Trafik analys

# Productivity via Procurement in the Rail Sector – *an international study*

PM 2011:10

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# Förord

Produktiviteten inom anläggningsbranschen är en viktig faktor för kostnads-effektiviteten i infrastrukturförsörjningen. Staten kan som beställare påverka produktiviteten i anläggningsbranschen främst genom sättet att upphandla anläggningsarbeten.

Denna studie syftar till att kartlägga och beskriva vilka erfarenheter transport-myndigheter i olika länder har haft när det gäller olika upphandlingsformer på järnvägsområdet, samt att identifiera de metoder som mest påverkar produktiviteten.

Trafikanalys tackar de personer som medverkat i undersökningen. Projektledare vid Trafikanalys har varit Björn Olsson. Författare och ansvarig för innehållet är Pekka A. Pakkala vid Aalto Universitet.

Stockholm i november 2011

Brita Saxton
Generaldirektör

# Contents

# 1 Project Introduction

This study was commissioned by the Swedish government agency Transport Analysis and performed by Pekka A. Pakkala at Aalto University who is responsible for the content and conclusions of the report.

This study was ordered by the Swedish government agency Transport Analysis (Trafikanalys) as a stepping stone to find ways to help improve the productivity of Sweden's infrastructure rail contractors. The research concentrates on the procurement mechanisms, which is the main tool that clients can apply. The findings herein are based upon an international study for the rail sector and include capital intensive projects as well as maintenance. This study is not aimed at productivity measurements or statistics, but mainly how productivity relates to project delivery methods. This section provides an introduction and background for the project.

## 1.1 Introduction

This international study was initiated to better understand what factors influence productivity and if lessons learned from other countries may help promote productivity gains in Sweden. This study concentrates on productivity from a procurement perspective.

Six countries were originally selected for the study, but both the USA and Canada rail sectors have been mainly privatized, so the focus will be directed toward Sweden, Finland, England, and Holland. Many of these countries are using alternative procurement practices to some extent and were selected as target countries, and are also part of the common EU framework.

## 1.2 Background

Transport Analysis desired to gather an understanding of how productivity issues are experienced by other countries that are using alternative or innovative project delivery practices. This project was implemented to study other countries' practices that might be applied to the Swedish context. Productivity is generally reported in terms of the entire construction sector and not just the rail infrastructure. Therefore, true productivity results are indeterminate and virtually impossible to determine under the present scenarios. Transport Analysis' main focus was to evaluate how the Swedish Transport Administration (Trafikverket) practices compare to international practices. This project was performed by the Transportation and Highway Engineering Department of Aalto University, in Helsinki, Finland.

A feasibility study showed that some countries have been using alternative procurement methods to gain benefits such as, efficiencies, cost savings, quicker delivery of projects, and value added benefits to society. Design-Build and its

variant models (DBOM, DBFO, BOTs and Alliance models) have been promoted through practical results, reports, studies and benchmarking. However, this study was to examine practices that might be more profound to influencing productivity. The results highlight those factors that have an influence on productivity and which approaches might encourage better performance.

## 1.3 Objectives

The objective was to determine what factors can potentially increase or decrease the productivity through the public procurement processes and identifies how productivity is potentially influenced in these models. The research objectives are summarized as follows:

- To identify the types of procurement practices used in other countries
- To identify better practices from other countries
- To determine the benefits, challenges, and issues with alternative methods
- To determine arguments used for different models
- To identify factors that contribute to productivity and innovation
- To determine the lessons learned from other countries

It is expected that the results from the study may be a catalyst for increasing the usage of alternative procurement methods that may provide an increase in productivity. Some of the expected results include:

- Determining procurement methods that have better results
- Identification of practices that promote innovation and productivity
- Determining factors that increase productivity and efficiency
- Can there be any Key Performance Indicators (KPIs) relating to productivity?
- What are the challenges when implementing the practices

## 1.4 Methodology

The research methodology was to gather resources through published reports, technical papers, internet searches, and with experts in the industry. Face to face interviews with the respective authorities were the main source of data collection, using a common questionnaire, as provided in Appendix B.

The interviews were conducted during January through June 2011 and Appendix A has a listing of those interviewed. The author's experience formed an overall addition to the report and studies are referenced in Pakkala (2002) and Pakkala et al. (2007). This study is a qualitative approach as it was not possible to perform a quantitative analysis due to time and budget constraints.

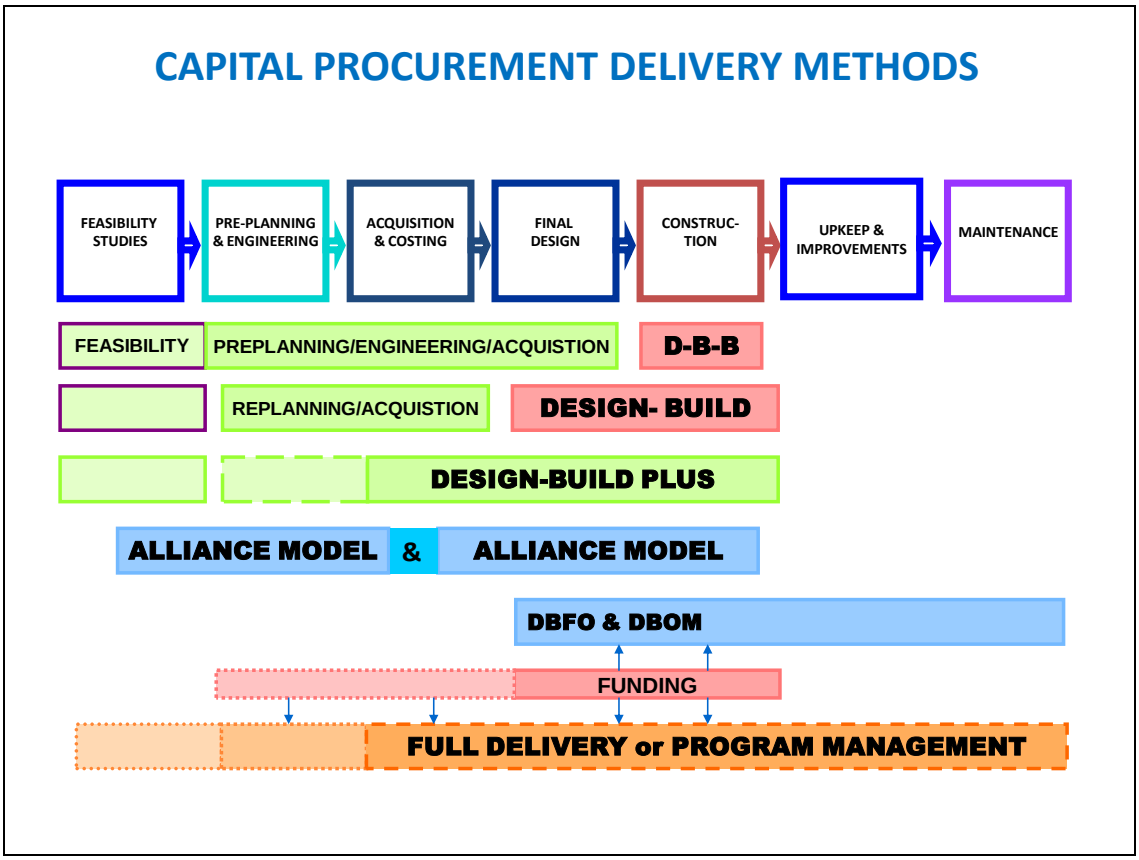
## 1.5 Procurement Methods

The main tool available for clients or owner agencies to influence the productivity of contractors is through public procurement processes. It is not possible to simply demand productivity gains from the contractors, but the client has the opportunity through the procurement process.

Selecting the best or most applicable project delivery method can be a complex decision making process and it should be made as early as possible in the planning and design stages. Selecting the appropriate project delivery method does make a difference in the outcome.
The most common project delivery methods or models include:

- Design-Bid-Build (D-B-B)
- Design-Build (DB)
- Construction Management (CM At-Fee)
- Construction Management (CM At-Risk)
- Design-Build-Operate (DBO) or Design-Build-Operate-Maintain (DBOM)
- Design-Build-Finance-Operate (DBFO) or some have terms such as Design-Build-Finance-Maintain (DBFM)
- Build-Own-Operate (BOO), Build Operate Transfer (BOT) and Build Own Operate Transfer (BOOT)
- Early Contractor Involvement (ECI) – a form of Alliance model
- Recently the "Alliance model"

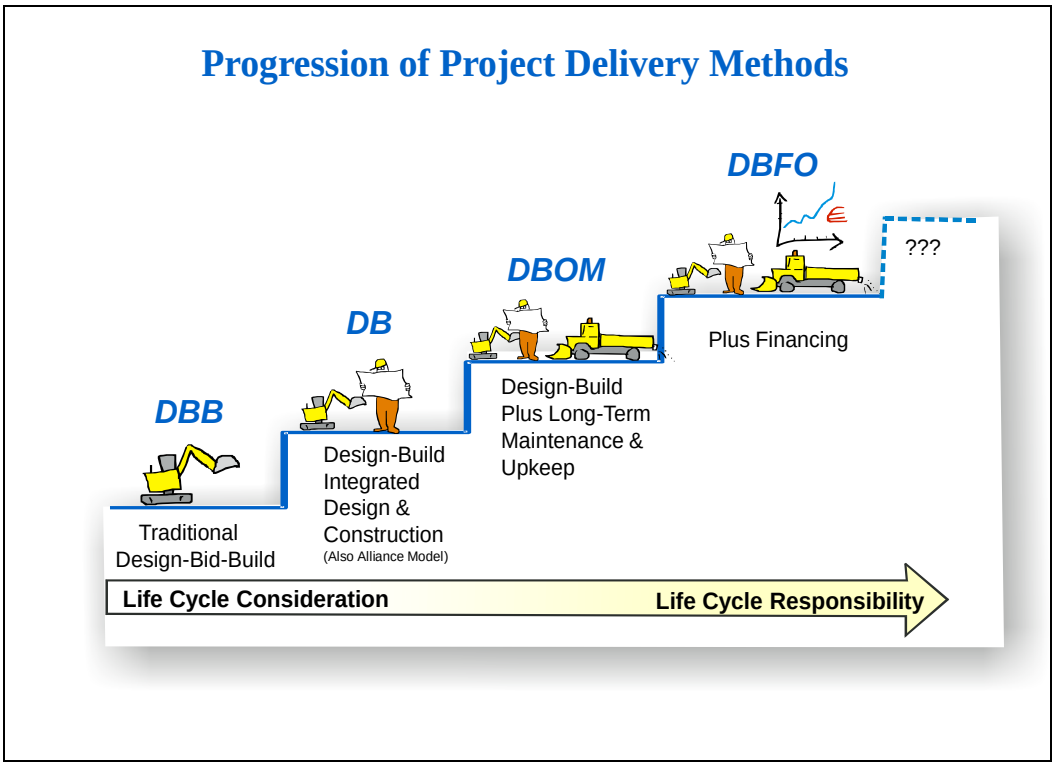
Figure 1 shows the main project delivery models from the perspective of the different steps used during the design, construction and maintenance processes.




