Transportation Megaproject Procurement: Benefits and Challenges for PPPs and Alternative Delivery Strategies, and the Resulting Implications for Crossrail

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Abstract

This thesis evaluates the applicability of public-private partnerships (PPPs) and alternative delivery strategies to transportation megaprojects. There has been tremendous expansion of innovative procurement and financing mechanisms in this area. However, there are still many hurdles to overcome before these options can penetrate the transportation market with any regularity. The thesis identifies the barriers and their origins, and suggests changes to policy and institutional frameworks that may be incorporated to encourage a broader range of delivery options.

There is potentially much to be gained from increased private sector involvement in transportation megaproject delivery, but it requires significant investment of public sector time and money at the outset to be able to identify the most appropriate course of action. The public and private sectors often have diverging short-term versus long-term interests that must be reconciled if PPPs are to provide improved outcomes.

The thesis introduces the various stages of megaproject development and the way public and private sector strengths may be packaged together throughout these stages to form alternative delivery strategies. It also provides an assessment of the many issues surrounding the business case, risk, management, and contracts. These issues are later revisited in an evaluation of several projects in the U.S. that have utilized "traditional" and alternative delivery strategies in the past. Included in this assessment are two larger case studies: Boston's Big Dig and Puerto Rico's Tren Urbano. Each incurred both successes and failures as a result of the traditional delivery strategy in Boston and the alternative delivery strategy in Puerto Rico, respectively.

The research provides guidance to Transport for London (TfL) as TfL proceeds with delivery of Crossrail; a large-scale rail initiative in the greater London region. As part of its preliminary analysis in advance of Crossrail, TfL has sought input from around the world on experiences with unconventional megaproject delivery. To that end, this thesis provides context from North America.

Yet the majority of the conclusions and recommendations are intentionally broad so as to have relevance not only for TfL, but for any public sector agency considering experimentation with alternative delivery strategies for transportation megaprojects.

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List of Acronyms

ADS – Alternative Delivery Strategy
AGT – Automated Guideway Transit
BAA – British Airports Authority
BART – Bay Area Rapid Transit
BH – Berkeley Homes
B/PB – Joint venture of Bechtel and Parsons Brinckerhoff on the Big Dig
BRA – Boston Redevelopment Authority
BRT – Bus Rapid Transit
CAG – Compliance and Assurance Group
Caltrans – California Department of Transportation
CA/T – Central Artery/Tunnel project, also known as the Big Dig
CEO - Chief Executive Officer
CLF – Conservation Law Foundation
CM – Construction Manager (or Management)
CM@Risk – Construction Manager at Risk
CPI – Consumer Price Index
CPTC – California Private Transportation Company
CRL – Crossrail Limited (formerly Cross-London Rail Links Limited, sometimes denoted as CLRL)
CSF – Critical Success Factor
CTRL – Channel Tunnel Rail Link
CTS – Central Tunnel Section
CWG – Canary Wharf Group
D-B – Design-Build
D-Ber – Design-Builder
DBIA – Design-Build Institute of America
DBFOM – Design-Build-Finance-Operate-Maintain
DBOM – Design-Build-Operate-Maintain
DfT – Department for Transport
DLR – Docklands Light Rail
DOT – Department of Transportation
DTOP – Puerto Rico Department of Transportation
EIS – Environmental Impact Statement
ExCom – Executive Committee
FAR – Federal Acquisition Regulation
FEIS – Final Environmental Impact Statement
FFGA – Full Funding Grant Agreement. The Federal government's funding commitment under FTA New Starts.
FHWA – Federal Highway Administration
FOC – Freight Operating Company
FTA – Federal Transit Administration
FY – Fiscal year
GAN – Grant Anticipation Note
GARVEE – Grant Anticipation Revenue Vehicle
GLA – Greater London Authority
GMAEC – General Management and Architectural and Engineering Consultant
GMP – Guaranteed Maximum Price
HBLRT – Hudson-Bergen Light Rail Transit System
HM Treasury – Her Majesty's Treasury. The U.K. government department responsible for public finance policy.
HoT – Heads of Terms
HOT – High Occupancy Toll
HOV – High Occupancy Vehicle
HUD – U.S. Department of Housing and Urban Development
IP – Intervention Point
IPO – Independent Project Organization
ISTEA - Federal surface transportation funding legislation from 1991-1997. Succeeded by TEA-21.
ITR – Indiana Toll Road
ITRCC – Indiana Toll Road Concession Company
JV – Joint Venture

LACMTA – Los Angeles County Metropolitan Transportation Authority
LRT – Light Rail Transit
LUL – London Underground (also referred to as "the Tube")
MARTA – Metropolitan Atlanta Rapid Transit Authority
Mass Pike – Massachusetts Turnpike
MassPort – Massachusetts Port Authority
MAX – Portland Metropolitan Area Express
MBTA – Massachusetts Bay Transportation Authority
METRO – Metropolitan Transit Authority of Harris County, Texas (Houston)
MHD – Massachusetts Highway Department (MassHighway)
MOU – Memorandum of Understanding
MPH – Miles per hour
MTA – Massachusetts Turnpike Authority
NASA - National Aeronautics and Space Administration
NEPA – National Environmental Policy Act
NJ Transit – New Jersey Transit
NR – Network Rail
NTI – National Transit Institute
NTSB – National Transportation Safety Board
OCTA – Orange County Transportation Authority
OIG – Office of the Inspector General
O&M – Operations and Maintenance
ONW – On Network Works
PAB – Private Activity Bond
Penta-P – FTA PPP Pilot Program
PDA – Project Development Agreement
PFC – Passenger Facility Charge
PFI – Private Finance Initiative
PMOC - Project Management Oversight Consultant
PPP – Public-private Partnership
PRHA – Puerto Rico Highway Authority
PRHTA – Puerto Rico Highway and Transit Authority
PVR - Present-Value-of-Revenue
QA – Quality Assurance
QC – Quality Control
RCF – Reference Class Forecasting
RfL – Rail for London
RFP – Request for Proposals
RFQ – Request for Qualifications
ROD – Record of Decision
ROW – Right-of-way
RP – Review Point
RTD – Denver Regional Transportation District
SAFETEA-LU – Federal surface transportation funding legislation from 2005-2009. Preceded by TEA-21.
SB – Sponsor's Board
SCC – Skyway Concession Company
SEP-14 – Special Experimental Project Number 14
SIR – Sustainable Investment Rule
SJMA – San Juan Metropolitan Area
TEA-21 - Federal surface transportation funding legislation from 1998-2003, and extended through August 2005. Preceded by ISTEA, and succeeded by SAFETEA-LU.
TfL – Transport for London
TIFIA – Transportation Infrastructure Finance and Innovation Act
TOC – Train Operating Company
TPH – Trains Per Hour
TTL – Transport Trading Limited
TU – Tren Urbano
UTR – Universal Testing Rule
VMT – Vehicle Miles Traveled
WMATA - Washington Metropolitan Area Transit Authority

Chapter 1: Introduction

1.1 Objective and Methodology

The objective of this thesis is to evaluate the roles of both the public and private sectors in the procurement of transportation megaprojects, and to formulate a set of strategies by which the two can work together more effectively to achieve efficiencies in transportation megaproject delivery. It will examine if and when alternative delivery strategies that provide for an augmented role for the private sector are appropriate for transportation megaprojects given their size, scope, and uncertainty.

The thesis will answer the following questions:

1. Under what circumstances are alternative strategies appropriate delivery mechanisms for transportation megaprojects?
2. How must the public sector reorganize itself in order to be able to provide proper oversight and management of private sector partners?
3. How might the lessons learned assist Transport for London with its delivery strategy for Crossrail?

These questions are answered by analyzing the various tradeoffs among these strategies and the extent to which they have been successful on transportation megaprojects delivered previously. Risks embedded in these projects are introduced and evaluated to demonstrate how they are traditionally allocated. The thesis also suggests how the public sector may be able to reduce and/or transfer certain risks to the private sector, and at what cost.

While certain outcomes may be unique to those individual projects, many of these overall lessons have widespread relevance for any public agency seeking to experiment with new strategies for project delivery. At the very least, the problems encountered should tell a cautionary tale, and the successes can be used as models to be replicated.

The goal of the thesis is to encourage the public sector to be more thorough in its preliminary analysis of transportation megaprojects so that it may become more effective at determining which of the many strategies now at its disposal is best suited to meet its goals.

1.2 Background

The continuing struggle to develop transportation infrastructure to serve a growing and increasingly mobile population, both in the United States and abroad, poses many challenges for the public sector. Over the last half-century, transportation has been a core function of government and one generally assumed to be most effectively delivered by the public sector. As public sector funds become increasingly scarce, the ability of government to retain the technical capacity needed to develop and implement large and unique projects is diminished.

Project delivery is the method by which an agency or an owner contracts for the development of a structure or facility. The common project delivery model in the U.S. is to secure a combination of federal, state, and local funds to finance megaprojects, use private sector consultant resources to plan and design them, and then contract out to the private sector for the construction of these facilities. Upon completion, the responsibility for operations and maintenance (O&M) falls back on government entities, or is contracted out to private parties. This prevalent sequence leads to problems when the public sector cannot adequately identify its objectives or ensure that they are being met.

Some suggest that this trend calls for less private sector involvement because of its ability to take advantage of these weaknesses inherent in the public sector agency delivery model. Or it may, in fact, call for greater private sector involvement if contract structures increase transparency, oversight, and adherence to quantifiable performance metrics.

1.3 Public Sector Inefficiencies

A public owner seeking to deliver a project first needs to know:

1. what it wants;
2. how to articulate what it wants;
3. the preferred strategy to go about getting what it wants; and
4. how to ensure it is ultimately getting what it wants.

The planning stage of development seeks to deal with the first two of these requirements. These are areas where the public sector must retain the most responsibility and competency. It is not in determining its goals where the public sector demonstrates signs of weakness, but rather in the execution of achieving them.

It is difficult to identify public sector agencies with the knowledge and in-house expertise to perform project delivery exclusively on its own. A reliance on the private sector, at least in a consultant's role, comes at a cost, but when the public sector attempts to perform these tasks internally the result is often delay and even more cost. Allocation of roles, responsibilities, and risk between the public and private sectors is a significant challenge, and one that is exacerbated as the size and scale of these projects grows.

1.4 Uniqueness of Transportation

Transportation megaprojects are very capital intensive, involve high initial sunk costs, are site and use specific, generally operate under conditions of limited competition, take a long time to complete, and their success or lack thereof depends heavily on long-term demand estimates. These features make delivery strategies particularly difficult to establish.

One characteristic relatively unique to transportation infrastructure investments is their "lumpiness." Transportation projects do not serve their function if only partially constructed, and tend to contribute exponentially when tied to a broader network. This makes it difficult to quantify the benefits of a megaproject given the financial and time investments required. With much uncertainty about funding and political support being able to endure long procurement and construction stages, the risk of failure becomes greater as projects grow in size, scope, and cost.

