ESPOO 2004 VTT PUBLICATIONS 549

Tiina Koppinen & Pertti Lahdenperä

The current and future performance of road project delivery methods

VTT PUBLICATIONS 549

The current and future performance of road project delivery methods

Tiina Koppinen & Pertti Lahdenperä
VTT Building and Transport

ISBN 951–38–6424–3 (soft back ed.)
ISSN 1235–0621 (soft back ed.)

ISBN 951–38–6425–1 (URL: http://www.inf.vtt.fi/pdf/)
ISSN 1455–0849 (URL: http://www.inf.vtt.fi/pdf/)

JULKAISIJA – UTGIVARE – PUBLISHER

VTT, Vuorimiehentie 5, PL 2000, 02044 VTT
puh. vaihde (09) 4561, faksi (09) 456 4374

VTT, Bergsmansvägen 5, PB 2000, 02044 VTT
tel. växel (09) 4561, fax (09) 456 4374

VTT Technical Research Centre of Finland, Vuorimiehentie 5, P.O.Box 2000, FIN–02044 VTT, Finland
phone internat. + 358 9 4561, fax + 358 9 456 4374

VTT Rakennus- ja yhdyskuntatekniikka, Hermiankatu 8 G, PL 1802, 33101 TAMPERE
puh. vaihde (03) 316 3111, faksi (03) 316 3497, (03) 316 3445

VTT Bygg och transport, Hermiankatu 8 G, PB 1802, 33101 TAMMERFORS
tel. växel (03) 316 3111, fax (03) 316 3497, (03) 316 3445

VTT Building and Transport, Hermiankatu 8 G, P.O.Box 1802, FIN–33101 TAMPERE, Finland
phone internat. + 358 3 316 3111, fax + 358 3 316 3497, + 358 3 316 3445

Edita Prima Oy, Helsinki 2004

Koppinen, T. & Lahdenperä, P. The current and future performance of road project delivery methods. Espoo 2004. VTT Publications 549. 115 s.

Keywords road procurement, project delivery, construction management, Design-Build, Design-Build-Maintain, Design-Build-Finance-Operate, Build-Own-Operate-Transfer, costs, value generation, performance, comparison, future, life-cycle

Abstract

Internationally, road authorities are becoming more of asset managers. As a result, road project delivery is enabling more integrated services, requiring broader know-how from service providers. Activities previously procured through several agreements may now be included under one inclusive agreement. The client's decision between traditional or more integrated project delivery is fundamental in setting up the framework for design, construction and maintenance, and for their management. The selected contract type should develop a cooperative relationship between the client and implementers, and provide incentives to the parties to achieve client objectives.

Clients should define the best ways to procure roads based on project size, complexity, risks, timing, external factors, environmental issues, etc. To assist in the strategic selection of the most efficient project delivery methods, this research determined the performance of the following methods: Design-Bid-Build, Construction Management (with some reserve), Design-Build, and Design-Build-Maintain (covering variations like DBOM, DBFO, BOOT, etc.).

The concept of economic efficiency was developed to describe the performance level of the different project delivery methods. Economic efficiency is determined as the ratio of value generation to cost performance. The more value the project delivery system generates at a certain project cost, the more economically efficient way it is to procure roads. The current performance of the project delivery methods was assessed based on the data provided by the interviewees in five countries (Finland, UK, Australia, New Zealand, and USA) and on an extensive literature review. The future performance potential of the methods was determined based on the development potential derived from the data gathered.

The analysis performed shows that the current economic efficiency of CM seems to be only slightly higher than that of DBB, while the economic efficiency of DB is significantly higher. DBM brings even more notable improvements as it doubles the efficiency improvement of DB. When development potentials of the project delivery methods are taken into consideration, the difference between traditional and more integrated project delivery methods only increases. Thus, DBB and CM will improve only marginally from the current situation, but both DB and DBM can improve notably their cost performance and value generation resulting in economically even more efficient project delivery. Also the changes expected in the operating environment will favour use of DB and DBM. Thus, it seems that the broader and more integrated service packages (DB and DBM) can provide better value for money and meet the needs and desires of the client better than DBB or CM. However, the full performance potential of each project delivery method can only be achieved provided that some improvements to the system are made. Each project delivery method has its weaknesses that currently hinder optimal performance.

It must also be taken into consideration that each method should be applied only in appropriate circumstances, which leaves room for DBB and CM. It is often still appropriate to use DBB, when projects are relatively small, simple, have well-defined end results, and offer no opportunities to innovate or to generate revenue. CM will retain its potential for big projects that are implemented under very restricted conditions or require flexibility to accommodate client changes. As DBM may be used in some, exceptionally large projects, this leaves DB as the normal alternative to DBB.

When adopting DB and/or DBM-type project delivery, public owners need to provide permanent market demand for competent contractors to fully capitalise on the potential of these methods. Changes should be made step-wise to allow the participants time to adapt to the new operating environment. Also, training of public sector representatives should improve successes in procurement, as better procurement skills lead to lower transaction costs, better value for money in projects, and faster delivery of public services. At the same time, private companies need to concentrate on relationship building and networking to enable more efficient cooperation over the whole project life and more successful outcomes with higher profitability.

Preface

This report is the result of a research project carried out by VTT Building and Transport called 'The Performance and Development Potential of Project Delivery Methods for Infrastructure' or INKA. The research concentrated on gathering data on the performance of different road project delivery methods and comparing the performance levels of these methods now and in the future. The project is part of The National Technology Agency's (Tekes) INFRA National Technology Programme that involves infrastructure design, construction, operation and maintenance, and development of associated services, techniques, products, production methods and equipment to provide a competitive and innovative environment in all infrastructure markets. Development of appropriate project delivery and procurement methods is one of the focus areas of the technology programme.

The first report summarising the collected data used as the basis for this performance analysis was published separately as a VTT Research Notes publication under the name 'Road Sector Experiences on Project Delivery Methods'. This report (second in order) aims to present the performance assessment of different road project delivery methods to allow the client to make an educated decision on the project delivery methods for future procurement. At the same time, the report highlights the deficiencies of each project delivery method and suggests potential means of improvement to eliminate problem areas.

This project began at the outset of 2003 and was completed by the end of August 2004. The work was largely done by Mrs. Tiina Koppinen (MScTech, MBA) with contributions and guidance by Dr. Pertti Lahdenperä.

The research was commissioned by The Finnish Road Administration (Finnra), The Finnish Road Enterprise, The Confederation of Finnish Construction Industries (RT), The Central Organisation of Earth Moving Contractors in Finland (SML), The Finnish Rail Administration (RHK) and The Finnish Association of Consulting Firms (SKOL). These parties also formed the steering group, which supervised the research. The Steering group consisted of:

Markku Teppo	The Finnish Road Administration (*Chairman*)
Jussi Kauppi	The Association of Finnish Local and Regional Authorities
Matti Kiiskinen	The Finnish Association of Consulting Firms
Pekka Pakkala	The Finnish Road Administration
Ilkka Romo	The Confederation of Finnish Construction Industries
Harto Räty	INFRA Technology Programme
Timo Vikström	Lemcon Ltd; representing The Central Organisation of Earth Moving Contractors in Finland
Tom Warras	The National Technology Agency, Tekes
Lars Westermark	The Finnish Road Enterprise
Harri Yli-Villamo	The Finnish Rail Administration

We want to thank all the above parties who made this research possible. We also express our gratitude especially to the interviewees, who were willing to devote their valuable time and share their experiences on road project delivery.

August 2004
Tampere, Finland

Tiina Koppinen Pertti Lahdenperä

Contents

Glossary

Alliance; Alliancing. Project Alliance is an agreement between two or more entities (the client and contractor(s) plus potentially other project participants or stakeholders) that undertake to work cooperatively, on the basis of sharing project risks and rewards, for the purpose of achieving agreed outcomes based on principles of good faith and trust and an open-book approach towards costs.

Alliancing. See Alliance.

Build(-Own)-Operate-Transfer (BOOT, BOT). A private company finances, designs, and builds the project and then operates it for a specified concession period. During this concession period, the company collects revenues (often user fees) from operating the project to recover its investment and to earn a profit. At the end of the concession period ownership of the project transfers to the client.

Client; Owner. The owner is the initiating party for whom the project is developed. This party is also in most cases the source of the financing. Owners may be public or private.

Consultant. The consultant is a construction expert hired by the client typically to administer the construction (and design) phase of the project on behalf of the owner in the absence of a construction manager.

Construction Management (CM). Construction Management is a project delivery method based on the owner's agreement with a qualified construction firm to provide leadership and perform administration and management for a defined scope of services.

Construction manager (CMr). The construction manager is the party responsible for the core duties in a project. The CMr may be a design firm, a contractor or a professional construction manager. Construction management services range from mere coordination of contractors during construction to broad responsibilities over project planning, design, construction scheduling, cost monitoring, and other management services.

Contractor. The general contractor is the entity charged with the responsibility of actually implementing the construction work. This party determines the means, methods, techniques, sequence, and procedures needed to direct the actual construction activities. In DB, the contractor (design-builder) is also in charge of finalising the design.

Design-Bid-Build (DBB). In this 'traditional' project delivery method a designer prepares complete construction documents for the owner. The owner then receives bids from contractors based on the design documents and awards a construction contract to the lowest responsive, responsible bidder. The contractor builds the project, and upon completion, the owner assumes responsibility for the operation and maintenance of the project. The owner provides all financing.

Design-Build (DB). In Design-Build the owner selects a single contractor to both design and build the project. Upon completion of construction, the owner assumes responsibility for its operation and maintenance. The owner provides all financing.

Design-Build-Finance-Operate (DBFO). This project delivery method integrates operation and maintenance with the tasks of design and construction. The responsibility for financing the project is assumed completely by the contractor, typically at the contractor's risk. The client pays for the service provided according to a pre-determined payment mechanism. Control of the asset may return to the client at the end of the concession period (i.e. contract period).

Design-Build-Maintain (DBM). This project delivery method integrates maintenance with the tasks of design and construction. The term is used here as a general term that covers all procurement methods that extend the contractors' responsibilities from pure design and construction to longer term maintenance liability, with or without other duties, such as operation and financing (DBFO, DBOM, BOOT, etc.).

Design-Build-Operate-Maintain (DBOM). This project delivery method integrates operation and maintenance with the tasks of design and construction. At completion of the contract, the owner assumes operation and maintenance

responsibilities himself or through another procurement process. The owner provides all financing and may collect third party revenues.

Designer. The designer/engineer is the party that designs the work.

Discount rate (*i*). The discount rate is the interest rate reflecting the investor's time value of money, used to determine discount factors for converting benefits and costs occurring at different times to a base time.

Discounting. Discounting is a technique for converting cash flows that occur over time to equivalent amounts at a common (present) time.

Economic efficiency (EE). Economic efficiency measures the performance of a project delivery method. The EE is expressed as the ratio of value generation to cost performance.

Key Performance Indicator (KPI). A Key Performance Indicator is a measure of the performance of an activity that is critical to the success of a project or organisation. Key Performance Indicators need to be quantifiable measures agreed to beforehand.

Present Cost (PC). Present cost is a discounted cash flow technique that calculates the sum of money that would be needed today to meet both the present and future costs of the project allowing the money needed in the future to gather interest. The PC of a project is calculated by adding up the present costs of all investment outlays. It is one of the most commonly used indicators of economic value.

Output specification. Output specification describes the total service solution the client desires to procure. It defines the quantity and quality of the service, but does not describe how the service should be provided.

Owner. See Client.

Performance-based specification. A performance-based specification states the client's requirements in terms of the required results and provides criteria for verifying compliance, but it does not state the methods for achieving results. It

defines the functional requirements for the product, the environment in which it must operate, and the interface and interchangeability requirements giving the service provider latitude to determine how to best meet the stated needs.

Private Finance Initiative (PFI). PFI is one of the alternatives of Public-Private Partnership (PPP) that involves private financing of schemes, where the investment is recouped through public sector service fees. Here a private sector entity takes the responsibility to design, build, finance and operate (DBFO) an asset used in the provision of public services for a contract period up to four decades. In addition, the private sector entity has ownership of the project asset for at least the contract period.

Procurement. Procurement means the acquisition of goods or services through a transparent, competitive, public process.

Procurement process. The procurement process is a series of activities in compliance with statutory and regulatory requirements by which owners acquire goods or services from the private sector.

Project delivery. Project delivery involves processes required to complete a good or service according to the contract.

Project delivery method; Project delivery system (PDS). A project delivery method is a system for organizing and financing design, construction, operations and maintenance activities that facilitates the delivery of a good or service.

Project delivery system (PDS). See Project delivery method.

Project Company (ProjectCo). A project company is the company responsible as the first tier supplier for organising the delivery of the DBM project to the client.

Public-Private Partnership (PPP). In PPP the public and private sectors combine their special capabilities to deliver the project most efficiently. The content of the contract may vary significantly, but generally the public sector transfers a significant level of risk and responsibility to the private sector for the long term.

Public sector comparator (PSC). A public sector comparator (PSC) is used in estimating the value of a proposed DBFO project. It is calculated by costing what the public sector would have to pay to procure the construction of the relevant schemes and the operation and maintenance of the project road over the selected concession period by the best alternative means (generally DBB or DB).

Request for proposal (RFP). The request for proposal is a legal document that specifies the project the client wants to get delivered. It offers instructions to bidders and provides the scope of the work and other important information that govern the construction of the project.

Shadow toll. The shadow toll is the payment per vehicle per kilometre for using a privately funded project road in accordance with a preset tolling structure. They are referred to as 'shadow', as opposed to real, tolls because the payment for usage is made by the public agency rather than the road user. /31/

Target cost; Target cost estimate (TCE). Target cost represents the maximum allowable expenditure for material, labour, outsourcing, overhead, and all other expenses associated with a project. In target cost arrangements a contractor's *ex post* profit consists of a fixed payment plus some share of the cost underrun /overrun, that is, the difference between an *ex ante* agreed estimation of the project cost and the actual cost. A target cost is generally proposed by the contractor, then checked and agreed by the client becoming the principal instrument in budgetary control of the works.

Target cost estimate (TCE). See Target cost.

Tendering cost. Tendering cost is the cost a bidder spends on preparing the tender. It can be expressed as a real money value or as a percentage of the total project cost/contract value. The contract value in DBB is the cost of construction, in DB the cost of design and construction, and in DBM the cost of design, construction and operation/maintenance.

Abbreviations

BOO	Build-Own-Operate
BOOT, BOT	Build(-Own)-Operate-Transfer
BTO	Build-Transfer-Operate
CM	Construction Management
CMr	Construction Manager
DB	Design-Build
DBB	Design-Bid-Build
DBFO	Design-Build-Finance-Operate
DBM	Design-Build-Maintain
DBOM	Design-Build-Operate-Maintain
DP	Development Potential
ECI	Early Contractor Involvement
EE	Economic Efficiency
EOI	Expression of Interest
EU	European Union
i	Discount rate
I/D	Incentives and Disincentives
IT	Information Technology
KPI	Key Performance Indicator
OM	Operate-Maintain
PC	Present Cost
PDS	Project Delivery System
PFI	Private Finance Initiative
PPP	Public-Private Partnership
PR	Public Relations
ProjectCo	Project Company
PSC	Public Sector Comparator
R&D	Research and Development
RFP	Request for Proposal
TCE	Target Cost Estimate
VE	Value Engineering
VFM	Value for Money

1. Introduction

1.1 Background

Globally, innovative delivery methods, where a contractor offers broader service packages, are increasingly used in infrastructure projects. Clients do not always desire to divide projects up and procure different kinds of services via separate contracts as has been the custom. In addition to construction and technical design, maintenance for a certain period of time and financing may be integral parts of the contract. This change in project delivery is driven by the infra-sector clients' quest to focus on their core business – securing adequate infrastructure nationally – and by the clients' and the contractors' aim to increase their benefits. Public owners are also consistently challenged to put public dollars to their maximum use.

The broadening of the service packages is believed to enable the optimisation of the process and the product as a whole, as well as to facilitate the development of the infrastructure sector. Performance-based contracting and large-scale competition are thought to offer a way to develop the sector and to benefit all the stakeholders. This trend has, however, been questioned. It is argued that by dividing up a project the client can increase competition in the market, maintain his decision-making power and ensure that good quality products and services are produced efficiently.

This contradiction raises the question of the appropriateness of different procurement strategies. Previous research and industry experience have repeatedly shown the importance of appropriate procurement systems, since there seem to be direct linkages between procurement strategy and cost and time over-runs and industry under-performance. While some research has been done on the performance of project delivery methods in road construction, there is a lack of comprehensive comparative approaches combined with adequate orientation into the future to provide a sufficient basis for long-term strategic decisions. Most studies are only historical surveys, while strategic papers are rare or, in any case, speculative by nature and do not form a solid groundwork for analytical judgement.

1.2 Objectives and scope

The purpose of this study was to compare the performance of the project delivery systems of road construction and to anticipate their future applicability in providing economical road investments. The research aimed at global assessment without being constrained to any single country. Thus, it had three distinct objectives:

1. To determine the current performance level of project delivery methods in terms of cost and value creation on the basis of real project data and experiences.
2. To assess the future performance of the project delivery methods in terms of cost performance and value generation on the basis of the systems' development possibilities and innovation potential.
3. To assess the changes in the operating environment in the foreseeable future (ten years or so), and impact of these changes on the applicability of different project delivery methods.

The project delivery methods included in the research are traditional Design-Bid-Build (DBB), Design-Build (DB), Construction Management (CM) and Design-Build-Maintain (DBM and its variants DBOM, DBFO, BOOT, etc.). In-depth discussion of financing issues is beyond the scope of this research. Assessment of the societal affects of different project delivery methods is also beyond the scope.

1.3 Implementation and reporting

The research concentrated mainly on experiences gained and reported in five countries: Finland, UK, Australia, New Zealand and USA. Literature from other countries was also reviewed. The main information source were interviews of the main actors in the road industry. The interviews concentrated on the true performance level achieved through the different project delivery methods used as the basis of the performance analysis. Additionally, the development needs and potential of each project delivery system were studied and reported, and future performance of the systems was assessed.

The report is structured as follows:

Chapter 2 explains how the infrastructure market operates. It also explores potential changes in the future road project delivery environment explaining expected challenges and opportunities to be considered and setting of requirements for future project delivery.

Chapter 3 describes the project delivery methods of interest for this study.

Chapter 4 describes the research methodology used in this study.

Chapter 5 describes the information gathering process implemented through semi-structured interviews in different countries. This work is more thoroughly reported in the first part of the research /1/[1].

Chapter 6 details the means of improvement available to each project delivery method to combat existing inefficiencies of the project delivery process.

Chapter 7 analyses the cost performance, value generation and resulting economic efficiency of the project delivery methods now and in the future. It also discusses the applicability of different project delivery methods.

Chapter 8 reviews the research and discusses the validity of the research findings and their contribution to knowledge.

Chapter 9 draws the principal conclusions and makes recommendations to clients and suppliers for better value for money project delivery.

[1] This report is also freely available in the Internet:
http://www.vtt.fi/inf/pdf/ tiedotteet/2004/T2260.pdf

2. Towards new business conditions

2.1 Infrastructure industry

Historically governments and municipalities/cities have been responsible for designing, constructing and managing infrastructure assets. As design and construction are today being largely out-sourced, the clientele of the infrastructure sector consists of these public clients. In addition to clients being mainly authorities, there are other special characteristics, too, that affect competition and project delivery in the infrastructure sector. Characteristics of the road sector include:

- Capital requirement is extensive as road construction requires large, expensive machinery. However, the work itself is so standard that it only allows limited profits. Many of the bigger companies do not have their own machinery, but rather subcontract activities to medium-sized companies that provide specialised earth moving, etc. services.
- The number of owners is limited imposing limitations on the size and business opportunities of national industry. As a result, in small countries growth for the industry and companies often needs to be sought beyond the borders.
- The fluctuating investment and reconstruction market affects the willingness of the organisations to develop their operations. When continuity in procurement cannot be provided, the willingness of the industry to invest in development is markedly reduced. As a result, there is lack of innovation in addressing project needs, and competitive advantage is mainly sought through reduced unit prices.
- The traditional culture of the sector is based on strict role separation that often leads to adversarial relationships, slow product delivery, low efficiency, delays and cost overruns. In this kind of operational model, know-how does not accumulate and development potential is left largely untapped.

2.2 External pressures driving changes

Urbanisation will continue, and people will drive more thereby increasing congestion and demand for roads. At the same time, public financing is becoming more and more constrained and deficient as people are ageing, which drives up health care and pension costs /7/. The infrastructure is also ageing rapidly. Thus, the level of construction and maintenance and the value of the road network need to be retained with less money. Available funds need to be used optimally to fulfil all the requirements set by the different stakeholders (see Figure 1).

The relative size of the working population is decreasing which causes significant shortfalls in the size and capacity of the workforce. Energy demand will increase emphasising environmental issues, and governments will set new environmental standards and create incentives for environmentally-sensitive operation. States will also confront pressures for greater transparency and participation in politics. Successful states will interact with non-state actors to manage authority and share responsibility. /7/

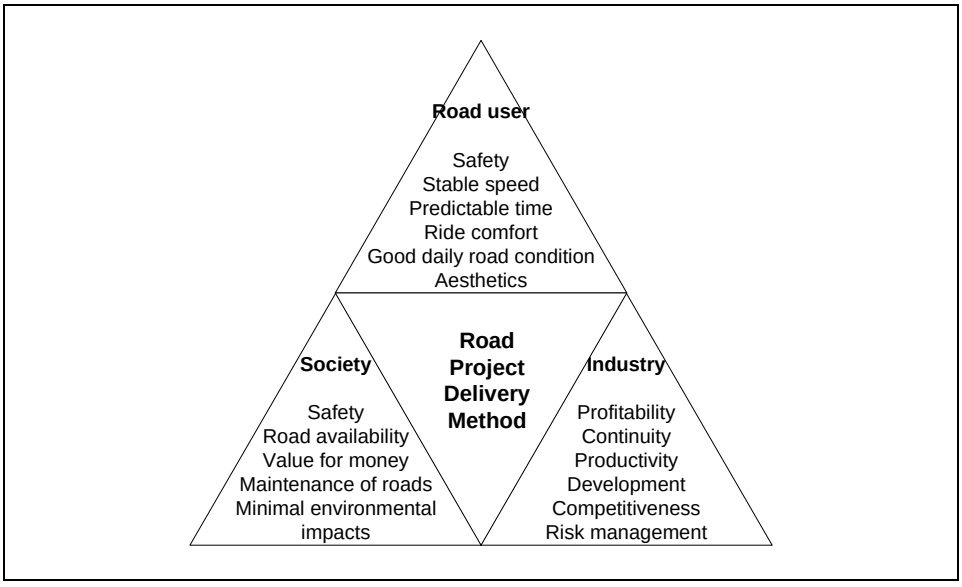

Figure 1. Goals of different project stakeholders /21/.

Globalisation will create demands for increased international cooperation on transnational issues. IT will be the major building block in international commerce, and the information revolution will enhance the ability of firms to learn best practices from the most successful enterprises which gives them significant efficiency gains. The integration of existing disciplines in order to form new ones will continue alongside lateral development of older established technologies into new markets and applications. Privatisation will also spur economic growth by generating competitive pressure to use resources more efficiently. /7/

2.3 Future business environment

The characterisation of the future business environment is based on the structural analysis method presented in /10/ (see Figure 2). According to the basic division of the method, inputs are transformed into outputs through activities, under constraints of control and with the help of the physical aspects of an activity, i.e. mechanism. Thus, the future operating environment depends largely on *controlling factors* that will drive and restrict the use of new approaches to project delivery in the road industry. Within these limits, by developing components and other *input factors,* it should be possible to construct a project that is characterised by changes in *output characteristics. Operative factors* then illustrate potential changes in operations. An effective operation can be ensured by means of new *mechanisms for success*. Figure 2 provides a comprehensive list of all these factors, while the main changes expected in the industry are listed here /39, 52, 4/:

- The client, aiming to be a network operator, is outsourcing services and requiring higher service levels from the industry. The product on the market is expanding from construction only to include development, design, operation, maintenance and possibly financing of the road, capitalising on the capabilities of different contract parties. As government-operated construction and maintenance decreases, the private market for these services increases.