Source: Pekka Pakkala GNA Presentation – Feb 15 2007

**Figure 1. Project Delivery Methods**

Figure 2 depicts an alternative approach and shows the progression of the procurement methods and the importance of starting at the lower levels before progressing to the higher levels. It is wise to achieve experience and practice at the lower levels before testing the higher levels.




Source: Pekka Pakkala and Finnra

**Figure 2. Progression of Project Delivery Methods**

The Design-Bid-Build (DBB) is often referred to as the traditional method and has a separation between the design phase and the construction phase. In DBB the owner/client hires a professional designer to provide the complete design services, which are used as the final construction documents. The owner/client tenders a separate construction contract to build the project according to the design documents.

The Design-Build (DB) model is when the owner/client procures a single organization to complete both design and construction services in one contract. There are various degrees of design development prior to the procurement and the entity agrees to complete the remaining portion of the client's design. This essentially means that the design and construction are integrated.

The Construction Management – At Fee or At Risk (CM@Fee and CM@Risk) is often referred to as "*Construction Manager General Contractor*". This is typically used when the owner/client does not have sufficient management skills or resources to manage and administer the project execution phase. The owner/client is responsible for the design, bidding process, and construction of a

project. In the CM@Fee method, the CM organization takes on the responsibility for administration and management, constructability issues, day-to-day activities, and assumes an advisory role throughout the project duration. When using Construction Management - At Risk (CM@Risk) approach, the owner/client has one agreement with the Construction Manager, who then interacts with the design consultant and subsequently takes on the role of a general contractor and is at risk for the project cost and schedule. The design and construction is still separate in these models.

The alternative variants of the DB model include DBOM, DBFO, DBFM, Early Contractor Involvement (ECI) and the Alliance model. The BOT and BOOT are similar to the DBOM and DBFO models, but there is an official transfer of ownership, with potential leasing and other options. The main goals are to produce projects that have better or equivalent quality, longer life cycles, bring savings to the client, transfer risks (to the organization best able to manage risks), include integrated processes, and potentially complete projects faster than traditional methods (DBB).

The ECI and Alliance model are like an extreme Design-Build model, where an alliance is formed early on to take advantage of inputs/impacts during the project planning phase. It includes the design and construction in one contract. Pakkala et al. (2007) and Koppinen and Lahdenpera (2004) provide more details on the Alliance model.

It is important to realize that one size does not fit all and that each project delivery method has its advantages and challenges. A wise client will choose the right delivery method for the right project. This requires good understanding, knowing the strengths and weaknesses, and the key drivers for the given project. All models are capable of delivering a successful project and each model should be used appropriately.

## 1.6 Productivity Issues

During the literature review, productivity can be defined in many ways and not always interpreted in the same manner. Sometimes productivity is described in terms of efficiency, effectiveness, performance, and even profit. In the manufacturing industry productivity is fairly well recognized and is typically described as the relation of output to all inputs.

This study is not aimed at productivity measurements or statistics, but mainly how productivity relates to project delivery methods.

### Productivity Definition

This leads to the issue of having a common definition of productivity that is used consistently. Productivity in this study is defined as the value of output divided by the value of all inputs. If value can be added or increased into the numerator portion of the productivity equation, then there should be productivity gains. Likewise, if the denominator portion can be reduced (more for less), then there are productivity gains too. So the real challenge is how do we get “more value or

less cost", so that productivity can increase, since most projects have a fixed budget?

## Challenges

Productivity results in the construction sector are typically compared with the manufacturing industry and other industries. However, this is an unfair comparison. Rail construction is normally performed in outdoor environments, susceptible to all types of weather related impacts, and not in ideal indoor environments as with typical manufacturing. Also, according to Olander (2010) maintenance is not included in the other sectors, but is included in the road sector. This is something to consider when comparing results.

Some of the challenges when discussing productivity include: are we measuring the right attributes; is the data accuracy high enough; is the definition used and understood by all stakeholders; is it a fair comparison when benchmarking one industry against others; at what level do you measure productivity; is it possible to determine productivity impacts using different procurement methods; and are you able to determine what caused the increase or decrease of true productivity.

If productivity is currently not measured by the clients, the next question might be, should they begin measuring productivity? Productivity statistics are generally measured by other governmental institutions and organizations, such as statistical authorities, and is an aggregate measure. There is also a widespread sense that the national productivity measures of the construction industry are much worse than other sectors, but until it is measured objectively, it is difficult to compare on a uniform basis. So there is great suspicion that the productivity data reported by the institutions and organizations are not accurate for the infrastructure sector.

Productivity measurements are usually measured at the same time construction is put in place. Some rail projects are more durable and have longer life cycles compared to others. As an example, if a higher level of quality is desired, it may be more durable over time, but may have lower productivity values. It is therefore difficult to assess the productivity over time and especially when compared to quality. This is an interesting and somewhat challenging aspect when assessing productivity data.

Productivity is certainly an issue that will continue to be discussed and debated. Measurements should be as objective as possible in order to allow comparisons.

## Productivity via Procurement

The intent of this project is to investigate productivity from a procurement perspective. If achieving productivity gains is a priority, then it is important to determine which procurement methods increase the potential for productivity. Even if a certain model might be potentially more advantageous, the productivity gains may not be automatic. It is important to understand what practices are used and why? Do alternative practices provide better performance, success, time savings, quality, or Value for Money (VfM) compared to traditional models?

These are important issues to obtain a comprehensive understanding of what models are available and which ones produce better outcomes or benefits.

Factors that reduce productivity are also important to identify so that clients are not directly contributing to any unproductive consequences to the contractors. It is not the intent of this report to concentrate on the productivity measurements and mechanisms, but it is important to understand that there are significant challenges when measuring productivity.

Alternative project delivery methods are relatively new to the infrastructure sector, especially for the rail sector.

## 1.7 Report Structure

The structure of the report is organized as follows:

| | |
|---|---|
| Chapter 1 | Project Introduction |
| Chapter 2 | Design-Build Model |
| Chapter 3 | Results from Capital Investment Project Interviews |
| Chapter 4 | Results From Maintenance Interviews |
| Chapter 5 | Significant Findings from Each Country |
| Chapter 6 | Summary and Principle Conclusions |
| Chapter 7 | Recommendations |
| Chapter 8 | Sources |
| Appendix A | Organizations Interviewed |
| Appendix B | Questionnaire for Capital and Maintenance |

# 2 Design-Build Model

This Chapter discusses the details, research findings, benefits, challenges, and important features in the Design-Build model, also called Design and Construct, that has been termed as an innovative or alternative model compared to the traditional model of Design-Bid-Build (DBB). All advanced variants of Design-Build, namely DBOM, DBFO, ECI and Alliance models use the Design-Build component. More information and aspects of the Design-Build model are provided hereafter.

The traditional model or DBB is widely understood and has been the common method for centuries. The industrial revolution resulted in the specialization of designers and contractors, and subsequently influenced DBB to become the common practice. The Design-Build method is much older and has its roots in ancient times according to Dorsey (1997). Design-Build was used as the main procurement method during the time of the pyramids and the "*Master Builder*" concept. The design and construction were performed by one organization and in an integrated fashion. Today, the Design-Build model is basically described as a procurement method, where the contractor is responsible for both completing the client's remaining design portion and constructing the project.

## 2.1 Studies and Observations

There have been numerous studies around the world addressing the Design-Build model and its use. Probably the most comprehensive study involved the comparison of DBB, DB, and CM@Risk and was termed as the Construction Industry Institute study (CII, 1997). The results of that study clearly identified Design-Build as the best performer based upon data from the research. Even though the study was applicable to buildings and industrial projects, the Design-Build component is the main feature that provides the overwhelming benefits. Some of the key findings from the CII study are summarized in Box 1.

**Box 1. Main Results from CII Study**

- Design and construction speed in DB is faster compared to DBB and CM@Risk
- Design and construction cost growth in DB is lower than DBB and CM@Risk
- Design and construction schedule growth is lowest in CM@Risk, and DB is lower than DBB
- Quality of DB is equivalent to CM@Risk and greater than DBB
- Intensity of DB is greater than DBB and CM@Risk

A more recent study in the road transportation sector by Ellis et al. (2007) contains interesting findings from transportation projects at the Florida Department of Transportation. The study benchmarked a total of 3130 road projects and the results clearly showed that the project delivery method chosen does indeed affect the project performance. The study compares alternative project delivery with the traditional method (DBB). The alternative project delivery methods include Design-Build, A+B bidding, lane rental, incentives and disincentives, lump sum, warranties, and a few others not commonly used by the participants in this productivity study. The overall findings include:

- Design-Build projects were about half the cost growth compared with traditional methods
- Lump sum projects experienced the lowest average cost growth
- Alternative contracting projects had one-fourth the total time growth compared with traditional methods
- Alternative and traditional contracting had about the same contractor performance
- Design-Build projects saved about 54455 project days (from 68 projects)
- The comparison of award cost to the FDOT official estimate were about 10% higher for alternative project delivery compared to traditional projects
- A+B contracting produced the highest time savings for construction
- Contractors achieved bonuses on 86% of the projects for A+B with bonus contracting, and 68% using bonuses alone

The Federal Highway Administration in the USA also performed a study termed the “Design-Build Effectiveness Study” in FHWA (2006). The conclusions revealed similar findings and showed that the Design-Build method typically does enhance time savings, lower cost growth and less change orders.

Adetokundo and Anderson (2006) also mention that the project delivery system selected greatly influences the efficiency and constitutes a success factor. Also, by having a structured process, it allows for greater insights for decision making.

Gransberg et al. (2010) also conclude that there is no optimum or best project delivery model that is applicable to all transportation modes.

Mostafavi and Karamouz (2010) also agree that there is no ideal project delivery system and selecting a method involves criteria that meet the client’s needs and requirements. As clients needs vary, then the criteria should be flexible.

Touran et al. (2011) evaluated transit projects in the USA and the study reveals that understanding the abilities and characteristics of various project delivery methods, will provide a rationale decision. Probably the biggest lesson learned is that rail is quite different than road and building projects.

Ibbs et al. (2003) addresses productivity in terms of cost change and schedule change. Discussion indicates that productivity levels for both DBB and DB were

very similar even though DB showed a slight increase in productivity when the project schedule is reduced (this is the main advantage of DB). Interestingly, the cost increased when the level of productivity decreased. It was also mentioned that cost savings are debatable when using DB. One key issue is to determine the appropriate project delivery method for any given project and not all projects are applicable to only one method.

