explore these contradictions. The Dutch Highways and Waterways Agency (RWS) is the case that was chosen, since in the last few years the agency has established new procurement strategies for infrastructure maintenance on its way to become a professional public-oriented network manager. The implemented performance-based contracts for infrastructure maintenance were chosen as the units of analysis for the research. Twenty-one interviews with contract and project managers, managers of regional areas and procurement staff were conducted. All interviews were tape recorded and transcribed for subsequent analysis. In addition, contracts, strategic documents and organizational guidelines were analyzed.

A. Case Description

The RWS manages the main road network, main waterways network and main water supply and drainage systems in the Netherlands. The main road network consists of 3,102 kilometers of main roads as well as 1,259 kilometers of entry and exit slip roads and link roads. The main waterways network covers 1,686 kilometers of waterways. In 2007, 9,019 employees were working for the RWS in 10 regional areas, including 20 road districts and 16 water districts, 5 corporate centers and 3 project directorates [6]. Since 2004 the RWS has been undertaking tremendous efforts to develop into a professional public-oriented network manager by focusing on the needs of the infrastructure users and increasingly engaging the private sector in the design, construction and management of its infrastructure. Driven by policies of the national cabinet, the RWS realigned its procurement strategy and organizational structure in order to take on more and more the role of a commissioning authority. New forms of contracts were introduced with the primary aim

of reducing the direct engagement of the RWS in designing, building, operating and maintaining infrastructure assets and putting suppliers in charge of integrated service packages [7].

In 2000, encouraged by experiences from other sectors, the corporate management of the RWS decided to introduce performance-based contracts for infrastructure maintenance. The main idea behind the new contract is to functionally describe the work a contractor has to deliver. Instead of stating, for example, when and how many asphalt damages have to be repaired, the work specification only refers to the allowed unevenness and crack width of the asphalt. The contractor is responsible for recognizing and removing possible deviations of these performance criteria, but simultaneously obtains the freedom to optimize its own work processes. The RWS employees no longer have to measure the amount of work the contractor does, they only have to check whether the work is done correctly, which finally reduces the administrative workload. Since 2004 all regional areas have been required to work with performance-based contracts, and the RWS has gradually increased the amount of maintenance work covered by newly awarded contracts [8]. In recent years the RWS has also changed its means of contract controlling by requiring contractors to indicate the fulfillment of their contractual obligations [9].

B. Case Results

Although the interviews indicate that through the introduction of performance-based contracts the amount of administrative work at the RWS regional areas has decreased, they also revealed that the intended effects of the new contracts on the cost-benefit ratio of the service provision remains ambiguous. For example, a main intention of performance contracts is to stimulate innovative solutions that improve the quality or reduce the cost of maintenance activities. Many contractors, however, still try to minimize the allocation of their resources to deliver the lowest acceptable maintenance quality. This is strongly associated with an increasing discrepancy in interpretation of the contractual requirements between the RWS and the contractors. That causes additional discussions and conflicts which counteract the reduction of administrative work. The case study revealed that the introduction of performance-based contracts evoked contradictions within and between the following activity components of the RWS maintenance regime:

- the **contract form** which involves the extent, duration and content of performance-based contracts
- the **contract controlling** which deals with safeguarding maintenance quality or infrastructure performance as specified
- the **public-private cooperation** which describes the routines, procedure and policies of the inter-organizational relationship between the RWS and the contractors
- the **competencies of employees** which refers to the profile of employees at the RWS and the contractors for carrying out infrastructure management

The dynamics and complexity of the contract introduction

at the RWS arise from the interdependency of the different components. Changes in contractual arrangements, for example, influence contract controlling and the behavior of project participants. A new method of contract controlling requires specific competencies and the cooperation of project members. In the following the contradictions related to the different components and their interrelations are presented.

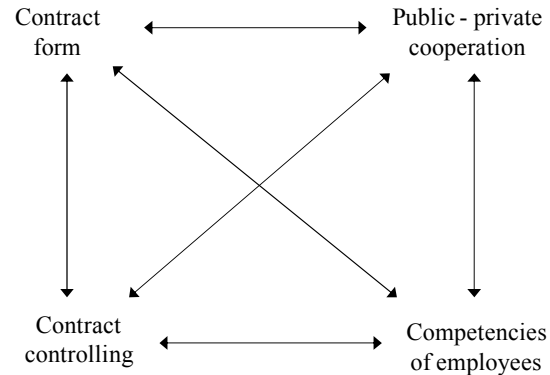


Fig. 2. Activity components causing contradictions in infrastructure management

1) *Contradictions due to Contract Form*: Central elements of performance-based contracts are the functional specifications of the maintenance service and the products to be provided. The main purpose of functional specifications is to offer more freedom to contractors for the organization of their work processes. An intended side effect is less administrative work for the RWS, since the contractors' work does not need to be described in detail and extensively controlled.