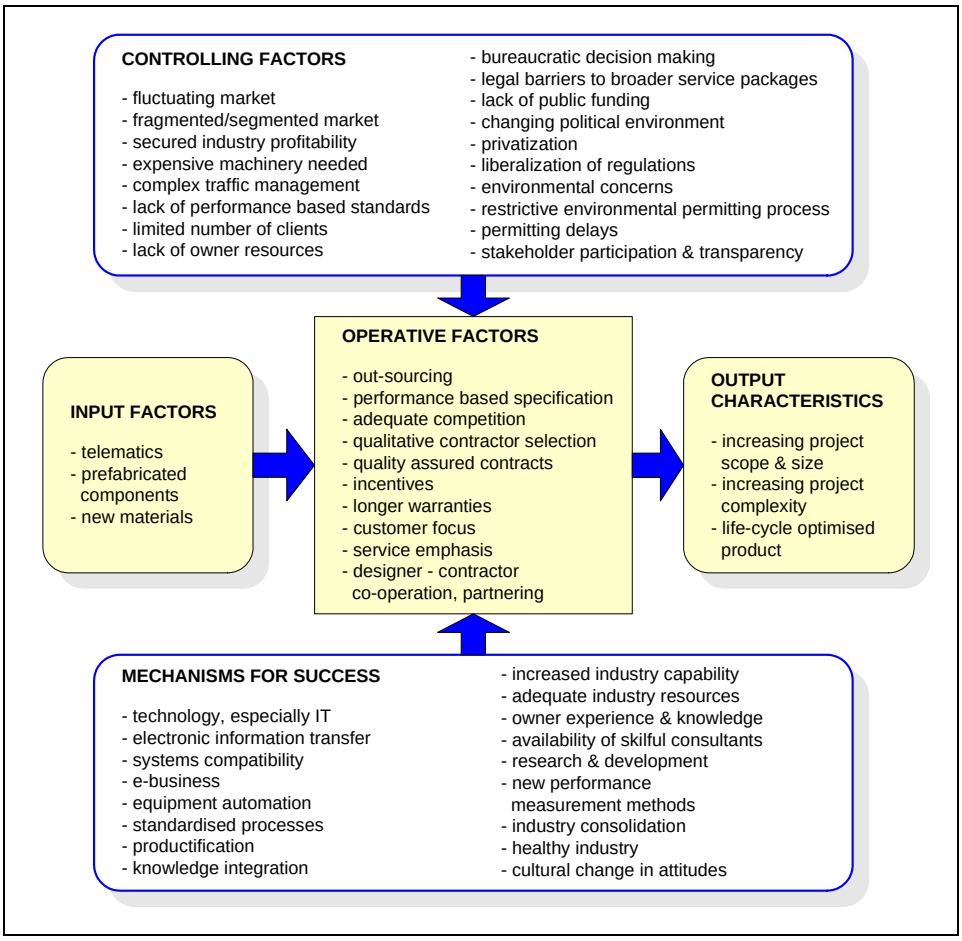

Figure 2. Changes in the infrastructure project delivery environment.

- Client staff is diminishing and can on some occasions be insufficient. Also client experience and competence are decreasing with experienced employees retiring. As a result, the use of consultants will increase.
- Competence-based appointment of service providers and outcome-based contracts are becoming more common, as clients increasingly want to ensure that contractors have the capacity and competence to complete the job.
- Internationalisation of competition and cooperation is leading to segmentation of the market into small and large projects.

- The market is consolidating and big companies will continue to drive the market. The number of contractors will decrease, but they will be better qualified and technically more competent.
- Companies will continue to diversify to reduce their reliance on the cycles of the industry. Contractors will also acquire design expertise in-house or form joint ventures. The greatest change will occur in the way the industry is structured and managed.
- Customer focus, meeting clients' needs, service orientation and a conscious investment in human capital (employee development and retaining, etc.) are emphasised.
- There is increasing focus on IT solutions and e-business, and their critical importance to a company's competitive position (use of Internet in procurement; automated information transfer and compatibility of applications in design; automated equipment and computer-integration in construction; IT in the roads and automated traffic management in operation/maintenance).
- Teamwork within the business and partnerships with stakeholders are increasing. Barriers created by economies of scale are lowered through co-operation and alliances, as well as through globalisation of business.
- Energy efficiency, environmental issues, sustainable development, waste management and recycling have an impact upon business operations and profitability through customer expectations, guidelines and regulations.

This assessment of the future operating environment is a composition of the estimates presented by the interviewees and literature. It forms a framework within which the future performance of different project delivery methods is assessed in Chapter 7.3.

3. Infrastructure project delivery methods

3.1 General

To overcome the shortcomings of traditional procurement, the construction industry has developed a large number of different project delivery systems /38/. Figure 3 classifies the project delivery methods on the basis of two key characteristics: integration of delivery and source of finance. Integration of delivery measures the degree to which the different project elements such as planning, design, construction, and operation are segmented or combined during the production cycle. Source of finance measures the degree of financial risk the owner assumes in executing the project /34/.

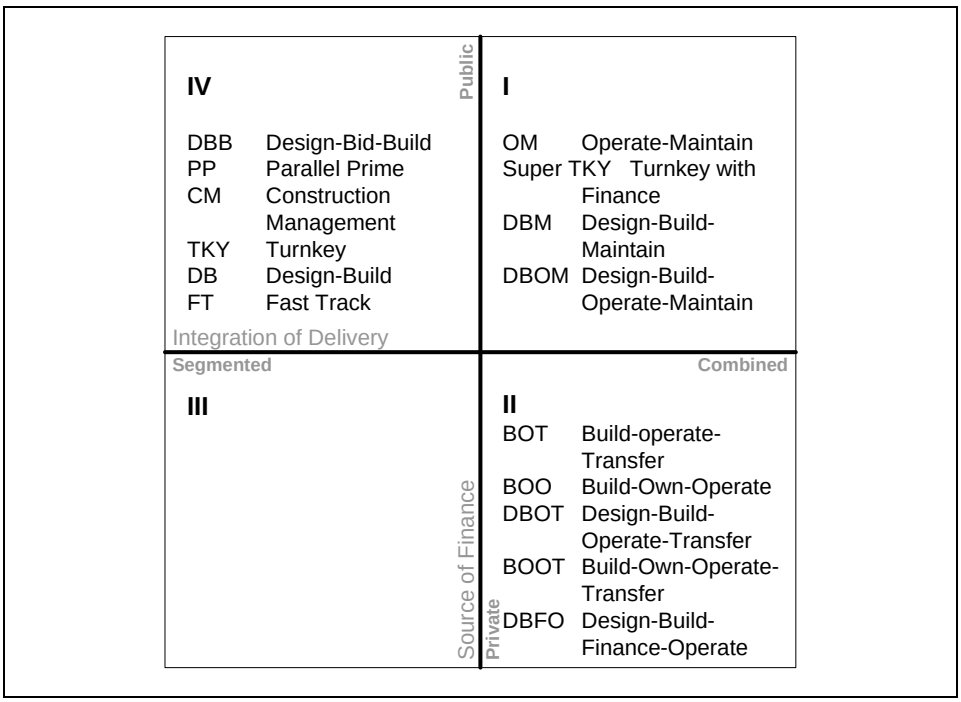

Figure 3. Operational framework for project delivery systems /34/.

The procurement route establishes the environment within which the relationships both up and down the supply chain are configured. Therefore formal contractual terms impact not only the ways in which knowledge and activity flow between the organisations within the construction project supply

chain, but also the way relationships are attained and sustained over the project timeframe /50/. As different contract types lead to different organisational structures and relationships between the participants, delivery systems have a heavy impact on the interests of participants /40/. The procurement method must address both the technical features of the project and the needs of the client, contractor and road user.

Often the decision to use any of the available project delivery methods is subjective. Contractual risks are seldom analysed and quantified by the client, even though consideration of risks at the procurement stage could save money and improve project delivery /16/. The key difference between the project delivery methods lies in the way risks and responsibilities are allocated to the parties to the contract (see Figure 4, where project delivery methods of interest are marked by yellow shading). There is an evident lack of consolidated knowledge about the specific merits of these potential alternative routes /36/.

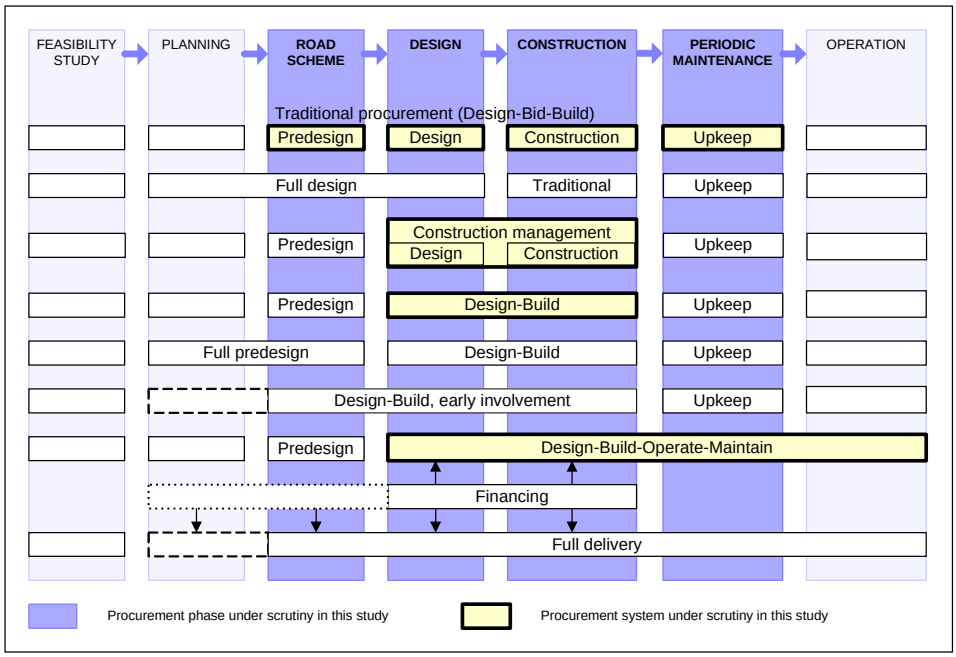

Figure 4. Activities covered by different project delivery systems.

3.2 Design-Bid-Build

3.2.1 Description

In Design-Bid-Build (DBB) the owner contracts separately with a designer and a contractor. This requires design completion prior to procuring construction. A contractor is typically selected based on the bid price and enters into an agreement with the owner to construct the road in accordance with the plans. Periodic maintenance is commissioned separately or performed in-house.

DBB is the most widely used project delivery method globally, and therefore well understood. It is driven by the belief that a public entity, armed with a detailed set of previously purchased plans and specifications, can achieve the lowest cost for the public through open, competitive bidding and proper supervision of the low bidder /37/. A project evolves in distinct stages and the owner coordinates and manages the entire process. The process minimises the owner's obligation to fully address the project objectives or definition before proceeding, as this will occur during design development. DBB simplifies the tasks of engineering, construction, and procurement community, promoting a series of 'commodity' purchases without significant need for professional judgement regarding appropriate delivery methods. Transparency and competition are guaranteed during the construction phase. The scope of work is defined by a 100%-complete set of construction documents. Risks are well defined and allocated by standard contracts /34/.

3.2.2 Responsibilities

Construction is managed based on ready-made designs, leaving constructability issues to the client. Design and potential deficiencies in it, delays and price effects, soil conditions and weather risks also remain with the client. The designer acts merely as a consultant with no risks on structural solutions as long as his conduct is professional. During the tender process, the contractor reviews risk issues to identify any value opportunities /42/, but a large number of risks

can be excluded from the contractor's price /28/. Extensive client risks may provide the contractor an opportunity to make money (partly unduly), if any client risks materialise.

3.2.3 Variations

Variations include a single contract or separate contracts (see Figure 5):

- In the single contract, the project is awarded as one entity to one contractor, who has the responsibility for delivering the project either in-house or with the help of subcontractors.
- In separate contracts ('multiple prime'), the client divides the project up and awards contracts to a few different contractors. One contractor is given the responsibility for coordination of works.

Payment basis for the project work also vary. The fixed lump-sum and the unit price contract are commonly used. Also, some design responsibility may be given to the contractor, if alternative designs are allowed at the tender stage or through value engineering opportunities during project delivery.

3.2.4 Applications

Generally DBB is considered suitable for projects:

- that are small, simple and/or highly constrained
- where the owner wants to carefully settle upon a design before committing to funding construction /34/
- where environmental, geotechnical, or regulatory issues leave no freedom for innovations
- that are unique, and of which only the client has experience, and/or
- where it is appropriate to take advantage of existing designs.

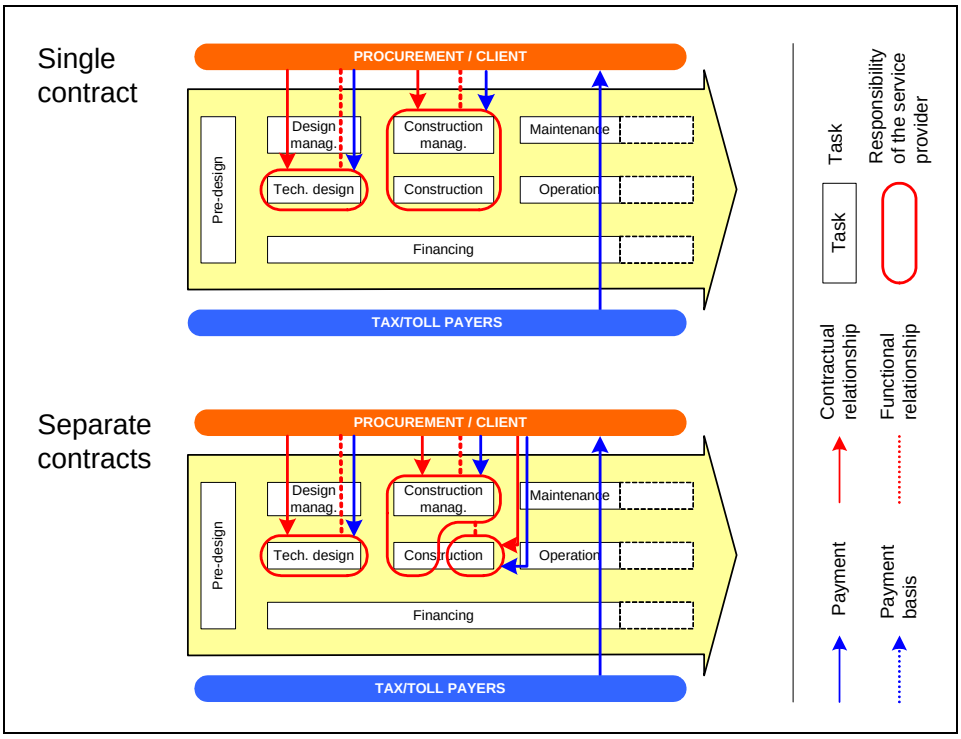

Figure 5. Variations of DBB.

3.3 Construction Management

3.3.1 Description

Construction Management (CM) is based on an owner's agreement with a qualified construction firm to provide leadership and perform administration and management for a defined scope of services. A construction manager (CMr) works throughout the various phases of a project and cooperates with the owner and a designer in furthering the interests of the owner /22/. Design and construction can usually overlap, but they are purchased in phases through many separate contracts. Periodic maintenance is commissioned separately or performed in-house.

3.3.2 Responsibilities

The CMr conducts constructability reviews, value engineering studies, construction estimates and contract packaging, etc. depending on the scope of services (see Chapter 3.3.3). Generally the financial risk of the CMr is small, but the risk of loss of reputation is high /40/. The client carries even more risks than in DBB due to the additional risks resulting from interfaces and coordination between multiple contracts and cost plus fee-type contracting. Designers' and contractors' roles remain much the same as in DBB.

3.3.3 Variations

The general CM variations are CM-at-fee and CM-at-risk (see Figure 6):

- In CM-at-fee, the construction manager is responsible for project and site management, but is not involved in actual construction work. Contracts are between the client and the contractors. The CMr monitors cost, time, quality and safety, but does not take responsibility for them /22/. Often large construction companies are not interested in CM-at-fee contracts, as they rather do the construction work. The CMr is paid a fixed or time based fee for services provided.
- In CM-at-risk, the CMr is also responsible for construction means and methods and delivery of the completed work, including quality and performance of the asset. All procurement in the project is done by the CMr, and the contracts are between the CMr and subcontractors. Still, the client retains the final decision in project delivery. The CMr is paid a fixed or time based fee for services provided and construction is paid based on cost and fee or guaranteed maximum price.

It must be noted here that this study focuses largely on CM-at-fee to be able to compare one CM alternative with DBB in a clear-cut fashion. As the CM variations are clearly very different from each other, their performances may differ significantly, and the performance assessment of CM-at-fee presented here should not be taken as a representation of CM-at-risk performance.

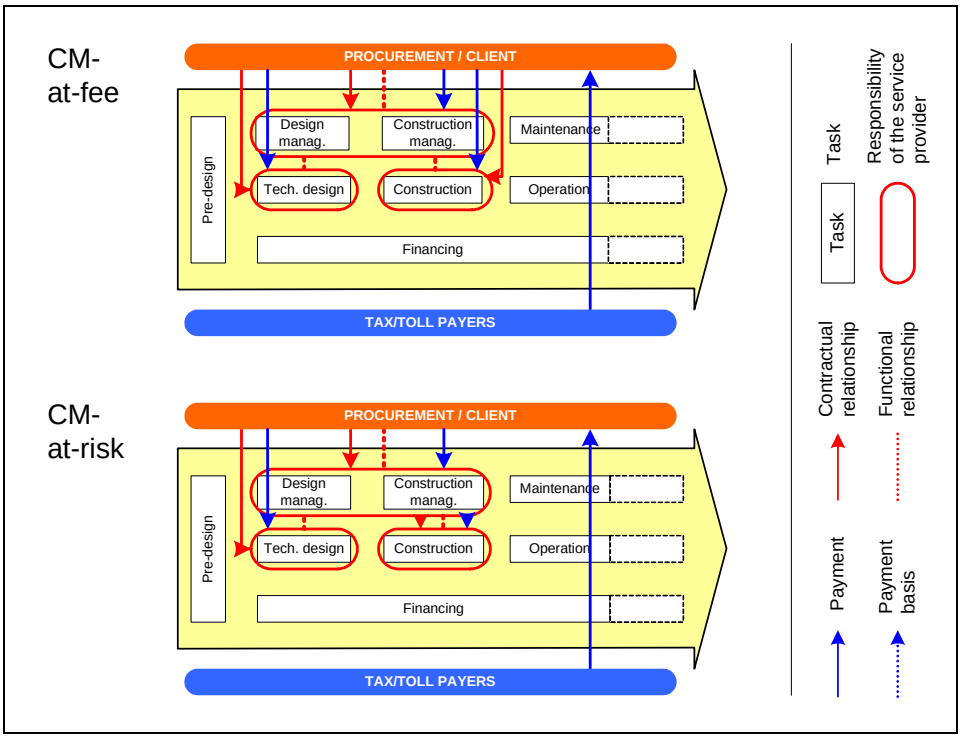

Figure 6. Variations of CM.

3.3.4 Applications

CM is seldom used in road building. The reason is that generally the number of trades and, subsequently, contractors involved in a road project is relatively small and easy to manage. However, when CM is used, the client tends to select it because of its flexibility with regard to the schedule and changes and the fiduciary relationship with the contractor before and during construction, while it also ensures competition for the work /40/. CM is suitable also when early completion is required /41/.

3.4 Design-Build

3.4.1 Description

In Design-Build (DB) one entity or consortium is contractually responsible for both design and construction based on the pre-design and design standards provided by the client. Combining design and construction creates a single point of responsibility and allows overlapping of design and construction. The client has an opportunity to assess both the price and technical solution offered by the bidders. Periodic maintenance is commissioned separately or performed in-house.

In DB, prospective bidders are provided 0–80% of the design, including mandatory requirements, in a Request for Proposal (RFP). The client identifies the project's desired end result, and defines clearly the scope of work and the requirements of the technical proposals. In return, bidders prepare a technical and price proposal showing how they intend to complete the remaining design and all construction /29/. Tender evaluation is more difficult than in DBB due to different technical proposals. Selection can be based solely on technical/quality assessment, solely on price or on a combination of price and quality /8/. The contract is, in practice, a fixed lump sum contract which lets the client know early in the process the final price of the project relatively accurately.

3.4.2 Responsibilities

In general, risks should be allocated to the party, who can best manage them. DB assigns a much greater risk to the contractor, who is responsible for design and construction risks, and often site risks. The design firm that usually subcontracts to the contractor often also assumes greater risks than in DBB. The designer’s role differs significantly from DBB, where the designer’s main interest is to protect his own and the owner’s interests. In DB, the designer is a co-worker of the contractor expected to benefit the DB team /40/.

3.4.3 Variations

There are many variations of the basic DB system (see Figure 7):

- Bridging: The owner provides a larger proportion of preliminary project design (50–80%) leaving less design responsibility to the contractor, who, however, assumes liability for design and construction as an entity. The contract is awarded based on the lowest bid price.
- Develop & Construct: The client contracts with a designer to develop 30–80% of design which clearly identifies and documents the basic solution. On this basis, contractors are invited to bid for the project. Selection may involve technical assessment in addition to price. After award the contractor becomes responsible for the initial design, too.
- Novation: Novation resembles Develop & Construct. However, when the contractor is selected, the contractual relationship between the client and the designer transfers to the contractor who is to produce any missing information required for construction /11/.
- Turnkey: In turnkey procurement, a single contractor acquires and sets up all necessary premises and equipment, and brings a project to a state of operational readiness (see Figure 7). The contractor also finances the project and is generally paid upon completion of the project, instead of the usual practice where payment is made in accordance with the progress of construction. Sometimes the contractor may continue to operate the facility for the client, but most often the client assumes operational control.
- Design-Build-Warranty: Design-Build-Warranty combines a longer than usual warranty provision with basic DB.
- Early Contractor Involvement (ECI): The contractor is hired early in the process to give input during preparation of the road scheme (see Figure 7). The early selection may be based purely on qualifications, as the target costing of the scheme happens only after contractor selection and adequate completion of the design. A DB contract will be entered into thereafter.

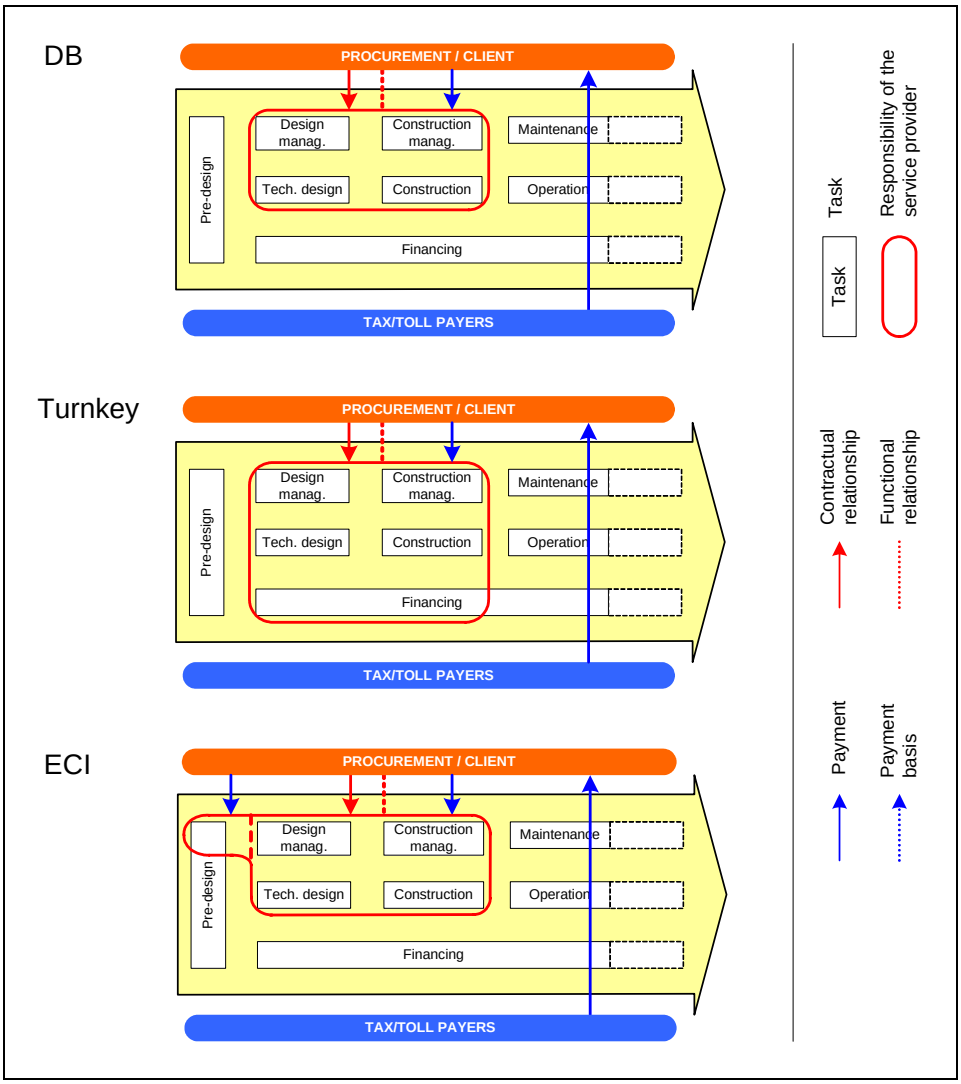

Figure 7. Variations of DB.

For the purpose of this study, DB is considered a generic form that leaves fair leeway for the design-builder to design the project with the designer selected by himself excluding bridging and novation-type alternatives. Early contractor involvement and longer warranties are also taken into consideration only as potential improvements to the more conventional DB approach, which involves warranties up to 5 years.