## 2.2 Benefits and Challenges

The benefits and main advantages of the Design-Build model are summarized in the following:

- Time savings (accelerate projects)
- Potential cost savings
- Lower cost growth
- Fewer change orders
- Co-location enhances the teamwork, productivity and interaction
- More Alternative Technical Concepts (ATCs)
- More innovative construction techniques
- More design freedom
- More freedom and flexibility compared to traditional model
- Integration of design and construction
- Functional requirements (performance requirements) go hand-in-hand with the DB model

Some of the challenges with DB are listed as follows:

- Client cultural change and internal resistance
- Design-Build projects typically require significant client involvement
- Implementation takes time when using alternative methods
- Sometimes designers have been treated unfairly (like low-bid)
- The tendering cost can be significant (consider using stipends)
- Sometimes contractors have difficulty pricing the risks
- Ability to accept alternative proposals and ATCs
- Quality control decision made by the contractor can be challenging
- Large DB projects are more suitable for large construction companies as they may reduce competition
- Lack of real teamwork, partnering, creative thinking and sharing rewards

Some other issues when using DB are as follows:

- Performance and technical requirements are sometimes conflicting
- Keeping the design development to a minimum to stimulate contractor's innovations (typically this means design is about 30% maximum)
- Allowing enough time for thorough examination for proposal preparation
- Specify the design review times required by owners/clients
- Having enough competitors to take advantage of DB
- Risks should be clearly identified and allocated appropriately
- DB has been used as a viable method to enhance project outcomes, but is not a solution for all projects
- Takes time to become savvy in all aspects of DB

## 2.3 Characteristics or Factors when Selecting DB Projects

It is important to identify potential projects that might be suitable for the Design-Build model. Not all projects are suitable for Design-Build and it is important to understand what trigger points or factors might steer the project to be considered for Design-Build.

A successful framework for the Design-Build model requires above all, a cultural change in both the client and contracting industry. This also includes the participation of the design community, which should understand how to solve challenges, yet retain their previous expectations as a quality proponent for the client.

Songer and Molenaar (1997) investigated the characteristics of successful public sector Design-Build projects and revealed six important factors:

- Projects were on budget
- Projects were on time
- Project met the specifications
- Project met the users expectations
- There was a high quality of workmanship
- Minimized client aggravation

Molenaar and Songer (1998) provide insights into the characteristics of projects to be considered as a successful framework for Design-Build. These findings include:

- Clear scope definition
- The schedule duration or completion date
- High confidence in budget definition
- Applicable to complex projects
- Having sufficient owner/client experience and staffing resources
- Adequate time to prepare proposals and work better with performance requirements
- Using a combination of quality and price criteria for contractor selection
- Having prequalification for Design-Builders

Gordon (1994) looked at project drivers, owner drivers, market drivers, contracting issues and risks. The main project drivers include time constraints, flexibility needs, preconstruction services, design interaction and financial constraints. The owner drivers evaluated construction sophistication, current capabilities, risk aversion, method restrictions, and external factors. These are included in flowchart scheme that will guide the owner selecting the correct method.

In Touran et al. (2011) the results from drivers and objectives in USA rail transit projects indicated DB was driven by meeting tight project delivery schedules, had a positive result in cost certainty, most projects performed well, and risk analysis was not always fully formalized in projects that had delays. The factors that typically motivate clients were to reduce or meet project delivery schedules,

encourage innovations, knowing the costs early, and taking advantage of early contractor involvement. In addition, the study revealed 24 pertinent factors in the selection criteria for transit projects.

Touran et al. (2009) provides guidelines for transit professionals as a practical tool to help transit agencies selecting the most appropriate project delivery method. The tool includes a three tier process for the selection of project delivery methods. The three tiers include an analytical, a weighted matrix, and an optimal risk-based approach.

## 2.4 Lessons Learned in Design-Build

When considering Design-Build it is important to consider lessons learned from other colleagues, publication resources and international practices. It is wise to study the practices and challenges from others because Design-Build is not a traditional way of doing business. Some lessons learned from Design-Build are presented in Box 2.

**Box 2. Design-Build Lessons Learned**

- Selection of project delivery method does matter
- Development of a systematic process to determine project delivery selection
- Not all projects are suitable for DB
- Changing the internal culture and practices
- It takes time to implement Design-Build successfully
- DB is most applicable for time critical and complex projects
- DB usually provides savings, but not always
- Use functional requirements as much as possible
- Develop a successful approval process for ATCs
- Use incentives and disincentives appropriately
- Keep Design-Builder's equipment and employees working throughout project (fast tracking)
- Co-location of client, contractor and designers on large DB projects. Co-location often improves the teamwork
- Good project management from client and contractor
- Partnering is an important feature when co-located

## 2.5 Design-Build in Rail Projects

Design-Build is not typically a common procurement method used in the rail sector as compared to the road and other sectors. Rail involves significantly more complex systems such as safety, ICT and electrification systems. There are numerous technical standards, regulations and requirements that influence decisions and how projects are procured.

Table 1 shows a list of rail projects around the world that are either completed or in process using the Design-Build model or its variants. Most projects have been for urban rail applications such as, light rail, and commuter rail. The table shows a various mix of DB, DBOM, DBFO and Alliance projects. This is not a comprehensive list, but shows that these alternative project delivery methods can be used successfully in rail projects.

**Table 1. Listing of Design-Build and DB Variants in Rail Projects**

| PROJECT | Completion Date | Method Used | Infra Sector |
|---|---|---|---|
| University Line, Utah - USA | 2002 | DB | Light Rail |
| T-REX _Southeast Corridor Light Rail, Colorado - USA | 2006 | DB | Light Rail and Road |
| Middleborough Road Rail Separation Project - USA | 2007 | DB | Rail |
| Greenbush Commuter Rail, Massachusetts - USA | 2007 | DB | Light Rail |
| Hudson Bergen Light Rail, New Jersey - USA | 2007 | DBOM | Light Rail |
| I-205 Light Rail Extension Project, Oregon - USA | 2009 | DB | Light Rail |
| HSL Zuid (High-Speed Line South) - Holland | 2009 | DBFO | High Speed Rail |
| TrackStar Alliance Rail Link for Brisbane's West- Australia | 2013 | Alliance | Rail |
| South West Rail Link, Glenfield Junction Alliance - Australia | 2013 | Alliance | Rail |
| Toronto Airport Rail Link Spur Project, Canada | 2015 | DBFO | Airport Rail Link |
| OV Saal Southern Branch Line - Holland | 2016 | Alliance | Rail |

# 3 Results from Capital Investment Project Interviews

Selecting the appropriate project delivery method can be a complex decision making process and it should be made as early as possible in the planning and design stages. The results in this section are mainly from the interviews with the rail clients and the influence between procurement practices on productivity. Other published resources are included to enhance the discussion. Capital investments are those projects that consume a great deal of capital or money to complete a project. It represents the building of the new rail projects, ballast, track, switches, bridges, tunnels, and significant rehabilitation or reconstruction.

## 3.1 How Infrastructure Clients Affect Productivity

The infrastructure clients can affect the productivity of contractors mainly through the procurement processes. Indirectly, the clients can also communicate their wishes to improve contractor's productivity through close communications, sharing of ideas, and some loose forms of client-contractor activities or associations.

Outsourcing or competition is the main way to increase productivity. In most cases the works or construction has been publicly tendered, but some works may have been completed by in-house forces before restructuring occurred in the rail sector. The issue then becomes, what forms of procurement potentially enhance the productivity of contractors.

One of the challenges in the rail sector is to have a fully functional competitive market for alternative project delivery methods, which may not exist in the Nordic countries. The experience is that there is limited competition in the rail market.

## 3.2 General Factors that Potentially Influence Productivity

One question in the survey was to determine the "*factors in general*" that contribute to the productivity of rail contractors. Based upon the literature review there were several reports that listed several factors that lead to productivity gains. Chapman et al. (2010) describe the usage of life-cycle processes, technology/innovation utilization, highly skilled workforce, offsite prefabrication and modularization, and the Building Information Model (BIM – described

subsequently in more detail) as factors that influence productivity. Also, the Construction Industry Institute (2008) states that newly developed construction equipment (intelligent machinery), automation and integration of project information systems, prefabrication and modular components, and interoperability via the BIM could all contribute to improved productivity.

## Factors in General that Potentially Influence Productivity

Box 3 summarizes the results from the interviews that describe the general factors that possibly improve productivity. These aspects have the ***potential*** to increase productivity, efficiency and even innovation.

**Box 3. General Factors that Potentially Influence Productivity**

- Open and healthy competition
- Incentives and disincentives in contracts
- More freedom and flexibility for the contractors (there are too many rules, regulations and restrictions)
- Use of performance-based requirements
- Prefabricated and off site production of bridges (SPBT)
- Use of innovation and ATCs
- Risk balancing
- Building Information Model (BIM): not fully developed
- Increased planning by contractors
- Warranties
- Partnering and teamwork – collaborative process
- Standardization broadly applied – even internationally
- Project management
- Bundling of projects

## Healthy Competition

Open and healthy competition in the rail works is very important, especially if alternative and innovative practices are desired. One key aspect was the opening of competition as rail has been in essence, a monopoly in the past. This is a challenge as it is difficult to quickly change practices in a short period. Where there is a healthy and competitive market for the services, there is more potential to influence the productivity and efficiency.

## Incentives and Disincentives

Some rail clients are using incentives and disincentives in the contracts and these have often led to productivity gains, because there was a motivation and reward mechanism in place. Reward mechanisms have been mainly applied to reducing the number of delays and failures to the rail operators. Time based criteria can also be used when there is a need to complete bridges or other

products to avoid travel delays (fewer working days or evening work). Several success stories have been reported when incentives and disincentives were used, especially when delays, disruptions, and time-based aspects were important.

## Flexibility and Freedom

Allowing the contractors more freedom and flexibility when performing the work can lead to productivity. There are numerous rules, regulations, and restrictions that need to be more flexible and this can be applied generally throughout the project.

## Performance/Functional Requirements

The rail sector has numerous technical standards and requirements since safety, durability, and repeatability are important considerations. The use of performance-based or functional requirements was agreed by all to increase the productivity of contractors. Functional requirements can provide flexibility, freedom to use alternative materials or methodology, and it enables contractors to be more smart and innovative. The development of functional requirements is more of a long-term process and it takes time to create measures that produce the right behavior for the contractors. In addition, an approval process is also required to be sure that the requirements meet the intended purpose and is repeatable. It is also known that there are many proven standards and long-term research behind the functional requirements and they should not be considered as a solution. A robust and proven approach is needed before performance requirements can be applied broadly.

## Prefabrication

The main issue seems to be construction or replacement of bridges and structures, without disrupting existing rail lines. Prefabricated bridges, off-site bridge production, and Self-Propelled Bridge Transport (SPBT) are used in some countries but rarely in the Nordic countries. This is an innovative solution which can be used without impeding or disrupting passenger or freight traffic. Prefabrication techniques have vastly improved since earlier years and are gaining acceptance. However, these new and innovative techniques may not be utilized due to untested/ unknown results and they require a new way of thinking from the bridge engineering departments, according to the interviewees. An example of this type of bridge innovation can be seen in Figure 3, which shows the installation of bridge elements along the corridor of the construction site of the “*Washington DC Metrorail Extension Project*”.

## Alternative Technical Concepts

Alternative Technical Concepts (ATCs) have been used successfully in some countries, but the difficulty arises when the evaluation of these technical concepts is included during the tendering phase. When ATCs are accepted, the contractors may provide the client with increased productivity, savings, and innovations (usually go hand-in-hand). ATCs can be used by any procurement method, provided that they are accepted and approved by the client. It is difficult to say why they are not used more often, but comments from the interviews

indicate it may be due to the lack of time constraints or expertise approving these ATCs. The inclusion of ATCs has been more of an exception than the normal processes. ATCs that present untested or unfamiliar techniques to the clients may be rejected due to the unknown risks and potential consequences for negative results. One example is the use of bridge advancements seen in some countries, where bridges are built near the site and placed in position within a few days. ATCs are significant challenges and it appears that the clients have to take the risks and be courageous to test these innovations.