Phoenix, for example, has just built its first light rail line. For such a car-dependent, sprawling city, this light rail line will have difficulty attracting ridership initially. The required shift in mindset for the potential rider may take years. This does not mean that it shouldn't have been built. A continued investment in policies that improve upon mass transit's viability in Phoenix is critical, however, if the full benefits of this initial investment are to be realized.

Another feature of transportation megaprojects is their physical footprint. They occupy a lot of land and span jurisdictions and territorial boundaries. This requires appeasing numerous constituencies and stakeholders. Many of them also include significant tunneling, which adds even more complexity. Issues related to right-of-way acquisition, interfaces with intersecting modes and operations, and environmental remediation cannot be fully addressed until after the project has undergone some level of design.

1.4.1 Political Turnover

The timeline for megaprojects is such that internal public sector power is bound to change hands throughout the procurement and construction processes, perhaps even several times over. With projects often requiring a dozen years or more to go from conception to completion, the turnover of key management personnel in the public sector is frequent and leads to a potentially detrimental loss of institutional memory.

Hence, it may be the private sector whose involvement is more stable over the long-term. A political administration may therefore find it advantageous to cede responsibilities to private sector firms, but must exhibit continuity and expertise to provide proper management and oversight of those firms.

1.4.2 Funding and Contractual Laws

Another constraint among megaprojects more generally is that funding and contractual laws often inhibit the public sector's ability to come up with the financial and technical resources necessary to deliver megaprojects effectively. These obstacles include:

- state and local laws that explicitly prohibit certain procurement strategies;
- requirements that a project is designed to a certain level before funding commitments are made; and
- annual appropriations processes that provide piecemeal funding, thus delaying delivery.

1.5 The Promise of Alternative Delivery Strategies

New strategies are emerging that seek to create a more collaborative environment with private sector entities in transportation asset delivery. An "alternative delivery strategy" (ADS) will be defined in this thesis as any delivery mechanism different than the traditional design-bid-build (D-B-B) delivery strategy. Under D-B-B, the public sector fully finances the project, designs the facility before bidding out for construction, oversees construction, and performs all operations and maintenance functions while retaining ownership of the asset. While private firms are usually engaged to assist the government throughout many of these stages, nearly all project risk is retained by government throughout the process.

Alternative delivery strategies are growing tremendously in the U.S.:

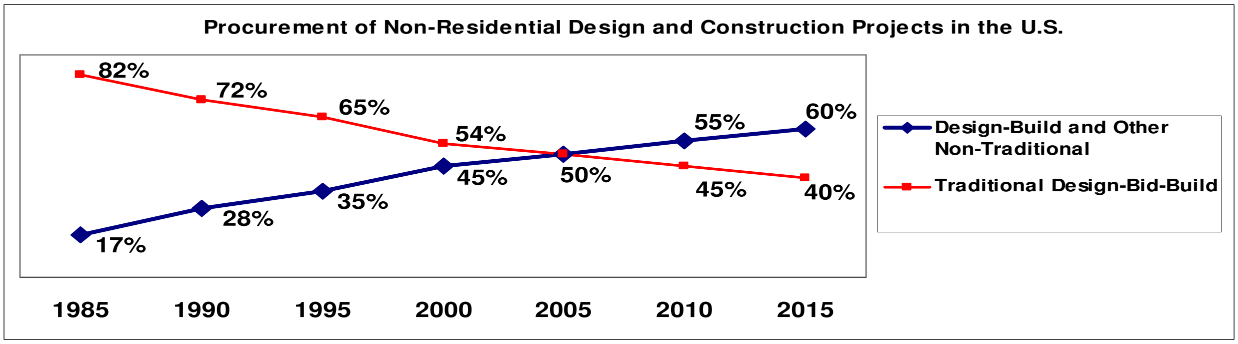

Figure 1.1 – Non-residential Procurement Trends in the U.S.

While there has been a growth in the transportation sector as well, it has not been as dramatic. Today, over half of all non-residential design and construction projects are procured by a method other than traditional D-B-B, though in transportation the percentage of projects using an ADS in the past ten years is closer to one-third[1]. The thesis will document the growth of these strategies.

1.6 The Risk of Inexistence

Alternative delivery strategies seek to reallocate the risks associated with projects, of which there are many. But perhaps the most overlooked and undervalued risk of all, especially when dealing with transportation megaprojects that literally have the ability to reshape cities and regions, is the risk of a project's inexistence.

Megaprojects are oft-maligned despite their transformational effect. In the case of Boston's Big Dig, its lasting legacy to many will be its cost overruns. True, the project did incur these cost overruns – severe ones at that – but the benefits are significant. They include aesthetic enhancements, congestion reduction, and the elimination of a key physical barrier that isolated neighborhoods. It was also the sparkplug for a multi-billion dollar reinvestment in the South Boston waterfront. More importantly, what was the alternative? Considering the lack of an above ground alternate route alignment, the Central Artery would have had to be shut down for several years during reconstruction, which would have crippled mobility into and through the heart of Boston.

Or take London's Jubilee Line Extension, which was 84% over its original £1.9B budget and delivered six years late, but has emerged as the prime catalyst for the development of an entire financial center at Canary Wharf and other regeneration opportunities in East London[2].

Transportation is the sole means to a myriad of ends. Revisionist history leads people to focus excessively on comparisons to baseline cost and schedule estimates which are often only preliminary, and are based on incomplete information.

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[1] Design-Build Institute of America. "What is Design-Build?"
[2] Priemus, Flyvbjerg, and van Wee, 189

1.7 Crossrail Defined

This thesis will conclude with recommendations for Transport for London (TfL) on the procurement of Crossrail. Crossrail is a proposed east-west rail line through central London expected to cost £15.9B, or approximately US$23B at the time of publication[3]. It is among the largest transportation capital projects being developed in the world today. The line will extend well beyond the City's boundaries, spanning 118.5 km, including 41.5 km in tunnels[4]. Crossrail will connect Maidenhead and Heathrow Airport in the west to Shenfield and Abbey Wood in the east via a new twin-bore tunnel under central London. Crossrail will serve 38 stations and 24 trains per hour are proposed to run through the central section in each direction at peak times[5].

Figure 1.2 – Crossrail Regional Map[6]

1.7.1 Crossrail Objectives

Crossrail's key objectives include[7]:

- supporting the economic growth of London and the regeneration of abandoned industrial land in East London by tackling congestion and the lack of capacity on the existing rail network;
- improving rail access into and within London;
- reducing cross-city journey times by creating new direct journey possibilities between points throughout the region;
- creating a new direct rail link between Heathrow Airport and East London; and
- improving connections to other London airports and international rail.

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[3] Crossrail. "Crossrail Announces Tender Lists for Major Project Contracts."
[4] Crossrail. **"**Major Boost for Crossrail as BAA Agrees £230 million Funding - Joint DfT & BAA Release.**"**
[5] Crossrail. **"**Major Boost for Crossrail as BAA Agrees £230 million Funding - Joint DfT & BAA Release.**"**
[6] Crossrail. "Regional Map."
[7] Crossrail. "Environmental Statement." Volume 1. Chapter 1, page 4.

1.7.2 Crossrail Timeline

Crossrail obtained the key parliamentary approval known as Royal Assent in 2008, and with a funding package in place is set to proceed with procurement and construction, to commence in 2009. Crossrail is currently at a critical stage during which many key decisions will be made that will define its path to completion by the anticipated date of 2017. Alternative delivery strategies for at least part of its development have not been ruled out.

1.8 What Makes a Project a Megaproject?

Whereas a $100M project may be commonplace in certain cities and countries, it may easily qualify as a megaproject in many others. The distinction lies in the scale of the project relative to other projects previously delivered in that particular location. Whether one establishes a lower bar of $2M or $2B as appropriate to qualify as a megaproject, the thesis still essentially identifies the same issues.

The nature of megaprojects is such that they are so big that there are few, if any viable alternatives that will provide the same net positive result. Megaprojects shouldn't be viewed as mere successes and failures. Rather, transportation megaprojects should be evaluated based on what is necessary to expand accessibility in an efficient and sustainable fashion.

1.9 Outline of Chapters

Following this introduction, Chapter 2 will introduce the basic stages of megaproject development, and Chapter 3 identifies the various ways these stages can be packaged together to form alternative delivery strategy (ADS) models. This chapter will also weigh the advantages and disadvantages of each of these strategies. Chapter 4 identifies factors comprising the business case to justify a project's development and help influence procurement decision making.

Chapter 5 introduces the notion of risk, which is precisely what the public sector seeks to minimize and/or transfer in its evaluations of ADSs. It also classifies key risks specific to transportation development; risks that will be analyzed at various points throughout the thesis.

Chapter 6 goes into detail about the various management structures that have the potential to aid the public sector in its relationships with private sector entities, but can also reduce control and accountability. Chapter 7 is devoted to the methods by which contractors are selected and paid, as well as the complex legal and regulatory minefield that public sector agencies often have to navigate when seeking to contract with the private sector utilizing an ADS model.

Subsequent chapters begin to look at specific cases where these many different strategies have been employed. Chapter 8 will provide some historical context into the evolution of ADSs, and Chapter 9 describes changes in public funding mechanisms that have created an environment more welcoming to innovative procurement. Chapter 10 summarizes several studies and surveys that have sought to gauge the industry's perceptions of ADSs.

Chapters 11 and 12 look more in-depth at two "complete" case studies, Boston's Big Dig and Puerto Rico's Tren Urbano; the former procured traditionally and the latter alternatively. These cases have been chosen based not only on their size and complexity, but also because of their unique governance structures and the wealth of local knowledge at MIT on these two projects in particular. Included in both of these chapters will be analysis of some of the successes and failures that can be directly attributed to their approaches to both management and delivery.

Chapter 13 provides a more thorough introduction to Crossrail beyond what is conveyed here in the introductory chapter. This chapter will examine the project itself, its business case, its role in London's long-term vision, and its delivery strategy.

Finally, in Chapter 14, this analysis is combined into a series of conclusions and recommendations that will ideally not only serve Transport for London in its continued efforts on Crossrail, but will also be of use to other public sector agencies wishing to experiment with ADSs in the future.

1.10 Terminology

There are certain terms that will each be elaborated upon at respective points in the thesis that call for a cursory definition here at the beginning:

Traditional design-bid-build (D-B-B) – the standard public sector procurement strategy that involves completing design fully before contracting for construction.

Alternative delivery strategy (ADS) – any procurement strategy other than traditional D-B-B. This is the term used in this thesis to denote what many define as a public-private partnership (PPP). PPP is a term that will predominantly be avoided in the thesis due to various ambiguities in its definition.

Public-Private Partnership (PPP) – see *Alternative Delivery Strategy*.

Design-build (D-B) – the most basic of ADSs. Under D-B, final design and construction are procured together under a single contract.

Crossrail – a new £15.9B rail line through central London scheduled to be constructed by 2017.