3.4.4 Applications

Generally DB is considered applicable in projects:

- where early completion and utilisation of the facility are of significant value.
- that have well-defined, well-understood construction objectives.
- that are large and technologically complex, and offer the most opportunities for innovation. This maximises the scope for a designer/contractor team to benefit from matching design and method for the best possible results /20/.
- that require expertise not available in-house.
- that do not involve complicated issues, such as utility conflicts, right-of-way acquisition, hazardous materials, wetlands and environmental concerns, or other issues that could affect the project. The project must be non-controversial in nature /37/. Projects, which suffer many and/or major third party interfaces, and in which the consequential risks can be better quantified by designing the works in detail, are ill-suited for DB /20/.

3.5 Design-Build-Maintain

3.5.1 Description

Design-Build-Maintain (DBM) contracts may vary extensively. One common denominator is the single contract that assigns the responsibility to design, build and maintain the asset to the private sector for the contract period. The contract may also include provision of private financing. Thus, DBM replaces the purchase of an asset with the purchase of a flow of services that derive from the asset. As a result, these projects are generally characterised by high risk transfer.

DBM models involve a long-term relationship between road authorities and contractors. The intent is to re-orient the public and private parties to assume a

mutual interest for the whole-life performance of the asset described in terms of supply quality and availability /50/. Effective management of these contracts requires understanding the project, the contractual arrangements and the ability to build effective relationships between the parties. Clients often seek advice from external advisers on legal and financial issues, contract management, and performance monitoring. Different skills are also required for the two distinct phases: design and build, and the provision of services /27/.

The service provider is usually a company established especially to carry out the contract (ProjectCo). The shareholders of the company usually include several companies, such as a construction company and a maintenance contractor. If the actual work executors are shareholders, they have a long-term financial interest in the project, contrary to DBB, where construction companies usually have no interest in the long-term performance of the asset. DBM motivates the consortium to estimate the full cost of constructing and maintaining the asset, to complete the construction as soon as possible and to ensure good quality of construction. /26/

The ProjectCo will consider the project successful, if it delivers the authorities' requirements while yielding a reasonable profit. For the client, the DBM project is successful, if it delivers value for money in the form of cost-effective, reliable, and timely services at the agreed price and of the agreed quality. The client also expects that the services are delivered consistent with legal standards, financial probity and management accountability. Through benchmarking services or market testing the client can regularly assess the value for money and risk transfer to ensure that they remain at the required level throughout the life of the project. As innovation and effectiveness are key factors contributing to better value for money, the client needs to minimise any unnecessary restrictions on innovation. /27/

3.5.2 Responsibilities

The client provides bidders an output specification of the services required, and the bidders determine how they will provide these services /27/. Thus, DBM represents a significant risk transfer to the private sector. At the same time, the ProjectCo has the opportunity to manage risk and add value for its own benefit.

It has to undertake risk analysis to ensure that the whole-life cost of the road is minimal and durability is high /42/. The payment mechanism puts into financial effect the allocation of risks between the client and ProjectCo. It determines the ProjectCo's incentives in service delivery highlighting the importance of appropriate performance indicators and related targets /27/.

3.5.3 Variations

There are different models for the provision of DBM services /9, 17, 19, 49/:

- Design-Build-Operate-Maintain (DBOM): In DBOM, infrastructure asset provision is via a lump-sum DB contract coupled with an operation and maintenance (OM) contract (see Figure 8). This is the simplest form of DBM. The concession period tends to be around 10 years.
- Design-Build-Finance-Operate (DBFO): This model builds on DBOM and includes greater risk transfer coupled with the provision of private finance (see Figure 8). The concession period is typically 15–30 years. The client retains title to the land and pays the service provider according to the preset payment mechanism.
- Build-Own-Operate-Transfer (BOOT), Build-Operate-Transfer (BOT): The private organisation designs, finances, builds, maintains and operates the facility during the contract period, and ownership of the facility transfers for a period to the private sector. In BOOT, the ProjectCo carries greater end-user risks as it gets paid based on usage (often through user fees) (see Figure 8). The concession period is 20–40 years.
- Build-Transfer-Operate (BTO): BTO resembles BOT, but here the private sector transfers the completed asset back to the public sector, which then lends it to the private sector for the contract period. This relieves the ProjectCo of furnishing the high-cost insurance required by the project during the operation of the facility.

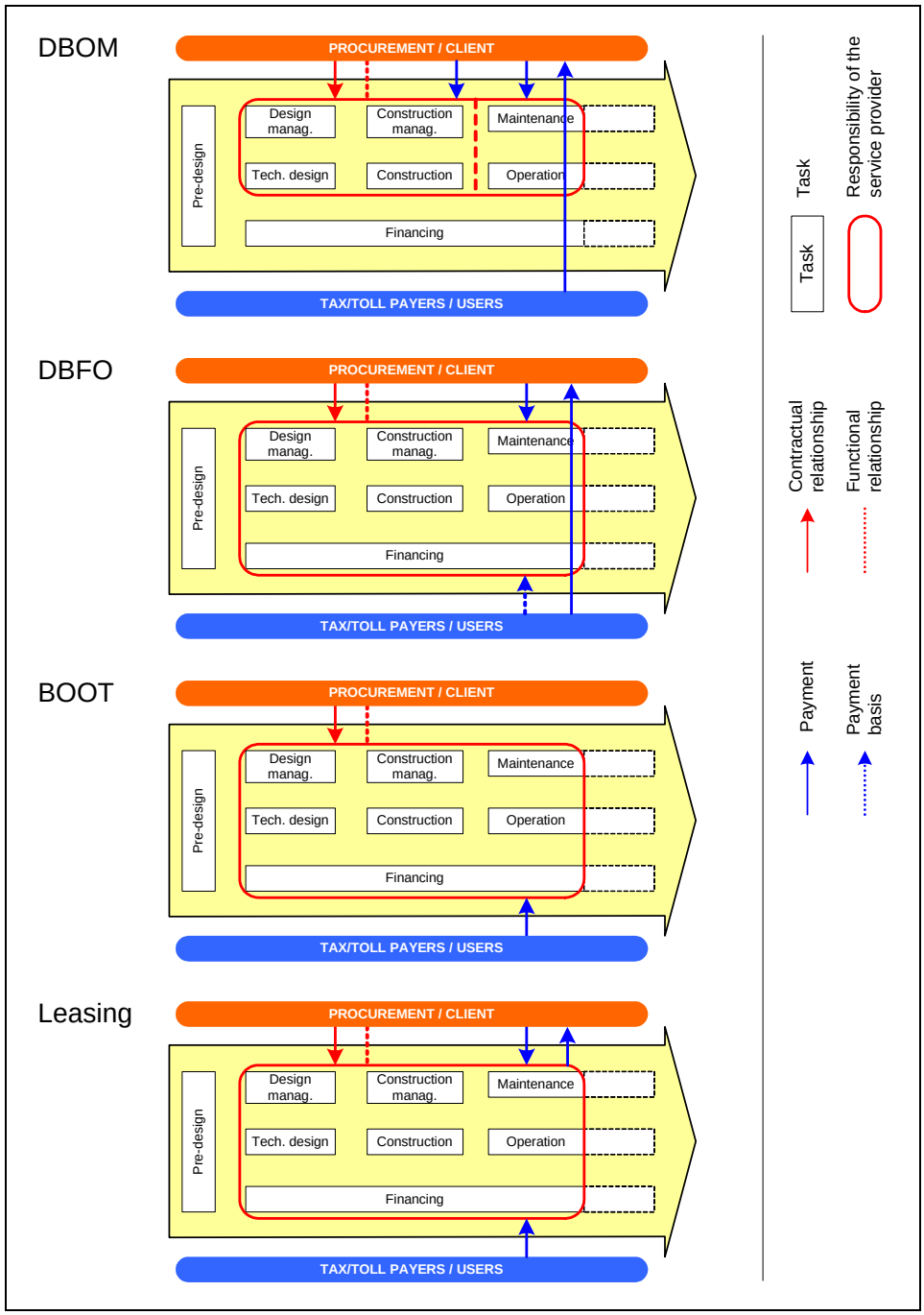

Figure 8. Variations of DBM.

- Build-Own-Operate (BOO): Like BOOT, but the private sector owns the facility, and ownership is not transferred to the public sector. BOO models may be considered partial privatisation.
- Leasing models: The private sector builds or rehabilitates the structure. The client may pay for the work, after which the private organisation operates the facility for the contract period and gets paid through a lease (see Figure 8). Leasing models are a combination of private and public funding. The ownership of the asset may transfer for a period to the private sector. The lease tends to run for around 10 years.

Two other related terms are often also used /17, 9/:

- Public-Private Partnership (PPP): In PPP the public and private sectors combine their special capabilities to deliver the project more efficiently. The contents of the contract may vary significantly, but generally the public sector transfers a significant level of risk and responsibility to the private sector by a long-term arrangement. PPP includes, in addition to the above listed DBM models, also relationship contracts like alliancing.
- Private Finance Initiative (PFI): PFI is one of the alternatives of PPP that involves private financing of the schemes, where the investment is recouped through public sector service fees. This term was adopted in the UK in 1992 as the framework within which DBFO projects are awarded.

This research examines the similarities between DBOM, DBFO and BOOT/BOT (hereinafter referred to as DBM) and compares them with DBB. Financing and proprietary issues are beyond the scope of the work and are mentioned only incidentally.

3.5.4 Applications

DBM projects are typically very large to ensure adequate economies of scale, to entice financiers and to compensate for the extra effort needed to bid for the work, finalise the contract, etc. Efficiencies should be achievable through integration of DB and OM responsibilities. Extended service packaging may be used to emphasise the importance of the quality and life-cycle perspective.

When private financing is involved, especially with BOOT/BOT-type procurement, the project should also be able to generate adequate revenues for the private sector. DBM is not applicable in small or very constrained projects. When financing is included and payment is dependent (even to a small proportion) on road usage, the project road should not be highly affected by other parts of the road network. Additionally, from the viewpoint of efficient project delivery, DBM should not be selected purely based on the lack of public funding, due to the client's desire to keep the project off the balance sheet or due to politics.

4. Research methodology

4.1 Research strategy

Given the fragmented nature of the infrastructure industry, the many forms of project delivery and their variations, and the unique nature of infrastructure projects in general, it is not possible to study either a typical project or a group of projects which represent the entire system. Thus, it was chosen to record primarily the experiences of the main market actors on actual projects, but not constrained to individual projects. When these experiences were compared to the findings in literature, an adequately accurate picture of the performance of different project delivery methods was formed. In addition, a systematic model was built based on the experiences of the market actors to enable determination of the future performance potential of the project delivery methods.

The research project reported here comprised the following stages:

Stage 1. Preliminary activities aimed at identifying the main project delivery methods and countries of interest, the principal sources of information, outlining of the main headings of the problem, and formulation of the research problems.

Stage 2. Development of the research strategy and methodology, and design of appropriate research instruments (interview forms, process maps, etc.).

Stage 3. This interview stage included preparation of the database of project contact details, contacting potential interviewees, conducting the interviews and their transcription. The interviewees included heads of procurement units; procurement specialists and project managers of different road administration organisations; clients' agents (consultants); members of ProjectCos; representatives of construction/design companies; and researchers of road project delivery. The interviews covered a multitude of project delivery issues including current performance and applicability, development needs and suggestions, market circumstances and trends, etc.

Stage 4. The data was further expanded through country-specific literature reviews, including policy statements, government guidance, available case

studies, academic publications and other kinds of project delivery-related publications, such as in the trade journals.

Stage 5. Summarising of data gathered through country specific interviews and literature review, and reporting of the first part of the research /1/.

Stage 6. Analysis of current project delivery performance based on all material gathered. Collected data was analysed primarily qualitatively. Results of the analysis include current cost performance, value generation and economic efficiency of the project delivery methods. Applicability of the project delivery methods in different circumstances was also assessed.

Stage 7. Evaluation of the future business environment and future performance potential and economic efficiency of the project delivery methods. Means of improvement available for different project delivery methods were also identified and studied prior to the evaluation.

Stage 8. Critical review of the research and its results, as well as related recommendations.

Stage 9. Report on the completed research consisting of two parts: the data gathering is reported in /1/ (stage 5) and the analysis and associated recommendations are reported in this, the second report.

4.2 Data collection

In addition to cost performance, the main interest of this research focused on the value generation of the project delivery methods. Value generation is an ambiguous term that includes partly subjective features. The research also looked into the future instead of only recording historic performance. This is why the primary means of data collection were interviews of main road sector actors in the selected countries. The global viewpoint also intensified the need for an interactive way of data collection, since it was not possible to gain necessary understanding of different cultural issues and drivers just on the basis of, for example, questionnaires. The interviewees were to have extensive experience from project delivery of alternative forms in order to be able to assess the performance level in each case. The information gathered through interviews was supplemented and verified by an extensive literature review.

The countries of interest were selected based on the preliminary study on the innovativeness of road project delivery in different countries /5/. That study came to the conclusion that the UK, Australia, New Zealand and USA were the most innovative foreign countries. Thus, these four countries were selected as the primary targets for this study in addition to Finland. In all five countries the road sector was to compare different, alternative project delivery methods with DBB.

The alternative project delivery methods of the research were selected based on the interests of the Finnish road sector. In Finland, Design-Build (DB) and Design-Build-Maintain (DBM) and their variants were considered the alternative procurement methods for future road project delivery. Construction Management (CM) was also included, since it is extensively used by local authorities. The work was started by defining the content of the selected project delivery methods and the allocation of responsibilities and risks in each case. Process maps and risk allocation matrixes were drafted for each project delivery method. They are presented in appendixes of /1/.

The data collection involved gathering general performance information instead of detailed, case-specific time, cost, etc. information. Interviewees were asked to give ‘average’ estimates based on numerous projects or to give estimates based on one or a few cases, whereby the impacts of potentially unique circumstances were eliminated. The reason was that there are no projects that can represent the typical road project. Each project is unique in one way or another. A statistical analysis would require collection of an extensive amount of case-specific, exact numeric data, and getting an adequate amount of such data was considered uncertain. Even with adequate current and past numeric data, an accurate picture of the future performance of the project delivery methods could not be provided due to the large number of variants. Thus, detailed case studies were not done, but a more qualitative analysis was carried out. The multi-national base data, gathered from culturally somewhat diverse countries, also required that the potential effects of the operating environment were taken into consideration to ensure general applicability of the overall analysis.

4.3 Analysis of the current efficiency

4.3.1 General

Analysis of the performance of project delivery methods was based on three factors: cost performance, value generation and economic efficiency. The current performance of project delivery methods was assessed based on the 'accurate' information provided by the interviewees and presented in literature.

4.3.2 Cost performance

The road project delivery process may be divided into direct and indirect activities. The latter make it possible to perform direct activities on a continuing basis, including activities such as scheduling, administration, quality assurance, etc. In many industries, indirect activities (such as quality assurance) may represent a large proportion of costs. Besides, indirect activities often affect the cost or effectiveness of other activities while the way other activities are performed, in turn, affects the need for and types of, for example, quality assurance activities. Linkages between value activities often also reflect trade-offs between the activities to achieve the same overall result. For example, more costly product design may reduce maintenance costs /30/.

In addition to generating costs, activities also create value. Porter /30/ has introduced the concept of the value chain, a general framework for thinking strategically about the activities involved in any business and assessing their relative cost and role in value generation. The material of this research did not provide adequate information to assess cost and value creation of each, separate activity (RFP preparation, tender assessment, etc.), but rather larger entities were examined. The entities were project phases: procurement, design, construction, maintenance. The cost of each phase under different project delivery methods was assessed. The cost was divided into direct (industry-generated) costs and indirect (client-administrative) costs. The cost of the external advice used in each phase was also taken into account as a separate cost factor. The way different phases are linked to others results in cost differences between different project delivery methods.

As no detailed case studies were done, the project cost comparison was mainly based on the interviewees' estimates of resulting savings or additional costs in different project phases using different project delivery methods compared to DBB. To get a realistic cost structure for the cost analysis, costs of two benchmark projects were collected systematically. However, the cost of maintenance needed to be estimated based on generic cost data. As maintenance of roads may vary significantly, to simplify the assessment, an average 5-yearly maintenance cost was divided equally to that time period. This gave a constant maintenance cost for the whole reference period. By using the collected cost data the costs of the other project delivery methods were calculated. Savings were varied within given ranges to reveal the effect of the estimated savings on the cost performance of the project delivery system. It is important to note that both the interviewees' estimates and the cost structure of the benchmark project were verified against literature data.

As all phases also have a time dimension that varies from one project delivery method to another, this was taken into consideration by calculating the present cost of the procurement, design, construction and maintenance over a period of 30 years (see Figure 9). This provided a clear and comparative cost parameter and also gave an indication of how long the road would be in use during a 30-year period, if the road was procured with different methods.

4.3.3 Value generation

Some project objectives are common to the owner and contractor. Yet, owners frequently have objectives not shared by the contractor, and similarly contractors have objectives not shared by owners. These objectives are listed in Table 1.

In addition to the pure client and contractor objectives, each road project involves a number of user/community objectives. These are mostly included in the client objectives (maximum road availability, minimum disruptions, flexibility to meet future needs, minimised need for maintenance interventions, low cost, aesthetics, etc.), since it is the client's duty as a community server to take the user needs into consideration. However, the importance of each user objective likely differs from the importance the client assigns to the factor. When assessing the value that each project delivery method creates, one should

look at the method's ability to address all the needs/objectives of different parties.

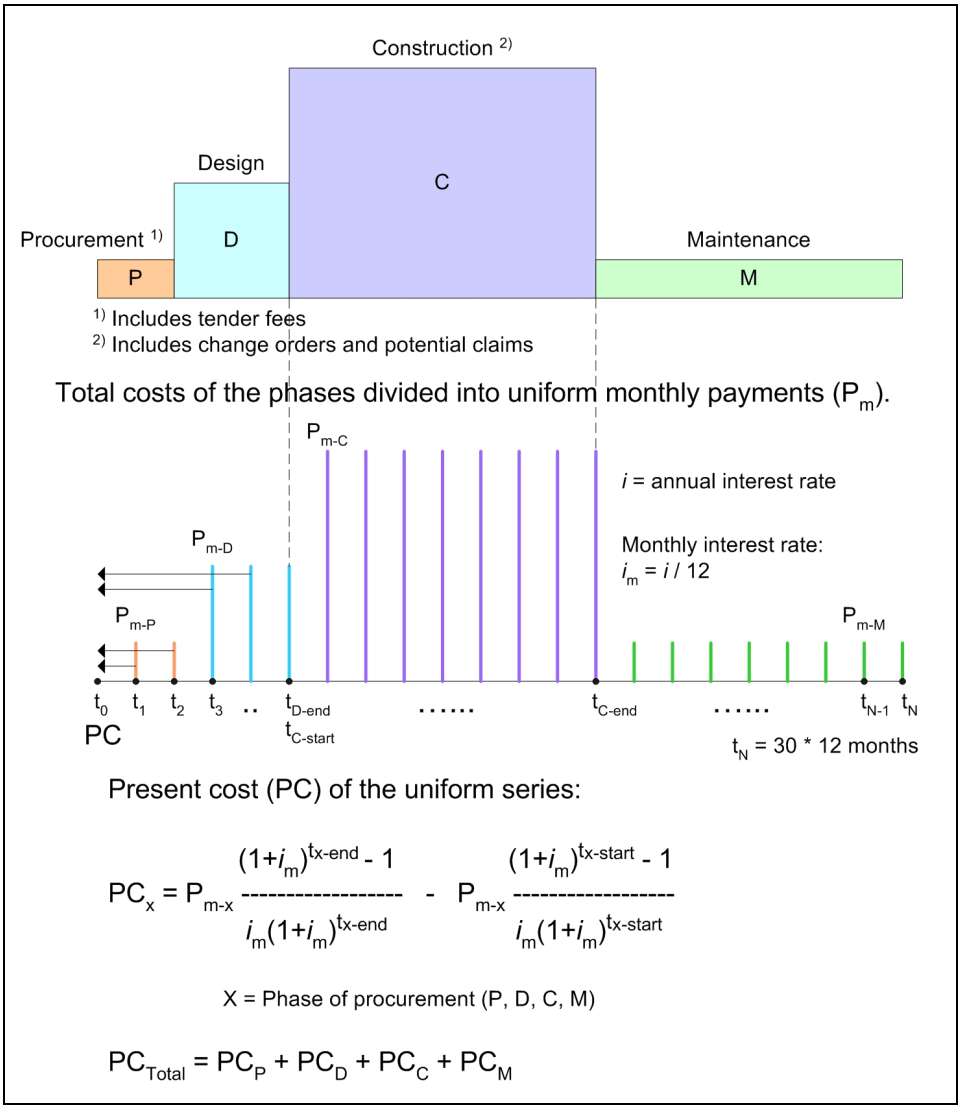

Figure 9. Calculation of Present Cost (PC).

Table 1. Owner and contractor objectives /53, 15/.

Owner objectives	Contractor objectives
• minimum road operating and maintenance costs • cost certainty • no claims/litigation • maximum road availability • minimum user inconvenience • minimum environmental impacts • benefits for community at large • flexibility to meet future needs • high service quality for users • optimum traffic capacity • exceeding of user expectations • establishment of a road constructing/operating industry • development of new and innovative technologies, materials and project delivery methods • optimum employment level • employee development	• managed, timely cash flows • quick profit generation • profit and other financial goals • satisfied client and repeat business • optimum tender work and hit ratio • competitive advantage • limited long-term liability • optimum employment level within contractor organisation • employee development • employee satisfaction • development of product • continuity of the business/ operations • flexibility to meet future needs
Shared objectives • cost effectiveness • time certainty / timely operations • optimum project cycle time • safe project execution without lost time accidents • appropriate product quality / quality workmanship	

Here value generation is determined mainly from the client perspective. The client values were derived from a literature survey and test interviews made in the early phases of the research. Value generation from the other stakeholders' perspectives is merely commented to verify that there are no insuperable hindrances to using any project delivery method. The interviewees assessed value generation between each project delivery method and DBB. The value generation of DBB was given a score of 3. If a project delivery system created less value than DBB, it would receive a score of 1 or 2. If it generated more value, its score would be 4 or 5. The divergent client values are grouped for the analysis under the following headings:

- *Cost certainty* – Does the project delivery method provide the client a reliable cost estimate at the onset of the contract? It is important for public clients, due to budgetary constraints and processes and accountability requirements, to have a reliable cost estimate at the beginning.
- *Time certainty* – Does the project delivery method provide the client a reliable schedule at the onset of the contract? It is important for public clients to ensure timely provision of needed infrastructure services for the users.
- *Short cycle times* (time performance) – Shorter cycle times allow faster delivery of needed infrastructure services and help to minimise the inconveniences experienced by the users due to construction-caused disturbances and lack of service. Faster project delivery results also in savings from the viewpoint of society.
- *Good quality product* – Good quality ensures a pleasant and comfortable road corridor for the users, and results in minimum user inconvenience during construction and due to maintenance activities.
- *Safe & environmentally friendly execution* – The importance of safety and especially environmental issues is increasing globally in all industry sectors.
- *Flexibility to client changes* – Does the project delivery method provide the client enough flexibility for necessary changes during the time period under examination (30 years)? There will always be issues that are not taken into consideration during the tender phase or that change during the life cycle of the road. Thus, it is important for clients to ensure adequate opportunities for changes.
- *Smoothness of procurement process and project delivery* (information transfer, claims and disputes) – Smoothness of the procurement process describes the service level and trouble the client has to go through during project delivery: difficulties in information transfer, and trouble due to claims and disputes. Due to reduced client personnel in the public sector, reductions in the client burden are essential.

- *Public inconvenience* (maximum road availability) – As clients pursue to maximise user satisfaction, it is important to minimise public inconvenience during project delivery and the road's life cycle.

The influence of value generation on client's finance and project costs is taken into account in the cost performance, and an attempt is made to eliminate it from the value factors.

4.3.4 Economic efficiency

Public owners are constantly challenged to put public money to its maximum use. They struggle to find the right combinations of cost, time, quality and other value determinants. This means that neither costs nor values can be the only critical measure of a system's superiority, but a more comprehensive meter has to be developed. To have a simple system for comparing different project delivery methods, the concept of economic efficiency was developed. Economic efficiency (EE) is determined by the ratio of value generation to cost performance (see Figure 10). The more value the project delivery system creates at a certain cost, the more economically efficient way it is to procure roads. Hence, economic efficiency describes value for money received by the client.

4.4 Analysis of the future efficiency

The research aims to provide answers to current and future project delivery problems. While interviewees were asked about the current and past performance of each project delivery method, their visions about the suggested means for improving project delivery methods, the PDSs' future performance and future market conditions, were also recorded. On this basis, examination of the future usability was divided into two steps: first, the future performance of each system was studied in relation to current performance, and secondly, the system's operational preconditions in the foreseeable, future operating environment were tested to ensure that the external environment would not pose insurmountable obstacles to the use of any of the project delivery methods of interest.