Source: Photo by Pekka Pakkala

**Figure 3. Example of Self-Propelled Bridge Transport. Installation of bridge elements along the corridor of the Washington DC Metrorail Extension Project.**

## Risks

Risks play a significant role in most capital projects. It is wise to know what factors cause risks to increase or decrease, as contractors will bid them in the contract. There is a tendency to reduce the risks for the contractors in order to achieve lower prices, but there is a proper balance or tradeoff. Balancing the risks usually comes from experience. When using alternative contracting methods, the risks are often transferred to the contractor, but there are some risks like geotechnical risks that should be shared or use a sliding scale risk for those difficult and challenging areas. A sliding scale risks may usually include a maximum risk that contractors will be responsible.

## The Building Information Model

The Building Information Model (BIM) is worth mentioning because it is used in other sectors like roads and buildings. BIM is expected to decrease the amount of design errors and omissions to a point where productivity gains can be

achieved. Land mass calculations, visualization of the end product for the key stakeholders, automated calculation of costs, and other parameters can be used from the BIM. When the BIM is fully operational it can be used directly into the production processes of the contractors or supply chain.

### Increased Planning

Rail sector projects are mainly renovation and reconstruction versus new alignments that are so called Greenfield type (with very little disruptions to existing alignments) projects. This can mean that a typical rail project (non-Greenfield) may require "*increased planning"* and take advantage of lean construction practices due to the limitations in construction times. This shows that a well designed and planned approach may lead to better efficiency and productivity.

### Miscellaneous factors

Other factors like warranties, partnering, as much standardization as possible, the project manager's competence, and the bundling of projects or individual activities will most likely contribute to a positive influence on productivity. Almost all interviewees stated that these factors influence productivity but are difficult to evaluate quantitatively.

## 3.3 General Factors that Potentially Decrease Productivity

There are also factors that contribute to potentially *decreasing* the productivity and may be attributed to several causes. A list of factors that potentially decrease productivity is presented in Box 4. Each is elaborated upon.

**Box 4. General Factors that Potentially Decrease Productivity**

- Too many rules, regulations, restrictions and constraints
- Too many method-based requirements
- Traditional cultural between client and industry
- The quality of design has decreased
- Not maximizing the usage of labor and equipment
- Yearly budgeting system requiring a net zero balance
- Mismatch in the Project Approval Cycles
- Additional environmental and administration burdens
- Shortage of skilled workers
- Unbundling of projects (slice and dice)

## Restrictions

Some of the countries are experiencing general issues or factor that have a negative effect on productivity. The most common response was the numerous amounts of rules, regulations, restrictions and constraints. These restrict the potential of contractors. Some common constraints are in working periods, especially where projects are located in large cities.

## Method-Based Requirements

Just as performance/functional requirements increase the potential of productivity gains, the significant amount of method-based requirements reduces the flexibility and freedom of the contractors to obtain productivity gains. The rail sector is very susceptible to having numerous and detailed method-based specifications.

## Traditional Culture

A "*stove-piped*" or traditional culture exists in many client organizations and sometimes within the construction industry. There is a long standing cultural and history of doing things a certain way and this often requires changed management principles to be overcome. This also applies to the contractors, but is more noticeable in the client organizations. Many contractors are also not willing to take risks unless rewards are substantial.

## Degrading Design Quality

In all countries there is a perception of degrading design quality. This was a shocking result that was common during the interviews. The cause of this was uncertain, but all countries in the study have reported more errors and omissions as well as poorer design quality compared to recent years. This may require a further study.

## Not Maximizing Resources

Only in Sweden were there comments of not maximizing the use of labor and equipment during the construction period. There is a perception that the labor and equipment is only being used four days a week and not utilized to its maximum potential. This may be due to labor rules or worker flexibility, but can cause a negative effect on productivity.

## Financial Considerations

Most countries require a net zero yearly balance budget for all project expenses. Actual spending must match the calculated/estimated yearly expected costs required by the governmental financial agencies. Project overruns or savings are not desired by the financial governmental institutions and require close scrutiny and monitoring of the spending accounts. Sometimes these conflicts may cause project delays and could have a negative impact on productivity.

### Mismatch in the Project Approval Cycles

Some project budgets in the Nordic countries are not approved until December (year ending) by the political decision makers. A typical result is construction tenders being awarded in the fall or winter of the following year, when very little physical work can be done. It would be more efficient and productive to have the design available during the winter periods and construction starting as soon as possible in the springtime. So project approvals can be affected by governmental requirements.

### Bureaucracy

The additional administrative burden along with increasing environmental requirements may result in a decrease in productivity. These may not have a significant impact on the overall outcome, but the client should demand compliance with procedures and processes only for those administrative issues that are relatively important. On the other hand, sometimes environmental requirements may also trigger innovations and ATCs.

### Skilled Worker Shortages

More recently, countries have been experiencing shortages in skilled labor as the technology gets more sophisticated. Equipment and systems are technically challenging and there were comments of not having enough skilled workers. This could potentially limit the use of equipment and systems and cause a downturn in productivity.

### Unbundling

In the rail sector, there is a classic practice of unbundling projects or dividing sections of the project into more projects. There are perceptions that unbundling can contribute to lower prices and increase the competitive market. However, the tendering of several extra projects would result in additional administrative burden. Also, the quality of each interface would require significant resources and may possibly cause tension in the boundaries. This is opposed to other sectors, where bundling of projects and elements has typically provided cost savings and better efficiencies. The concept of bundling or not is debatable and without quantitative data for either argument, it is difficult to assess. This too would require further study.

## 3.4 Factors in Procurement that Potentially Influence Productivity

The factors influencing productivity in general were described in an earlier section and many of these can be included in the procurement practices. According to the results from Ellis et al. (2007) and from practical experiences, it does matter which project delivery method is chosen and which ones influence productivity. Adetokundo and Anderson (2006) also state that the project delivery system selected greatly influences the efficiency and success of a project. They also mention that having a structured process allows for greater insights for decision making. The results from the interviews are subsequently listed and

provide insights to those methods that influence productivity. Box 5 shows the main factors in procurement that influence productivity.

**Box 5. Factors in Procurement that Potentially Influence Productivity**

- Healthy competition is vital and even internationally
- Design-Build model (integration of design and construction)
- Early Contractor Involvement (ECI)
- Incentives and disincentives
- Performance/functional requirements
- Innovative or Alternative Technical Concepts (ATCs)
- Warranties
- Time based criteria by minimizing delays and disruptions
- Prefabricated or off site fabrication (Self Propelled Bridge Transport - SPBT)
- Bundling of projects
- Partnering - indirectly
- Standardization generally applied
- Project manager's competence
- Building Information Model (BIM): not fully developed

## Design-Build Model and its Variants

A majority of all interviewees stated that Design-Build has the potential to improve productivity and provide better performance. The integration of design and construction provides the framework for potential innovations, efficiencies and time savings. When implemented correctly, Design-Build permits problem resolution, integration of many services and creativity. However, there are certain characteristics that need to be implemented and some pre-requisites were mentioned in Section 2.

It was interesting to observe that a majority of the countries have tested the "Alliance or ECI model" (except Finland – one in process). The findings vary from country to country, but the overriding experiences are that cooperation, partnering, teamwork and problem resolution function extremely well. It is uncertain at this time if Value for Money (VfM) was achieved. A significant challenge when attempting to use the Alliance model would be limited competition.

## Miscellaneous Factors

Other factors like incentives and disincentives, more performance requirements, allowing for contractor innovations and ATCs, warranties, time-based criteria by minimizing delays and disruptions, bundling of projects or individual activities, partnering, standardization broadly applied, the project manager's role, and the potential of the BIM will most likely contribute to the positive influence on productivity. These were already discussed and highlighted in Section 3.2.

The main challenge or difficulty is measuring the quantitative influence of each aspect towards productivity. This was not possible in this study and requires further research.

## 3.5 Discussion and Observations

The experiences from the Design-Build projects show mixed results, some have performed well and some not so well. Some of the poor performing DB projects might be explained by a lack of experience with DB, not having enough resources for the client and contractor (phasing of projects), not treating the design entity fairly, lack of performance/functional requirements, lack of creativity with local designers, and not considering risks in the project. On the other hand, there have been numerous examples of good outcomes and successful projects. The Design-Build (DB) method was considered having the most positive effect on productivity due to the integration of design and construction.

Ibbs et al. (2003) address productivity in terms of cost change and schedule change. The study indicates that productivity levels for both DBB and DB were very similar even though DB showed a slight increase in productivity when the project schedule is reduced (main advantage of DB). It was interesting to note as the cost increased, the level of productivity decreased. It was also mentioned that cost savings are debatable when using DB. These results come from building and industrial applications and it would be interesting to complete a systematic study for the productivity of rail contractors.

In most cases DB has provided savings, but not always. It depends upon the different motivators for the project and what constraints might be applicable.

Only Holland had experienced a DBFM rail project and the results are not available, but comments indicated that it may be more costly.

The Alliance or ECI models have been used in England and Holland. Sweden has not used the Alliance model and Finland has recently tendered their first one. The model is quite new on a global scale except for Australia and New Zeeland. The teamwork and cooperation aspects are the strongest benefits and expediting the project to a point where the projects costs can be determined. The Value for Money (VfM) has not been evaluated or is perceived to be lower compared with other models. However, there needs to be a systematic appraisal in order to properly allow comparisons with other models.

The Design-Build model is not completely accepted by all rail sector clients except for England, but most agree it should be tested and used more often to determine its acceptance and validity. Many comments revealed that the competition for Design-Build in the rail sector is limited. Other concerns are the lack of experience from the client and contractors, the higher costs of tendering, too many technical restrictions and regulations, and that DB is not perceived as a solution.

A long term procurement strategy or plan should be introduced by the client organization in order to drive the process and communicate the long term needs, so contractors are able to react accordingly. This would assist meeting the challenges previously described and knowing that it takes time to change from the traditional practices. Announcing a procurement strategy is a common practice in many countries.

Alternative Technical Concepts (ATCs) have been successfully implemented in some countries, but the difficulty arises when the evaluation of these technical concepts need to be completed during the tendering phase. When ATCs are accepted, the contractors have often provided the client with increased productivity, savings and innovations. ATCs can be allowed in any procurement method but the inclusion of ATCs has been more of an exception than the normal process.

One example is the use of bridge advancements seen in some countries, where bridges are built near the site and placed into position within a few days. Prefabrication techniques have vastly improved from earlier years and are gaining acceptance. These newer techniques may not be utilized, due to untested/unknown results over the usable life, and it requires a more long-term approach by the bridge engineering departments. ATCs are a significant challenge if the client is unwilling to accept bridge innovations, due to the long time acceptance of traditional practices. It appears that the clients would take the risks and be courageous to test these innovations. The question then becomes, how can the client become more willing to accept the risks of ATCs? This is a key challenge since ATCs are examples of innovations and potential productivity gains. One possible solution is to test these innovations via pilot projects and possibly applied to non-critical locations.