Client/sponsor/owner/agency – each of these terms is used interchangeably to describe the public sector entity that represents the public side of any public-private procurement strategy.

Bidder/joint venture (JV)/consortium/firm – each term refers to the private sector side of any public-private procurement strategy.

Constructor/builder – the entity in charge of construction.

Franchise/concession – the transfer to a private party the right and responsibility to operate a facility for a given period of time.

Concessionaire/vendor – the entity in charge of a franchise/concession.

Facility/project/end-product/asset – each refers to the final deliverable as part of a delivery contract, such as a rail line.

Chapter 2: Transportation Megaproject Development

This chapter identifies individual components of transportation megaprojects. It also introduces the various ways that these components may be packaged, or "bundled," in an effort to combine functions at potentially reduced overall cost and leading to a better quality end-product.

2.1 Project Stages

There are six main stages of transportation megaproject development: planning, design, construction, operations, maintenance, and financing[8]. The first five stages generally follow a linear progression, while financing can take many shapes and is often a prevalent issue throughout development. The following is a representation of a traditional transportation project timeline[9]:

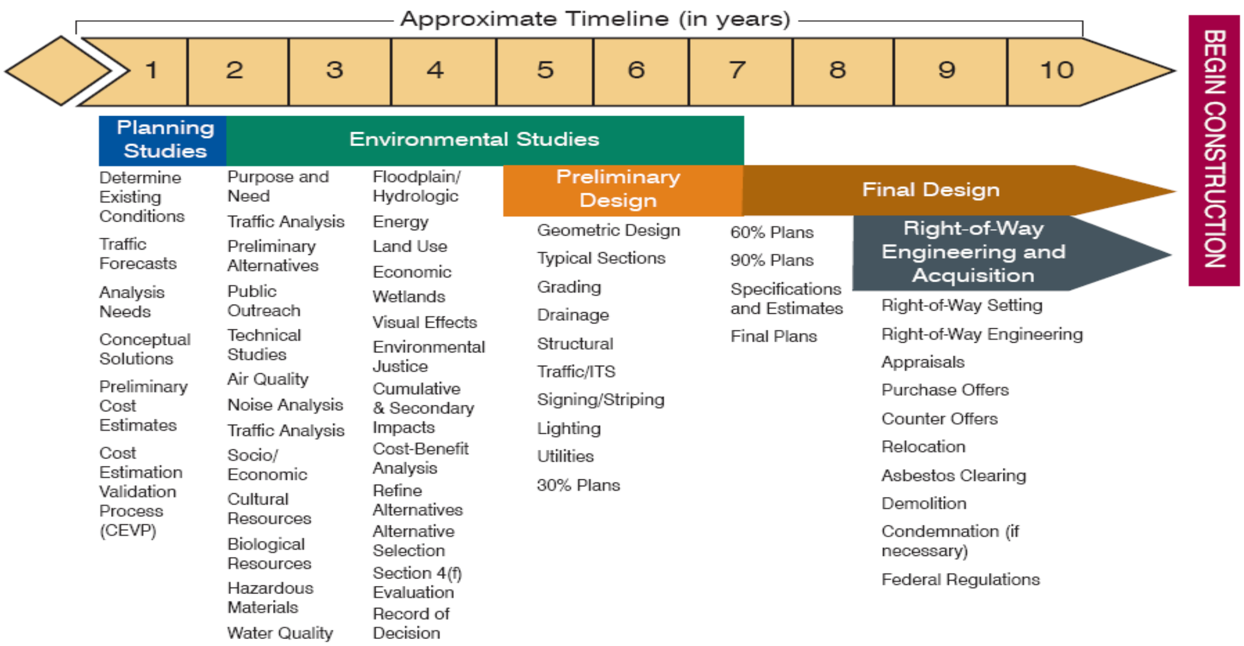

Figure 2.1 – Typical Transportation Project Development Process

2.1.1 Planning/Feasibility/Appraisal/Conception

The first stage of any transportation project, "mega" or otherwise, is a detailed planning process. This ranges from basic scoping issues such as identifying the project's purpose and location to more specific functional design frameworks and detailed analyses of project alternatives. This is the stage during which a project is validated to policymakers and stakeholders who ultimately hold the power to give the project the go-ahead.

Although little of any project's expenditures are made during this stage, it is by far the most important. With each subsequent stage, the owner's ability to impact a project's costs and benefits decreases while expenditures increase[10].

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[8] Beard, Loulakis, and Wundrum, 115.
[9] Nevada Department of Transportation. "Typical Transportation Project Development Process."
[10] Chris Gordon Lecture, MIT.

2.1.2 Design

During design, the client develops detailed solutions to reflect parameters and constraints conceptually outlined in the planning stage[11]. This is an iterative process that witnesses the evolution of the design from concept to eventually a final design that details proposed physical features and functional characteristics. Designs are submitted to planning authorities in order to obtain permits required for construction. These permissions may or may not be granted based on compliance with rules and regulations pertaining to building codes, zoning, health, and safety. If not granted, it can lead to increased cost and possibly reduced function if the project scope is altered to meet the requirements.

2.1.2.1 30% Design

The project sponsor generally performs in-house or contracts with an engineering and design firm to prepare conceptual plans[12]. Developing conceptual plans brings the project to what is commonly known as the "30% design" stage, suggesting that the design is about 30% complete. At this point, the project's costs and schedule can be better ascertained. The 30% design stage is critical because it is generally when the public agency makes decisions about how the rest of the delivery should proceed. By now the public agency has only invested a small percentage of the project's total costs and can still theoretically abandon the project entirely, although that is rare even at this stage. Soon thereafter, however, the project becomes too far along, or "too developed to fail," such that the only means to incorporate change is through increased cost, reduced functionality, or both.

2.1.2.2 Final Design

In traditional D-B-B procurement, the project is developed to its full 100% design stage before construction contracts are issued. Ideally, design is executed with construction and other later stages in mind. However, it is extremely difficult to accurately envision at the outset how the design of a complex transportation megaproject will be implemented by a separate construction entity that did not contribute to the development of the design.

Designs of megaprojects are truly never final. The design should be allowed to evolve throughout the delivery process in response to newly-emerging issues.

2.1.3 Construction

Construction entails managing various resource inputs, including labor and materials, needed to produce the final product[13]. There are different technical and management processes required in infrastructure construction. Standard projects can get by on routine procedures, while innovative construction requires highly flexible management philosophies to adapt to complex situations. The final activity in construction is the testing of the product before turning it over to the owner.

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[11] Howes and Robinson, 22.

[12] U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," 3.

[13] Howes and Robinson, 23.

2.1.4 Operations and Maintenance

The next stage is to operationalize and maintain the asset according to the relevant performance benchmarks, operational targets, and the expectations of the users of the facility[14]. Operations may also include the collection of user fees, repairs, cleaning, landscaping, security, and support facilities. Traditionally, all responsibility is handed over to the client at the end of construction, with the exception of defects liability. Thereafter the client arranges for facility management.

It is extremely advantageous for the client to secure an operator early so that their functional expertise may be incorporated prior to the "final design" completion. The services derived at the operational stage need to be sustainable over the whole life-cycle of the project and the owner will need to take measures to conserve the asset over that lifespan.

2.1.5 Financing

Project financing is traditionally secured by the public sector, most often through various forms of taxation. Alternative delivery strategies attempt to achieve cost savings and to shift costs to other levels of government and onto future users. The public sector may seek to shift financial risk to the private sector, though that has significant implications on project costs.

This thesis will address many of the key financing elements inherent in any transportation megaproject, including those specific to the case studies described throughout, however transportation megaproject financing under alternative delivery strategy models is generally outside the scope of this thesis. With regard to financing, this thesis focuses more on the implications of *who* finances a project and what approach these entities may take to transfer and/or reduce their financial risk, more so than on *how* they secure financing.

Given the amount of financing necessary to deliver transportation megaprojects, it is also inherently difficult to make broad-based generalizations about financial plans. The global financial climate is variable enough such that each project needs to be evaluated on a case-by-case basis.

Project funding mechanisms change significantly over time as well. For decades the U.S. Federal government covered 90% of the capital costs for the Interstate Highway System, but once declaring the system complete has precipitously reduced its contribution. The financial outlook in London today may be quite different several years from now, while Crossrail is still being developed. The long gestation periods for megaprojects suggests that the financing element may have to be revisited throughout delivery.

2.2 Project Bundling

In the conventional "unbundled" public procurement model, each stage is viewed independently. Full design of the facility is completed before any construction begins and only once a project is completed or near completion are the operations and maintenance stages considered. Opportunities for overlap and efficiency are rarely explored.

[14] Ibid, 24.

Over the past few decades, however, the public sector has occasionally fostered experimentation in combining, or "bundling," one or more of these tasks. Bundling is normally argued for on the grounds that it enhances the potential for economies of scale and scope.

The following diagram provides a brief introduction into the various bundling techniques that may be employed on transportation megaprojects. These will be further elaborated upon in Chapter 3[15].

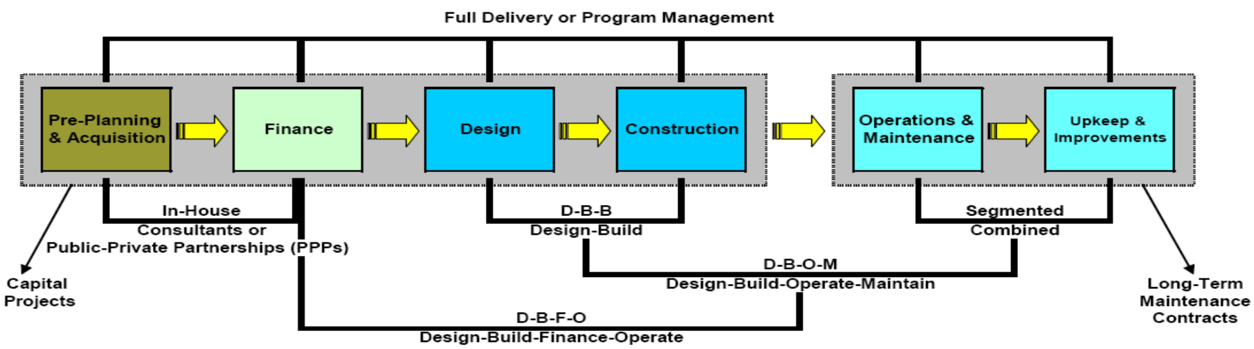

Figure 2.2 – Project Stages and Delivery Options

2.3 Factors Influencing Decision Making

The decision on whether or not to bundle functions often comes down to whether informed assessments can be made a priori regarding costs and risks. The difficulty in bundling megaprojects is that it is extremely hard to put a dollar amount on any single element, let alone the entire project. Plus, bundled contracts for megaprojects, particularly those that include operations and maintenance, are usually very lengthy – typically 20-30 years on average.