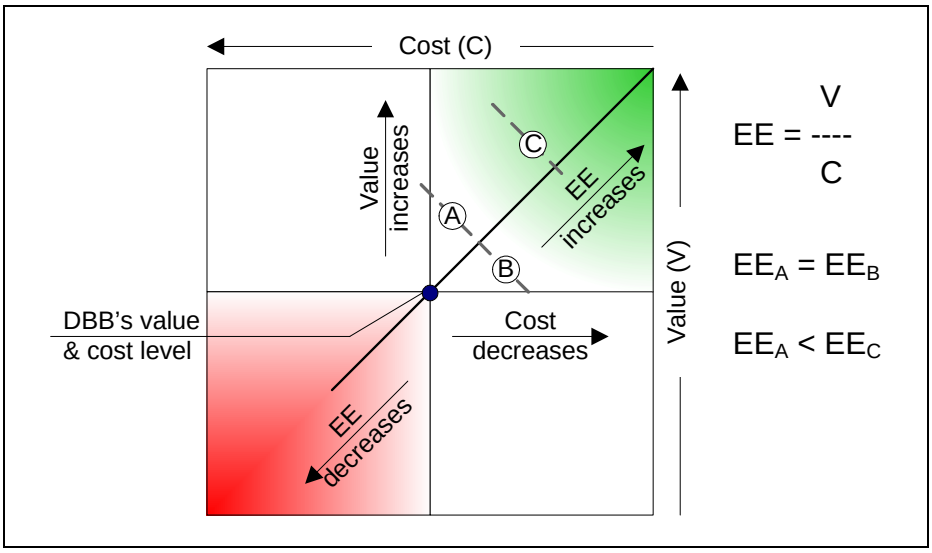

Figure 10. Determination of Economic Efficiency (EE).

The assessment of the future performance of the project delivery methods was based on the evaluation presented by the interviewees of issues affecting the development potential of the methods. These factors, according to Figure 11, are 1) process adaptability, 2) knowledge generation and 3) team coherence, in addition to 4) means of improvement available in each case. The first three factors are common preconditions for operational and business development in the long term, just based on accumulating experience and learning in the organisation. The fourth factor covers concrete changes to the current practise suggested by the interviewees or literature. The effectiveness mechanism of these changes was critically assessed and more easily determined. In the end, the effect of all four factors both on cost performance and value generation was estimated to gain an understanding of the development potential of PDSs. When it was incorporated with the current performance, the future economic efficiency of the project delivery methods could be determined (see Figure 12).

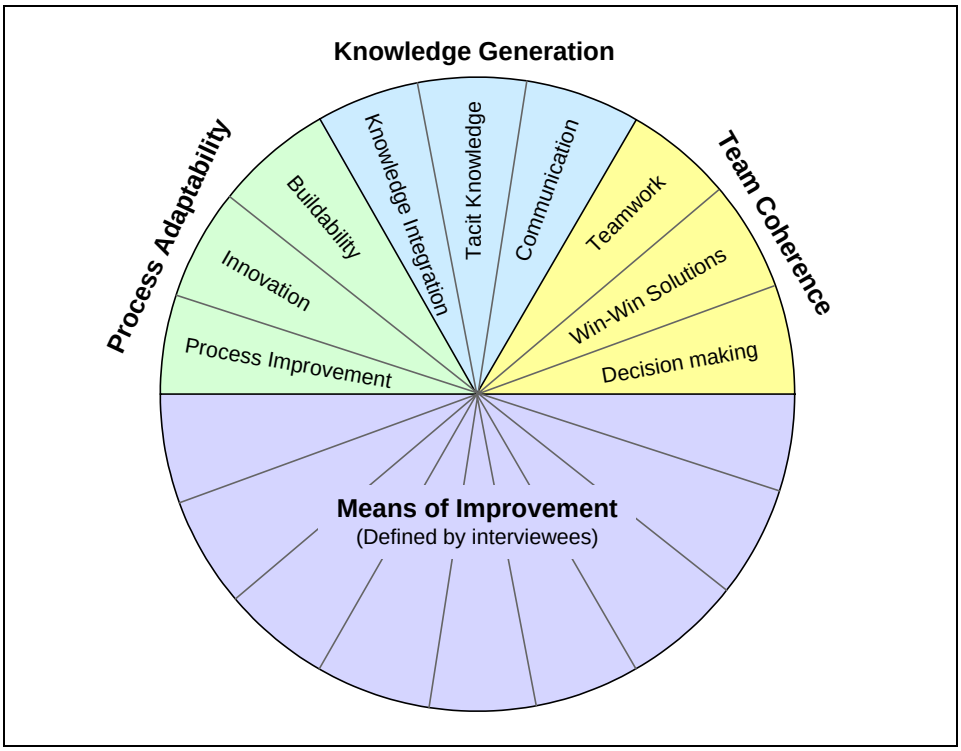

Figure 11. Determinants of Development Potential (DP).

Finally, to provide a broader picture of the future operating environment, future-oriented literature on mega-trends was also reviewed. It was integrated with the visions of the interviewees to create the framework in which the future projects must be delivered (see Chapter 2.3). This framework helped in assessing operational preconditions of the different project delivery systems. As the future environment remains somewhat uncertain, the framework is used mainly to ensure that there are no visible trends that would create significant barriers for application of any of the project delivery methods. Additionally, the framework makes it possible to anticipate whether some forms of project delivery will benefit more from the expected changes than others.

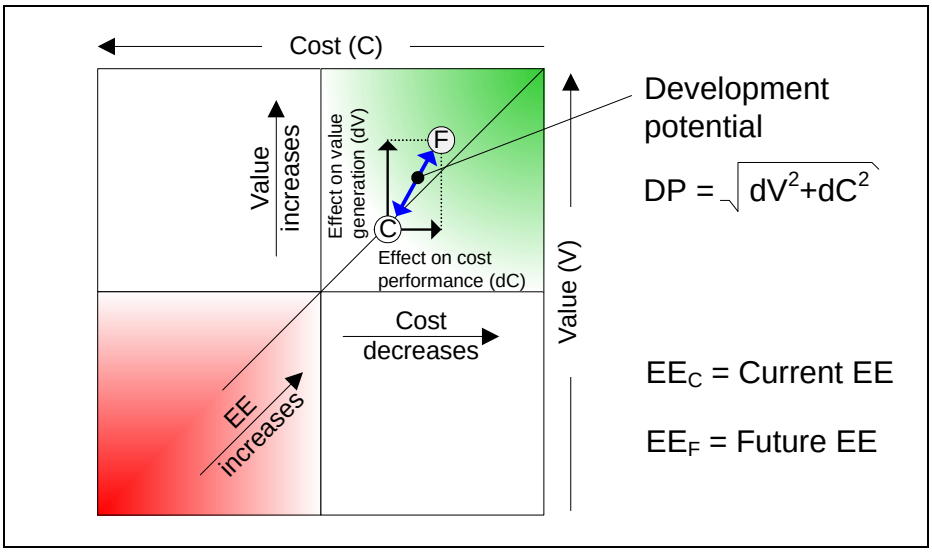

Figure 12. Determination of DP and future EE.

5. Implementation of data collection

A large volume of information was generated through the semi-structured interviews reported in /1/. The interviews attempted to shed light on all aspects of project delivery from statutory requirements to periodic maintenance and warranties. The interviews dealt with various project-specific and non-project-specific issues relevant to procurement practises in the selected countries. Thus, two types of interview forms were used: case specific (C) and general (G). The questions were grouped under the following headings:

- Interviewee
- Client objectives (G)
- Project delivery in general (G)
  - General experiences
  - Applicability
- Project information (C)
- Project delivery process
  - Service provider selection
  - Design
  - Construction
  - Periodic maintenance
- Project output
  - Risks and responsibilities
  - Project team
  - Administration
  - Schedule
  - Cost
  - Quality
  - Change orders
  - Claims and disputes
  - Innovation
  - Client satisfaction
  - Project success
- Lessons learned
- Market issues (G)

The interviews were designed to extract real and accurate numeric information from the interviewees. In the absence of purely objective data, explicitly expert evaluations were recorded to depict the extent and effect of different factors. These data were supplemented and verified through an extensive literature

review. The literature provided information mainly on the time, cost and quality performance of different project delivery methods, but also on problems related to relationships between the project parties. The final analysis of the project delivery methods is based on both the opinions of the informed and expert respondents from the road industry, including both private and public sector representatives, and literature available at the time of the research.

Industry experiences and views were charted in Australia, England, Finland, New Zealand and the United States, where a total of 66 persons were interviewed as shown in Table 2 (and identified in an appendix of /1/). The interviewees and potential projects were selected through expert referrals, industry journals and databases, local road administrators' web pages, and referenced articles. The client organisation in each country was the national road administration organisation. In order to maximise the input of each interviewee, questionnaires were sent to them approximately two weeks prior to the meeting. If possible, the interview was based on an actual project to focus the conversation on real, experienced effects of the project delivery method used. As a result, the 15 projects of Table 3 were viewed in the selected countries. The summaries of country-specific interviews were sent to the interviewees to verify that the information recorded appropriately presented their views and the situation in the market.

Exact numbers on the use of different road project delivery methods in each country are difficult to give, as usage differs from state to state and from road region to road region. However, the project delivery methods used by the clients and explored during interviews in each country are listed in Table 4. Interviews on CM were done only in Finland, and on BOOT and DBOM only in Australia.

Table 2. Research interviews.

Country	Client	Contractor	Designer	Consultant
Finland	11	4	1	1
UK	5	2	0	1
Australia	12	4	1	4
New Zealand	1	1	1	2
USA	4	1	2	8
In total (66)	**33**	**12**	**5**	**16**

Table 3. Cases studied in each country.

Country	CM	DB	DBO	Alliance
Finland	1	3	1	
UK		1	1	
Australia		2	2	
New Zealand		1		1
USA		2		

Table 4. Road project delivery methods used in the different countries.

	DBB	CM	DB	DBOM	DBFO	BOOT	Alliance
Finland	**O**	O	**O**	O	**O**		
UK	O		**O**	O	**O**		
Australia	**O**	O	**O**	**O**	O	**O**	**O**
New Zealand	**O**		**O**				**O**
USA	**O**	O	**O**	O		O	

O Project delivery method used/common.
O Project delivery method used in the past/will be used in the future/is rare.

Therefore, CM, DB and DBM (combining data gathered on DBOM, DBFO, BOOT) were included in the analysis presented in Chapters 6 and 7. While alliance is attracting increasingly attention, experiences with it are so far somewhat limited. Thus, it was excluded from the analysis, but it is recognised that it may provide an attractive alternative for procuring complex and high risk projects in the future. Benefits, disadvantages and the performance of alliancing based on the interviews and literature is reported in /1/.

All in all, this first phase of the study, focusing on the experiences and realised results from different project delivery methods in different countries is extensively reported in /1/. This report combines information given by the 66 interviewees and about 150 articles/books into about 240 pages of text. It also sheds light on the procedures used and allocation of risks in different project delivery methods.

6. Means of project delivery improvement

6.1 Common means of improvement

6.1.1 Partnering

Partnering is applied outside the contract to align goals and objectives of the parties and to facilitate communication, teamwork and joint problem solving /51/. The partnering process includes an initial workshop to define the co-operative principles and potential follow-up workshops with all key players, regular meetings onsite, and regular discussions and sharing of knowledge both at work and during get-togethers. The arrangements generally include sharing of risks/rewards and open evaluation and constructive feedback on the partner's operations. Rewards ensuing to the contractor should be proportionate to the benefits that the client achieves, and penalties should be tied to losses that the client might suffer.

Partnering is common in the UK, USA and Australia with all delivery methods, as there a strong and open relationship between the parties is considered the sign of a successful project /35/. Partnering is often an integral part of DB projects, where a higher degree of communication and collaboration is required /23/. Partnering is most valuable in projects with tight schedules, where open communication enhances the efficiency of critical decision making /33/. Complex, difficult and high-risk contracts will also benefit from partnering.

Continuous partnering improves project performance /33/, as savings up to 5% for the contractor and as much for the client are possible. However, contractors see the main advantages of partnering in being able to produce quality work on time and within budget, in identifying problems before they become serious issues, and in building relationships which create greater confidence in future dealings with other parties /46/. Other partnering-related benefits have also been reported /12, 51, 18/. Where partnering has been used, the parties are generally not willing to return to the situation before its introduction.

6.1.2 Standardisation

The cost of preparing RFP documentation, tendering and preparing contract documentation is often mentioned as the biggest problem with DB and DBM-type procurement. With experience the work is reduced. However, many clients are working to standardise the documentation to facilitate and fasten the initial stages of project delivery. The procurement process may also be facilitated through a more standardised approach to risk assessment and management. Standardisation is beneficial even though some adjustments to the documentation need to be made on a project by project basis. Standardisation brings up-front costs to the client and may initially cause some project delays, but it saves both time and costs in the long run.

In vertical construction, standardised processes have helped clients achieve better projects by finishing projects on time and meeting quality and cost objectives. Moreover, more contracts can be let with fewer in-house people, and internal costs are decreased. Cost overruns can be reduced from 10% of project costs to 2%, the reduction in staff can amount to 20%, and construction time reductions can be 29% /6/. Standardisation of processes also increases the confidence of the private sector in the transparency of the procurement process, while standardisation of documentation increases the private sector's confidence in the continuity of procurement which keeps them interested.

6.1.3 Hybrid delivery methods

Hybrid delivery methods include elements of different procurement routes. They may be developed to best suit the complexity and risks associated with a particular project. Especially DBB procurement can be enhanced by incorporating some elements of DB into it, or DB by incorporating early contractor involvement elements into it. For example, in DBB, contractors could be short-listed early during the technical design phase, when they have the opportunity to interact with the client to clarify any fully designed elements and to check the design window for any design-construct elements. Once the design is complete, the short-listed contractors would submit a full tender for the work. This would encourage innovation, identify and allocate risks better, allow greater use of lump sum pricing, align the scope better and reduce design

redundancy. At the same time the contractor's tendering costs and risks would be reduced /32/. However, the client needs to ensure that he does not end up paying excessively for the work due to reduced competition.

6.1.4 Contractor selection

Contractors have concerns over the use of both the weighted criteria attributes and quality/price trade-off methods. Methods and processes used to assess quality are not sufficiently transparent for tenderers to gain their confidence in the process thereby encouraging them to advocate the use of the lowest price conforming tender /32/. However, any supplier selection method that emphasises cost, encourages suppliers to interpret the client's requirements frugally to achieve a price advantage over competitors. The resulting problems are more prevalent in small projects, where suppliers are selected less carefully.

Developing quality/price trade-off procedures and communicating them clearly increases transparency. Short-listing of prospective suppliers not only ensures that high quality suppliers are selected, but also reduces the administrative burden of evaluating tenders and the cost of tendering for the industry. The client must consider the cost of tendering, complexity of the tender process and project complexity before deciding to adopt the short-listing process, as over-using short-listing can weaken smaller suppliers' sustainability and the industry's competitiveness. /32/

Interactive tender meetings also help to clarify clients' wishes thereby ensuring expected project quality and specified outcomes. The meetings allow tenderers to put forward an outline of their conforming and alternative concept designs, and for the client to provide feedback on the designs' acceptability. Contract documentation can be improved to ensure that all parties are comfortable with the specified requirements, and participant objectives can be better aligned. Additional investigations can be done to more clearly identify and manage risks. However, this interactivity often lengthens the tender period slightly. /32/

6.1.5 Incentives/disincentives

Use of incentives in road construction is increasing at the same time as use of DB and DBM methods is becoming more common. The primary benefit of incentive clauses is that they allow owners to identify and prioritise their project goals. Incentives and disincentives (I/D) motivate a service provider to complete the work on or ahead of schedule, or to provide a product of a higher level of quality, safety or overall performance. Incentives are also used in target cost contracts in the form of 'pain/gain share' to ensure that the contractor delivers the road most cost-efficiently /18/.

If appropriately structured, I/D encourage innovation in order to meet the I/D requirements. However, there is always a cost to the client, who needs to consider the benefit achievable. The I/D need to be strong enough to motivate the service provider, but in proportion to the benefits. The service provider must also be able to manage the work related to the I/D goal /18/. Often the difficulty associated with I/D relates to the valuation and measurement of the achievement of the I/D goal /3/.

6.2 Improvement of project delivery methods

6.2.1 Design-Bid-Build

Strengths & weaknesses. While DBB is a well-known project delivery method that promotes competition and ensures transparency, there are significant problems with the process as well. With DBB the challenge is the extensive need for client resources in managing the contract. It does not allow co-operation between different project participants thereby hindering industry innovations. As each party has its strict responsibilities, technological improvements and integration of systems are blocked. Moreover, competition is based solely on price. The strengths and weaknesses of DBB are listed in Table 5.

Table 5. Strengths and weaknesses of DBB project delivery.

Strengths	Weaknesses
• well-known delivery method • universally applicable • easy to tender • ensures work for contractors of all sizes • industry capability available • adequate competition • low tender cost • transparency • allows the lowest contract price • provides complete documentation allowing preparation of bills of quantities before construction • client control over project delivery • emphasis on aesthetics possible • client-determined quality level • monitoring of quality transparent • stable and familiar technologies used • pre-qualification encourages better performance • develops client capability • client expectations generally met	• prescriptive specifications • only one design solution available • no contractor contribution to design • lack of buildability of design • lack of innovations • price only competition • low industry profitability • does not promote privatisation • does not develop industry • extensive need for client resources in managing the contract (client as a middle man) • separation of roles • self-serving adversarial behaviour & adversarial relationships • problems associated with low price contractor selection • does not encourage technological improvements or integration of systems • no emphasis on whole-life cost • lengthy project delivery process • ineffective information transfer • more difficult to enforce quality conformance due to divided responsibility • multiple change orders • lack of cost certainty • cost and time overruns • no international competition

Improvements. There are multiple solutions to addressing the above weaknesses. They are presented in Figure 13. In the first phase, similar, country-specific value networks were produced for all project delivery methods /1/. These networks included the experienced strengths and weaknesses of the delivery methods, potential means of improvement and linkages between these characteristics and the owner values. Based on these country-specific value networks, the means of improvement (the numbered circles with green text) are

here considered actions taken. The resulting effects, and effects of the other characteristics of the project delivery method (circles with text in black), on client value generation (circles marked by yellow shading in the middle) are depicted with green, solid (facilitation) and red, dashed (hindrance) arrows. The potential improvements are shortly explained in the text with numbering referring to the numbers in the value network.

To increase innovativeness, the contractor may become involved earlier in the process through *1) constructability reviews*. At the tender stage, *2) alternative tendering* may be encouraged. The client must clearly state the scope of permissible alternatives and provide a design brief and tender evaluation criteria which include *3) both price and non-price factors* in addition to any weighting of the criteria (best value selection). However, as alternatives cause extra work for all contract parties and new approvals may be required causing delays, the potential benefit has to be significant enough to be attractive to the client /14/. A pre-closure tenderers' meeting may be arranged to inform tenderers on techniques required and existing problems. So called ‘cost + time tendering’ has also fostered innovation as it compels the contractor to think more thoroughly about how he will do the work within an optimal timeframe. During project delivery the contractor may be encouraged to look for improvements through *4) value engineering* and *5) incentives* tied to improved road performance with *6) regular performance measurement* and/or savings.

The risk of quantities may be transferred to the contractor through *7) a fixed, lump sum contract* /44/. When lump sum contracts are used, the contractor puts more effort into the job and preparing the tender. Even though the construction cost per kilometre of road tends to be 11% less expensive, of greater significance is the cost certainty achieved /16/. Additionally, lump sum contracts require less client management and deliver a more harmonious working relationship between the client and the contractor. However, where risks are best carried by the client, the traditional approach may deliver better cost performance.

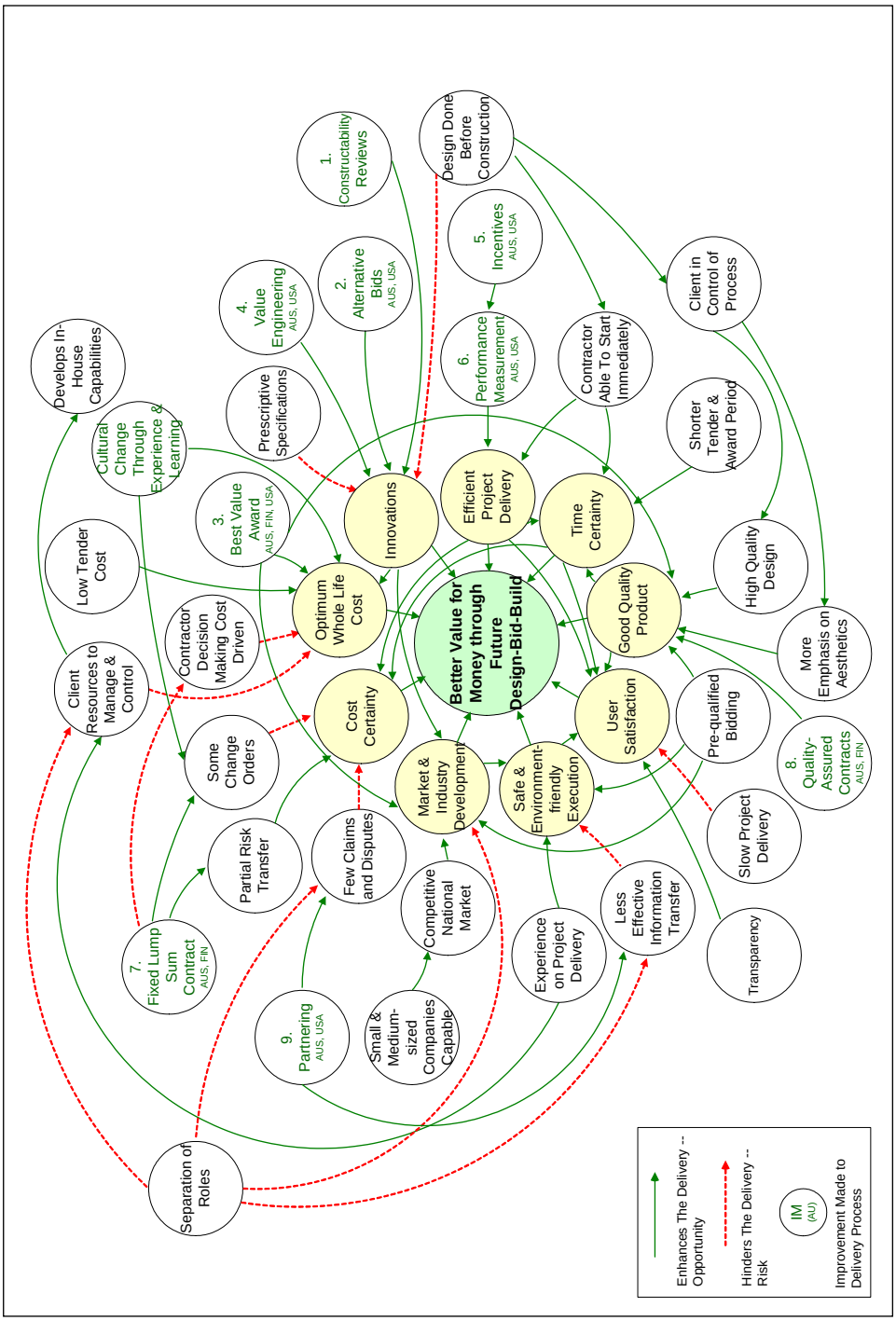

Figure 13. Improved DBB delivery system.

The contractor should be responsible for quality through *8) quality-assured contracts*, where the client assures only through auditing that the road will be built according to specifications. *9) Partnering* and relationship management are used increasingly to facilitate processes and eliminate adversarial relationships. Partnering helps keep communication lines open, when problems occur. Partnering has delivered excellent public consultation and quality outcomes and reduced disputes and claims significantly.

Results. Despite potential improvements, there are some issues that will remain problematic. They include prescriptive specifications and separation of design and construction that stand in the way of innovations, encourage adversarial relationships and slow down project delivery due to the sequential nature of implementation. Client surveillance will also remain at a high level.

6.2.2 Construction Management

Strengths & weaknesses. CM is, from the organisational point of view, very much like DBB except for an external project manager and multiple contracts. Thus, this project delivery method which promotes (price) competition and ensures transparency is familiar to the industry. However, in some markets there may be a lack of competent project managers. And the method does not allow co-operation between all project participants restricting the number of industry innovations, technological improvements and integration of systems. The strengths and weaknesses of CM are listed in Table 6.

Improvements. As CM is not used very extensively, the suggested improvements to the system are quite limited. However, the ones suggested, found in literature or based on DBB improvements, are listed in Figure 14 (see Chapter 6.2.1, 'Improvements' for reading instructions). The inherent cost emphasis can be reduced by adopting *1) best value contractor selection* instead of pure price competition and by *2) emphasising the importance of CMr references in selection*. So-called *3) Life-Cycle CM* is also being studied as an opportunity to emphasise the importance of the life cycle. In life-cycle CM, the CMr is hired for the long term to procure and manage design, construction and maintenance for the client. The somewhat limited competition of CMr contracts can be improved by *4) increasing project size* to encourage *5) international*

competition. Cost certainty and performance can be improved by using increasingly *6) target cost contracts*, and innovativeness can be enhanced by allowing *7) contractor value engineering.* Unnecessary duplication of quality control cost and improvement of ownership of the work can be enhanced by using *8) quality-assured construction contracts*.

Results. Despite potential improvements there are some explicit problems with CM delivery. As design is done before construction, contractor contributions are not possible and separation of roles is encouraged. This does not facilitate market development which mostly results from cooperation between different trades. CM will also always lead to the purchase of small work packages reducing the need for and motivation of companies to develop their capabilities and resources which reduces their margin potential.

Table 6. Strengths and weaknesses of CM project delivery.