England has been pro-active in the application of pedestrian bridge innovations because of the need to prevent significant delays or adversely affect journey times. They have used common bridge span elements to construct other bridges and take advantage of innovations.

Cost certainty was mentioned by some clients and the importance of collecting the cost data and unit prices. It is important for the client to determine which costs affect which elements or categories and hence influence the prices. Despite collecting the cost data and the market prices, contractor behavior and other factors could influence cost certainty. It may be inconclusive to have cost certainty, but collecting the cost data is important.

Table 2 shows a summary of the project delivery methods used by each country. It is interesting to note that most of the projects are mainly using the DBB method, except for England (14% by costs). England extensively uses the Design-Build methods and is planning to use the Alliance model more often. Holland is the only country that has used the DBFO.

Most of the DBB projects are small in value, because these are typically upkeeps and renovations and not new alignments. They are typically replacements of an

aging infrastructure and updating to today's requirements. Sweden on the surface appears to be using more Design-Build contracts, but they are only 4% by costs as compared with Holland in which it is 25% by costs. Finland is the most conservative and almost all projects are done via DBB.

**Table 2. Comparison of Capital Project Delivery Methods**

| | DBB Projects | | DB Projects | | ECI or Alliance | | DBFO Projects | |
|---|---|---|---|---|---|---|---|---|
| | **By #** | **By Cost** | **By #** | **By Cost** | **By #** | **By Cost** | **By #** | |
| **England** | 22% | 14% | 76% | 69% | 2% | 17 % | 0 | |
| **Finland** | 99% | 92% | <1% | 8% | 0% | 0 % | 0 | |
| **Holland** | 87% | 70% | 12% | 25% | 1% | 5% | 1 | |
| **Sweden** | 82% | 96% | 18% | 4% | 0% | 0% | 0 | |
| | | | | | | | | |

Note: Data is collected from the last 3-5 years

Every project has a different set of requirements, objectives, challenges, and the owner should carefully consider these requirements in the context of their own culture, environmental issues, and technical characteristics to decide which project delivery method provides the best opportunity for success.

The main benefit of the Design-Build model is the potential to foster innovation, reduce project duration, and address customer oriented solutions (especially disruptions) by integrating the design and construction phases.

Productivity on the other hand is mainly driven by the contractors' processes, methodology, ingenuity, project management skills, innovation, and lean construction practices (reducing waste in all phases). The main influence by the client is to use the best procurement method for the project and allow enough freedom for the contractors without corrupting the objectives of the customers. There is no guarantee for success, but the clients should provide the best opportunity or framework for success.

## 3.6 Characteristics or Factors when Selecting DB Projects

Another topic from the structured interviews was to describe pre-requisites, characteristics, or factors when selecting Design-Build. Many factors or characteristics were already described in Section 2.3. These can be valuable information for other clients who are not as experienced in what makes a good Design-Build project. In the rail sector, there are very few clients that have developed a guidebook or framework for successful Design-Build projects, and what characteristics promote a good DB project. As mentioned in Section 2.3,

one such guidebook is described in Touran et al. (2009) from the USA transit agencies and may be a good resource to consider. Box 6 shows characteristics or factors used when selecting Design-Build that were mentioned during the interviews.

**Box 6. Characteristics when Selecting Design-Build Projects**

- Less design development
- Complex projects
- Schedule driven or urgent completion dates
- Suitable for innovation
- Having enough staff resources to manage projects
- Level of performance requirements used
- Not applicable where too many constraints
- Risks need to be analyzed and taken into consideration

## 3.7 Potential Performance Indicators

A single measure of productivity or index is extremely difficult or not measureable for the infrastructure contractors and is therefore not reported. Labor productivity results are typically used for the entire construction industry and a fair comparison is not practical.

The interviewees were asked whether there are any indicators that might represent some relationship to productivity. It was very difficult to objectively correlate any indicators of productivity, but cost (€/km) was the most common recommendation and is a typical benchmark in the rail sector. The unit prices are not used for productivity requirements, but merely to assist in the cost estimation of future projects and for benchmarking against other countries. It is also very difficult to compare the costs that are not homogenous and to compare cost of urban versus rural areas.

**Box 7. Potential Key Performance Indicators (KPIs) in Capital Projects**

- Project cost (€/km)
- Schedule (on time)
- Quality (subjectively)
- Number of change orders submitted by contractors
- Failures and disruptions
- Train delays
- Customer satisfaction during construction (subjectively)
- Safety (both to workers and rail users)
- Environmental requirements like $CO^2$
- Verification, validation and performance

EU countries share common practices and there are many measures used in the common EU framework. The rail sector benchmarks are much more common compared with the road sector.

However, it is possible to have qualitative productivity indicators or Key Performance Indicators (KPIs) that resemble some form of productivity, even though they cannot be measured objectively. Some of these KPIs stated by rail clients are included in Box 7. Some measures are very difficult to objectively quantify, for example quality and customer satisfaction.

## 3.8 Other Findings

There were other findings or factors not specifically related to procurement or productivity measures. Some are general in nature, others are indirect, but they have some effect or correlation to productivity. These findings are presented in Box 8.

**Box 8. Other Findings**

- Lack of systematic evaluation in procurement methods
- Using lean construction practices
- Low bid was not always used in contractor selection criteria
- Rail is different than other infra sectors
- Rail has higher productivity – subjective comments
- Trials may change attitudes
- Communicating a procurement strategy
- Collaboration, communication and teamwork
- Upset pricing – stipulating the maximum tender price
- Contractor working methods
- Co-location of parties in Design-Build

### Lack of Systematic Evaluation

The main finding shows a lack of systematic benchmarking between the objective results used from different project delivery methods. Many comparisons were more of a subjective nature and not based upon quantitative measures. There was a significant consensus that prices were lower for Design-Build projects, but lacked real comparisons. Most agree that DB produces shorter project duration, but should be calculated and reported. This is one lesson to be learned and that a quantitative evaluation should be performed for each project.

### Lean Construction Practices

Lean construction principles and practices do increase the productivity along with the type of working methodology/practices of contractors. These factors are mainly determined by the contractors and difficult for clients to demand. Clients

should contemplate those factors in the contracts that provide a framework for success and drive the correct behavior.

### Low Bid or Not

Another observation was that “low bid” was not always used by all countries in contractor selection criteria for the project delivery method. DBB tends to favor more price-based selection, but the Design-Build and its variants include more factors other than price. Possibly, this can be attributed to more technical requirements. Interviewees stated that they did not want poor or lower quality services because safety is such an important issue.

### Rail is Different

There were comments from a few interviewees that the rail sector has better productivity. This is not substantiated, but may have some merit because much of the work (non Greenfields) is only accomplished during selective time periods and requires better planning and efficient practices.

Unlike other sectors, rail projects need a different perspective when selecting a project delivery method. Significant constraints include the lack of robust performance requirements, many specialty type contractors, limited resources, and often providing supplies and materials to take advantage of economies of scale. There are also strict working standards, permit requirements and dealing with local government and municipalities.

### Trials May Change Attitudes

Nevertheless, if there has not been significant testing and use of alternative project delivery methods in the rail sector, it is not possible to benchmark and know what project delivery methods are more successful than others. There also needs to be a change in attitude from “*why change*” to “*why not try*” the alternative methods instead of the traditional practices, according to the interviewees.

### Other Findings

Other findings include; development of a procurement strategy and communicating this to the construction industry is useful, test the use of upset pricing, encourage efficient contractor working methods, and co-location of all key parties (all working together are same site/location) in DB projects. When the designer, contractor and client are co-located there is much more potential for productivity gains because decisions are made quicker and with less administrative burden. This goes hand in hand with collaboration, communication and teamwork philosophy.

## 3.9 Lessons Learned from the Interviews

There were many lessons learned compiled from the face-to-face interviews. A collection of the lessons learned are presented in Box 9. Some of these were discussed in earlier sections and this is not an exhaustive list.

**Box 9. Lessons Learned from Interviews on Capital Projects**

- Productivity of rail contractors is difficult to measure
- Pick the right project with the right procurement method
- Develop a systematic evaluation of all delivery methods
- Alternative methods should be tested
- Rail projects may require a modified approach
- It is a challenge to change the internal culture and practices
- There are good and poor examples of DB projects, but a majority have been favorable
- It takes time to implement alternative methods successfully
- Cultural differences affect acceptance and implementation
- Robust performance requirements need to be developed
- Providing freedom and flexibility to the contractor
- Alliance model has good potential, but lacks proof of VfM
- The good practices in DB and its variants can be also applied and added into the traditional model - DBB
- Challenges dealing with local and national government
- Collect the cost data and unit prices
- Incentives and disincentives can be applied to time based issues, disruptions and delays
- Use of prefabricated and off site production of bridges (self propelled bridge transport)
- Client should be an active participant in alternative models
- Consider using upset prices
- Contractor selection should not be low bid
- Client scope needs to clearly defined and communicated
- Approval process for approving innovations (ATCs)
- Find and use factors that drive the correct behavior
- Lean construction practices should be applied
- Increased planning by contractors
- Formal or informal partnering is important
- Encourage development of the BIM

Probably the most important lesson learned is that rail is significantly different compared to road and building projects. The project delivery method used should be grounded on good business decisions, specific characteristics of the rail sector, demonstrate efficiency, and consider regulatory issues.

# 4 Results from Maintenance Interviews

Maintenance projects significantly differ from capital type projects and the productivity of maintenance works is not measured by any country in this study. A productivity measure is therefore not available and it is virtually impossible to have any productivity measures for maintenance. It may be possible to measure the performance of maintenance contractors, but there is a lack of measurements related to productivity.

Selecting the appropriate contracting model for maintenance is not as complex as compared with capital projects. The results in this section are mainly from the actual interviews with the rail clients and how the procurement practices relate to productivity and what factors potentially influence the productivity of maintenance services.

## 4.1 Background Information

Maintenance of the rail infrastructure was previously in the hands of the public organizations for a long time and was considered a public monopoly. After restructuring of the rail sector and the mandate for open competition, most of the maintenance services have been performed through competitive tendering and open competition, except in England. The greatest challenge is to develop a healthy competitive market for rail maintenance services. For comparison, the road sector has been competitively tendered for over 10 years in several countries. The amount of competitors in the road typically ranges from 3-5 according to Lodenius et al. (2010). The rail sector is not as competitive and this might be explained by the high cost of market entry.

All countries interviewed have placed maintenance services into open publicly competition in the form of area based contracts, except for Network Rail in England. Network Rail has gone back to providing the services in-house, partly due to previous challenges and experiences. Healthy competition is a concern for all countries outsourcing the maintenance, because the previous in-house organizations had a competitive advantage and a competitive market is not automatically created. Also, maintenance and management are included in maintenance contracts or by the in-house staff at Network Rail.

Maintenance in practice is defined as the act of fixing, replacing, providing services (e.g. snow removal) as opposed to constructing or building the infrastructure. One of the challenges is to predict or estimate time to failure and use effective asset management practices. The purpose of maintenance is

extending the service life to its functional limits, which can be very difficult to determine in advance. This in essence requires good asset management practices and having systems that measures the asset conditions, so that the maintenance services are efficiently and effectively delivered. It would be beneficial to have a Life Cycle Costing (LCC) system utilized.