One scenario that makes bundling an attractive option is when the construction techniques to be used are particularly innovative and tailored specifically for a single project. A private sector entity may, for example, be expert at a particular tunnel excavation method and can leverage this expertise to assist in performing other related functions too. This "special-purpose" approach is fairly common in transportation megaprojects, but can give much leverage to the lone, or very few, construction firms that are capable of delivering them.

The public sector must be wary of such situations when a private sector consortium is given too much power simply because the public sector lacks financial or managerial expertise. The specialization that the private sector may provide has to be weighed against the cost to the public sector of acquiring the skills necessary to perform key delivery tasks or to provide adequate oversight of those to whom it has delegated these roles. Failure to evaluate this tradeoff has often led to non-competitive bidding processes and monopolistic qualities among private sector entities, neither of which benefit the public sector.

15 U.S. Department of Transportation. Federal Highway Administration. "Design-Build Effectiveness Study – Required by TEA-21 Section 1307(f)," i.

Chapter 3: Alternative Delivery Strategies

Alternative delivery strategies (ADSs) seek to combine conventional public approaches to project delivery with private sector competencies, where appropriate. Incorporating private sector expertise allows the public sector to concentrate more on its strengths in policymaking and regulatory control. This chapter elaborates on these strategies as well as the perceived advantages and disadvantages of each. Many of these advantages and disadvantages will be a focus in a later analysis that looks at projects utilizing these alternative strategies.

3.1 Alternative Delivery Strategies

Delivery strategies run the gamut, from each component considered separately, to all being delivered by the same entity in a single contract. With growing numbers of tools in the procurement toolbox, there is increasing opportunity for the public sector to explore new ways of delivering on transportation investments based on their in-house capacity and the scale and complexity of the project to be undertaken.

Attitudes towards delivery strategies have changed with growing dissatisfaction towards conventional procurement and construction methods[16]. Purely private ventures and purely public ventures have each had their own problems independently. Political scientists and economists remind us that neither perfect governments nor perfect markets exist[17].

For strictly private development, hurdles have included raising capital, and vulnerabilities to changes in technology and regulation[18]. The public sector has tended to get bogged down by bureaucracy and political meddling, and struggles to find a balance between performing adequate operations and maintenance of existing facilities versus investing in new capital projects. This, coupled with the traditional procurement model becoming increasingly plagued by time delays and cost overruns has led to a growth in alternative delivery strategies in the past couple of decades.

3.1.1 A Note on "Public Private Partnerships"

Before delving into the definitions of procurement methods, a key distinction needs to be made about the term Public-Private Partnership (PPP). The U.S. DOT defines a PPP as "a contractual agreement formed between public and private sector partners, which allows more private sector participation than is traditional[19]." Because of this term's overuse and ambiguity, this thesis will tend to avoid the term PPP in favor of more specific delivery strategy monikers soon to be defined, such as Design-build (D-B).

To avoid confusion, when speaking more broadly about non-traditional forms of collaboration the term Alternative Delivery Strategy, or ADS, will be used. An ADS will be defined in this thesis as any delivery method other than "traditional" design-bid-build (D-B-B).

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[16] Grimsey and Lewis, 51.
[17] Berg, Pollitt, and Tsuji, 3.
[18] Grimsey and Lewis, 71-72.
[19] U.S. Department of Transportation. Federal Highway Administration. "Case Studies of Transportation Public-Private Partnerships in the United States," 2-2.

3.2 Traditional Design-Bid-Build (D-B-B)

The "traditional" procurement method is also known as design-bid-build (D-B-B). Under D-B-B, government assumes the role in planning, financing, and operating projects. The client will appoint an in-house design team and in most cases engage the services of a private sector manager who may also be the principal designer[20]. The design team will develop the design to roughly the 30% level and begin the process of obtaining environmental approvals. If the client decides not to develop final design on its own, it will contract out to a design firm the delivery of the design from 30% to 100%.

The public agency then conducts a bidding process for the selection of a construction contractor. Traditionally, contracts are awarded to the bidder that proposes to complete the job for the lowest price. Other factors, such as schedule and contractor qualifications, may also be considered[21].

The construction contractor assumes responsibility for the construction by the agreed-upon time in the contract with the client. The public sector agency inspects and oversees the implementation of the final design. This allows the agency to hold its contractor accountable, assuming the agency can adequately perform this oversight role or hire consultants to provide oversight on its behalf. Under traditional procurement, the construction contractor can be held liable for negligence or a breach of warranty, but is otherwise immune to project failure[22]. The public agency retains all project risk, including the risk of design defects and design changes.

The contractor often hires several, if not dozens, of subcontractors who specialize in certain trades. In 1991, subcontractors accounted for 75% of all construction companies, and that number has been growing ever since[23]. Subcontractors are theoretically accountable to their contractor, and the prime contractor accountable to the owner. Owners retaining risk need to be able to identify inadequacies in work performed by both contractors and subcontractors, and intervene when necessary, though doing so risks reducing the general contractor's accountability.

Both public agencies and private firms have tended to stick to this traditional method. On the public side, the perceived transparency instills a level of public confidence and corresponds with a low degree of political risk. On the private side, the traditional competitive arena minimizes financial risk.

3.2.1 Traditional Design-Bid-Build (D-B-B) Advantages

1. *Designer directly accountable to client.* Under D-B-B, the design entity has a clear obligation to protect the long-term interests of the client.
2. *Few legal, political, and administrative barriers.* Since D-B-B has been the predominant delivery strategy for many decades, most public agencies have established guidelines that permit its use. Many even go so far as to strictly prohibit any other delivery method.

[20] Howes and Robinson, 121.
[21] Ibid.
[22] Loulakis, 190.
[23] Levy, 2006, 9.

3.2.2 Traditional Design-Bid-Build (D-B-B) Disadvantages

1. *Designers and clients may lack oversight capacity.* When 100% design drawings and specifications are handed over to a construction contractor, as is the case in D-B-B, the client needs to recognize that a contractor may seek to cut corners. If the client cannot be the watchdog, it will often have to contract with the designer to perform that function skillfully.
2. *Longer project duration.* By having to develop a design fully before tendering construction contracts, traditional D-B-B has been known to add years to a project's duration. The efficiency gains from beginning construction on some elements while final design is still being developed are usually lost in D-B-B.

3.3 Design-Build (D-B)

Rather than contract for a designer and then separately for construction, design-build (D-B) is an integrated package whereby a single contractor has full responsibility for both functions. Once a D-B team is assembled, an incremental process of negotiation usually leads to the agreement of a guaranteed maximum price (GMP) for a finalized design and specification. The figure below displays a typical timeline of both a D-B and a D-B-B project, and the potential time savings associated with D-B[24]:

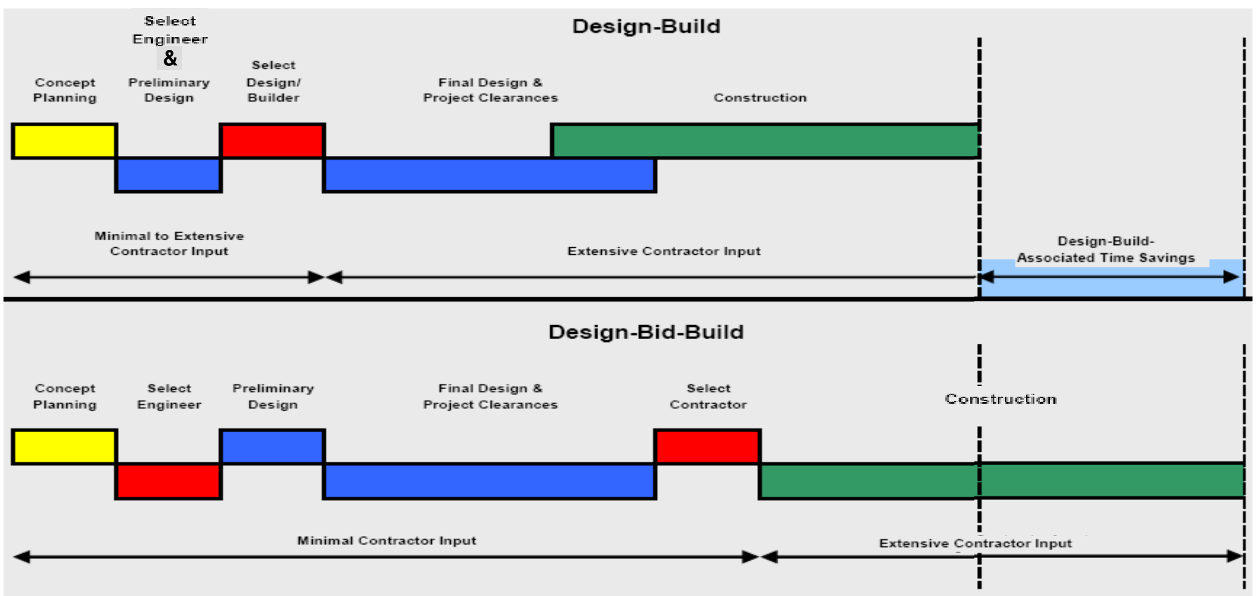

Figure 3.1 – Design-Build vs. Design-Bid-Build Timeline

Significant time savings are associated with the overlap of final design and construction in D-B. D-B-B loses time in having to first select one or more engineers to design the facility, and later a contractor to construct the facility.

[24] U.S. Department of Transportation. Federal Highway Administration. "Design-Build Effectiveness Study – as Required by TEA-21 Section 1307(f)," vii.

Design-build is really the foundation for these alternative delivery strategies. Most others have design-build at its core, and tack on additional tasks as deemed appropriate.

3.3.1 Design-Build Advantages

1. *Single-source responsibility*. Design-build contracts provide clarity about the roles of various players, and also the risks for which each is expected to account. The owner can more easily hold a D-B firm accountable for poor performance. With D-B both the designer and contractor are not only involved earlier and from the same general starting point, but they also cannot easily point fingers at each other since they are contractually bound and equally accountable to the owner.
2. *Construction begins earlier*. There are many features of construction that are technically ready even at the 30% design stage. The ability to begin construction at 30% design can shave years off a project's timeline and achieve savings in construction inflation costs. Sped up construction will reduce the likelihood of negative inflationary impacts.
3. *Value engineering*. D-B fosters innovations in the way that the designers and constructors collaborate. Designs are not static, and under D-B can be allowed to adapt. Competing D-B firms bidding at the 30% design stage will be truly invested in the value engineering solutions they propose, though the owner should hire a representative to ensure that the designer's role is not minimized by a dominant contractor. Traditional value engineering, on the other hand, is usually only a speculative assessment of potential value since it is accompanied by no binding contract.