Strengths	Weaknesses
• well-known delivery method • ensures work for small & medium-sized contractors • increased competition • low tender cost • transparency • client control over project delivery • emphasis on aesthetics possible • client determined quality level • flexibility • CMr contributions to design • better relationships between the CMr and contractors • lower investment cost • fewer changes • less burden some for client • accurate price information for client • shortened delivery process • procurement scheduled optimally	• lack of capable construction managers • no contractor/designer cooperation • separation of roles • lack of innovations • lack of ownership • demanding work organisation • price competition emphasised • potentially reduced quality level • low industry profitability • does not encourage international competition • does not promote privatisation • does not develop industry • technological improvements and integration of systems limited • no emphasis on whole-life cost • lack of cost certainty

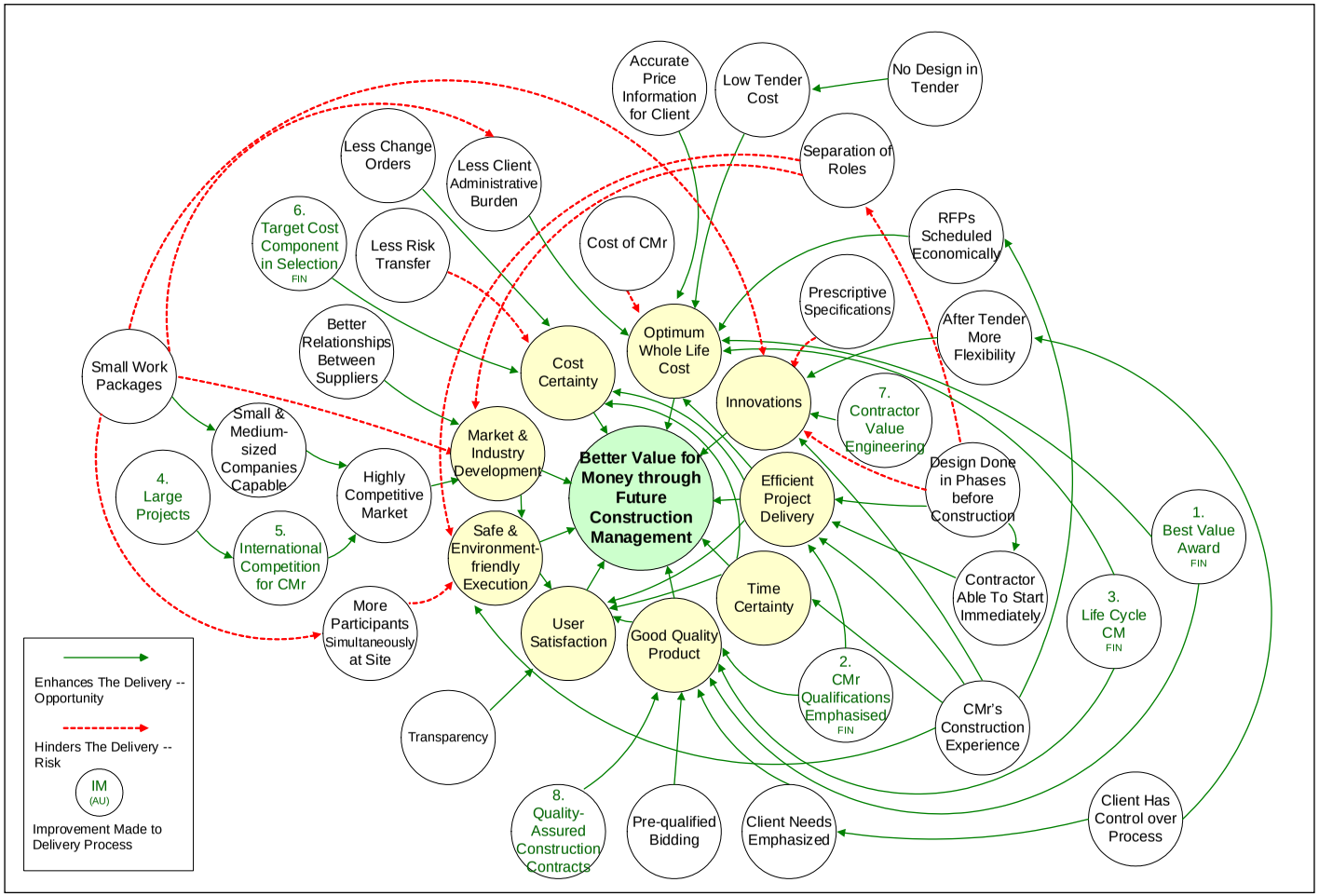

Figure 14. Improved CM delivery system.

6.2.3 Design-Build

Strengths & weaknesses. While DB is still a relatively new project delivery method in some countries (Finland, USA) whose experiences from it are somewhat limited, extensive experiences exists in other countries (UK, Australia). With DB the challenges are the new, extended responsibilities of the contractor and cooperation between the designer and contractor. So far, industry innovations have been somewhat limited, but there is more potential. The strengths and weaknesses of the DB are listed in Table 7.

Improvements. During the interviews and literature review many improvements were suggested which are presented in Figure 15 (see Chapter 6.2.1, 'Improvements' for reading instructions). High tender costs may be reduced in various ways. *1) For simple DB projects with well-defined end results, the low bid process* is ideal, since it *2) minimises need for voluminous technical proposals*. For larger and more complex projects the *3) best value concept* is more appropriate, since it encourages innovations and allows contractors to optimise their work force, equipment and schedule /29/. *4) The automated tender process*, short-listing based on *5) pre-qualification* and standard documentation also help reduce costs.

Competition is encouraged through *6) appropriate work packaging*, *7) partnering* and *8) joint ventures*. In addition to contractor-contractor joint ventures, also contractor-designer joint ventures are very beneficial in improving the position of designers, facilitating their involvement in DB projects and improving the co-operation between the two main project participants for better overall success of the project. As a limited number of large, national companies may reduce potential competition, *9) international competition* may be enticed by *10) enlarging project size*. Also, to improve the position of subcontractors and designers, bidders should *11) name their project delivery teams and common operating principles in the tender*. This would allow the client to assess the capability of the parties to work together for the benefit of the project. Subcontracting offers work to smaller, local companies in the same way as awarding separate, *12) early works contracts*. Early works, such as bridges, will also reduce the risks (and risk premiums) associated with the DB project. 13) *Risk transfer should generally be negotiated* with the proponent in order to achieve optimal risk allocation.

Table 7. Strengths and weaknesses of DB project delivery.

Strengths	Weaknesses
• performance-based specifications • pre-qualification encourages better performance • best value selection • better buildability through contractor contributions • risk transfer (single point of responsibility) • more efficient risk management • innovations encouraged • contractor emphasis on higher productivity & lower production cost • more efficient delivery process • lower investment cost • improved industry profitability • develops industry through cooperation • better relationships • encourages integration of systems • more efficient information transfer • knowledge integration • shortened delivery process • promotes productification and R&D • few change orders • improved cost certainty • lowered client administrative burden • optimum short term quality • longer warranties • ownership of the work • user inconvenience minimised	• extensive need for client resources in procurement (senior people) • high tendering cost due to design requirements • lack of DB projects in small markets • limited experiences with DB • less work for small and medium-sized contractors • limited competition in large projects • lack of industry capabilities in risk assessment and pricing • problems associated with sub-contracting (price competition, etc.) • limited number of innovations due to restrictions imposed on the delivery (permitting, risk averse client, technical specifications) • problems associated with permitting delays during delivery • lack of aesthetic consideration • reduced quality level • client experience may be lost • inadequate contractor quality control and assurance • client control diminished • reduced flexibility • difficulties experienced due to old roles • designers experience heightened stress levels • cultural change required • no emphasis on whole-life cost

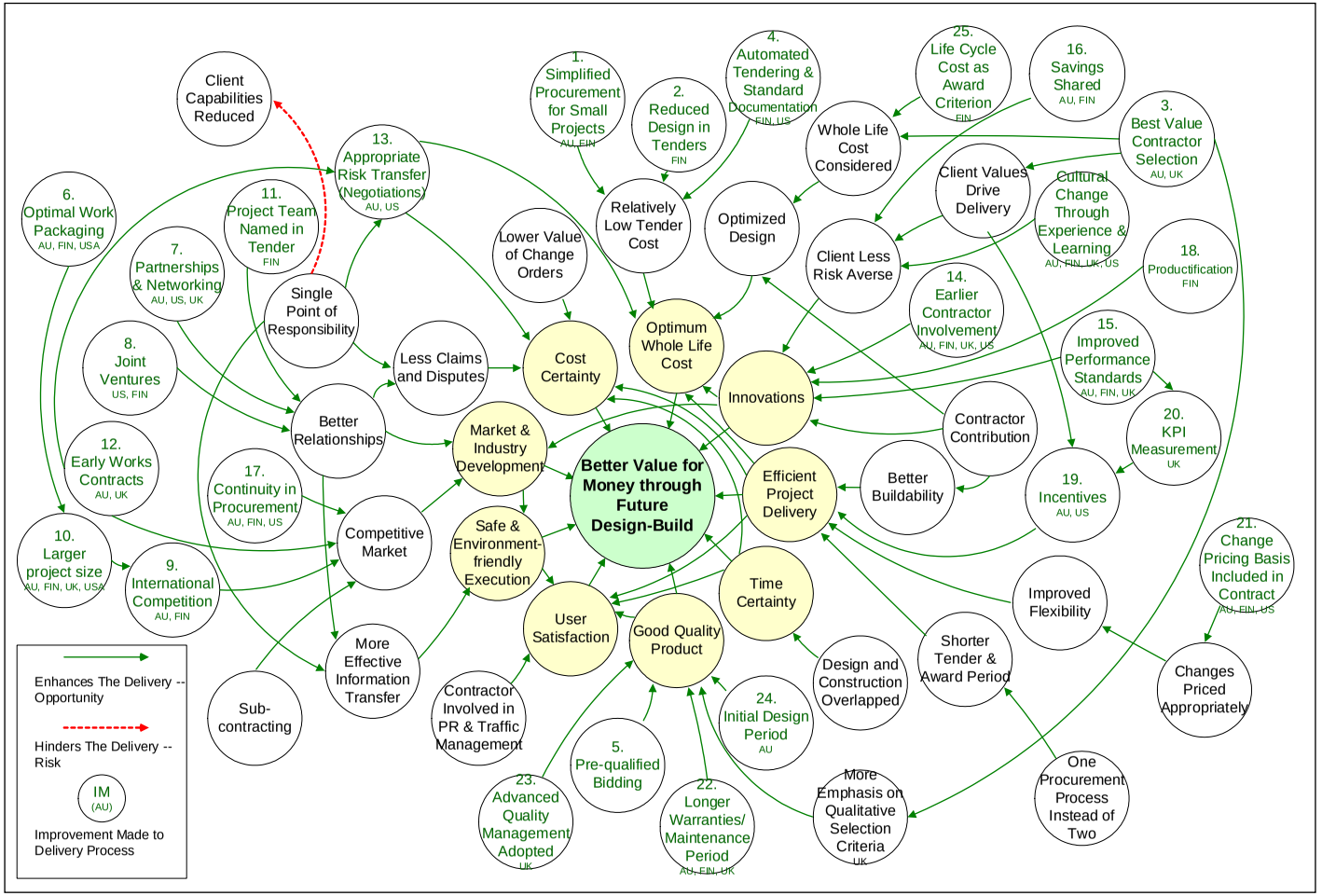

Figure 15. Improved DB delivery system.

Innovations may be encouraged through *14) contractor involvement at an earlier stage*, when project scope is adequately defined, but there are still plentiful opportunities for alternative solutions. However, early contractor involvement is somewhat difficult because of long lead times and the competitive pricing desired at the tender stage. Thus, *15) performance-based standards may be improved* to encourage innovations. Appropriate specifications that guide the innovation process, and *16) sharing of resulting savings* reduce client reluctance to accept innovations. When the industry sees *17) continuity in the DB project delivery*, companies will be more interested in investing in the development of their operations and *18) productification* to gain a competitive advantage.

More efficient project delivery may be encouraged through *19) incentives* and *20) continuous performance measurement* associated with incentives. Inclusion of important issues, such as *21) basis for pricing of changes*, into the contract will also reduce negotiations during project delivery. Quality improvements may be achieved through *22) longer warranties*. When contractors adopt *23) advanced quality management systems* and see the benefits gained through an adequate *24) initial design period*, these will improve quality as well. The importance of the road's life cycle may be emphasised by using *25) life-cycle cost as one of the award criteria*.

Results. With all the improvements mentioned, the problems associated with DB may be effectively eliminated. A risk that will remain is that the client organisation may slowly lose some of its capabilities and experience, as its responsibilities are mainly limited to procurement and the maintenance stage.

6.2.4 Design-Build-Maintain

Strengths & weaknesses. DBM is a relatively new project delivery method of which there is somewhat limited experience. It requires/enables extensive co-operation between different project participants encouraging industry innovations, technological improvements and integration of systems. At the same time it introduces significant uncertainties associated with long-term contracts. The strengths and weaknesses of DBM are listed in Table 8.

Table 8. Strengths and weaknesses of DBM project delivery.

Strengths	Weaknesses
• performance-based specifications • whole-life cost based selection • risk transfer (single point of responsibility) • more efficient risk management • better buildability & maintainability • innovations encouraged in project management and project delivery • emphasis on higher productivity & lower production cost • more efficient delivery process • improved industry profitability • develops industry through cooperation • better relationships • encourages integration of systems • more efficient information transfer • knowledge integration • more accurate cost reporting • shortened project delivery process • improved time certainty • promotes R&D • improved cost certainty with minimal change orders • lighter administrative burden • optimum long-term quality • ownership of the work • user inconvenience minimised • possibility to include financing • promotes privatisation	• extensive need for client resources in procurement (senior people) • expensive tendering • lack of DBM projects • limited experiences with DBM • limited number of innovations due to restrictions imposed on the delivery (permitting, risk averse financiers, technical specifications) • problems associated with permitting delays during delivery • less work for small and medium-sized contractors • limited competition • lack of industry capability in risk assessment and pricing • less emphasis on aesthetics • client experience may be lost • client control diminished • client freedom in network management diminished • difficulties experienced due to old roles • difficulties experienced in ensuring value for money during operation period • difficulties in work packaging to gain efficiencies in maintenance • cultural change required

Improvements. Use of DBM is in its early stages, but already many improvements have been suggested which are presented in Figure 16 (see Chapter 6.2.1, 'Improvements' for reading instructions). To reduce tender costs, short-listing based on qualifications followed by *1) best value selection* is appropriate. Moreover, *2) minimised tender design* in selection of the preferred bidder also facilitates tendering. The preferred bidder should then do more extensive design to finalise his offer. *3) Automated tender process*, *standard*

documentation and *4) continuity in procurement* will also help reduce tender costs and increase tenderers' interest in these large projects.

Competition is ensured through *5) appropriate work packaging* that brings efficiencies of scale and encourages international competition. *6) Risk transfer should be negotiated* with the proponent in order to achieve optimal risk allocation. *7) Early works contracts* and subcontracting offer work to smaller companies, and *8) partnering* and joint ventures help develop the market and encourage more efficient information transfer.

Truly life-cycle optimised project delivery may be achieved by *9) awarding of a single contract for both DB and OM* by *the ProjectCo (if used only as a risk management mechanism with limited resources to take an active role in project delivery)* instead of splitting the works into separate contracts. Innovations may be encouraged through *10) contractor/ProjectCo involvement at an earlier stage*, when project scope is adequately defined, but there are still plentiful opportunities for alternative solutions. *11) Improved performance-based standards* may also be used to encourage innovations and quality through appropriate *12) performance measurement* and 13) *payment based on availability and performance*. Quality improvements may be achieved also through *14) greater emphasis on qualitative issues in ProjectCo selection*. *15) Providing adequate flexibility for changes in the contract* will reduce negotiations during project/service delivery and ensure adequate flexibility for technological and other necessary changes during the long contract period.

Results. While DBM offers plenty of development potential, there are some issues that cannot be overcome. DBM restricts the work available for small and medium-sized companies and it will, even in the future, when clients and the industry have more experience with the delivery system, require more extensive use of external advice to draft contracts, etc. Tendering will also remain relatively burdensome. Additionally, client experience may be lost as well as some flexibility in road and network management.

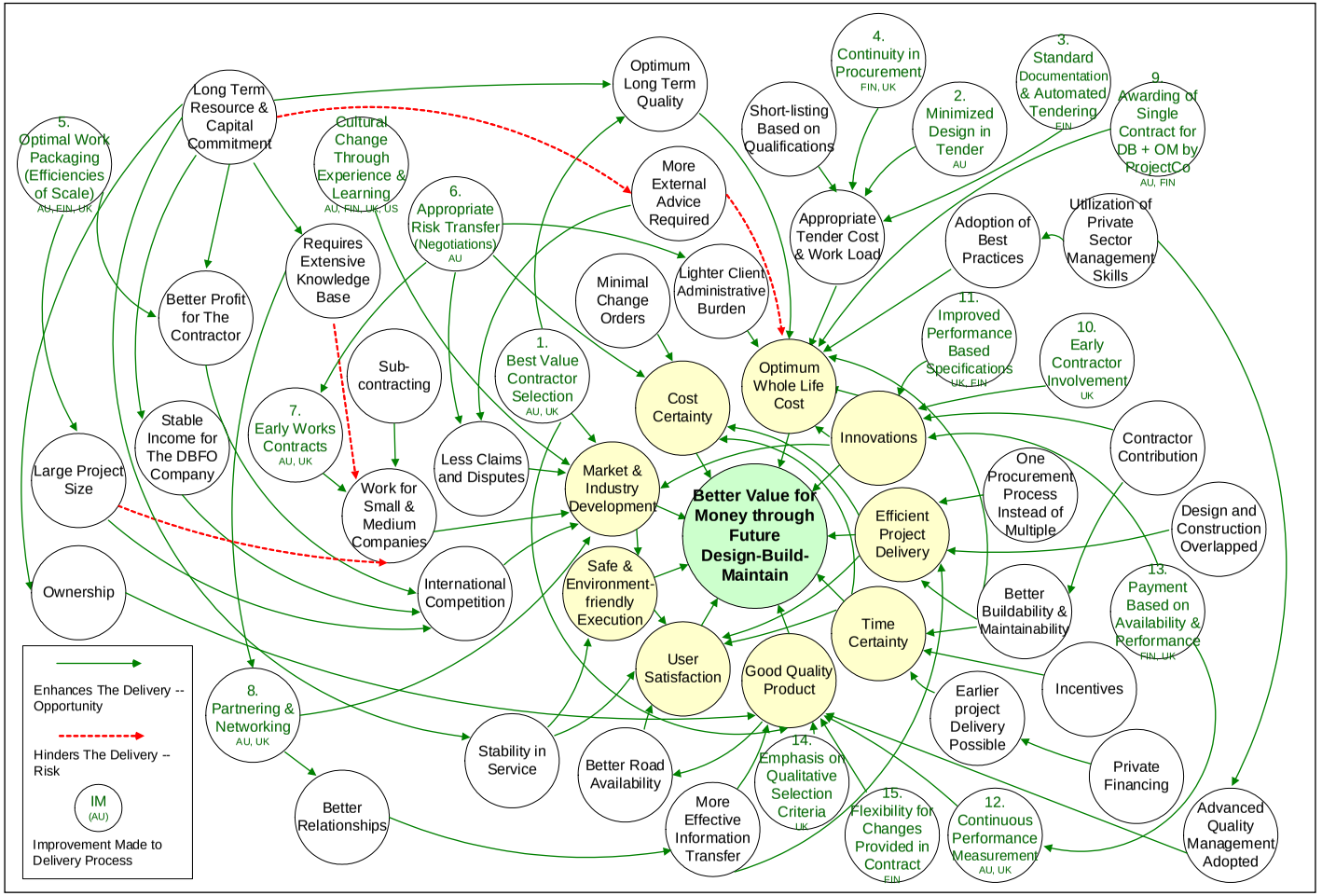

Figure 16. Improved DBM delivery system.

6.3 Summary

The road sector will experience significant changes in the future which are going to affect the way roads are procured. Project delivery methods that allocate more responsibilities to the contractor, but ensure appropriate project delivery through client-determined performance-based specifications and performance measurement, have a better opportunity of meeting the client's needs. However, each project delivery method has its weaknesses that need to be addressed to ensure efficient project delivery in the future environment. While this chapter lists the means of improvement available in each case, more thorough explanation of the potential means, and the reasons why this type of actions have been suggested, are found in the first report of the project /1/. Thus, this summary serves only the later evaluation of system-specific development potential. Some development strategies presented may also be alternatives for each other.

Despite the improvements available, some weaknesses in DBB and CM project delivery cannot be prevented from limiting their applicability in the future. With DBB these problems include prescriptive specifications, separation of roles, lack of innovations, slow project delivery and extensive client surveillance. With CM, separation of roles, lack of contractor contributions, small work packages, lack of industry development, and reduced industry profitability act as hindrances. DBM also incorporates some features that must be considered weaknesses even in the future (less work for small and medium-sized companies, more extensive use of external advice and loss of client experience and flexibility). With DB, other problems may be largely eliminated, but the potential loss of client experience remains.

7. Performance of the studied project delivery methods

7.1 General

The comprehensive analysis of the performance of the different project delivery methods was made possible by the fact that the interviews implied that highly similar procurement processes are used in different countries with only slight differences in the interaction between the project parties, in the use of selection criteria and in the level of decision making. Thus, the data gathered from different countries were assumed to be comparable. However, risk allocation tends to vary more extensively between the studied countries, and even case-by-case. As this has a significant effect on the cost structure and performance of a project, it merely confirms the initial statement that it is difficult (or even impossible) to find a typical project for the only and reliable basis of performance analysis. However, since the analysis requires putting the project delivery methods on the same line, some simplifications were allowed to be able to perform the following comparisons. Overall differences between countries are hardly more significant than the variation within a country.

7.2 Current performance

7.2.1 Cost performance

There is a certain time and cost associated with each phase of a project: procurement, design, construction, and maintenance. The base case for the cost performance analysis of the four project delivery methods (DBB, CM, DB, DBM) was a real Finnish DB project with a verified cost structure. Based on the cost and time structure of this base case and the known differences (derived from the interviews and literature review) between DB and DBB project delivery, the cost structure of the actual benchmark (DBB) was calculated. This was then used to calculate the costs of DBM and CM (although limited amount of data on CM reduces the validity of its comparative cost structure).

The cost structure of the base case and the whole analysis were also tested against the cost information of another project, but the basic cost structure turned out to be very similar to that of the above case. Thus, only one cost assessment is presented in detail.

Costs of the benchmark project and estimated savings with the other project delivery methods are listed in Table 10 based on the interviews presented in /1/. The information on savings differed slightly from one country to another. The interviewees mostly agreed on the savings achievable through DBM, while perceptions on DB varied. However, the overall perception was that savings would result from using DB instead of DBB. The numeric values used in calculating the costs were selected as the most common values or average values based on the interviews. Time factors are listed in Table 9. Project time scales seemed to be very similar in all countries. The differences mainly involved the length of the procurement phase.

Table 9. Basic time information used in the cost analysis.

Time factor	DB-case	DBB	CM	DBM
Procurement	10.5 months	2 * 2.5 months (variation 4–6 months)	2.5 months (variation 2–3 months)	18 months (variation 16–20 months)
Design	3 months (tender) + 75% of construction	16 months	16 months (75% during construction, variation 50–75%)	4 months (tender) + 75% of construction
Construction	41 months	41 months	41 months	37 months (10% savings)
External advice	41 months (construction)	41 months (construction)	45 months (design+ construction, variation 45–49 months)	55 months (procurement + construction, variation 53–57 months)
Maintenance	25.75 years	24.83 years	26.04 years (variation 25.66–26.04 years)	25.42 years (variation 25.25–25.58 years)
TOTAL	*30 years*	*30 years*	*30 years*	*30 years*

Table 10. Basic cost information used in the cost analysis.