Most countries incorporate a systematic measuring process using a series of response times that must be met in the asset maintenance regime. Some are using asset condition measurements such as the Track Quality Index (TQI) which is captured via automated measuring systems. The maintenance practices are using a performance based approach, where the contractor is encouraged to use innovative or new practices. However, there are time restrictions when the work can be done, usually during the late evening or early morning periods. The challenge is to have (functional) performance requirements that are robust and are measuring the appropriate aspects.

Since the rail sector is heavily regulated and has numerous standards and restrictions, there are common measurements or benchmarking within the EU countries.

## 4.2 How Infrastructure Clients Affect Productivity

For maintenance projects it is even more difficult to increase the productivity, as maintenance is the repair or preventative approach to keep assets in reasonable condition. The infrastructure clients can affect the productivity of contractors mainly through the procurement processes or through an in-house performance measurement system (Network Rail). Indirectly they can also influence the contractors' productivity through close communications, sharing of ideas, and some loose forms of client-contractor cooperation.

The main influence on productivity for the clients is to choose the best maintenance contract model. In the case of Network Rail in England, productivity can be affected through a reward system and benchmarking against other maintenance crews.

## 4.3 General Factors that Potentially Influence Productivity

Open and healthy competition is probably the best way to improve productivity, efficiency and cost savings. The outsourcing of maintenance or competition is the most important factor to increase productivity. This can be done in many ways and each country included uses a different approach, but there are more common practices compared to the numerous differences in the road sector. The success also varies from country to country and some have achieved significant savings compared to others. Productivity gains are a result of competition, performance orientation, larger service areas (economy of scale), bundling of

services (economy of scope), and by using long-term agreements. It is difficult to quantitatively determine which factors contribute the most.

## General Factors that Potentially Influence Productivity

During the course of the study, there are many general factors that contribute to the productivity of maintenance service providers. These factors are listed in Box 10.

**Box 10. General Factors that Potentially Influence Productivity**

- Restructuring of the public rail monopoly
- Open and healthy competition
- Performance-based approach
- Longer term contracts (depreciate capital expenses)
- Larger service areas (economies of scale)
- Bundling of activities (economies of scope)
- Using incentives and disincentives
- Measuring the performance of the service providers
- Use of GPS and ICT systems (for quality and efficiency)
- Less restrictions
- Better planning and arrangement of services (new thinking)
- Sharing of best practices
- Good project management
- Encouraging innovation (difficult because of risk)
- Commitment to safety (long term effect)
- Standardization applied generally

## Performance Based Approach

A performance based approach provides more freedom and flexibility on how the contractors arrange their services. The intent is to provide the services efficiently without too many restrictions or constraints. The rail sector has so many requirements that make it difficult to provide services effectively. In contrast, the road sector has much more freedom in providing performance based requirements.

## Long Term Contracts

The longer the duration of the contract, the more potential for efficiency and cost savings, and this can potentially translate into productivity gains. In a five or seven year contract it is possible to depreciate the capital cost, which in turn can stimulate equipment innovations, provide flexibility for long lead items and upgrade systems.

### Larger Areas and Increased Scope

Some countries like Finland have increased the size of the area contracts and reduced the number of tenders to 12 and taken advantage of the economies of scale. Most are bundling as many services as possible into one contract, like Sweden to increase the economies of scope. These both tend to increase the potential for better productivity and efficiency.

### Incentives and Disincentives

The use of incentives and disincentives are commonly used in the rail sector as opposed to the road sector where there are very few, if any. Incentives can be applied to aspects such as trip delays, faults, TQI, and safety.

### Response Times

Since most of the measures are related to response times, it is easy to measure the performance of the contractor. These performances results can be aggregated to determine an overall performance and this in turn can be used as an award scheme to reward or penalize the contractor.

### Innovations

Innovations, new ways of thinking and increasing the contractor planning can all lead to productivity and efficiency gains. These are not automatic productivity gains, but are potential ones. There have been innovations in automated equipment and ICT tools have resulted in better efficiencies. Since further innovations are desired, it remains to be seen how to affect further advances.

### Project Management

Just as project management skills in capital projects contribute to the likelihood of a successful project, it has a similar effect on the success of maintenance contracts. This was one area where there was complete agreement, even though it is hard to measure from a productivity standpoint. A competent project manager from the contractor's perspective can affect the success of a project, but there needs to be an equivalent competence form the client's representative.

### Sharing Best Practices

The sharing of best practices and having a system that captures these can spread the efficiency and potential for productivity gains. This is especially relevant to in-house organization, such as Network Rail, where it is easy to broaden any good practices and shared innovations.

## 4.4 General Factors that Potentially Decrease Productivity

There are also factors that contribute to a productivity *decrease*, which could be due to additional requirements in administration or management. These factors that potentially decrease productivity, based upon the interviews, are summarized in Box 11.

**Box 11. General Factors that Potentially Decrease Productivity**

- Restrictive requirements, constraints and too many method-based standards
- Not enough freedom and flexibility for contractors
- Difficulty in accepting and evaluating proposed innovations
- Not enough robust performance requirements
- Contractors not willing to take risks

## 4.5 Factors in Procurement that Potentially Influence Productivity

The factors potentially influencing productivity in general were described in the previous section and many of these can be used in procurement practices. This is applicable for those countries that are outsourcing the maintenance services and not the in-house service providers. All countries outsourcing the maintenance services have reported lower costs even though rail traffic has increased and the network is aging. It is difficult to assess which specific aspects contributed to the savings, but most have commented that the restructuring of the rail sector and having competition produced the most significant impacts. As a result there has been some form of productivity increases, but it is difficult to quantify.

It also does matter how the maintenance contracts are implemented and what aspects contribute to better efficiencies. This may explain any differences achieved from country to country. It is important to establish and maintain a healthy/functional maintenance industry for these services, because they will also be needed in the future. This is probably the greatest challenge for outsourcing the maintenance.

Box 12 shows those factors that can be used in the procurement process for influencing the productivity.

**Box 12. Factors in Maintenance Contracts that Potentially Influence Productivity**

- Performance-based approach
- Longer term contracts (depreciate capital expenses)
- Larger service areas (economies of scale)
- Bundling of activities (economies of scope)
- Using incentives and disincentives
- Less restrictions (client added administration and practices)
- Encouraging innovation (difficult because of risk)
- Standardization applied generally
- Risks clearly defined in contract

## 4.6 Discussion and Observations

The rail sector has experienced restructuring and recent opening of competition for both the infrastructure maintenance and operations. Maintenance of the rail infrastructure requires more technical expertise compared to the road sector. The systems are more complex, have rigid safety requirements, and need to be managed efficiently and effectively. The greatest challenge is to develop a healthy competitive market for rail maintenance services. Presently, the rail sector is not as competitive as desired and this might be explained by the high cost of market entry.

Most countries are using area based contracts that contain performance requirements along with technical requirements. Most are also trying to develop more performance requirements, but it has its challenges. These contracts have duration of about five years and try to bundle as many services as possible. Finland seems to be taking more advantage of the economies of scale and has only 12 area based contracts, while others have about 25-35 area contracts.

Network Rail in England has 40 delivery units for their in-house maintenance services. Results have showed that there were savings and increased quality, but are difficult to quantify. The units are using metrics to measure performance, work identification and inspection, and they benchmark the performance of each delivery unit. Best practices are shared between the units and they use an advanced asset management system for maintenance services. One important observation is the conflict between efficiency and driving down costs.

One comment made by most countries is the need to have multi-skilled or cross trained maintenance labor so that deficiencies can be managed effectively and efficiently. Regulatory and technical requirements often contribute to unproductive practices, and therefore cross training might be an effective approach.

One significant challenge in the rail infrastructure is the use of a single track. Any interference could cause train delays and operational inefficiencies. It is very difficult to maintain services when there are only a select number of hours available to perform the work and perform upgrades. Also, the track widths vary in many countries, which may lower the equipment utilization and transfer. This has resulted in small markets like the Nordic countries and reduces the potential for international competition.

There seems to be a conflict when clients provide information and data to the contractors. There appears to be a data dumping approach versus good communication and openly sharing the data and information. This is also common in capital projects in which contractors desire more data and the clients complain that they provided all the data, but the contractors are not using the data. A cooperative approach or maybe having pre-proposal kick-off meetings can be fruitful to make sure all have a clear understanding of the meaning of the data and what is required from the contractors.

It is important to have a Life Cycle Cost (LCC) process so that maintenance is not perceived as a last resort. This situation goes hand in hand with budget reductions and lower resources by both the client and contractors. There is no equitable solution and many are concerned about the life cycle cost, when the infrastructure is due for significant renewals or replacement.

Most countries incorporate an asset management system where there is an organized process to measure the response times and the conformance to these measures. Many of these functions are automated as the data is captured in real time and though automated systems. These are much more advanced in comparison with the road sector where much of the data collection is done by observations and human inspections. Asset management systems are important and may be take time, resources, and re-engineering. The benefits and return on investment often take time to be realized.

There is a strong desire by the rail clients to have further innovations from the contractors. This is a challenge when there are too many constraints and restrictions. Innovation is expected, but the challenge is how to drive the correct behavior and what type of a reward system is suitable to promote innovation.

Table 3 shows the summary of the maintenance contracts used in each country. The common trends are the use of the hybrid model, contract duration of about five years, not using low bid, and there is significant bundling of services. One potential development might be the inclusion a certain amount of fixed work for addressing periodic maintenance schemes. England uses in-house maintenance workers which is denoted by N/A (not applicable) in the table.

**Table 3. Summary of Maintenance Contracts**

| | OUT-SOURCED | CONTRACT TYPE | CONTRACT DURATION | SELEC-TION CRITERIA | # OF AREAS | COMMENTS |
|---|---|---|---|---|---|---|
| Sweden | ~100% | Hybrid | 5-7 Years | 70 Price 30% Quality | 35 | Incentives & Disincentives |
| Finland | 100% | Hybrid | 5 Years | 60 Price 40% Quality | 12 | Incentives & Disincentives |
| Holland | 100% | Hybrid | 5-6 Years | 50 Price 50% Quality | 25 | Incentives & Disincentives |
| England | In-House | N/A | N/A | N/A | 40 Units | |

## 4.7 Potential Indicators

The interviews did not reveal any quantitative productivity measurements applicable to the maintenance contractors. However, there may be some indicators that resemble some productivity achievements or factors related to productivity, efficiency or performance. It is possible to have qualitative indicators or Key Performance Indicators (KPIs). A possible overall indicator of maintenance might be cost per kilometer (€/km). This may not be a balanced measure, but can serve as a general guideline and is often reported in international statistics. Some of the KPIs used in some countries are included in Box 13.

**Box 13. Key Performance Indicators (KPIs) in Maintenance**

- Project cost
- Cost per kilometer (€/km)
- Contractor's performance
- Safety
- Track Quality Index (TQI)
- Availability and travel delays
- Faults and incidents
- Quality (subjectively and difficult to measure)
- Asset group condition ratings – different categories

### Unit Prices

Many rail agencies have collected maintenance costs and these are often reported as cost per kilometer. The difficulty is when comparing the assets that are not homogenous. There are too many variables that influence costs, such as urban versus rural and old versus new. Comparisons are difficult to make and unit prices provide a baseline comparison, but not in all the cases.