3.3.2 Design-Build Disadvantages

1. *Pre-contract delays and costs*[25][26]. The scrutiny placed on the terms of a D-B contract often leads to an intense negotiation period lasting several months. Time elapsed can lead to large increases in costs due to market fluctuations, hopefully offset by savings later on.
2. *Designer marginalization*. In D-B there are instances when the builder assumes a dominant position, thus undermining the skills and input of the designer. The builder has a larger staff and may use its influence to proceed with construction absent a rigorous design component. With D-B the owner tends to lose a lot of control once the contract is signed, and thus may be rendered powerless to ensure this situation doesn't deteriorate. The retention of the conceptual designer to lend oversight capacity can help the owner overcome this flaw.
3. *Lack of competition*. Sometimes D-B RFPs have difficulty attracting interested and qualified bidders. Though there are a growing number of firms that specialize in D-B, still the majority of D-B work brings together both a designer and builder whose project portfolios contain mostly traditional D-B-B work. The amount of work required to develop a D-B proposal may not be worth the time, effort, and cost.
4. *Constraints on construction industry and exclusion of small firms*[27]. D-B lends itself well to the largest internationally-recognized design and construction firms. These companies may have entire

[25] Vining, Boardman, and Poschmann, 215.
[26] Yescombe, 19.
[27] Ibid, 20-21.

departments that deal strictly in D-B. These firms are also better-suited to secure project financing, the amount of which is of course much larger for megaprojects. Small and even medium-sized firms express discouragement at being unable to penetrate the D-B market. The increased demand for construction contractors and subcontractors also tends to drive up costs. The private venture may be able to offset this demand by bringing in large contractors from outside the region that can supply the necessary labor, but political pressure to rely on local providers can limit this option.

5. *Unbundling of bundled contracts*. A D-B team may seek to unbundle individual tasks depending on how the contract is written[28]. There is no implicit guarantee of cooperation among private partners in a joint venture. Public agencies fall into a trap of assuming that the private sector is self-managing. D-B requires an apt public sector agency to provide oversight of the private D-B consortium.
6. *Loss of checks and balances*. Under traditional procurement the designer is primarily accountable to the owner, and may or may not remain on staff to watch over the construction contractor on the owner's behalf in a kind of "Design Plus Oversight" model. Because the designer in a D-B contract is part of the contractor team, some owners believe that D-B impairs the designer's performance and ability to produce the best design for the owner, thus leading to lower quality[29]. The owner may employ a program manager to help ensure that the design and implementation is in line with the owner's objectives.

3.4 Design-Build-Operate-Maintain (DBOM)

Design-build contracts may also seek to achieve greater integration by including stipulations that the private contractor operate and maintain the facility for a set period of time following construction. This delivery method is known as Design-Build-Operate-Maintain, or DBOM. A key provision with DBOM is the condition of the asset upon transfer back to the public sector. Theoretically, by tacking on an operations and maintenance (O&M) stipulation to a D-B contract the contractor is forced to consider and select the best solutions that will serve the full life-cycle of the output.

However, the private sector's short-term profit orientation may offset this theoretical advantage. It is often the case that the private operator will seek opportunities to renegotiate contracts after they have been signed. This can shift back the life-cycle risk to the public sector if the operator is consistently successful in prompting these renegotiations.

DBOM contracts are common on projects that have user fees, such as transit lines and toll roads. O&M on such projects is doubly important because the quality of the service impacts revenues. Public agencies can choose to retain, share, or fully transfer the risk that usage meets projections. The decision should rest not only on the public sector's ability to conduct and feel confident in their revenue projections, but also their level of influence on future demand through service reliability and improvements.

[28] Quiggin, 58.
[29] Loulakis, 544.

3.4.1 Design-Build-Operate-Maintain (DBOM) Advantages

1. *Early operator involvement.* Having the operator under contract early on in the development process allows for coordination between the entity building the system and the entity that is going to be running it. Designers are concerned more about "constructability" than about "operability," so even the best designs do not ensure solidly functional products. A DBOM consortium has a vested interest in both aspects.
2. *Higher quality.* DBOM induces the builder to internalize potential cost reductions and quality improvements during the operations and maintenance stages that can be brought about by investment during development[30]. Otherwise, an inadequate design may lead to lower construction costs that are later offset by higher O&M costs.
3. *Whole life-cycle cost assessment.* DBOM requires a long-term assessment of asset value. In many ways the length of the contract in DBOM is almost as important as the price paid. If an asset with a 30-year lifespan only has a 15-year DBOM term, then the contractor may be less likely to consider asset depreciation, but a full 30-year term or longer makes for an entirely different set of incentives.
4. *Demand risk transfer.* It is common for there to be at least some demand risk transferred in a DBOM contract in order to incentivize the operator. Demand is based primarily on factors exogenous to O&M, so if a DBOM contractor assumes this risk it will often bid a higher amount to cover the uncertainty of demand forecasts.
5. *Technological advances.* In an effort to achieve efficient operation of a facility, the DBOM contractor may be more inclined to use the latest technologies. One common example that is proving to be quite common in the U.S. is that of electronic toll collection. An existing facility still using outdated manual methods of toll collection may wish to DBOM the transition to electronic toll collection. If growing pains are anticipated, the private sector may be better equipped to mitigate them. However, if the new technologies provide for less labor-intensive methods and may lead to a loss of jobs, the public sector is often politically constrained from adopting them.
6. *Maintenance prioritization.* The public sector is hindered by annual budget limitations and as a result may engage in short-term opportunistic behavior to avoid properly maintaining existing facilities. By delegating O&M to a DBOM entity, the public sector is assured those functions will be given proper attention. Passengers will appreciate being treated not merely as captives, but rather as riders who have a choice in their transportation options and who require a good quality service to retain their loyalty.

3.4.2 Design-Build-Operate-Maintain (DBOM) Disadvantages

1. *End-of-contract term negotiations.* The public sector agency will want to include stipulations in the contract that ensure the asset they receive back is in a well-functioning condition, but that is difficult to both define and enforce. At the same time, weak public sector agencies often lack internal capacity to perform its own O&M. It is critical that these agencies do not renew existing O&M contracts simply out of complacency. These contract renewals should be competitively bid along the same lines as the original O&M or full DBOM contract.

[30] Maskin and Tirole, 1-4.

2. *Potential loss of public support.* Though certainly not endemic of all, or even most DBOM contracts, it is important to note that DBOM is really the first alternative delivery strategy along the spectrum where the casual public user of the facility comes face-to-face with the reality that a function they may perceive to be a core government responsibility has been placed in the private sector's control. This can have negative repercussions for policymakers who authorized the decision, and stoke fears of rampant government privatization.

3. *Possible neglect of O&M responsibilities.* Even though the DBOM structure technically requires the contractor to account for O&M, it is still possible for short run construction cost minimization techniques to dominate the decision making process. This is especially true if the DBOM contract is for a relatively short period of time, which will later be described in the Tren Urbano case. The public sector needs to carefully stipulate its preferred terms for the O&M portion of the DBOM contract, and must also have the ability to enforce those terms.

3.5 Design-Build-Finance-Operate-Maintain (DBFOM)

In a design, construction, finance, operations, and maintenance (DBFOM) contract, the private sector sponsors generally provide equity financing in the amount of 10%-30% of total project cost and seek debt financing for the balance of the investment[31]. The debt financing is obtained from commercial banks, international financial institutions, or bilateral governmental lenders[32]. Private finance can also be included as part of D-B-B and D-B contracts, though it is much more common on contracts that include O&M, in which the financier accepts additional risk.

DBFOM does not necessarily imply that all project financing is provided by the private sector. The private sector financial contribution may be only a partial one, with government picking up the rest of the tab. This is commonly the case on rail transit projects, since revenues are usually insufficient to cover operating costs, let alone capital costs.

3.5.1 Design-Build-Finance-Operate-Maintain (DBFOM) Advantages

1. *Private financing.* Projects that may otherwise never have been possible with solely public sector financing now become feasible. This provides the public sector with more assurances about its budget, since it will not have to account for the long-term costs of deferring maintenance or driving away customers through poor service.
2. *Risk spreading*[33]. Private financing allows risks to be spread among government and other project sponsors, constructors, suppliers, and financiers. Government will still typically provide the site, reduce legal uncertainties, and purchase the output upon the completion of the DBFOM contract.
3. *Filter out bad projects*[34]. Especially if the repayment structure is heavily dependent on user fees, the private sector only has an interest in backing projects for which they are virtually assured of their desired rate of return. The private sector will impose more scrutiny so that they do

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[31] Levy, 1996, 17.
[32] Ibid, 23.
[33] Grimsey and Lewis, 34.
[34] Engel, Fischer, and Galetovic, 12.

not put themselves in the position of risking a loss. This ultimately provides a net benefit to society because there is a less likely chance of underperforming projects ever being built.

3.5.2 Design-Build-Finance-Operate-Maintain (DBFOM) Disadvantages

1. *Default risk.* Anytime the private sector is putting up its own capital, it does so with little equity and a lot of debt. The private sector does not have the fallback position of being able to raise taxes to account for shortfalls. If costs escalate or if revenue projections are gravely overestimated the private sector risks default. This may leave the public sector with an underperforming asset that is likely to continue to lose money.
   Some argue that bankruptcy is a positive sign for the public sector because it means it can easily take back an asset and either re-bid it or choose to operate the facility itself[35]. Others are much less optimistic. The Democratic Caucus of the Pennsylvania House of Representatives, in evaluating the feasibility of privatizing the Pennsylvania Turnpike, notes that lenders to a defaulting concessionaire have too much money at stake and will either then run the facility themselves or appoint a "successor" corporation[36]. The Caucus contends that, as long as cash flows exceed O&M costs, it makes economic sense for a successor to take over[37].
   Still others suggest that the private sector may feign financial weakness in order to get the public sector to renegotiate the contract, especially once a project has become "too big to fail" and the public sector is left with little choice. Even the hint of default or bankruptcy on a high-profile project can escalate the public sector risk of political loss at the polls.
2. *Higher private sector interest rates.* The public sector will usually be able to borrow on better terms than the private sector because of its ability to rely on taxes to cover shortfalls. Private sector interest rates on debt are likely to be 1%-3% higher than the public sector[38]. This suggests that the private sector has to include at least that much contingency when bidding on a DBFOM to account for the higher interest it will pay on debt. Depending on the tax treatment of depreciation this problem may be partially offset.

3.6 Asset Privatization

Privatization of transportation assets has been the subject of much debate worldwide in recent years. In some countries, the private sector has ample opportunity to purchase tracts of land upon which it may build a highway or a transit line, for example. This was the way much of the U.S. rail network was developed. With an abundance of land and growth potential, as well as a lack of regulation, the federal government allowed private parties to purchase lengthy rights-of-way and capture the increased value of the land achieved by the investment. This approach minimized the need for public finance and risk, but shifted substantial value to private sector developers.

Today, this extreme type of full-scale privatization from inception is rare in the U.S. Most land is already in private ownership or declared for public use, so the value capture possibilities are fewer. The Las Vegas Monorail, the Dulles Greenway in Virginia, and the SR-91 Express Lanes in

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35 Massachusetts Joint Committee on Transportation Hearing, November 26, 2008.
36 Democratic Caucus of the Pennsylvania House of Representatives. "For Whom the Road Tolls: Corporate Asset or Public Good," 39.
37 Ibid, 40.
38 Grimsey and Lewis, 132.