However, contradictions occur due to the way the maintenance work is functionally described, which diminishes the effectiveness of performance-based contracts. There are deviating answers within the RWS to the question: when are functional specifications reasonable. The contracts in place are based on technical performance requirements instead of service-related performance requirements. For example, when a contractor is asked to repair a bridge joint, the functional specification of the bridge joint is given to the contractor. The contractor has the freedom to choose a bridge joint which he believes fulfills the technical performance requirements. He is responsible for the product he is delivering. In other words, he bears the risk that the bridge joint may not show the required performance, and he will have to replace the bridge joint if this in fact occurs. However, the risk of traffic disturbances as a consequence of additional work lies with the RWS, since the contractor is not accountable for the accessibility of the road. Some regional areas of the RWS prevent these risks by still prescribing critical products to be used by the contractor. Particularly for objects with a high risk profile (e.g. for water protection), not only technical performance requirements are seen to be problematic but also service-related performance requirements. It is argued that contractors are not able to bear the risks of malfunctions of these objects.

In addition, different answers within the RWS but also between the RWS and the contractor exist to the question:

what maintenance work has to be done. Functional descriptions such as “a clean road” or “a visible board” allow multiple and subjective understandings of extent and frequency of maintenance work. Not surprisingly, the contractor tries to comply with the requirements with a minimum of resources. That may include that he maintains technical components in a way that the component fulfills the requirements for the duration of the contract, but that the same problems occur after the contract has expired. Besides differences in expectations – the RWS may assume the replacement of the component – the critical state of the component may lead to a claim of remaining maintenance made by the next contractor. Moreover, the effect of maintenance work on the life-cycle of single components or whole systems is not addressed by the way functional specifications are formulated. The single-method based contracts the RWS used in the past precisely prescribed how often certain maintenance work had to be done in order to achieve the intended life-span of the infrastructure. Performance-based contracts, on the other hand, provide functional specifications the infrastructure product of system has to meet. As long as the functional specifications are guaranteed, the contractual obligations are fulfilled. The effect of maintenance on the life-cycle of the infrastructure is neglected. For example, if a sewer system has to ensure a free flow of water, the system can be partly clogged but still can allow the water to flow freely. However, the contamination of the system may lead to an accelerated deterioration and the replacement of the system before the expected life-span is reached.

2) *Contradictions due to public-private cooperation:* With performance-based contracts the RWS integrates maintenance work, and one contractor becomes responsible for the execution of the work. At the same time the duration of these contracts is extended. With increased contract complexity, situations with unexpected incidents or problems which are not covered by the contract also increase. Cooperative solutions of these problems between public and private parties become more important for the success of the maintenance contracts.

Contradictions, however, appear through cultivated views on the behavior of the contract partner which act as barrier for an intensified cooperation. Within the RWS different interpretations exist as to whether cooperative behavior is possible and how it can be attained. At the RWS the perception dominates that many contractors potentially show opportunistic behavior, and the RWS employees therefore have a high level of mistrust. For some employees the behavior of contractors is independent from the contract form and cannot be educated. For other employees the contract can influence the behavior of contractors, if for example the contractor’s maintenance planning becomes part of the contract or the contractor has to inspect the infrastructure before the contract is awarded. While many RWS employees still show the same behavioral patterns, they expect from the contractors an immediately changed behavior. They act on

the assumption that the contractors will be more proactive, yet the extensive prescription and controlling of the contractors’ work in the past induced a strong passive behavior of the contractor. It has been neglected that contractors need time to adjust to their new role, to organize their work and to change their behavior. Moreover, immediately after the integrated, performance-based contracts were initiated, many RWS employees thought they no longer needed to engage in maintenance work. The expectation prevails that the contractor completely and independently manages all maintenance aspects but also problematic situations.

3) *Contradictions due to contract controlling:* With integrated, performance-based contracts, the RWS introduced a new way of contract controlling. The most important change is that RWS employees no longer directly control the work done by the contractor. The contractor takes on a much more active role. He writes a project quality plan and has to prove constantly that he complies with what he promised in this plan. The RWS, on the other hand, occasionally audits the process and product provision of the contractors.

Contradictions again arise due to the internalized behavior of the contract partners but also due to the lack of competencies, thus reducing maintenance quality assurance. Employees of the RWS and the contractor have different interpretations of how contract controlling should take place. In particular, employees who have been working at the RWS for a longer period face difficulties in trusting the contractors’ work. They were accustomed to directly observing and controlling in situ what the contractors were doing. As mentioned above, their relationship with the contractor is primarily characterized by mistrust, and this mistrust is reinforced by the passive role they are now expected to play. These employees believe that they lose control of the infrastructure quality. They experience more uncertainty about the work the contractors deliver. Their beliefs are not only rooted in mistrust but also in capabilities and competencies that are no longer suitable for the new way of ensuring the requested work to be delivered.