### Measuring Contractor's Performance

The performance of the maintenance contractors can be measured by the performance measurement or asset management system. Most measures are time and response, so the performance can quite easily be measured and is often automated. This can be a valuable tool to identify trends in performance and benchmarking of different contractors performance.

### Safety

Safety is an extremely important indicator and a tool to understand trends. Maintenance services should not result in any incidents, but it is proper to measure the response times to emergencies or incidents. Safety can be applied to both the workers and passengers.

### Other Measures

Other potential KPIs include TQI, availability, travel delays, faults or incidents, quality, and measuring the asset conditions. It may be possible to obtain an overall value that represents the total performance, but is not presently done.

## 4.8 Other Findings

There were also other findings from the interviews, not specifically related to procurement or productivity measures. Some are general in nature while others are indirect and may not have an effect or correlation with productivity. These other issues are presented in Box 14.

**Box 14. Other Findings from the Interviews**

- Need Identification of planned and non-planned work
- Most performance requirements are time and response
- Most countries use some form of price indices (inflation)
- Reduced maintenance budgets and increasing backlogs
- Innovations were not as expected
- Low bid was not used in contractor selection criteria

## 4.9 Lesson Learned

When opening the competition and developing maintenance contracting practices, it is important to consider the lessons learned from other agencies and especially internationally. It is wise to study the practices and challenges from others and include the practices and lessons learned into your culture. A collection of lessons learned is presented in Box 15. This is not an exhaustive list, but provides a broad perspective.

**Box 15. Lessons Learned in Maintenance**

- Productivity is not measured in maintenance
- Difficult to open the competition and have a healthy market
- Changing the internal culture and practices is difficult
- It takes time to change and implement
- Consider a hybrid contract to balance risks
- Using as much performance requirements as possible
- Longer term contracts are better
- Bundling of activities (economy of scope)
- Larger areas are better (economy of scale)
- Use incentives and disincentives appropriately
- Measuring the performance of the service providers
- Better planning and methods of contractors (new thinking)
- More freedom/flexibility versus demanding restrictions
- Good project management is important
- Low bid is not used or appropriate for rail maintenance
- Formal or informal partnering is important
- Political decision makers are disrupting practices through budget reductions/restrictions
- Use adequate asset management systems and ICT systems as they have great potential for focusing resources and tracking performance
- Encouraging innovations (difficult because of risk)
- Contractors not willing to take risks (clearly defined)
- Collecting the cost data and unit prices
- Commitment to safety (long-term effect)
- Standardized broadly applied
- Sharing best practices
- Cooperation with the private market players is needed
- Most performance measures are time and response

# 5 Significant Findings from Each Country

This section will highlight some of the interesting and unique findings observed from each of the countries. They are listed alphabetically by country name.

**1) England**

Network Rail in England has changes from public to private and then back again in public management for the maintenance services. These services were taken back in-house in 2003, due to quality and costs.

The rail infrastructure is aging and Network Rail is committed to meet the challenges. Many upgrades are in place and plans are to restore critical areas. Capital projects are mainly completed through framework agreements with the designers and contractors. There is a minor portion of the design performed in-house, but more for smaller projects. Due to the high density of rail, time based requirements are very important, as well as minimum delays to travel times. As a result, pedestrian bridges can be installed in a few days and bridge innovations are very important.

The main aspects in procurement are not necessary which methods are used. Factors like collaboration, equitable risks, repeatability, and finding that some models are better for different assets. Design-Build and Early Contractor Involvement (ECI) are extensively used and there is a strong desire to use those methods more often. England has the highest use of alternative project delivery methods and is the most progressive country in this study.

Just like many rail clients, Network Rail does provide materials like sleepers, ballasts and track. The client typically can have better economies of scale versus individual project purchases by contractors.

England endorses the collaborative procurement processes and has a formal Gateway process where all projects are evaluated to determine the appropriate project delivery method during the early preparation stages.

**2) Finland**

Finland has merged the road, rail and waterways administrations into one organization known as the Finnish Transport Agency (FTA). The organization is more in line with a matrix organization and the first two years has been a “frantic” situation in finding the roles, responsibilities and administration policies.

The rail portion of FTA is extremely traditional and has not taken notice of alternative project delivery methods as compared with the road sector. Much of the infrastructure is single track and density is higher within the capital area and

the larger cities. There is a lack of motivation and innovation related to the use of project delivery methods. The traditional DBB method is extensively used and FTA hires construction managers to manage the contracts on their behalf. There are only a few Design-Build projects that were used for electrification aspects.

The maintenance services are more aligned with progressive maintenance contracts used in other countries. They are performance oriented, larger contract areas, and five year contract duration. There are incentives and disincentives included in the contracts. The main challenge is creating a healthy competitive market as there are basically two service providers capable of tendering.

The Nordic type environment presents its challenges and the last two severe winters experienced poor rail performance and significant travel delays.

Finland is developing the Infra BIM as an interoperability tool and making its way into the rail sector.

The biggest issues are with the new organization and if it is able to take advantage of a multi-modal transport organization and if efficiencies through alternative procurement practices will be considered.

**3) Holland**

Prorail in Holland has been testing and using alternative project delivery methods for over 10 years now. Design-Build, the Alliance model and even DBFO has been used in the Dutch railways. Holland can be perceived as being progressive in the use of newer models even though the DBB model is used more often.

Capital projects have been delivered using diverse project delivery methods and resulted in experiences varying between very good and not so good. Design-Build applications were very good in the beginning, but were met with challenges. Challenges include having too many projects in a short period (market concerns), risks were not always known, not enough experienced with Design-Build (creative and qualified), and not enough performance (functional) requirements. The Alliance model has been used four times and is achieving good results, however the Value for Money (VfM) studies are unavailable. The only DBFO project was quoted to be somewhat costly and not delivering satisfactory VfM.

Prorail is very progressive and is re-engineering the practices to achieve more VfM. Unlike other countries, Prorail does not supply sleepers, ballast and track, but does supply strategic items like interlocking and power supply.

The maintenance contracts are aligned with the progressive countries and use a performance based approach, five year maintenance contracts, bundling of most all services, includes small renewals, and uses incentives and disincentives. Savings were reported to be about 25% in these contracts and Prorail is receiving higher services levels, according to Van Veldhuizen (2011). Prorail's practices are aligned with innovative thinking, can do attitude, and realizing what works and what needs further adjustments.

**4) Sweden**

Sweden, similar to Finland, has also merged the road and rail administrations into one organization called the Swedish Transport Administration (STA). However, Sweden has kept the regional offices within their organizational structure. STA is finding its way in the new organization and is experiencing similar challenges as in Finland and it will take time for the organizational changes to mature.

Sweden is using similar project delivery methods as Finland. Design-Build projects are not used as often and DBB is still the most dominant. However, there were comments during the interviews that Design-Build should be used more often and should be evaluated properly to determine if DB is an acceptable project delivery method for broad applications.

Sweden has a cooperation forum with the contracting industry that is termed "Renewal in the Construction sector" (Förnyelse i Anläggningsbranschen, FIA), where ideas, practices and cooperation between the client and contracting industry can be discussed and developed. Communications is an important part of keeping the trust and cooperation.

Just as in Finland, the Nordic environment presents its challenges and the last two severe winters experienced poor rail performance and significant travel delays.

Sweden is also outsourcing the rail maintenance activities and has almost full competition. They are using a performance based approach, five year contracts with a two year option, and area based contracts. It is aligned with the developments in other countries and is moving toward fewer area contracts to increase the economies of scale.

Sweden like Finland is very conservative with the project delivery models and this study is considered an important step that will hopefully provide the momentum to shift into testing and benchmarking the alternative practices. Maintenance contracts are considered to be world-class practices.

**5) USA and Ontario, Canada**

Both USA and Canada intercity and freight rail sectors are essentially privatized, with the main exception being AMTRAK in the northeast corridor of the USA. USA also has a high speed rail initiative by the federal government. This study was not intended for the private market and they are not included in the study.

However, in the USA there are numerous transit authorities that are providing light rail, underground metro rail and commuter rail services. Some of these transit authorities are utilizing DB and DBOM methods. Dallas Area Rapid Transit (DART) was recognized and received an award for its extensive use of Design-Build in over 47% of transportation projects, based upon contract value.

Infrastructure Ontario in Canada is underway with a DBFO (RFP stage) for the Airport Rail Link Spur Project, which connects the airport to downtown Toronto.

# 6 Summary and Principle Conclusions

Transportation projects require a custom-made solution and not a one size fits all solution, and it is important to compare many factors during project selection. All project delivery methods have provided successes, not so successful attempts, and results between favorable and unfavorable. Every project has a different set of requirements, objectives, challenges, and the owners should carefully consider these requirements in the context of their own culture, environmental issues, and technical characteristics to decide which project delivery method provides the best opportunity for success. On the other hand, it does make a difference which project delivery method is selected and countries should have a systematic decision making process to assure that the best method or best likely method is used for each project. Also, having quantitative data will assist the decision making process.

Productivity is difficult to measure and compare in the case of rail contractors and there are many factors that can influence productivity both positively and negatively. Design-Build and its variants, if used correctly, have better potential to influence productivity. Early Contractor Involvement (ECI) and the Alliance models reveal promising outcomes and tend to provide innovation solutions, but have not been extensively analyzed and studied.

It is possible to foster productivity in any procurement method by including those factors and concepts mentioned in this report or accrued elsewhere. One key aspect is to drive the correct behavior with the rail contractors by having a successful framework and enough flexibility to be more innovative and efficient.

In the final state, productivity is driven by the contractors' processes, methodology, ingenuity, project management skills, innovation, and lean construction practices (by reducing waste in all phases). The main influence by the client is to use the best procurement method for the project and allow enough freedom for the contractors without corrupting the objectives for the customers. There is no guarantee for success, but the clients should provide the best opportunity or framework for success.

## 6.1 Capital Projects

Rail agencies have a significant challenge in the building of the infrastructure due to the technical complexity and numerous constrictions. The clients mainly influence productivity through the project delivery methods. According to this study, even though somewhat subjective, the Design-Build method and its variants, if used correctly, have a better potential to influence productivity.

This study also revealed factors that contribute to productivity of the contractors. These factors are listed in the following:

- Open and healthy competition
- Incentives and disincentives in contracts
- More freedom and flexibility for the contractors (there are too many rules, regulations and restrictions)
- Use more performance-based requirements (functional)
- Prefabricated and off site production (e.g. self- propelled bridge transport)
- Partnering and teamwork – collaborative process
- Standardization broadly applied – international standards
- Project management
- Bundling of projects
- Increased planning
- Warranties
- Building Information Model (BIM): not fully developed

These factors were already discussed in the body of the report. These factors as well as other proven factors should be considered wisely and applied to the context of each project. Also, what works in one country may not necessarily work as well in your country, and the cultural differences are often significant. Also, the Design-Build model and its variants need to be tested, implemented and used correctly in order to receive the intended benefits

The overall productivity control is by the means and methods used by contractors to organize the work processes so that just in time, lean construction practices and innovation are used to the maximum level in a given project. These are not typically under the influence or control of the clients, but can be encouraged by providing the right circumstances, the right incentives, and attempting to drive the correct behavior. In essence, creating an environment of opportunities and framework for success can have a positive influence on the productivity of rail building contractors.