California are among the very few projects that have been completed as fully private endeavors in the past 15 years. These three examples are very similar to a DBFOM with one very key distinction. In a DBFOM, ownership is retained by the public sector, but in a privatization ownership is transferred up front to the private sector for the length of the contract.

More often than not, however, transportation asset privatization in the U.S. describes the sale of existing facilities, such as the Chicago Skyway or Indiana Toll Road (ITR). These concessions are granted for a set period of time. In Chicago and Indiana those durations are 99 and 75 years, respectively. Each of these projects will be further evaluated in Chapter 8.

To be clear, a transportation asset may be privatized before even being constructed, once the project has been completed and is operational, or at any point in-between. A key motivation for privatizing an existing facility is that the public sector can avoid the political backlash from having to increase tolls or transit fares, as long as those future increases are perceived by constituents as being out of their legislators' control. Even though it will be the public sector that stipulates the terms of toll or fare increases in the contract it signs with the concessionaire, it is a one-time decision. It is a decision with eventual political repercussions, but in theory will not again be an issue until later in the concession period.

The advantages and disadvantages with asset privatization are similar to those under a DBFOM structure. The main difference is that by transferring to the private sector ownership in a privatization agreement, the public sector may relinquish powers that it would otherwise retain under DBFOM. These powers may pertain to toll rate-setting policy, asset management, and capacity expansion. It is crucial that any public sector agency considering asset privatization decides which of these responsibilities it wishes to retain, and then stipulates those requirements in the contract.

3.7 Public and Private Sector Responsibilities

The following chart sums up the various public and private sector roles and responsibilities under each of the aforementioned traditional and alternative delivery strategies:

Delivery Strategy	D-B-B	D-B	DBOM	DBFOM	Privatization
Design and Construction	Public and/or Private (Public may do in-house design)	Mostly Private (Public may do ~30% design in-house)	Mostly Private (Public may do ~30% design in-house)	Mostly Private (Public may do ~30% design in-house)	Public and/or Private (depends on whether new or existing facility)
Operations and Maintenance	Public	Public	Private	Private	Private
Ownership	Public	Public	Public	Public	Private
Finance	Public	Public	Public	Public and Private (or only Private)	Private
Who Pays?	Public	Public	Public sector or users	Public sector or users	Public sector or users
Who is Paid?	n/a	n/a	Public and/or Private (Private may assume minimal revenue risk)	Private	Private
Who bears risk?	Public	Public & Private	Public & Private	Mostly Private	Mostly Private

Table 3.1 – Roles and Responsibilities Under ADS Models

Chapter 4: The Business Case and Public Policy

This chapter examines the various factors that comprise the business case upon which the decision to proceed is made and the delivery strategy selected. It also introduces the ways in which the case can be exaggerated or misleading, and will provide potential remedies to these biases.

4.1 Achieving Value for Money (VFM)

"Value for Money" (VFM) is a term commonly associated with the ultimate goal of a delivery strategy. It is simply "the optimum combination of whole life-cycle cost and quality to meet the user's requirements[39]."

Based primarily on the U.K. experience, Her Majesty's Treasury (HM Treasury) notes the following as key factors that drive VFM[40]:

1. Optimum **risk allocation** between the various parties;
2. Focusing on **whole life-cycle costs**, particularly for long-term contracts;
3. Use of an **output specification** to describe the agency's requirements;
4. Sufficient **flexibility** to ensure that any changes to the original specifications can be accommodated at reasonable cost;
5. Ensuring sufficient **incentives** within the procurement structure and also the project contracts to achieve on-time delivery, with appropriate rewards and deductions as may be appropriate;
6. **Competition** among bidders;
7. Establishing the proper **length of the contract**;
8. **Managing the scale** and complexity of the procurement; and
9. Sufficient **skills and expertise** in both the public and private sectors.

Accordingly, VFM can be achieved by[41]:

- establishing a competitive and contestable market for infrastructure projects;
- incorporating private sector innovation and skills in asset design, construction techniques and operational practices; and
- transferring key risks in design, construction delays, cost overruns, and finance and insurance to private sector entities for them to manage.

Opponents of alternative delivery strategies say that they never offer good VFM[42]. One argument is that the partnership arrangement bundles together a number of different functions so unique in their

[39] Ibid, 135.
[40] Her Majesty's Treasury. "Value For Money Assessment Guidance," 8.
[41] Grimsey and Lewis, 153.

characteristics that a joint venture will rarely, if ever, include the entities most qualified for each of those functions and that it is always best to unbundle them into multiple contracts.

Any prudent VFM assessment must include a comparative analysis between traditional and alternative delivery methods. The way agencies in the U.K. go about performing this assessment is by generating what is known as a Public Sector Comparator, or PSC. These comparisons are common in the U.S. as well, but are generally known as in-house estimates, or simply cost estimates.

4.2 Public Sector Comparator (PSC)

A PSC is defined as a "hypothetical, risk-adjusted" costing by the public sector, expressed in net present value terms[43]. It is an independent, objective assessment of project costs if delivered solely by the public sector, against which eventual private sector contract bids and evaluations may be judged. For large projects, it is not unusual to spend several months calculating a PSC[44].

PSCs are generally performed before an RFP is issued and may or may not be shared with prospective bidders. The decision on whether or not to release the PSC to bidders is often based on its perceived accuracy. The risk in releasing the PSC to bidders on a project with uncertainty is that if the private sector believes the PSC is low they will be unlikely to bid, but if they believe the PSC is high then they can potentially increase their profit significantly by bidding a high price that still comes in below the PSC. Competition will ideally help to keep bid prices down. When bidders are eligible to obtain the PSC document they are often required to sign a non-disclosure agreement.

4.2.1 PSCs in the U.K.

The following table shows the PSC amount and winning bid amount for selected U.K. highway Private Finance Initiative (PFI) contracts, which are akin to DBFOMs[45]:

Table 5. Summary for Value-for-Money for United Kingdom PFI Transportation Projects

Project	PSC[a] (£m)	Winning DBFO bid (£m)	Value for money (£m)	Savings (%)
M1-A1	344	232	112	32.6
A1(M)	204	154	50	24.5
A419/A417	123	112	11	8.9
A69	57	62	(−5)	−8.7
M40	276	182	94	34.1
A19	177	136	41	23.3
A50/A564	77	67	10	13.0
A30/A35	149	148	1	0.7
A1DD	245	203	42	17.14
A249	98	100	(−2)	−2.04

[a]PSC=public sector comparator.

Table 4.1 – Value for Money Assessment for U.K. PFI Transportation Projects

42 Ibid, 129.
43 Industry Canada. "The Public Sector Comparator: A Canadian Best Practices Guide," 11.
44 Ibid, 12.
45 Abdel Aziz, 925.

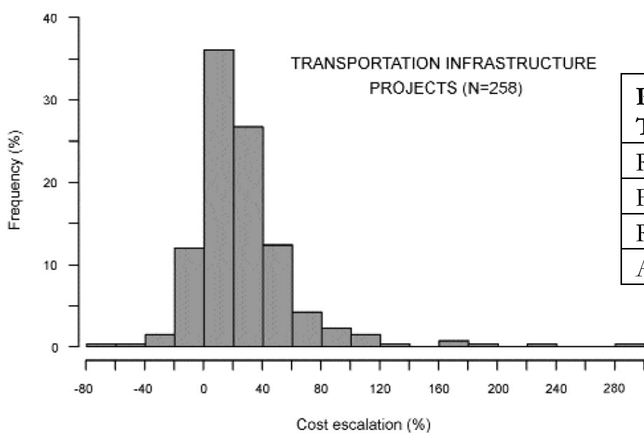
On eight of these ten projects, the winning bid came in under the PSC and the savings to the public sector as compared to its own assessment was as high as 34.1%. Two of the projects had winning bids that came in slightly higher than the PSC, but were still perceived as good PFI projects because the contractor provided additional output than was required by the project scope.

4.3 Cost Underestimation

The theory of "optimism bias" suggests that the public sector has a perverse enticement to underestimate costs, since a project has little chance of getting off the ground if estimates are too high. Furthermore, politicians "discount the future," implying that they are primarily concerned with their next election[46]. If they can claim credit for getting a megaproject started they can not only use that success story in their campaign platform, but they may be out of the public limelight by the time any potential problems arise.

4.3.1 Optimism Bias

Danish professor Bent Flyvbjerg of Aalborg University is among the pioneers in optimism bias research. Flyvbjerg et al. (2002) examined 258 large transport infrastructure projects covering 20 countries, the overwhelming majority of which were developed using traditional D-B-B procurement[47]. Costs were found to be underestimated in 90% of the cases. For all projects the average cost escalation was 27.6%, but rail projects had by far the highest average cost escalation of 44.7%[48].



Project Type	Number of Cases (N)	Average Cost Escalation (%)
Rail	58	44.7
Fixed-link	33	33.8
Road	167	20.4
All Projects	258	27.6

Figure 4.1 – Prevalence of Cost Escalation in Flyvbjerg et al. (2002) Optimism Bias Study
Table 4.2 – Average Cost Escalation by Mode in Flyvbjerg et al. (2002) Optimism Bias Study

Flyvbjerg's analysis suggests that in order for a public agency to accept a 50% risk for cost overrun in a rail project, cost estimates need to be 40% higher than they are currently[49]. If willing to accept only a 10% risk for cost overrun, then the required uplift is on average 68%[50].

46 Engel, Fischer, and Galetovic, 15.
47 Grimsey and Lewis, 72.
48 Flyvbjerg, Skamris Holm, and Buhl, 284.
49 Flyvbjerg, 23-29.
50 Ibid.

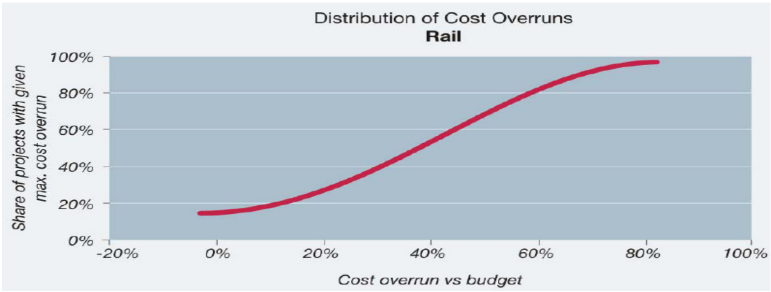


Figure 4.2 – Cumulative Distribution of Cost Overruns for Rail Projects

A separate Flyvbjerg study also noted that rail passenger forecasts were overestimated by 105.6%, and that these trends have been unchanged over the past 70 years[51].