Cost factor	DB-case	DBB	CM	DBM
Procurement	€ 54 000	2 * € 30 000 (variation € 48 000–72 000)	€ 30 000 (variation € 24 000–36 000)	€ 216 000 (variation € 216 000–256 000)
- Tender fees	€ 90 000	-	-	€ 180 000 (variation € 180 000–900 000)
Design	€ 3 015 000 (16% saving, variation 10–20%)	€ 3 589 286	€ 3 409 821 (5% saving, variation 0–15%)	€ 3 409 821 (5% saving, variation 0–10%)
Construction	€ 57 285 000 (10% saving, variation 5–15%)	€ 63 650 000	€ 57 285 000 (10% saving, variation 5–20%)	€ 48 692 250 (15% saving, variation 8–20%)
- Changes	€ 2 412 000 (4% of contract cost, variation 2–5%)	€ 6 365 000 (10% of construction cost, variation 8–15%)	€ 6 069 482 (10% of contract cost, variation 8–15%)	€ 624 040 (1% of design+ construction+ maintenance, variation 0-2%)
- Claims	- (variation 0–1%)	- (variation 0–5%)	- (variation 0–2%)	- (variation 0–0.5%)
Client administration (design + construction)	€ 246 000 (variation 0.69% of construction & design – 60% of DBB)	€ 2 689 571 (4% of design+ construction, variation 3–9.7%)	€ 1 092 507 (1.8% of design+ construction, variation 1–5%)	€ 246 000 (same as DB, variation same as DB – 50% of DBB)
Maintenance	€ 11 446 584 (0% saving, variation -5–0%)	€ 11 446 584	€ 11 446 584 (0% saving, variation -3–0%)	€ 10 301 926 (10% saving, variation 0–20%)
Client administration (maintenance)	€ 457 863 (4% of maintenance, variation 3–9.7%)	€ 457 863 (4% of maintenance, variation 3–9.7%)	€ 457 863 (4% of maintenance, variation 3–9.7%)	€ 206 039 (50% of DBB)
External advice	€ 418 000 (0.69% of contract cost, variation 0.3–1%)	€ 3 182 500 (5% of construction, variation 1–5%)	€ 6 069 482 (10% of design+ construction, variation 8–12%)	€ 6 069 482 (4% of procurement+ design+ construction+ maintenance, variation 3-5%)
TOTAL [mill. €]	*75.1–80.5*	*91.0–96.4*	*79.7–93.6*	*66.9–76.2*
Savings [i=0%]	*11.5–22.1%*		*2.8–17.9%*	*16.3–30.7%*

The total, average project costs with different project delivery methods are presented in Figure 18. The figure also shows the discounted, relative cost distribution in each case with the discount rate (*i*) of 6%, which, based on the extensive literature review, seems to be the most common interest rate used in this type of project cost estimation. The discount rate is varied between 2–10% (see Figure 17) to assess its effect on the present cost in each case. In the case of DBM project delivery, the cost is assumed to be paid monthly, as in the other project delivery methods, which resembles mostly DBOM-type project delivery.

Generally, the project cost structure varies slightly from country to country and even from project to project, since each project is, in a way, unique. Figure 18 shows that the cost structures of the different project delivery methods are quite different from each other. Generally, traditional project delivery is the slowest and at the nominal value the most expensive way to get the road built. However, DBB may outperform poorly performing CM. Also, when calculating the present costs, higher discount rates favour DBB, the present cost of which becomes lower than that of CM, where faster project delivery causes the present cost to be less affected by the discount rate. The relative ranking of CM, DB and DBM is not affected by the changes in the discount rate.

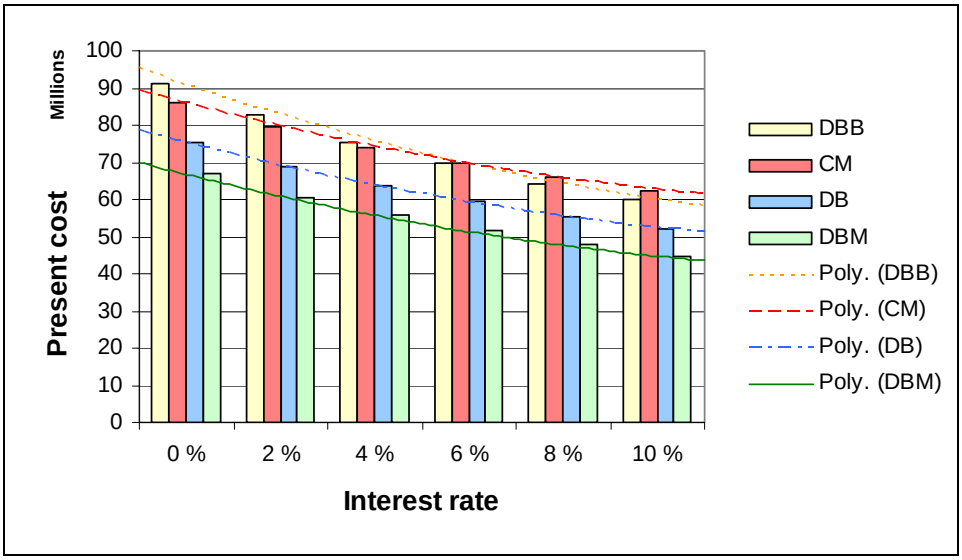

Figure 17. Discounted total project cost with different project delivery methods.

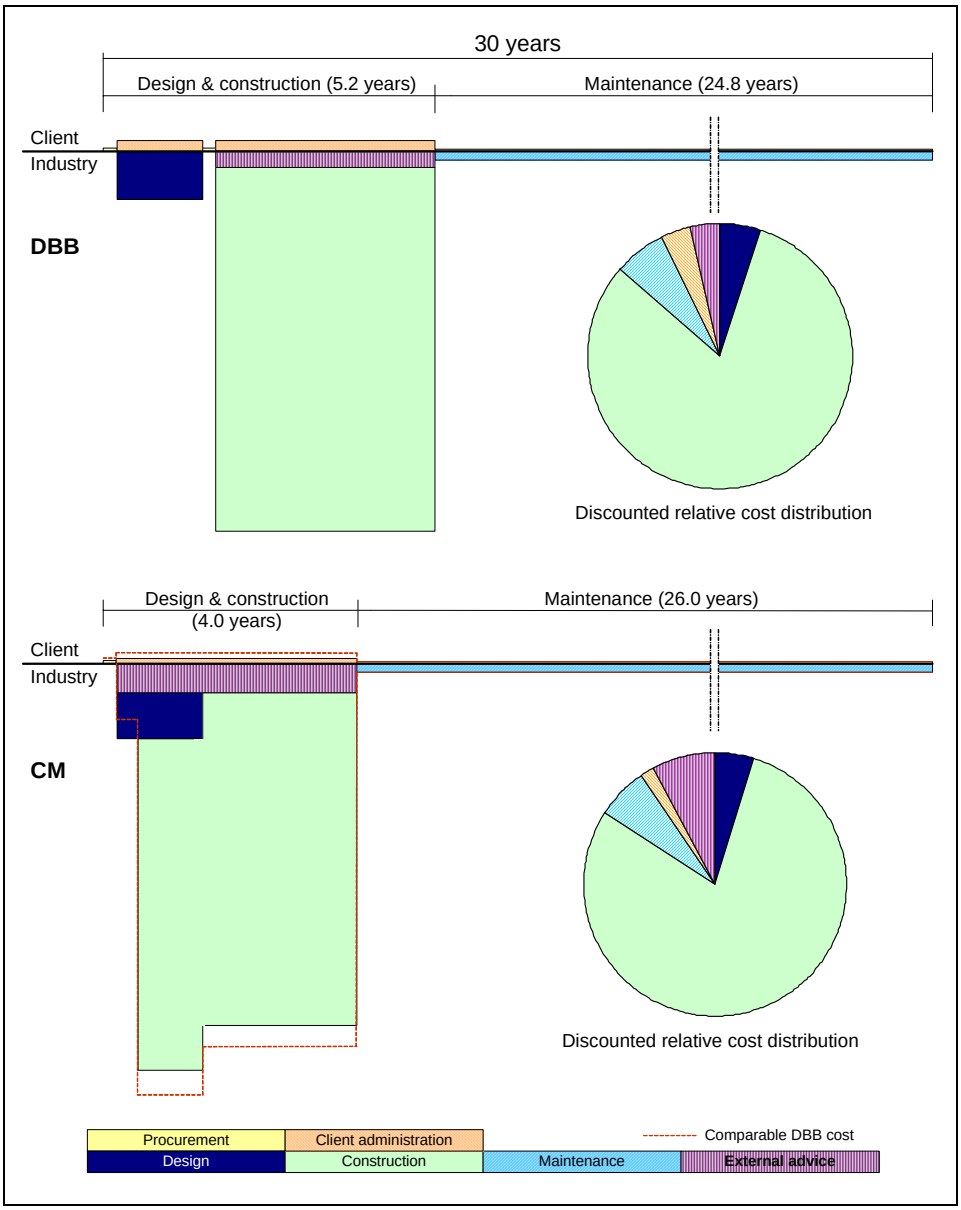

Figure 18: part 1/2. Cost distribution with different project delivery methods.

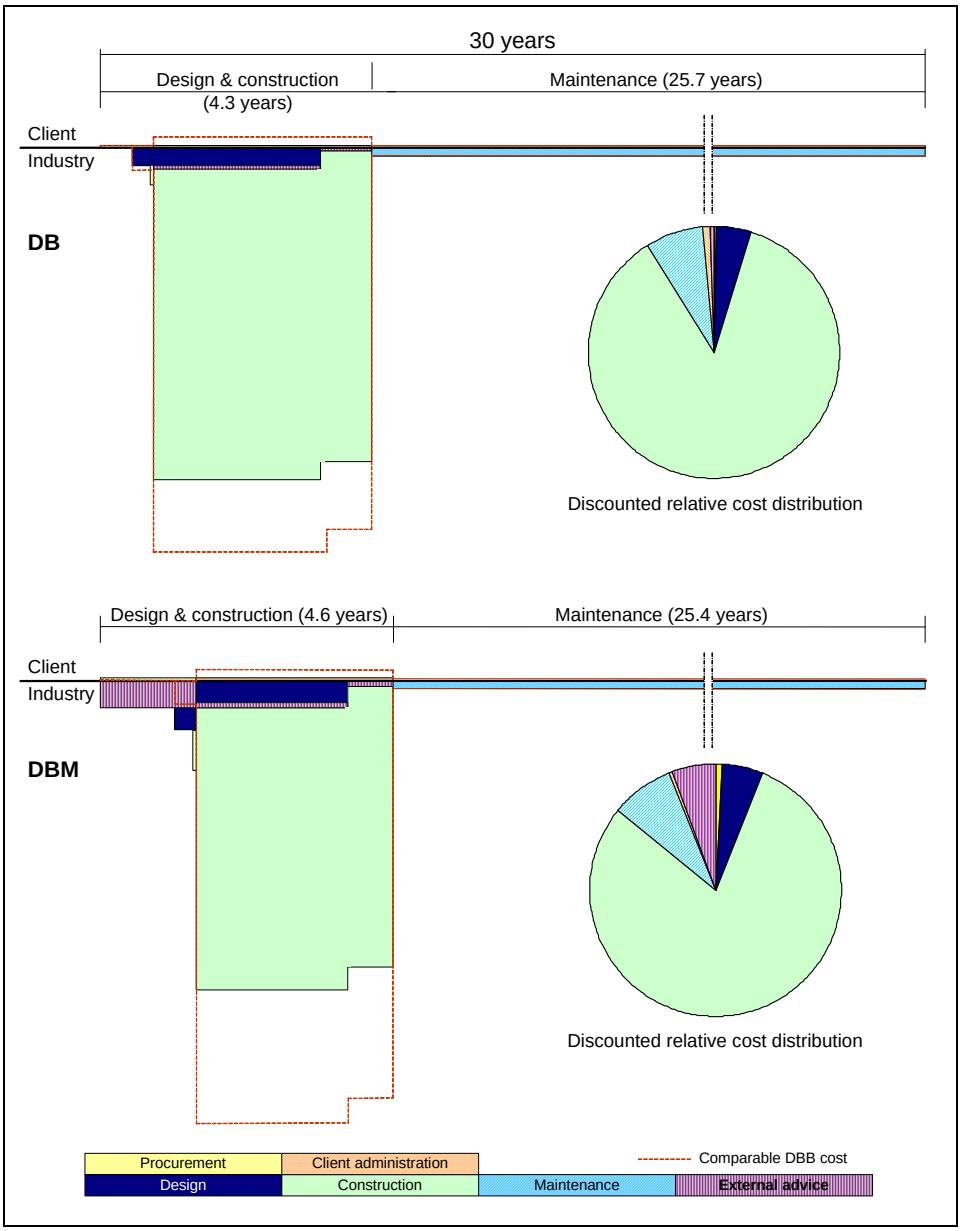

Figure 18: part 2/2. Cost distribution with different project delivery methods.

If, in addition to the average cost values used above, the variation derived from the interviews is considered, some differentiation occurs. CM generally results in higher project costs than DB, but when CM is able to produce higher than normal construction cost savings and DB performs poorly, CM can slightly

outperform DB. CM is likely also somewhat faster than DB, as it shortens the procurement time compared to DB. DB always outperforms DBB.

The present cost of DBM is on average lower than that of DB. However, in a case, where the design and construction savings with DBM are assumed to be minimal in the pursuit of reducing maintenance costs maximally, the present cost of DBM may turn out to be higher than that of well performing DB. Even then DBM outperforms DBB and CM.

The reasons for the improved cost performance of DB and DBM are manifold. However, the major reason seems to be their ability to reduce construction costs. Additionally, DB and DBM project delivery can reduce costs of contract administration, project management, and engineering as they help avoid duplication of these activities /23/. The effect of maintenance costs during the period under review seems to be minimal.

Sensitivity review

The cost analysis favoured DB and especially DBM. Even though there are uncertainties that may affect cost analysis, generally the relative ranking of the project delivery methods is not expected to change:

- With DB and DBM the service provider carries more risk than with DBB or CM, whereby clients pay a risk premium, which is included in the contract price. With DBB and CM this risk premium is omitted, and not considered in project cost estimation as the client carries the risks. Thus, if this cost factor was included in the analysis according to normal risk management practice, the cost of DBB and CM would increase, with CM experiencing slightly higher increases.
- Here the study period is 30 years, which results in faster project delivery methods paying more maintenance costs. If the maintenance period would be set equal in all alternatives, DB, DBM, and especially CM, would improve their cost performance. However, due to the relatively low maintenance cost and discounting, the effect is minimal.
- Time value of money is taken into consideration by using cost structures of real, freshly completed projects. Due to lack of actual maintenance

cost data on these project roads the cost of maintenance is estimated based on the level that prevails in the market. Potential future price increases are not taken into consideration. Therefore, the assessment underrates maintenance costs. An increase in maintenance cost and its relative weighting have the greatest influence on DB which loses some of its efficiency advantage over CM and DBB. The influence is, however, minimal compared to its current efficiency advantage.

- The client administrative cost is the most uncertain cost as it is generally not recorded exactly, contrary to contract prices that are known with certainty. Thus, the margin of error may be relatively high. However, as it is a small factor in the total cost, it will not significantly change the analysis.

Interestingly, due to the good cost performance of DB and DBM, payment of tender fees to unsuccessful, short-listed tenderers (generally 2–3 bidders) does not undermine their relative position in cost performance terms. Thus, one opportunity to overcome one of the biggest perceived problems with these procurement alternatives, i.e. high tender cost, is paying higher tender fees to create more competition when needed. Even if two tenderers had their whole tender cost reimbursed (which is neither required nor recommended), DB and DBM would well retain their relative position in cost performance terms.

7.2.2 Value generation

Here the project delivery methods' value generation is determined mainly from the client perspective (see Figure 19). Value generation is assessed by comparing each project delivery method with DBB. The value presented here is calculated as an average of the estimates given by the interviewees. The divergent values of the client are grouped according to Chapter 4.3.3:

- Cost certainty – CM is perceived to provide the same level of cost certainty as DBB, while both DB and DBM improve cost certainty significantly. This is mainly due to lump sum-type contracts and risk transfer. Additionally, DBM provides a preset price for long-term maintenance.
- Time certainty – While DB is perceived to provide only approximately the same level of time certainty as DBB due to increased risk levels, CM

provides somewhat better time certainty. DBM is perceived to provide the best time certainty of the methods assessed due to its intrinsic aim for faster project delivery and revenue collection.

- Short cycle times (time performance) – CM, DB and DBM are perceived to reduce cycle times significantly compared to DBB.
- Good quality product – Quality is a somewhat difficult concept due to the discrepancy between the terms “good quality” and “optimal quality”. DBM is generally the only project delivery method that is perceived to provide a truly better quality product than DBB due to the long-term commitment of the ProjectCo. DB and especially CM are perceived to provide lower quality than DBB. The reduction in quality with CM is perceived to be due to lack of ownership of work, difficulties in interfaces, high price pressure and time pressure. Quality problems with DB are associated with overall price emphasis and contractors’ aim to reduce construction price. However, at the same time some interviewees claimed that DB actually provides optimum quality (no unnecessary spending on unimportant issues like high-level finishing of drawings or aesthetics), while DBB provides over-quality (unnecessarily long design-life, money spent on aesthetic issues, high-level finishing of drawings).
- Safe & environmentally friendly execution – CM is perceived to provide the same level of safety and environmental consideration as DBB, while both DB and DBM improve these important factors. This is mainly due to a single point of responsibility, more efficient project delivery and the need for the service provider to consider his own public image. With DBM the ProjectCo often has to consider his image especially in the eyes of financiers, as safety issues tend to be emphasised by international financiers.
- Flexibility to client changes – CM is perceived to provide the same level of flexibility as DBB, while both DB and DBM reduce flexibility. This is mainly due to broader service packages involving lump sum contracts and extensive risk transfer. Additionally, DBM contracts reduce clients’ flexibility for the whole contract period even in network planning.

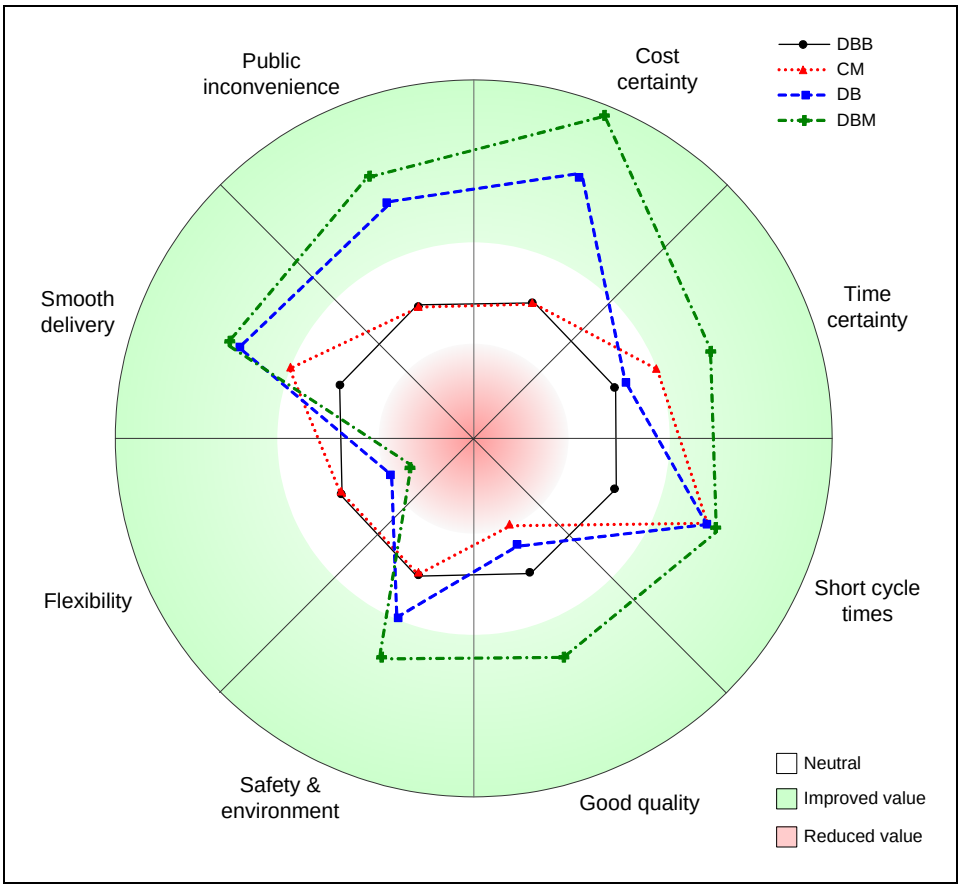

Figure 19. Value generation.

- Smoothness of procurement process and project delivery (information transfer, claims and disputes) – CM, DB and DBM are perceived to improve smoothness of the procurement process. The broader the service package procured, the smoother the project delivery process. This is mostly due to the reduced number of interfaces, and risk transfer.
- Public inconvenience (maximum road availability) – CM is perceived to cause the same level of public inconvenience as DBB, while both DB and DBM improve road availability significantly. This is mainly due to faster and more efficient project delivery, and the contractor being responsible for informing the public and for PR. Additionally, in DBM also maintenance is done very efficiently and on time reducing public inconvenience even further. The main incentive in DBM is the payment method.

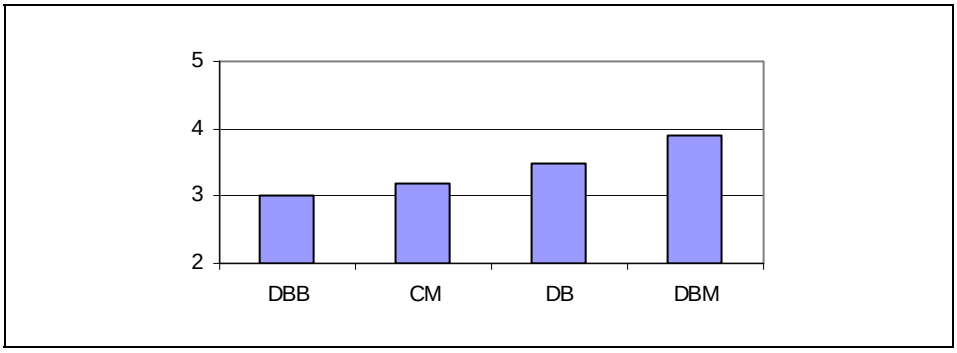

Figure 20. Average overall value generation of the project delivery methods.

Generally, procurement systems that include contractor-led design (DB, DBM) keep the project value chain more or less intact. Client-led design (in DBB, CM) results in additional interfaces and causes more disruptions in the project value chain /42/. This can also be seen from Figure 20, where all values are weighted equally. According to the interviewees, DB and especially DBM meet the needs and wants of the client better than traditional or CM project delivery. The only problem areas with these broader service packages are inflexibility of the delivery process to client changes and the perceived lack of quality in DB. However, it is important to note, that weighting of the different value items is always case-specific and dependent on project type and constraints and the client. Thus, the figure does not tell the whole truth.

The contractor, designer and user/community values differ somewhat from the client perspective. As the client values aim to take into consideration user satisfaction, user value generation corresponds best to the value generation of the client. DB and DBM decrease user inconvenience effectively and improve user value generation compared to DBB and CM. These broader service packages are also perceived to bring better value for money for tax payers. However, when value generation is assessed from the contractor or designer perspective, things change a bit:

Contractor

DBB is generally perceived to be a good way to deliver roads. It is well known, brings transparency to the selection process and everybody knows how to compete for projects. However, often the contractors' margins may be quite low

due to tough price-only-competition. While change orders may help increase profit levels, they are likely to cause disagreements between the parties. Also, DBB makes it difficult to develop operations and increase market share as the competition is quite level. CM is generally perceived to be similar to DBB.

On the other hand, DB and DBM allow more efficient and timely project delivery, optimisation of the quality and cost of project delivery, and development of operations. However, even though there is potential for higher profits, so far they have seldom been achieved in DB which slightly reduces the contractors' interest in the project delivery method. This problem is highlighted by the high tender costs which reduce competition in large DB and DBM projects. Contractors also often consider their risk share to be excessive. Additionally, there is some friction in the designer/contractor co-operation that hinders truly optimised project delivery and causes some unnecessary costs due to redesign and rework. Also, the ever increasing project size causes some concerns. While large construction firms see enticing opportunities in offering broader service packages and in improving their competitive advantage and long-term relationships with the client, smaller and medium-sized companies see serious threats to their existence.

Despite the concerns presented above, it seems that there are potential bidders in all markets for projects procured in different ways. The segmentation of the market, subcontracting and the use of traditional project delivery systems with certain project types offer markets for different size firms ensuring a healthy industry structure and potential work for newcomers. Therefore, there are no severe hindrances to the use of alternative project delivery methods considering that action is undertaken to eliminate the problems experienced so far. Thus, for instance, utilisation of incentives, partnering, joint ventures, etc. are supposed to remove the friction from the process, while development of the implementers' selection process is underway to reduce initial barriers.

Designer

DBB is generally perceived to be a good way to deliver roads. It is well-known, brings transparency to the selection process and everybody knows how to compete for the projects. Designers also prefer the opportunity to work directly for the client, allowing them to earn better margins in a less stressful working

environment. CM is perceived to be similar to DBB. DB project delivery reduces the designers' margins and puts them into a difficult position. Designers often feel increased stress levels due to tight timeframes, contractor requirements to minimise costs and their own professional need to produce good quality design. Contractors are perceived to give inadequate recognition to the importance of design work in overall project delivery and in winning the tender. Additionally, contractors often want to allocate too much risk to designers (for example at the tender phase), who do not have the resources to bear extensive risks. Only designers working in joint-venture arrangements have been very positive about DB project delivery. DBM is considered to give designers more power than the DB delivery process, as the importance of design is recognised there. Designers can produce better quality design, and the time allowed for design is often longer than in DB.

Generally, designers feel comfortable working with DBB, CM and DBM arrangements. They are also willing to work in the DB environment, if necessary, but they feel that they need to be selective in with whom they work. However, designers would like to see clients passing on their design procurement experience to the contractors. Also, the suggested improvements to DB project delivery in the form of best value selection and improved performance-based specifications help the contractor realise the critical status of good design. This is the case especially in incentivised joint-venture arrangements, use of which may be increased by clients controlling the appropriateness of organisations to be selected and their cooperation strategies as part of best value selection.