## 6.2 Maintenance

Rail maintenance is important in order to preserve the given infrastructure in adequate condition, without significant disruptions to travelers. Maintenance is typically done in the late evening hours to avoid delays. Productivity in maintenance is not measured, but the performance of the service providers can be evaluated.

The main productivity gains are achieved by placing the maintenance work into open competition and when/if the rail restructuring occurred. The main factors influencing the productivity of maintenance contractors are as follows:

- Restructuring of the public rail monopoly
- Open and healthy competition
- Performance-based approach
- Longer term contracts (depreciate capital expenses)

- Larger service areas (economies of scale)
- Bundling of activities (economies of scope)
- Using incentives and disincentives
- Measuring the performance of the service providers
- Use of GPS and ICT systems (for quality and efficiency)
- Less restrictions (client added administration and practices)
- Better planning and arrangement of services (new thinking)
- Sharing of best practices
- Good project management
- Encouraging innovation (difficult because of risk)
- Commitment to safety (long term effect)
- Standardization broadly applied

Having a well organized and efficient maintenance regime certainly contributes to the productivity, but they are mainly dependent upon the contractor's processes and practices. The main influence by the clients is to establish a framework for success by using maintenance contracts that provide opportunities for efficiency and productivity. This may require a learning process and re-engineering the practices to influence the proper results. The biggest challenge is to create a healthy and competitive market for the maintenance services so that innovation, efficiency and productivity can be realized.

# 7 Recommendations

The study has produced significant information on the factors influencing productivity and the procurement methods used in many of the pro-active countries. Productivity through procurement was the main theme of the research. The project delivery system selected greatly influences the success of a project and is substantiated by practical results and other research studies.

## 1 Systematic Evaluation

There is a lack of a thorough systematic quantitative evaluation of each project and via project delivery method comparison. This would be significantly useful to practitioners in determining the success level of a completed project. Also, hand-in-hand is to develop a decision matrix for selection of project delivery methods, which could potentially determine the best fit. There are guidelines available from other countries, which could be used for a base reference and be considered for further development.

## 2 Testing Alternative Methods

It is wise to test each method and learn best practices for the given method. Design-Build should be the first step before advancing into the complex variants, because they typically demand more knowledge and resources. A few projects may not be sufficient to determine its merits and validation.

It is not possible to evaluate the success if alternative project delivery methods have not been used or tested to some degree.

## 3 Freedom, Flexibility and Innovation

Allowing the contractors more freedom and flexibility when performing the work, can lead to productivity gains. Innovations are strongly desired and the best approach should be determined, whether by Design-Build or other methods. Also, a system/process should be created to determine the acceptance of ATCs. This is a significant challenge with rail due to the numerous rules, regulations, and restrictions. More freedom and flexible should be applied generally throughout the project.

## 4 Collect Cost Data

There is a concern that the cost data in the form of unit prices need to be collected and used for evaluating productivity. The question then becomes at what level do you desire to compare the productivity and if it is the clients' obligation? Cost data is a good benchmark as is a quantitative measure. However, collecting the cost data is not a means to an end, even though the cost data is important. Even if the costs data is collected, it is important to have homogenous elements within the cost data to make objective comparisons. Cost data is also important politically and not knowing the costs of various

elements/group a project is not a good outcome. Knowing the cost is also important when considering Life Cycle Cost (LCC) and also important in asset management.

## 5 Implementing Robust Factors

Factors that influence productivity have been gathered and demonstrated. The next step is the implementation into the procurement practices. These diverse factors can be used in all project delivery methods.

It is also important to identify which factors are more favorable and their relative importance. This means that a robust collection of data and results is needed to determine the scale of importance. This may or may not be possible to determine objectively, but may be qualitatively inferred.

## 6 Continue Benchmarking

The study shows several findings and the complexities of productivity related to procurement. The Design-Build method shows promising results, but should not be considered a panacea. It is recommended to continue benchmarking as there may not have been enough projects to objectively compare results. It is possible that the lessons learned and best practices were not utilized properly during the first few Design-Build projects so this should be taken into consideration for the next application of DB.

## 7 Design Degradation

The study revealed that the design quality is not as good as in the past, according to the interviewees. This seems to be a common problem internationally. This requires further analysis to determine if this is possibly related to the outsourcing of design, the procurement practices (lower bids), a loss of expertise, or some other factors.

## Recommendations – Maintenance Services

For maintenance contracts a healthy/functional market is the single most challenging aspect in the rail sector. This is true now and more so in the future. Part of the difficulty is opening the maintenance competition from a previous in-house monopoly position. Each country needs to find ways to make it happen.

The other recommendation is to continue adding more performance requirements when appropriate (not all aspects have fully developed robust performance requirements). Also, it is suitable for the integration of services (bundling) as much as feasible.

A hybrid model which uses both performance and technical requirements seems to balance the risks, which has the possibility to allow for innovations. Presently, it appears that five to seven year duration (the longer the better) is appropriate. Also, the use of incentives and disincentives to steer the correct objectives should be evaluated and applied appropriately.

Asset management systems need to be robust and flexible to manage the complexity of the rail assets and make sure that performance, reliability, and quality are satisfactorily maintained.

## Final Thoughts

Knowing that the implementation of alternative methods and changing the culture takes time, it is still considered being a worthy process. Design-Build for infrastructure projects should be seriously considered because the time element is the benefit most widely accepted by professionals around the world. Most infrastructure projects today consider time, innovation and productivity as important features. Teamwork was an original intend in the DB method and is an important tool to solve problems and disputes.

In both capital and maintenance contracting, productivity gains are mainly at the control and destiny of the contractor and if there are any means and methods to increase the contractor's procedures, processes, and speed, then those factors should be included, whether procurement related or by other means.

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# Appendix A: Organizations Interviewed

The meetings with the experts from each country were completed during face-to-face interviews. The countries and organization interviewed are listed below.

**ENGLAND**
Network Rail – Rail Capital Investment Projects
Network Rail – Rail Maintenance

**FINLAND**
Finnish Transport Agency – Rail Capital Investment Projects
Finnish Transport Agency – Rail Maintenance

**HOLLAND**
Pro Rail - Rail Capital and Maintenance Projects

**ONTARIO, CANADA**
Infrastructure Ontario
Ontario Ministry of Transport – Transit Infrastructure

**SWEDEN**
Swedish Transport Administration - Rail Capital Investment Projects
Swedish Transport Administration - Rail Maintenance Division

**USA**
U.S. Department of Transportation – Federal Railroad Administration
Dulles Corridor Metrorail Project

# Appendix B: Questionnaire for Capital and Maintenance

## Capital Projects

1. Please provide a short overview of your procurement practices?
2. How do you measuring the Maintenance Contractor's Performance or Productivity? How is it accomplished? What key performance measures (KPIs) or indices are you using? If there are no measures, what are some potential measures?
3. What factors in general contribute to productivity and innovation? What factors in Maintenance Contracts contribute to productivity and innovation?
4. What are the incentives for increasing productivity using procurement? How does the procurer benefit from more productivity in maintenance?
5. What are the present Procurement Practices used for Maintenance Contracts?
6. What are your experiences, benefits, and challenges from using each method? Were there any pre-requisites before using the various models? What changes were needed? Are there any quantitative results?
7. Is rail infrastructure and electricity distribution (technology) always tendered as a package or is it procured separately? What quantities are procured as a package and as separate contracts? Can you influence the contractor's supply chain and how?
8. How do you tender the Maintenance Contracts? What Contractor Selection Criteria is used?
9. What are some of the Best Practices in Contractor Selection Criteria? Are there any Incentives used? What are the challenges? How can a contractor propose innovations during the tendering phase and also during the actual project implementation? Any examples?
10. Does the use of Performance Specifications/Measures increasing productivity or innovation? Please explain how?
11. Is there any standardization or other innovations? What are some examples? (It could be for processes, specifications, work flows, prefabrication, off-site techniques or others).
12. Does Project Management affect productivity? What are some examples?
13. What type of evaluation is done after contract duration? What factors are considered? Do you have a systematic approach? Is there any government agency involved in evaluation of the project? Or involved in evaluation of the procurement process? What are you measuring in terms of cost? (Unit prices, overall cost or other)?

14. What are Contractor's concerns, challenges, and perception from the Maintenance Contracts?
15. What are some of your success stories? Challenging projects? Which models have better overall cost containment?
16. Is partnering used? Is it formal or informal partnering? Describe how it functions? Is there a systematic problem resolution process or hierarchy? Any other forms of Teamwork used?
17. How do you train the client's staff in becoming procurement experts? Are you using consultants? Are there any official training classes? How is this implemented all the way into the organization and to the local offices? Please provide some examples?

## Maintenance Contracts

1. Please provide a short overview of your procurement practices?
2. How do you measuring the Maintenance Contractor's Performance or Productivity? How is it accomplished? What key performance measures (KPIs) or indices are you using? If there are no measures, what are some potential measures?
3. What factors in general contribute to productivity and innovation? What factors in Maintenance Contracts contribute to productivity and innovation?
4. What are the incentives for increasing productivity using procurement? How does the procurer benefit from more productivity in maintenance?
5. What are the present Procurement Practices used for Maintenance Contracts?
6. What are your experiences, benefits, and challenges from using each method? Were there any pre-requisites before using the various models? What changes were needed? Are there any quantitative results?
7. Is rail infrastructure and electricity distribution (technology) always tendered as a package or is it procured separately? What quantities are procured as a package and as separate contracts? Can you influence the contractor's supply chain and how?
8. How do you tender the Maintenance Contracts? What Contractor Selection Criteria is used?
9. What are some of the Best Practices in Contractor Selection Criteria? Are there any Incentives used? What are the challenges? How can a contractor propose innovations during the tendering phase and also during the actual project implementation? Any examples?
10. Does the use of Performance Specifications/Measures increasing productivity or innovation? Please explain how?
11. Is there any standardization or other innovations? What are some examples? (It could be for processes, specifications, work flows, prefabrication, off-site techniques or others).
12. Does Project Management affect productivity? What are some examples?
13. What type of evaluation is done after contract duration? What factors are considered? Do you have a systematic approach? Is there any government agency involved in evaluation of the project? Or involved in evaluation of the procurement process? What are you measuring in terms of cost? (Unit prices, overall cost or other)?

14. What are Contractor's concerns, challenges, and perception from the Maintenance Contracts?
15. What are some of your success stories? Challenging projects? Which models have better overall cost containment?
16. Is partnering used? Is it formal or informal partnering? Describe how it functions? Is there a systematic problem resolution process or hierarchy? Any other forms of Teamwork used?
17. How do you train the client's staff in becoming procurement experts? Are you using consultants? Are there any official training classes? How is this implemented all the way into the organization and to the local offices? Please provide some examples?

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