One of the hypotheses as to why rail projects are underestimated with higher frequency and greater degree than road projects is because public funds for rail projects are much more scarce than for road projects. Highway projects in the U.S. do not go through rigorous cost-benefit studies, while transit projects are evaluated exhaustively. Rail promoters must present their projects in as favorable a light as possible, and one of the ways to do so is to underestimate costs and overestimate benefits[52]. Also, the uncertainty surrounding tunneling procedures may contribute to rail transit project cost underestimation.

In another study conducted in 2002, the U.K. Treasury commissioned the consulting firm Mott MacDonald to review the outcome of 50 large-scale projects in the U.K. over the past 20 years[53]. This study came to similar conclusions. On average, projects were completed 17% later than expected, capital costs were 47% over budget, and operating costs exceeded those estimated by 41%[54][55].

Don Pickrell, economist at the U.S. DOT Volpe Center, performed a study in 1990 strictly on U.S. rail transit projects with a total value of $15.5B in 1988 prices[56]. Taking year-by-year inflation into account, the average capital cost overrun for these ten projects was 61%, ranging from a 10% savings to a 106% overrun.

4.3.1.1 *Optimism Bias Contributing Factors*

A study by Mackie and Preston (1998) of the transport sector identified no fewer than 21 sources of error and bias in transport projects. Some of these include[57]:

- failure to clarify project objectives at the outset;
- political commitment coming too early, before projects can be appropriately appraised;
- omission of the "do nothing" alternative;

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51 Priemus, Flyvbjerg, and van Wee, 122.
52 Ibid, 125.
53 Grimsey and Lewis, 72.
54 Ibid, 72.
55 Ibid, 72.
56 Pickrell.
57 Grimsey and Lewis, 75.

- overestimation of external factors such as population growth and income;
- overestimating asset lives;
- difficulties of evaluating environmental impacts;
- benefits counted twice or even three times in different parts of the appraisal; and
- downplaying the risk that projects are susceptible to changing political, financial, and economic circumstances, especially for megaprojects.

Flyvbjerg et al. explicitly reject the idea that optimism bias can be attributed to the difficulty of predicting the future. Rather, they identify three contributing factors[58]:

1. *Short political tenure*. Politicians who advocate for projects are often out of office by the time actual viability can be checked.
2. *Rent-seeking behavior*. Special interest groups can promote projects at no cost or risk to themselves because others will be paying the costs.
3. *Spin*. Contractors are adept at producing overoptimistic tenders. The potential profits often outweigh significantly the penalties involved.

Optimism bias may also stem from an inaccurate selection of the benchmark against which final costs are meant to be compared. Project evaluation tends to be narrow, user-benefit oriented, and may ignore other, more difficultly quantifiable metrics such as increased mobility.

4.3.1.2 Optimism Bias Solutions

Mackie and Preston propose three solutions[59]:

1. Establish groups within organizations whose sole purpose is project appraisal;
2. Expose projects to open scrutiny at public inquiries; and
3. Spend more time learning from past successes and failures.

Flyvbjerg et al. look to four remedies[60]:

1. Increased transparency and public involvement;
2. Use of performance specifications with a goal-driven approach based on outputs;
3. Formulate a clear set of goals governing the project development, construction, and operation; and
4. Include private risk capital in public infrastructure, so projects are subject to market tests. This is an argument, in particular, that has been undermined by recent economic failure.

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58 Ibid, 78.
59 Ibid, 77.
60 Ibid, 78.

4.4 Reference Class Forecasting (RCF)

Another potential remedy to optimism bias is Reference Class Forecasting (RCF). RCF consists of taking an "outside view" of the project being forecasted, and comparing it to a class of similar projects built before it on an objective basis. RCF requires the following three steps for an individual project[61]:

1. Identify relevant reference class of past projects. The class must be broad to be statistically meaningful but narrow to be truly comparable.
2. Establish a probability distribution for the selected reference class. This requires access to credible data for a sufficient number of projects.
3. Compare the specific project with the reference class distribution, in order to establish most likely outcome for specific project.

One problem with RCF as it pertains to megaprojects, however, is that the reference class is often not sufficiently large to be statistically significant.

4.5 Quantitative Cost Estimation

Sensitivity analysis and Monte Carlo simulation are both tools that cost estimators use to appraise projects. Simply put, these simulations run scenarios thousands, or even millions of times to generate a distribution of possible cost outcomes. These analyses can provide outliers that simulate best- and worst-case scenarios.

One potentially detrimental outcome of sensitivity analysis is that it provides lower bounds; bounds that are at least within the realm of possibility, even plausibility. For example, an analysis may suggest that there is a 50% likelihood that a project will be completed for less than, say, $100M, and the same likelihood that the project will come in higher than that. But the analysis may also say that there is a 10% chance that the project will come in under $50M. Depending on how the recipients of such information may wish to "spin" the results, you may be more likely to see public disclosure of a number closer to $50M than $100M.

4.6 Avoiding Optimism Bias Through Alternative Delivery Strategies

There is a danger that optimism bias is masked in various contingency factors that are portrayed as protective measures to prevent cost overruns. One of the main advantages of alternative delivery strategies is that they can help guard against both optimism bias *and* excess contingency by providing a much earlier market test of likely costs than traditional D-B-B. This earlier encounter with market reality forces a process of identifying responsible ways to cut cost without sacrificing function, or identifying increased revenues to cover the costs. In an extreme case the early market test could lead to project cancellation, though it is much more costly to cancel a project after final design is complete (as in traditional D-B-B) than after only preliminary design is complete (as in D-B).

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[61] Priemus, Flyvbjerg, and van Wee, 133-134.

Chapter 5: Risk

At the core of the decision on delivery strategy is identifying the various risks involved in procuring a transportation megaproject and determining how these risks may be reduced and best allocated. This chapter provides a breakdown of the risks involved in transportation megaprojects and how various delivery strategies seek to redefine the way these risks are apportioned.

5.1 Risk

The public sector is taking a big gamble even simply by proposing a transportation megaproject. Risks can emerge early, late, or be prevalent throughout. Traditionally, the public sector retains nearly all project risks; risks that carry substantial, often unvalued, cost. These may be risks that an agency is unable to effectively handle. Fundamentally, a risk should be allocated to the entity best able to reduce and manage that particular risk.

5.2 Risk Transfer and Risk Reduction

While much of the literature on the subject of risk delves primarily into the notion of risk *transfer*, it is risk *reduction* that may be a more practical goal. It is also one that can have as much, if not more beneficial impact on a project than risk transfer, particularly for the public sector.

Every private sector entity makes its living based on taking risks and then attempting to exceed expectations in order to maximize return. It is simply the way business is done by profit-seeking enterprises. There is truly nothing wrong with this approach, as it is a core principle in any capitalistic, free-market economy.

The public sector must be keenly aware of this dynamic, however. A private sector entity wishing to conduct business with the public sector will always seek to exploit perceived weaknesses in the public sector's own internal risk assessment.

Risk transfer is difficult to execute, not to mention expensive. Also, a risk transfer is simply that, a transfer from one entity to another, with no net benefit to either party given perfect information. Public sector agencies are better served by putting more effort into reducing the probability that a given risk arises, and also minimizing the potentially negative impacts of a risk if it materializes.

5.3 Types of Risk

There are a myriad of risks associated with transportation megaprojects. The following is a list of some of the risks that will come up throughout the thesis, though this list is by no means exhaustive:

- **Competency/capacity/institutional** risk – the risk that the public sector agency lacks the competence or the capacity to deliver the project;
- **Design** risk – the risk that the design cannot deliver the services at the required performance or quality standards set forth in the output specifications;

- **Construction** risk – the risk that the construction of the physical asset is not completed to specification;
- **Operation/functional** risk – the risk that the service cannot meet the required performance standards;
- **Demand/revenue/ridership** risk – the risk that the demand for the service is lower or higher than expected;
- **Political/legislative/regulatory/legal/planning** risk – the risk that changes to laws and regulations impact a project;
- **Corruption** risk – the risk that either a public or private sector party has ulterior motives and is not acting in good faith;
- **Inflation** risk – the risk that inflation rates are different than anticipated;
- **Environmental** risk – the risk that the project has an environmental impact not originally identified;
- **Availability** risk – the risk that the asset will not be available by the time agreed upon;
- **Maintenance** risk – the risk that costs associated with maintaining the asset to a state of good repair are different than expected;
- **Interface** risk – the risk that relationships between the project and other assets with which it may interact or interfere have adverse affects;
- **Public Relations** risk – the risk that public opinion for a project is weakened;
- **Technological** risk – the risk that technologies incorporated into a project become outdated or obsolete;
- **Residual value/life-cycle** risk – the risk related to the uncertainty of the value of the asset at the termination of the contract;
- **Credit/default** risk – the risk that a debtor may default;
- **Financial** risk – the risk that the project's costs are different than expected; and
- **Force majeure** risk – the risk that an unnatural or natural disaster delays or destroys the project.
- **Existence** risk – the risk that because some or all of the above factors, potentially valuable investments simply do not materialize.

5.4 Risk Allocation

In theory, the concept of risk allocation is straightforward. When the government is effectively able to transfer a risk it then becomes the purchaser of a service or good that is risk-free in the sense that government does not pay if the service is not delivered, or is not delivered to specified standards[62].

[62] Grimsey and Lewis, 106.

In practice, risk allocation is much more complex. Thinking back to the maxim that risk should always be retained by the entity best able to reduce and manage that particular risk, the question inevitably turns to how to determine which entity that may be. Because the private sector does not accept risk cheaply, poor risk assessment by the public sector can add substantial overall cost to a project. In this sense, risk transfer is a risk in and of itself.

Since the government can spread risk across taxpayers, there is an argument that the government has an advantage over the private sector in terms of managing risk[63]. Conversely, the private sector can spread risk across many different financial markets, thus diversifying its risk portfolio. Private sector risk managers may also be more skilled than those in government. Risk management needs to be assessed on a case-by-case basis, making it difficult to achieve consensus about risk allocation.

Generally, a risk matrix is created as an organizing framework. It identifies all risks for a particular project and broadly sets out the public agency's perception of who might be best able to manage each of those risks. Some risks are straightforward and are easily delegated. Many other risks are completely outside the control of either party. In this case, the optimal risk allocation should be based on how the private party "prices" the risk and whether it is reasonable for the government to pay that price, or otherwise hope that it will be able to deliver on the task itself for less cost. The uncertainty regarding most risks means that the private party will include a contingency, or premium on that risk as a form of insurance should that risk materialize.