Sensitivity review

The variation between the interviewees' assessment of value generation in each country was relatively low. Also, when country- and project delivery method-specific values were calculated as an average of the individual assessments, the average values between different countries were well in line with the average deviation of only 7.5%. However, in a few cases (DB's flexibility and DBM's maximum road availability) the deviation between country-specific assessments was nearly 20%.

In the above analysis, all values were weighted equally. However, different clients and different projects may emphasise certain values over others changing the relative ranking of the project delivery methods. This requires quite extensive differences in weighting, though. DBB can outperform DB only, when quality and flexibility are both assigned a weight of 1/3 (together 65%) or more. (It is assumed that the other values are weighted equally based on the remaining weight). For DBB or CM to outperform DBM requires sole emphasis on flexibility. CM may outperform DB, if flexibility and time certainty are both assigned a weight close to 1/3 (together 56% or more). DBB outperforms CM, if the weight of quality is more than 1/3 (37% or more).

7.2.3 Economic efficiency

Economic efficiency is the ratio of the two earlier analysed factors, value generation and cost performance, which enables graphical presentation of the current performance of the different project delivery methods presented in Figure 21. Cost is taken as the achieved saving in present cost terms (i = 6%), when the PC of each project delivery method is compared to that of DBB. In the figure, the maximum saving is assumed to be 40% (i.e. 60% of DBB's cost). Values are based on the value differences presented in the previous chapter. In the figure, the maximum value score is 5 (DBB's score is 3). However, to calculate the EE, the maximum improvement in value generation is assumed to be 40% (corresponds to a score of 5) producing 140% of DBB's value.

As seen in Figure 21, CM is economically slightly more efficient than DBB, while the economic efficiency of DB, as a comparison figure, is 1.3 times that of DBB. DBM brings notable improvements as its economic efficiency is 1.6 times higher than that of DBB. However, economic efficiency is highly dependent on the scale used for value, and should only be taken as indicative of a project delivery method's performance level, not as a true numeric representation of it.

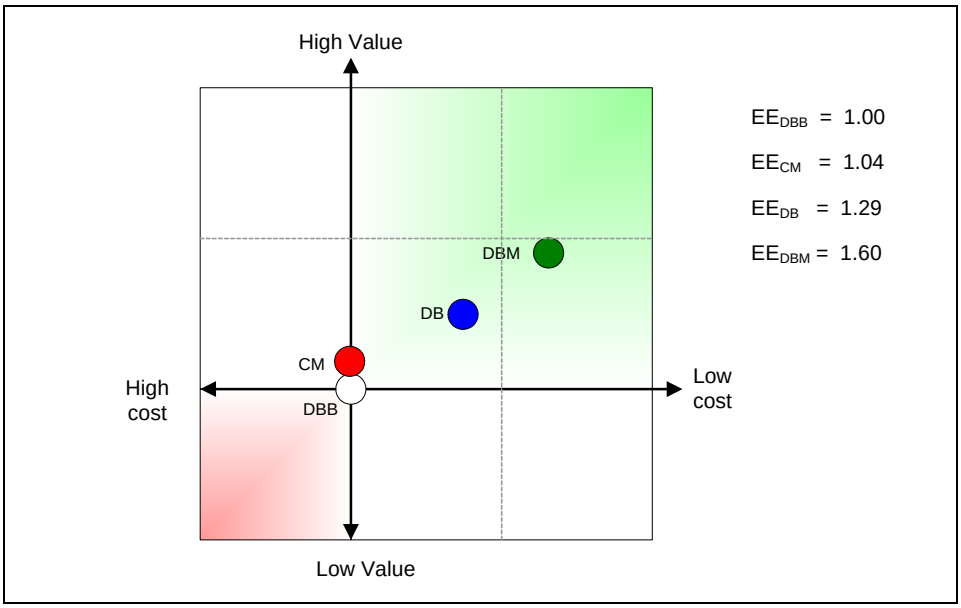

Figure 21. Current economic efficiency of the project delivery methods.

Economic efficiency describes Value for Money (VFM). The interviewees were also asked to estimate 'the value for money' achieved through different project delivery methods in order to check the internal consistency of lower level estimates and to verify the result on an overall level. Generally, CM was perceived to provide roughly the same level of value for money as DBB (average score 3.00), while DB provided a somewhat better value (score 3.67; i.e. 1.22 times DBB's VFM). DBM was perceived to provide significantly better value for money than any of the other project delivery methods (score 4.83; i.e. 1.61 times DBB's VFM). This is consistent with the analysis presented above, considering the qualitative nature of the research and margin of error related to value weighting and scaling. Generally, the reasons for improved value for money delivered through DB, and especially through DBM, were perceived to be many: risk transfer, optimised project delivery and product quality, utilisation of private sector management skills, etc.

7.3 Future performance

7.3.1 Development potential

In order to be able to assess the future performance of the project delivery methods, their overall Development Potential (DP) needs to be determined. DP has two components: the project delivery method's inherent ability to develop and the available means of improvement. The inherent ability to develop is assessed based on the project delivery method's process adaptability, knowledge generation and team coherence (see Table 11). The overall effect of these factors was rated by the interviewees (CM's average rating was 3.17, DB's 3.78 and DBM's 4.09). Based on a critical analysis of the interviews, these total scores (differences from benchmark DBB that was assigned a score of 3.0) were divided into cost performance and value generation scores. Considering the mainly qualitative approach, the influence of the alternating direction of DP on the assessment of future EE was considered marginal and was not taken into consideration. Another marginal error may also result form setting DBB as the benchmark with inherent development potential of 0. However, as DBB has been used extensively for decades, it may be assumed, that it has already reached close to its peak performance. Thus, this error can be assumed marginal.

Table 11. Future performance-based on project delivery methods' inherent ability to develop (DBB at the 0 level, scores -2…2).

Factors	**Cost performance**				**Value generation**			
	DBB	CM	DB	DBM	DBB	CM	DB	DBM
Process adaptability		+	++	++		+	++	+++
Knowledge generation		+	+	+			++	++
Team coherence		–	+	++			+	+++
TOTAL	0	0.12	0.49	0.58	0	0.12	0.61	0.92

The effect of the potential improvements on the project delivery systems also needs to be considered (see Table 12). These means are identified based on the interviews and explained in more detail in Chapter 6. The relative effect of each means on cost performance and value generation was assessed by the authors based on critical assessment of available data. In practise, the potential influence gained through different means is not, of course, undisputable, but rather comes down to cost/value trade-off. Additionally, there are some partly overlapping improvement suggestions causing a margin of error. Thus, the table is not expected to provide an absolute numeric value, but rather the project delivery methods' DP component's magnitude and direction in relation to each other. It is assumed that if multiple means of improvement have been suggested for a project delivery method (e.g. DB), its DP component is greater than that of one for which only a few, weak means for development in the future have been proposed (e.g. CM).

Table 12: part 1/2. Future performance-based on means of improvement (scores -2…2).

Factors	**Cost performance**				**Value generation**			
	DBB	CM	DB	DBM	DBB	CM	DB	DBM
Project packaging		+	++	++				+
International competition		+	++	+++				
Pre-qualification	+		+		+		+	
Improved performance standards			+	+			++	+++
Automated & standardised tendering			++	++			+	+
Simplified procurement (small projects)			++	+				
Reduced tender design			++	+				
Alternative bids	+				++			
Team named in tender							++	
Negotiated risk transfer			++	++			+	+

Table 12: part 2/2. Future performance-based on means of improvement.

Factors	Cost performance				Value generation			
	DBB	CM	DB	DBM	DBB	CM	DB	DBM
Qualifications emphasised				+		+		
Best value selection					++	+	++	+
Fixed lump sum contracts	++				+			
Target costing		++	+				+	
Payment based on service level				+				+++
Quality assured contracts	+	+			++	+		
Longer contracts & warranties					+	+	++	
Change basis part of contract			++	++				+++
Continuity in procurement			++	+++			+	++
Early works contracts			++	+				
Early contractor involvement	+		++	+	+		++	+
Initial design period			+				++	
Value engineering	+				++	+	+	
Savings shared			+				+	
Productification			++	+				
Incentives & performance measurement	+		+	+	+		++	++
Advanced quality manag.			+				++	+
Partnering & joint ventures	+		+	+			+++	+
TOTAL	0.21	0.12	0.71	0.57	0.31	0.12	0.62	0.48

The two components rated above determine the development potential of the project delivery methods (see Table 13). The DP of each project delivery method is calculated as a weighted average of the totals of Tables 11 and 12. Since the relative importance of the two components – inherent development potential and means of improvement – is not known even in theory, both tables are here weighted equally, but weighting may be changed based on the perceived importance of the components. However, whatever the weighting is, DBB and CM stay far behind DB and DBM. Weighting means of improvement more heavily will improve the DP of DB in relation to DBM, while greater weighting of inherent ability to develop will favour DBM even more.

7.3.2 Economic efficiency

When development potential of the project delivery methods is taken into consideration, it is seen that the difference in value for money between traditional and more innovative project delivery methods increases further (see Figure 22). While the actual change cannot be anticipated as an exact measure, the systematic examination made depicts the relative development between the systems. Thus, DBB and CM will have approximately the same economic efficiency, only slightly improved from the current situation, but both DB and DBM can improve their cost performance and value generation notably resulting in even more economically efficient project delivery. The difference between the two is not clear, but it seems that the method that is performing better nowadays, i.e. DBM, has characteristically more development potential. Therefore, no change in the mutual ranking of the project delivery systems based on their performance can be seen in the future.

Table 13. Development potential of the project delivery methods.

	Cost performance				**Value generation**			
	DBB	CM	DB	DBM	DBB	CM	DB	DBM
DP	0.11	0.12	0.60	0.58	0.15	0.12	0.61	0.70

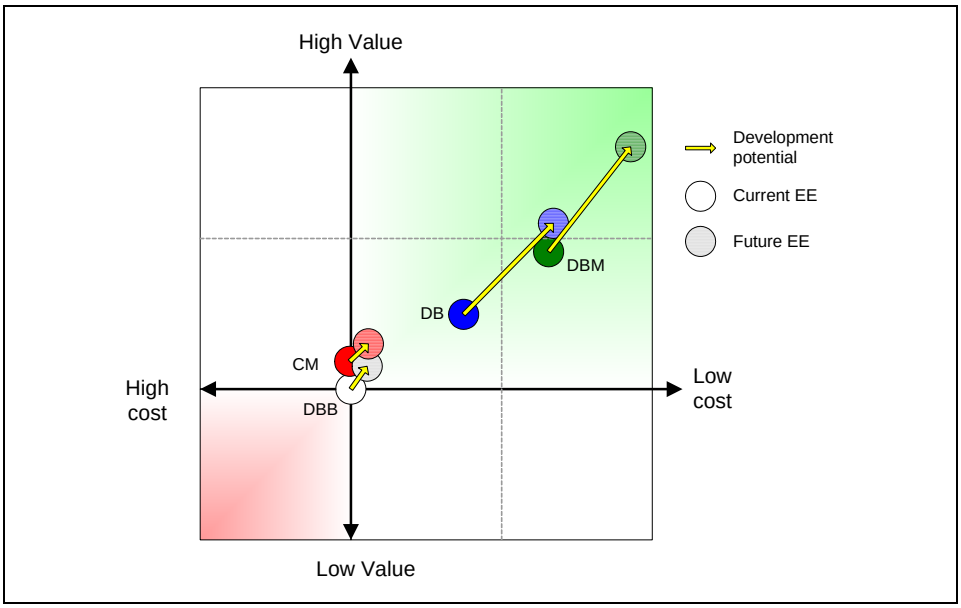

Figure 22. Future economic efficiency of the project delivery methods.

7.3.3 Influence of the future business environment

To verify that there are no external factors (see Figure 2 in Chapter 2.3) that would significantly affect the applicability of any project delivery method assessed, effects of expected changes in the operating environment on usability of each project delivery method were also considered (see Tables 14–18). These detailed change-specific evaluations are predominantly a systematisation of the qualitative research approach and are presented here only to provide transparency to conclusions made.

It seems that external factors merely confirm the rank of the project delivery methods, since changes tend to favour (+) use of DB and DBM, while usability of DBB and CM may, in some cases, be affected negatively (–) by the future operating environment. (In Table 14 '+' means 'meets better the challenge', while in Tables 15–18 it means 'takes better advantage of the issue'.) As a result, it can be inferred that DB and DBM can better accommodate the expected future changes providing feasible alternatives for procuring roads in general.

Table 14. Future performance based on controlling factors (scores -2…2).

Factors	**Usability**			
	DBB	CM	DB	DBM
Fluctuating market	–		–	+
Fragmented market	+	+		–
Secured industry profitability	–	– –	+	++
Expensive machinery needed		–	+	++
Complex traffic management	–	–	+	+
Lack of performance-based specifications			–	– –
Limited number of clients	+	+	–	– –
Lack of owner resources	–	+	+	++
Bureaucratic decision making	–	–	++	++
Legal barriers to broader service packages			–	– –
Lack of public funding	–	–	–	+++
Changing political environment	–	– –	+	++
Privatization				+++
Liberalization of regulations			++	+
Environmental concerns	+	+		
Restrictive permitting processes			– –	– –
Permitting delays		+	– –	– –
Stakeholder participation & transparency	++	++		–
TOTAL	-0.07	-0.04	0.00	0.26

Table 15. Future performance based on input factors (scores -2…2).

Factors	**Usability**			
	DBB	CM	DB	DBM
Telematics	+	+	+	++
Prefabricated components	+		++	++
New materials		–	+	++
TOTAL	0.44	0.00	0.88	1.33

Table 16. Future performance based on output characteristics (scores -2…2).

Factors	**Usability**			
	DBB	CM	DB	DBM
Increasing project scope & size	–	+	+	++
Increasing project complexity		+	+	+
Life-cycle optimised product			+	++
TOTAL	-0.22	0.44	0.67	1.11

Table 17. Future performance based on mechanisms for success (scores -2…2).

Factors	**Usability**			
	DBB	CM	DB	DBM
Technology, especially IT			++	++
Electronic information transfer	+	+	++	+++
Systems compatibility			+	+
E-business	+	+	+	
Equipment automation	+		++	++
Standardised processes & documentation	Included in Table 12			
Participation & transparency	++	++		–
Productification	Included in Table 12			
Knowledge integration	Included in Table 12			
Increased industry capability		–	+	++
Adequate industry resources	+	+		–
Owner experience & knowledge	++			– –
Availability of skilful consultants		–		– –
Research & development		– –	+	++
New performance measurement methods			+	+
Industry consolidation		–	++	++
Healthy industry	+	+	+	+
Cultural change	+		++	++
TOTAL	0.44	0.04	0.71	0.53

Table 18. Future performance based on operative factors (scores -2…2).

Factors	**Usability**			
	DBB	CM	DB	DBM
Out-sourcing	+	++	++	+++
Performance-based specifications	Included in Table 12			
Adequate competition	+	+	–	– –
Qualitative contractor selection	Included in Table 12			
Quality assured contracts	Included in Table 12			
Incentives	Included in table 12			
Longer warranties	Included in Table 12			
Customer focus	–			+
Service emphasis	– –			++
Partnering	Included in Table 12			
TOTAL	-0.17	0.5	0.17	0.67

7.4 Applicability of the project delivery methods

While broader service packages seem to offer better value for money in ‘an average project’, the question that remains is: in what circumstances is one procurement option more desirable than the others? After all, all projects are different. Additionally, the project delivery methods are neither equally effective nor produce equal results under all project conditions. Any one of the resulting processes may be the most effective one only under certain conditions.

It is still often appropriate to use DBB, when projects are relatively small, simple, have well-defined end results, and offer no opportunities to innovate or to generate revenue (see Figure 23). DBB is also appropriate, when it is necessary to undertake a significant portion of the design to obtain planning

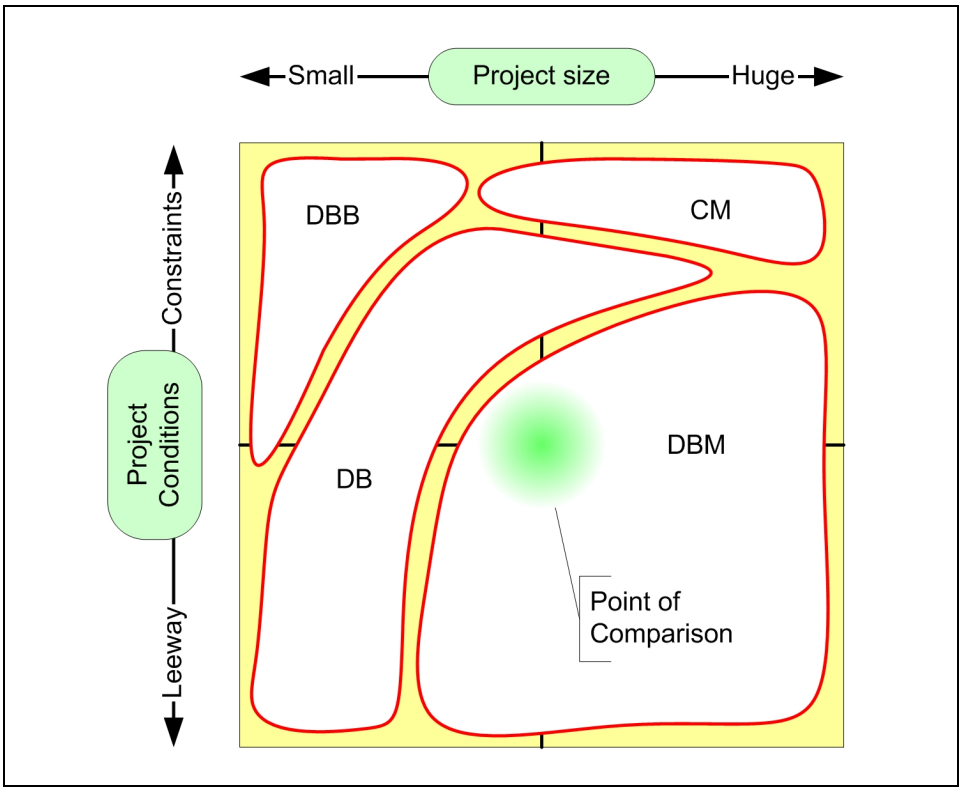

Figure 23. Applicability of the project delivery methods.

approvals, acquire property or resolve utility service requirements, or for highly constrained projects in urban environments. DBB is applicable, when access to the site cannot be guaranteed in a timely fashion, when the project scope cannot be defined well, or in areas of unknown or difficult ground conditions. In addition, if politics is likely to lead to substantial changes during the project, the relative flexibility of DBB is advantageous. However, the usage of DBB is likely to decrease in the future, but it will remain one of the road project delivery alternatives.

Networking and partnering within the infrastructure sector is leading to integrated groups of service providers, reducing the need for CMr services and separate project management organisations. Also, the clients' aim to gain greater price certainty, outsource more responsibilities, transfer more risks and reduce in-house administration, has decreased the usage of CM. However, at the same time, need for external advice is increasing, as clients have smaller in-house resources and projects are becoming more complex. The role of the consultant will, however, differ more and more from that of the traditional CMr. CM will retain its potential for big projects that are implemented under very restricted conditions and projects requiring flexibility to accommodate client changes.

Generally, the trend is to move to broader service packages as project size and innovation potential increase /32/ and, as suggested by the research, to meet greater efficiency requirements. Projects in well-known conditions, without complicated third party issues, lend themselves well to DB. Also, restart of a delayed DBB project may benefit from switching to DB /23/. However, DB projects need to be of adequate size to justify the higher tendering costs. This results in smaller projects being packaged together. It is also important to note that even though Figure 23 presents DBM as the most prominent project delivery method with largest range of applications, most road projects tend to be quite small and can most often be delivered economically through DB.

The principal weakness of DBB, CM or DB is the insufficient attention paid to the post-construction period in the road's useful life. During it value for money may be achieved through DBM that, based on the research, is the most efficient project delivery method. However, DBM should be used only, where most of the following circumstances apply /48, 47/

- the project size justifies the transaction and management costs
- output specification omits unnecessary prescription of delivery mechanisms
- there is a defined, measurable service delivery function or output mechanism
- there is scope within the project delivery for the optimisation and allocation of manageable risks to the private sector
- there are benefits from using private sector management skills
- there is potential for innovation and scope for value adding and/or cost reductions in the delivery and operation of the service
- there are real benefits from integrating responsibility for operation and maintenance with that for construction and design
- the road is not highly affected by other parts of the traffic network, and it is unlikely that there will be large changes in the network that would affect the project road during the contract period
- there is continuous performance measurement and incentives
- there is an identifiable market of private sector bidders prepared to compete for the opportunity to deliver the project
- interests of public and private sectors are aligned and
- there is adequate transparency of processes.

While life-cycle models are here grouped under one heading (DBM), there are differences between the variations. DBOM involves no financial responsibilities and a shorter maintenance period than other life-cycle models, resembling mostly DB with a long warranty period. The DBFO process, again, tends to allow the client greater control over service levels provided than BOOT due to the payment mechanism used. For instance, in DBFO part of the payment may be determined by the travel times, lane availability and safety record achieved, if the client considers these valuable to society. In BOOT the level of payment or revenue over the contract period is usually set through user paid tolls, and the service level delivered is determined by this commercial reality. Hence, for the duration of the contract, BOOTs are further along the scale of full privatisation than DBFOs, emphasising the importance of initial service identification and output specification. Since the government will always be held accountable for the level of service regardless of any notional arrangements, DBFO may have more attraction as it allows greater client influence /2/. However, it is noted that the selection between different DBM variations is also a political issue.

Although the primary project delivery method may be selected based on Figure 23, it is not presented as the final recommendation, but rather as an educated guess. Only by considering the conditions of each project, by eliminating unnecessary constraints and by packaging projects appropriately, is it possible to achieve economically more effective road project delivery. Based on the extensive literature review, the relevant factors affecting the client's choice of a procurement system are listed in Table 19.

Table 19. Factors affecting project delivery system selection /43, 44, 35, 13/.

• speed of delivery	• size of the project
• price certainty needed (budgetary constraints)	• need/opportunity for early commencement/completion of work
• flexibility and expected changes during project delivery (volatility of the project environment)	• external factors (political givens, physical constraints, government regulations)
• quality standard (design quality and conformance quality)	• community, stakeholder and environmental issues
• potential for innovation in design by combining design, construction and maintenance	• needs of the client organisation (in-house resources, project objectives)
• the extent to which the project involves state of art technology	• extent of scope definition
• project risk level and risk allocation	• responsibilities
• project complexity	• funding arrangements
	• market competitiveness

8. Discussion

8.1 Review of the research paradigm

This research compared the performance of the different project delivery methods now and in the future based on the introduced concept of economic efficiency. Economic efficiency is determined as the ratio of value generation to cost performance. While cost performance can be explored relatively reliably, the same may not be true with value generation that is a subjective and more ambiguous concept.

Thus, it is very difficult to make exact and valid quantitative comparisons between the different project delivery methods, as all projects are different and contract contents differ from one project to another, as well as from one continent to another. While road projects may not be entirely unique, they are sufficiently unique for differences to outweigh similarities. This is why no profound case studies were done, although some projects were looked at a bit more thoroughly. The unavailability of accurate data would also have hindered that approach.

A rather more qualitative approach was taken to emphasise the value aspects of road procurement. Qualitative research is usually used in exploration of a subject area, on which only a limited amount of knowledge exists, and when the data collected are complex. While the objectivity of qualitative analysis is often questioned /25/, it is believed that here qualitative research was required to improve understanding of the key features of procurement that include a lot of perceived and value-associated issues that cannot be sufficiently explored through quantitative research. The survey on the goal-oriented means of improvement deals with features that could not have been studied appropriately without the selected approach.

8.2 Validity of research findings

There were some difficulties in obtaining accurate cost data due to the sensitivity of such information, as its disclosure could mean loss of competitive advantage. It was also found that in some cases, like with public domain clients, no such

cost data existed. Thus, the research was designed to be independent of detailed cost data by asking about relative costs of phases rather than costs of tasks. The questionnaire included multiple questions concerning percentages with which one procurement method outperforms or underperforms others. However, the problem faced there was that the individuals interviewed, or their organisations, had neither recorded nor collected systematically this sort of data. Thus, mostly anecdotal information could be gathered. If an interviewee had prejudices against any of the project delivery methods, this may have affected his/her perception of the merits of the project delivery systems causing discrepancy in the analysis. However, the low variation between the interviewees' estimates supports the reliability of the assessment.

While there were slight differences in the perceived cost performance and value generation of the project delivery methods between the different countries, the differences were relatively low, and the information from different countries was found to form a coherent set of data backing up the overall assessment. However, at the same time, it is recognised that, if the verified cost structure used in the calculations is very different from the cost structure of a real application, the assessment of the cost performance is defective. The same is true, if the value set of a client largely differs from the value set used in the analysis.

The analysis favours DBM over the other project delivery alternatives. However, at the time of the research, no DBM project had come to the end of its contract period, as the oldest BOOT contract was 20 years old and the others much younger. Therefore, the whole-life cost savings over the project's duration could not be measured *ex post* nor were they reported anywhere. Additionally, it is too early for the long-term benefits of DBM-type procurement to manifest themselves. Thus, benefits may only be hypothesised based on different solutions as to the design, building and maintenance of the road from the solutions provided by traditional procurement.