4) *Contradictions due to competencies of employees:* As indicated above, integrated, performance-based contracts require new capabilities and competencies of both public and private organization. Contradictions occur through the existing capabilities and competencies which are no longer applicable and which have to be replaced with newly acquired ones. Employees of the RWS and the contractors not only have to learn how to manage and control the contracts and to cooperate with each other, they also have to unlearn the way of working and the behavior they were used to. The changed contract controlling, for example, requires thinking in processes on a high level of abstraction instead of detailed knowledge about technical solutions. In addition, other communication and negotiation capabilities need to be developed. Particularly for the RWS employees, the focus is shifting from saying what to do to asking how work is done. Within the RWS, employees differently interpret this

competency shift or the extent to which capabilities and competencies have to be unlearned and which capabilities and competencies are needed in the future. For some RWS employees operational and technical competencies are essential to effectively manage infrastructure. This includes, first of all, system knowledge or knowledge about the interaction of infrastructure networks, objects and components. This knowledge has been gained throughout the years and contractors need time to build it up. Changing contractors after a new contract has been awarded is seen to intensify the situation.

IV. DISCUSSION AND CONCLUSION

The introduction of integrated, performance-based contracts is the attempt of many public organizations to increase the effectiveness and efficiency of their asset management activities. It has resulted from misalignments between the use of single method-based contracts for infrastructure maintenance and the changed politically-induced expectations about the outcomes of infrastructure management. The answer to the dissatisfaction with the maintenance practice was the development of the integrated, performance contract. However, our research showed that the new contract itself represents a disturbance of maintenance practice causing contradictions which so far have prevented the achievement of its intended improvements. The reason can be found in the historically and socially developed structure of the infrastructure management system, which includes a number of interrelated activity components. The integrated, performance-based contract tries to rearrange the way infrastructure management is carried out, but interferes with the familiar behaviors, understandings and roles of public and private parties. Two kinds of contradictions – new and aggravated – could be observed. New contradictions are related to different interpretations about the feasibility of the contract itself. The new contract elements (e.g. functional specification) entail situational and behavioral limitations which contradict the initial expectations. Aggravated contradictions already existed under the previous maintenance regime and are mainly related to the relationship of public and private organizations. The new contract reinforces their occurrence. In the case of the Dutch Highway and Waterways Agency, particularly the new way of contract controlling intensifies the disturbances caused by mistrust between the different parties. Although the importance of effective contract controlling increases with e.g. the bundling of single contracts, the implemented contract controlling cannot ensure the required infrastructure quality since employees need to unlearn capabilities, competencies and behavior acquired and cultivated throughout the years. Here also lies one of the major shortcomings of public organizations when implementing new contractual arrangements for infrastructure management. The case study suggests that the effects of integrated, performance-based contracts on working procedures, competencies of employees and

relational behavior of contract partners are insufficiently taken into consideration. Forced to quickly present a changed situation, the dynamic and complex character of the contract change is widely neglected. That also means that much effort is employed to find adequate answers to problems in the management of infrastructure, but less effort is spent to find ways how these answers could become part of the operational practice. The entire process from the first application in a pilot project until the wider use within the organization is hardly addressed. The adjustment of contracts to the peculiarities of the network is one reason why changed practices require additional effort and resources. Another reason is that often only through the application of a contract can its performance be observed and compared with the expected outcomes. The target/actual comparison form the basis for further improvements. As mentioned above, what is often neglected is the fact that the change process does not stop with a new concept or a first successful test in a pilot project. Implementation and consolidation of new practices are also connected with conflicts and problems emerging from contradictions with the existing social, legal and technical environment of which the new idea becomes part. Additional effort and resources are needed to meet these problems and to integrate the new solution into its surroundings.

REFERENCES

- [1] L. Vygotsky, *Mind in Society*. Cambridge, CA: Harvard University Press, 1978.
- [2] A.N. Leont'ev, *Activity, Consciousness and Personality*. Englewood Cliffs, NY : Prentice Hall, 1978.
- [3] F. Blackler, N. Crump and S. McDonald, "Organizing processes in complex activity networks," *Organization*, vol. 7, no. 2, pp. 277-300, 2000.
- [4] Y. Engeström, "Expansive Learning at Work: toward an activity theoretical reconceptualization", *Journal of Education and Work*, vol. 14, no. 1, pp. 133 -156, 2001.
- [5] J. Virkkunen and K. Kuutti, "Understanding organizational learning by focusing on "activity systems", " *Acting., Mgmt. & Info. Tech.*, vol. 10, pp. 291-319, 2000.
- [6] Ministerie van Verkeer en Waterstaat, RWS Annual Report, 2007.
- [7] Ministerie van Verkeer en Waterstaat, RWS corporate inkoopstrategie, 2004.
- [8] Ministerie van Verkeer en Waterstaat, Kadernotitie doorgroei naar presentatiecontracten, 2004.
- [9] Ministerie van Verkeer en Waterstaat, Handreiking systeemgerichte contractbeheersing, 2007.