Performance information for CM was available only from a few interviewees and only in Finland, leaving some unanswered questions concerning the validity and generalization of that information. Therefore, the presented performance evaluation of CM should not be considered an absolute truth. Somewhat conservative estimates may have also been used as the average resulting savings

in CM in the final cost assessment and discounting. However, this was perceived appropriate due to the wide range of the relatively few precise answers and the fact that CM has been often criticised and largely abandoned in other countries. Thus, it may be assumed that its performance potential is not considered significantly better than that of DBB, which is still used in other countries except the UK.

The future research is always somewhat debatable, since the future is unknown at the time of the research. There are trends that affect all markets, and there are industry-specific issues affecting only a single industry. Also, some trends may end up being of prime importance, while others may have only minimal effects on the business environment. The resulting business environment determines the final constraints imposed on project delivery and applicability of the project delivery methods. However, it seems that the expectations in the global market place seem to be well in line emphasising the same issues (lack of public funding, outsourcing, integration of services, etc.). Therefore, the future business environment depicted in this research can be seen as a state-of-art framework for future-oriented performance assessment.

It is also recognised that the subject countries are at different stages of development, with the UK and Australia having more experiences from integrated project delivery methods from a longer period, and the USA and Finland still being somewhat more conventional. However, largely similar experiences have been gained and problems recognised in these countries with only slight differences in the perceived importance of the different issues. Additionally, the recorded value for money perceptions on road project delivery were generally well in line with the analysis performed. Thus, considering the success in defining the research paradigm and collecting coherent data, it can be supposed that the implementation of the research and the results are valid.

8.3 Contribution of the research

While there are a lot of project-specific and detailed studies on the performance and development possibilities of project delivery methods, other studies tend to be heavily problem-oriented historical surveys and often concentrated on one country. Additionally, these studies tend to make improvement suggestions for

the short term, without truly considering the long-term performance. Thus, this research seems to be the first research that:

- makes a global assessment of the project delivery methods' performance resulting in a universal and comprehensive analysis, and
- has a systematic development and future focus that provides strategic solutions to both today's problems and future challenges.

As a result of the systematic, future-oriented research strategy, this research will contribute to existing knowledge and to increasing the industry's efficiency in a number of areas, as it:

- strengthens the theoretical understanding of project delivery
- develops a novel methodology to assess performance of different project delivery methods
- provides evidence on whether the project delivery methods used deliver value for money for the client and profit for the private sector
- identifies the factors in the project delivery process that either encourage or discourage value for money delivery
- develops potential solutions to inefficiencies in different project delivery methods now and in the future, and
- provides a framework for the future applicability of the road project delivery methods.

9. Conclusions

9.1 Results

On average, the current economic efficiency of CM seems to be only slightly higher than that of DBB, while the economic efficiency of DB is significantly higher than that of DBB. DBM brings even more notable improvements, as it doubles DB's efficiency improvement. When the development potentials of the project delivery methods are taken into consideration, the difference in value for money between traditional and more integrated project delivery methods is going to increase further. Thus, DBB and CM seem to be of about the same economic efficiency, and are likely to improve only marginally, but both DB and DBM will improve their cost performance and value generation notably resulting in economically even more efficient project delivery. Therefore, no change in the mutual ranking of the project delivery systems based on their performance can be expected in the future. Thus, it seems that for most projects, DB and DBM meet the needs and desires of the client better than traditional or CM project delivery.

9.2 Recommendations

The client should fairly early in the project's life cycle define the best way to procure the road based on project size, complexity, risks, timing, external factors affecting the project, environmental issues, road location, etc. The client's decision is fundamental in setting up the framework for all subsequent activities – design, construction and maintenance – and for their management.

To ensure the best value for public money, Design-Build and Design-Build-Maintain are options worth considering as primary project delivery methods. However, often the typical small project size may eliminate potential use of DBM as uneconomical. By packaging smaller projects into larger, rational entities, economies of scale may be improved. Thus, DBM may be used in some exceptionally large projects leaving DB as the normal alternative for DBB. When adopting DB and/or DBM-type project delivery that requires private sector innovations and contributions, public owners need to provide permanent

market demand for competent contractors to capitalise fully on the potential of these methods.

While DB and DBM outperform DBB and CM, there is still room for these models in heavily constrained projects. It is also recognised that the public client needs to manage the economy by balancing the work between companies of different size. Occasionally, there may be also other societal issues, examination of which was beyond the scope of this research, but which compel the client to deviate from the primary strategy suggested. All this supports continuation of traditional procurement as well.

No matter what project delivery method the client selects, the contract type should develop an appropriate cooperative relationship between project participants, and provide incentives to the participants to achieve client objectives. The selected project delivery method may also be further improved to reduce the timescale over which the project is delivered and to improve economic efficiency to ensure that value for money is not compromised. The suggested improvements to different project delivery methods are listed in Table 20.

As change is often inhibited by fear of the unknown, further training of public sector representatives should improve successes in procurement and lead to lower transaction costs, better value for money, and faster delivery of public services. Contract standardisation and procurement automation also reduce bid costs and ensure that a consistent approach to risk sharing is maintained. At the same time, private companies need to focus on relationship-building, communication, work methods, delivery strategies, design, and electronic applications. They need integrated and interoperable systems for tracking design, time, costs, documentation, asset management and operations. Time and cost pressure and increased project complexity require working together over the project's life, and a business with a team culture will have more successful outcomes and higher profitability. Social responsibility and stakeholder management are also key performance issues.

Table 20: part 1/3. Improvement of the project delivery methods.

Design-Bid-Build • Involve contractors earlier in the process to improve quality of design through constructability reviews. • Allow alternative tendering to encourage innovations. • Select contractors based on both price and non-price factors to improve project delivery and encourage market development. • Encourage value engineering to improve buildability of the design. • Offer incentives to improve performance in key performance areas. • Measure performance regularly to provide opportunities to improve delivery during the project. • Use fixed lump sum contracts to transfer risks and motivate the contractor to take a more careful look at the project. • Use quality-assured contracts to improve quality and to reduce duplication in contract administration. • Encourage partnering to improve cooperation between the project participants.
Construction Management • Emphasise references of CM bidders more to ensure efficient and good quality project delivery by selecting a truly capable CMr. • Select contractors based on both price and non-price factors to improve project delivery and encourage market development. • Consider hiring CMr for a longer term to manage procurement of maintenance in addition to design and construction. This would emphasise the long-term performance of the road. • Increase CM project size to encourage international competition to overcome the lack of capable CMrs in the national market. • Use target cost contracts to improve cost certainty of project delivery. • Encourage contractor value engineering to improve buildability of the design. • Use quality-assured contracts to improve quality and to reduce duplication in quality control and assurance.
Design-Build • Use normal low bid process for small and simple DB projects to reduce tendering costs. • Reduce voluminous technical proposal requirements to reduce tendering costs in larger and more complex projects. The technical proposals may concentrate on structures, where alternatives are sought. *(Design-Build to be continued)*

Table 20: part 2/3. Improvement of the project delivery methods.

Design-Build *(continues)*

- Adopt automated tendering and develop standardised documents to facilitate procurement phase.
- Use pre-qualification to reduce industry tendering costs and to improve project delivery.
- Use best value contractor selection to improve project delivery and to encourage company development.
- Package work appropriately to offer adequate economies of scale and to reduce unnecessary risks.
- Increase project size to encourage international competition to overcome the lack of national resources.
- Encourage partnering to improve cooperation between project participants.
- Encourage joint ventures to improve cooperation between project participants and to improve the position of designers.
- Ask for detailed information on project delivery teams and mutual operating principles in the tender to ensure that the project team is coherent and capable of delivering the project efficiently.
- Award early works contracts to reduce significant risks from the DB contract.
- Negotiate risk transfer with the short-listed bidders to ensure that risks are allocated appropriately.
- Adopt earlier contractor involvement, where it can improve project delivery and offer innovations.
- Use arrangements, where savings resulting from innovations are shared to ensure mutual benefit.
- Improve performance-based standards to ensure expected project outturn.
- Encourage productification and prefabrication to develop the market and its product, and to reduce production costs.
- Offer incentives to improve performance in key performance areas.
- Measure performance regularly to provide opportunities to improve delivery during the project.
- Include basis for change pricing in the contract to reduce change costs and to facilitate required negotiations.
- Use life-cycle cost as one of the award criteria and adopt longer warranties to emphasise the importance of road life cycle.
- Encourage adoption of advanced quality management systems to improve road quality and to reduce quality control costs.
- Encourage initial design period to allow more time for design to reduce re-work due to design errors.

Table 20: part 3/3. Improvement of the project delivery method.

Design-Build-Maintain
• Reduce design requirements in selection of the preferred bidder to reduce tendering costs. • Adopt automated tendering and develop standardised documents to facilitate procurement phase. • Use best value ProjectCo selection to improve project delivery and to encourage company development. Greater emphasis on qualitative issues in selection may also help to reduce tendering costs. • Package work appropriately to offer adequate economies of scale and to ensure benefits of service integration. • Assess risks appropriately and negotiate risk transfer with the short-listed bidders to ensure that risks are allocated optimally. • Award early works contracts to reduce significant risks from the DBM contract. • Assess the way the ProjectCo will implement the project. Favour cooperation models, where a single contract is awarded for both DB and OM, as this encourages the implementer to truly optimise the life-cycle costs without inefficiencies caused by organisational boundaries. • Encourage partnering to improve cooperation between project participants • Adopt earlier contractor/ProjectCo involvement, where it can improve project delivery and offer innovations. • Improve performance-based standards to ensure expected project outturn. • Improve performance by tying payment to road availability and performance. Measure performance regularly. • Include the basis of changes in the contract to reduce lengthy negotiation during the contract and to ensure value for money throughout the contract. One way to improve flexibility is to set up a contingency fund to allow reasonable changes.

9.3 Implementation

One of the major obstacles to the increased efficiency of the industry is the fundamental resistance to change: many contractors are unwilling to give up the well-known and common price-competition that makes tendering easy and transparent; often designers are unwilling to bid for the contractors and negotiate with them instead of the client; and many client representatives still want to maintain control in projects. As the problem stems from fear of the unknown and

lack of detailed industry knowledge, this research should motivate market actors to seek means of adapting to new ways of doing business, as the reasons for using different project delivery methods and the positive experiences gained appear to be very similar globally.

Chapter 9.2 lists recommendations at two levels: selection of the procurement route, and project delivery method-specific issues. Recommendations at the procurement level are ones that should be implemented to improve the efficiency of road project delivery. However, it is not necessary to implement the project delivery method-specific recommendations in whole. Rather, clients can adopt the improvements suggested to overcome real and experienced problems and postpone the others. In fact, changes should, in most cases, be implemented step-wise to allow the industry time to adjust to the new practise and to accept it. The client also has to communicate the changes clearly to the industry to reduce obscurity and resistance and to provide chances for the industry to develop its business to meet the changing client needs.

At the same, time the client has to recognise that the DB procurement process, and especially DBM, demands different skills to those most public servants have developed over the years of traditional procurement. The procurement process encompasses a blend of financial, legal, and technical expertise with commercial negotiation and decision-making. Thus, the clients also need to develop their in-house skills over time to meet the challenges brought by the integrated project delivery methods.

References

1. Koppinen, T & Lahdenperä, P. Road Sector Experiences on Project Delivery Methods. VTT Tiedotteita – Research Notes 2260. Espoo, Finland, 2004. 214 p. + app. 32 p. Available also at: http://www.vtt.fi/inf/pdf/tiedotteet/2004/T2260.pdf.

2. Doile, N.& Beattie, K. Transport Infrastructure Public Private Partnership in Queensland Context. Conference of the Australian Road Research Board, May 18-23 2003, Cairns, Australia. Proceedings. 7 p.

3. Weed, R.M. A rational method for relating as-built quality to pavement performance and value. Transportation Research Record 1632, Paper No. 98-0372. Pp. 32–39.

4. Contract Administration: technology and practise in Europe. U.S. Department of Transportation, Federal Highway Administration. International Technology Exchange Program. October 2002. 104 p.

5. Pakkala, P. Innovative Project Delivery Methods for Infrastructure - An International Perspective. Finnish Road Enterprise, Helsinki, Finland, 2002. 120 p.

6. Gibb, A.G.F. & Isack, F. Client drivers for construction projects: implications for standardisation. Engineering construction and architectural management, Vol. 1, No. 8, 2001. Pp. 46–58.

7. Global trends 2015: A dialogue about the future with nongovernment experts. National Intelligence Council. Report NIC 2000-02, December 2000, USA. 88 p.

8. Molenaar, K.R., Songer, A.D. & Barash, M. Public-sector design-build evolution and performance. Journal of management in engineering, March/April 1999. Pp. 54–62.

9. Lahdenperä, P & Rintala, K. Ajatuksia elinkaarivastuuhankkeista – Brittiläisten tilapalveluhankintojen tarkastelua uuden suomalaisen käytännön

kehittämiseksi [Thoughts on DBFO. A study of UK accommodation service procurement for the benefit of Finnish practice]. VTT Tiedotteita – Research Notes 2192, Espoo, Finland, 2003. 52 p. + app. 2 p.

10. Marca, D. & McGowan, C. Structured analysis and design technique. McGraw-Hill Publishing Company. New York, US, 1988. 392 p.

11. Ng, S.T. & Skitmore, R.M. Contractors' risks in Design, Novate and Construct contracts. International journal of project management, Vol. 20, 2002. Pp. 119–126.

12. Manley, K. & Hampson, K. Relationship Contracting on construction projects – A study commissioned by Queensland Department of main Roads. QUT/CSIRO construction Research Alliance, School of Construction Management and property, Queensland University of Technology. October 2000. 72 p.

13. Achieving outstanding performance, Queensland Department of Main roads, Value Management Workshop, Relationship based contracting – Output document, 24-25 August 2000. SRD Consulting. 35 p.

14. Sidwell, A.C. & Budiwan, D. The significance of the tendering contract on the opportunities for clients to encourage contractor-led innovation. Construction innovation, Vol. 1, 2001. Pp. 107–116.

15. National Audit Office, Report by the comptroller and auditor general. The private finance initiative: The first four design, build, finance and operate roads contracts. National, Audit Office, Department of the Environment, Transport and the Regions HC 476 Session 1997-98. Published 28 January, 1998. 78 p.

16. Langford, D.A., Kennedy, P. Conlin, J. & McKenzie, N. Comparison of construction costs on motorway projects using measure and value and alternative tendering initiative contractual arrangements. Construction management and economics, Vol. 21, December 2003. Pp. 831–840.

17. Junnonen, J-M & Lindholm, M. Julkisen ja yksityisen sektorin yhteistyö – Yksityisrahoitusmalli julkisissa rakennusinvestoinneissa. Rakennusteollisuuden Keskusliitto, Kehitys & tuottavuus, Nro 56, 1998. 95 p.

18. Scott, S. Guidebook to highway contracting for innovation: the role of procurement and contracting approaches in facilitating the implementation of research findings. Transportation Research Board. National Cooperative Highway Research Program. Report 428. National Academy Press, Washington D.C. 1999. 45 p.

19. Levy, S.M. Build-Operate-Transfer – Paving the way for tomorrow's infrastructure. John Wiley & Sons, Inc. New York, USA, 1996. 411 p.

20. Marshall, C. The Öresund Tunnel – Making a success of design and build. Tunnelling and Underground Space Technology, Vol. 14, No. 3. 1999. Pp. 355–365.

21. Jokela, P. Elinkaarimalli - Tiehallinnon hankintastrategia, osaraportti [Life cycle model]. Tiehallinnon selvityksiä 54/2002. Tiehallinto, Helsinki 2002. 48 p + app. 20 p.

22. Dorsey, R.W. Project Delivery Systems for Building Construction. Associated General Contractors of America. America, 1997. 283 p.

23. Transit Cooperative Research Program. International Transit Studies Program, report on the spring 2001 Mission – Design-Build Transit Infrastructure Projects in Asia and Australia. Research Results Digest, November 2002, No. 53. 31 p.

24. HM Treasury. PFI: meeting the investment challenge. July 2003. 128 p.

25. Rintala, K.M. The economic efficiency of accommodation service PFI projects. Draft 20/12/2003. Doctor's Thesis. Bartlett School of Graduate Studies, University College London, University of London. 235 p.

26. National Audit Office. PFI: Construction performance. National Audit Office, Report by the Comptroller and Auditor General HC 371 Session 2002–2003: 5 February 2003. 21 p.

27. National Audit Office. Managing the relationship to secure a successful partnership in PFI projects. National Audit Office, Report by the Comptroller and Auditor General HC 375 Session 2001–2002: 29 November 2001. 49 p.

28. Mott MacDonald. Review of Large Public Procurement in the UK. Mott MacDonald Study for HM Treasury. July 2002. 84 p.

29. Ardani, A. & Jesaitis, P. Evaluation of Design Build Practice in Colorado IR(CX)70-4(143). Colorado Department of Transportation, Research branch. Report No. CDOT-DTD-R-99-5, Final Report. July 1999, Colorado, USA. 42 p.

30. Porter, M.E. Competitive Advantage - Creating and sustaining superioir performance. The Free Press, New York, US, 1985. 558 p.

31. [Web-document] http://www.highways.gov.uk/roads/dbfo/value_in_roads/01.htm . DBFO - Value in Roads. Highways Agency.

32. Transit New Zealand. Long-term Procurement Strategy. December 2000. 49 p.

33. Gransberg, D.D., Dillon, W.D., Reynolds, L. & Boyd, J. Quantitative Analysis of partnered project performance. Journal of construction engineering and management, vol 125, nr 3, May/June 1999. Pp. 161–166.

34. Miller, J.B., Garvin, M..J., Ibbs, C.W. & Mahoney, S.E. Toward a new paradigm: simultaneous use of multiple project delivery methods. Journal of management in Engineering, May/ June 2000. Pp. 58–67.

35. Skinner, D.G. Project delivery system selection. Transport Technology forum, 4 August, 1999. Australia. 7 p.

36. Kumaraswamy, M.M. & Dissanayaka, S.M. Developing a decision support system for building project procurement. Building and Environment, Volume 36, Issue 3, 1 April 2001. Pp. 337-349.

37. [Web-document] http://www.ic.usu.edu/IC-Overview/Design%20Build/DesignBuild%20OVERVIEW.htm.
Design Build. Utah Technology Transfer Center.

38. Alhazmi, T. & McCaffer, R. Project procurement system selection model. Journal of construction engineering and management, Vol 126, No. 3, May/June 2000. Pp. 176–184.

39. Innovation 2010 – Building for growth. Industry Science Resources, Competitive Australia. The Commonwealth Department of Industry, Science and Resources. 24 p.

40. Peña-Mora, F. & Tamaki, T. Effect of delivery systems on collaborative negotiations for large-scale infrastructure projects. Journal of Management in Engineering, April 2001. Pp. 105–121.

41. Love, E.D. Influence of project type and procurement method on rework costs in building construction projects. Journal of Construction Engineering and Management. January/February 2002. Pp.18–29.

42. Standing, N.A. Value management Incentive Programme – innovations in delivering value. Thomas Telford Publishing. London, UK, 2001. 126 p.

43. Chang, C.-Y. & Ive, G. Rethinking the multi-attribute utility approach based procurement route selection tehnique. Construction management and economics, Vol 20. 2002. Pp. 275–284.

44. VicRoads. Project management guidelines – Project delivery. VicRoads publication number 01303. 11 p.

45. Cheung, S.-O., Lam, T.-I., Leung, M.-Y. & Wan, Y.-W. An analytical hierarchy process based procurement selection method. Construction management and economics. Vol. 19, 2001. Pp. 427–437.

46. New tools for contracting – Partners in progress. The earthmover and civil contractor, July 1993. Pp. 37-39.

47. Queensland Government, State Development. Public Private Partenrships guidance material – Value for money framework. August 2002. 31 p.

48. Queensland Government, State Development. Public Private Partenrships guidance material – Policy. August 2002. 7 p.

49. Queensland Government, State Development. Public Private Partenrships guidance material – Supporting Documents – Business case development. August 2002. 49 p.

50. Hall, M., Holt, R. & Graves, A. Private finance, public roads: configuring the supply chain in PFI highway construction. European Journal of Purchasing & Supply Management, Vol. 6, No. 3–4, December 2000. Pp. 227–235.

51. Main Roads Project Delivery System, Volume 1 – Selection of Delivery Options, Version 2.0. Queensland Government, Department of Main Roads. October 2003.

52. W 92 CIB Procurement. Procurement – the way forward. Keynote papers presented to the International Symposium of Commission W92 of the International Council for Building Research, Studies and Documentation. CIB Proceedings, Montreal May 1997. CIB Publication 217. 94 p.

53. Howard, W.E., Bell, L.C. & McCormick, R.E. Economic principles of contractor compensation. Journal of management in engineering, September/October 1997. Pp. 81–89.

Published by

Series title, number and report code of publication

VTT Publications 549
VTT–PUBS–549

Author(s)
Koppinen, Tiina. & Lahdenperä, Pertti

Title

The current and future performance of road project delivery methods

Abstract

Road authorities are increasingly becoming asset managers. As a result, activities previously procured through several agreements may now be included under one agreement. The client's decision between traditional or more integrated project delivery is fundamental in setting up a framework for design, construction and maintenance. To assist clients in the strategic selection of the most efficient project delivery methods, this research determines the performance of Design-Bid-Build, Construction Management, Design-Build, and Design-Build-Maintain. Performance is determined based on the data provided by interviewees in five countries (Finland, UK, Australia, New Zealand, and USA) and on an extensive literature review.

The concept of economic efficiency was developed to compare performance levels of the project delivery methods. The more value a project delivery system generates in relation to project cost, the more economically efficient it is for procuring roads. The analysis shows that the broader and more integrated service packages (DB and DBM) can provide better value for money and meet the needs and wants of the client better than DBB or CM. Achievement of the full performance potential presupposes, though, that some improvements to the delivery systems are made to address their current weaknesses.

It must also be taken into consideration that each method should be applied only in appropriate circumstances. It is still often appropriate to use DBB, when projects are relatively small, simple, have well-defined end results, and offer no opportunities to innovate or to generate revenue. CM will retain its potential in big projects that are implemented under very restricted conditions or require flexibility to accommodate client changes. As DBM may be used in some, very large projects, this leaves DB as the normal alternative to DBB.

Keywords

road procurement, project delivery, construction management, Design-Build, Design-Build-Maintain, Design-Build-Finance-Operate, Build-Own-Operate-Transfer, costs, value generation, performance, comparison, future, life cycle

Activity unit

VTT Building and Transport, Hermiankatu 8, P.O.Box 1802, FIN-33101 TAMPERE, Finland

ISBN	Project number
951–38–6424–3 (soft back ed.) 951–38–6425–1 (URL:http://www.vtt.fi/inf/pdf/)	R2SU00764

Date	Language	Pages	Price
October 2004	English	115 p.	C

Name of project

The performance and development potential of project delivery methods for infrastructure

Commissioned by

National Technology Agency TEKES, Finnish Road Administration Finnra, Finnish Road Enterprise, Confederation of Finnish Construction Industries RT, Central Organisation of Earth Moving Contractors in Finland SML, Finnish Rail Administration RHK and Finnish Association of Consulting Firms SKOL

Series title and ISSN

VTT Publications
1235–0621 (soft back ed.)
1455–0849 (URL: http://www.vtt.fi/inf/pdf/)

Sold by

VTT Information Service
P.O.Box 2000, FIN–02044 VTT, Finland
Phone internat. +358 9 456 4404
Fax +358 9 456 4374

Road Authorities' decision between traditional or more integrated project delivery is fundamental in setting up the framework for design, construction and maintenance. To assist clients in the strategic selection of the economically most efficient project delivery methods, this research determines the performance of the methods: Design-Bid-Build, Construction Management, Design-Build, Design-Build-Maintain. The current performance of the project delivery methods is assessed based on the data provided by the interviewees in five countries (Finland, UK, Australia, New Zealand, and USA) and on an extensive literature review. The future performance potential of the methods is also determined.

The analysis shows that broader and more integrated service packages can provide better value for money and meet the needs and wants of the client better than more traditional-type project delivery. However, it must be taken into consideration that each method should be applied only in appropriate circumstances, leaving room also for traditional project delivery. In addition, the full performance potential may only be achieved by addressing the weaknesses of each project delivery through the improvement suggestions listed in the report.

Tätä julkaisua myy
VTT TIETOPALVELU
PL 2000
02044 VTT
Puh. (09) 456 4404
Faksi (09) 456 4374

Denna publikation säljs av
VTT INFORMATIONSTJÄNST
PB 2000
02044 VTT
Tel. (09) 456 4404
Fax (09) 456 4374

This publication is available from
VTT INFORMATION SERVICE
P.O.Box 2000
FIN–02044 VTT, Finland
Phone internat. +358 9 456 4404
Fax +358 9 456 4374

ISBN 951–38–6424–3 (soft back ed.)
ISSN 1235–0621 (soft back ed.)

ISBN 951–38–6425–1 (URL: http://www.vtt.fi/inf/pdf/)
ISSN 1455–0849 (URL: http://www.vtt.fi/inf/pdf/)