5.5 Risk Evolution

Priemus, Flyvbjerg, and van Wee (2008) developed the following chart that shows to what degree, and when in a megaproject's development certain risks arise[64]:

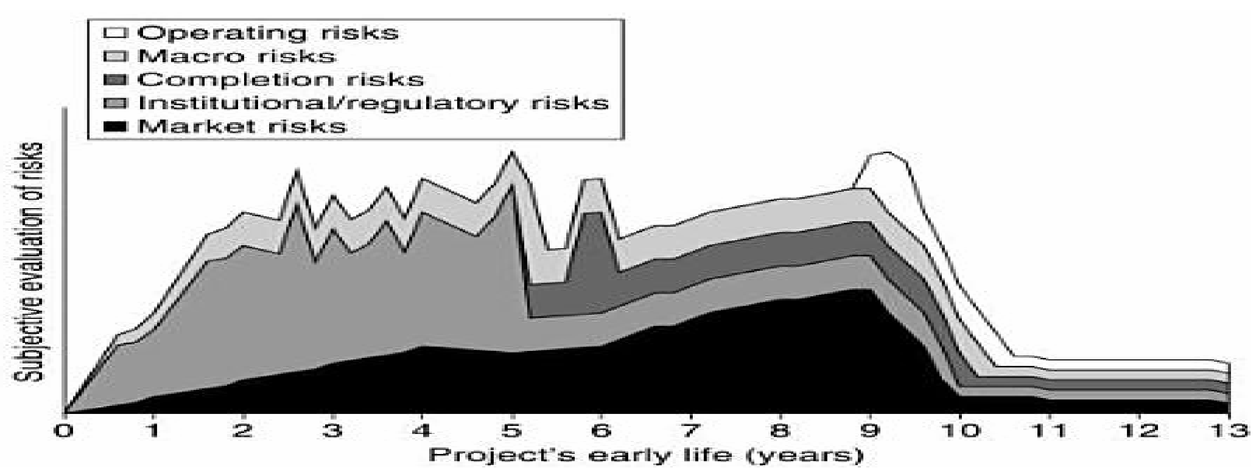

Figure 5.1 – Level and Types of Risk at Various Stages in the Development Process

According to their analysis, total risk spikes throughout the middle years of the project, largely as a result of institutional and regulatory risks during construction. As the project progresses, those risks

[63] Hemming, 13.
[64] Priemus, Flyvbjerg, and van Wee, 151.

dissipate just as the risk of completing the project on-time emerges, as well as do market pressures. Finally, as the project moves closer to completion, operating risks emerge while others subside.

5.6 Risk Management Plans

In order to determine the optimal risk allocation, a risk management plan is first needed which includes the following steps:

1. Identify all project risks;
2. Examine the potential for risk reduction, and take steps to execute those reductions;
3. Examine each risk and identify which are best able to be managed by the public sector and hence left in public control, and which are best transferred;
4. For each risk to be transferred, price them accordingly;
5. Decide whether any of the remaining risks should be shared between the public and private sectors and how they are to be allocated; and
6. Adjust the contract terms to reflect the optimal risk allocation structure.

Risks that tend to be retained by government include those related to legislation or policy changes, and also the risk of government wishing to alter service or quality standards.

The Council of Standards Australia and New Zealand lends this diagram as a framework by which a public sector agency may pursue a risk management plan[65]:

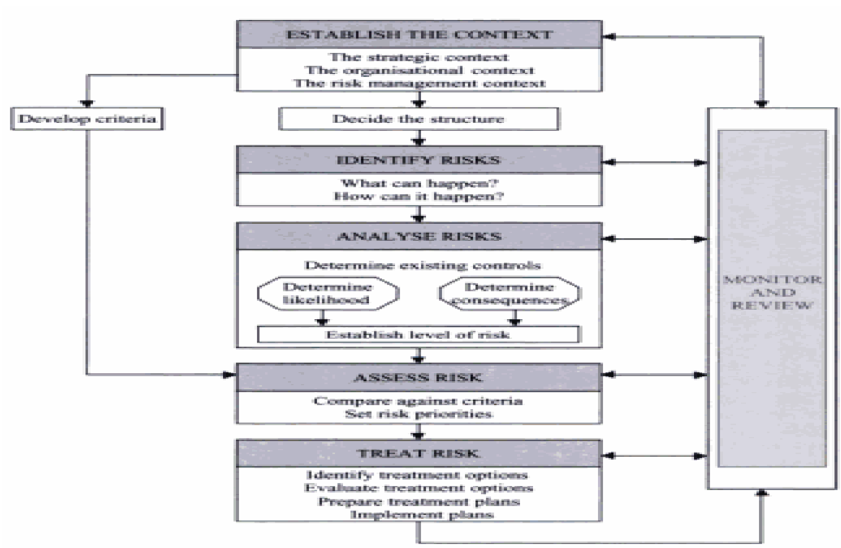

Figure 5.2 – Sample Risk Management Plan

The key to any risk management plan is the feedback loops that allow for consistent monitoring and reviewing of risks. There needs to be a mechanism in place that provides for periodic reassessment of how a particular risk is to be treated.

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[65] Flyvbjerg, Bruzelius, and Rothengatter, 82.

A clear output specification reflecting government policy objectives is a pre-condition for achieving the desired level of risk transfer[66]. Both the quality and the quantity of the service must be able to be evaluated using performance indicators. There is a danger, however, in being too prescriptive in RFPs, thus discouraging innovation among the bids with regards to the range of service delivery options and pricing proposals.

5.7 Risk Preference Survey

Akintoye et al. did a survey in the U.K. in 1998 of contractors, clients, and lenders in Private Finance Initiative (PFI) contracts. Here is how each party ranked the risks posed to them in the survey (1 = most important)[67]:

	Ranking of risks			
Risks	Contractors	Clients	Lenders	All
Design risk	1	5	10	1
Construction cost risk	2	6	6	2
Performance risk	4	2	8	3
Risk of delay	7	3	7	4
Risk of cost overrun	3	9	3	5
Commissioning risk	17	1	5	6
Volume risk	8	10	2	7
Risk of operating/maintenance cost	9	4	13	8
Payment risk	10	14	1	9
Tendering cost risk	6	17	9	10
Contractual risk	5	11	15	11
Legal risk	11	19	12	12
Market risk	14	16	11	13
Residual value risk	16	12	14	14
Planning risk	13	18	19	15
Environmental risk	15	8	23	16
Safety risk	21	7	20	17
Financial risk	12	22	18	18
Credit risk	25	24	4	19
Possible change in government	20	20	16	20
Project life risk	19	13	26	21
Changes in European legislation	24	15	22	22
Development risk	18	21	24	23
Bankers' risk	23	26	17	24
Debt risk	22	25	21	25
Land purchase risk	26	23	25	26

Table 5.1 – Risk Ranking From Akintoye et al. (1998) Study

The variation among the groups is not surprising, though quite telling. Contractors were most concerned with the risks associated with design and construction. Clients ranked institutional and performance risks as the most critical. Lenders focused on financial risks.

Contractors and clients aligned their preferences similarly, and as a result the overall risk preferences point to those associated with delivery as being the most critical on the whole. These included design and construction risks, as well as risks of delay, cost overruns, and performance.

[66] Grimsey and Lewis, 177.
[67] Akintoye, Beck, and Hardcastle, 40.

5.8 Alternative Delivery Strategies Blurring Risk Ownership

One drawback to an alternative delivery strategy like D-B is that when risks are transferred from the public sector to the private sector there are usually multiple firms that makeup the private sector consortium. Therefore, a given risk must then be allocated among private sector firms themselves.

There may be multiple prime contractors under an ADS model, such as a design firm and construction firm combining to form a joint venture. The design firm more predominantly steers the trajectory of the project even though it is the construction firm that may be more invested in the long-term. This can lead to power struggles and conflicts over who should take ownership of a particular risk within the team.

Legally, the joint venture collectively "owns" the risk. The problem is that the designer, being smaller, has less power, so the contractor makes decisions based on its short-term interests related to construction, while the client is rightly more concerned with performance and commissioning. This requires that the client have competent representation to oversee final design, as well as engineering and implementation.

Chapter 6: Management

Public sector coordination with, and management of private partners is especially important when the public entity is entering uncharted territory in terms of the type of product being delivered and/or the delivery strategy to be implemented. The public sector can protect itself by hiring consultants that may be able to assist them with procurement. Though these consultants are almost always employees of the private sector, the relationship between them and the public agency can be structured in such a way that they will gain only when the public sector's objectives are met. This chapter seeks to identify some of the avenues to which the public sector may turn if its own management capacity is insufficient.

6.1 Project vs. Program

For the purposes of this chapter, it is important to point out the ambiguities in the terms used to describe a "project" and a "program." Throughout this thesis, the term "project" describes the final deliverable. However, there are actually many individual tasks within the overall project framework that may themselves be defined by others as individual "projects," which wouldn't fit the definition used in the thesis.

For this chapter only, in an attempt to mesh with conventional definitions of managerial responsibilities, "project" will denote any one of a smaller subset of tasks that are essentially combined to complete the end-product. A "program," on the other hand, refers to a portfolio of policies and strategies within which one or many "projects" may exist. The program tends to encompass many of the roles noted as top priorities for the client in the Akintoye analysis from Chapter 5, including performance and commissioning.

6.2 Program Manager/Owner's Representative

When delivering on transportation capital, an owner is traditionally responsible for:

- defining the basic project scope;
- selecting the delivery method;
- preparing design criteria;
- identifying the completion date;
- evaluating financial options and providing the funding;
- establishing the budget;
- electing procurement options within the chosen delivery method;
- selecting, contracting with, reviewing, and supervising a designer;
- choosing the types of contracts to let;
- preparing contract documents;

- selecting, contracting with, monitoring, and supervising a contractor;
- selecting, contracting with, monitoring, and supervising an operator;
- handling legal, accounting, auditing, permitting, and insurance services;
- commissioning the facility; and
- supervising startup of operations.

As the list grows, it becomes evident that the owner should seek assistance in some or all of these areas in the form of a program manager, or owner's representative ("rep"). In an alternative delivery strategy model like D-B, a program manager will act as a liaison between the owner and D-B team. They will communicate the project objectives to all parties that will have contractual obligations, and hence accountability, to the owner. The program manager focuses on long-term performance, thus ensuring construction contractors and their short-term interest in finishing the job quickly and at least cost does not dominate.

Owners who employ program management are looking for services beyond what is traditionally provided by architects, engineers, and constructors. For example, the program manager may be retained to provide training to facility managers and operators, or conduct ongoing maintenance services for the facility[68].

Program mangers are vital for owners who wish to use an alternative delivery process and develop a project to the 30% design level prior to procurement. It is often the program manager who will develop that level of design and then provide oversight of the designer or D-B entity then hired to complete the design. Program managers are utilized in this way to minimize the owner's perceived loss of design control under D-B[69]. They help keep the owner involved throughout design, and also help to enforce the D-B team's culpability. To be effective, program managers should survive political transition and ensure that the institutional memory of one administration is not lost during the shift to the next.

If it is the owner's first use of a particular delivery method, it is recommended that they employ a program manager from the start. No matter how much responsibility is delegated to a program manager, however, the owner should always have a primary role in leadership and in making key decisions. An absentee public owner is asking for problems, considering it is the taxpayer's money, the owner's budget, and the public's interest to be preserved.

The typical fee for a program manager ranges from 2%-6% of total project cost on an inverse sliding scale – the larger the project the lower the percentage[70]. The problems that occur if the public agency does its own program management, especially on a megaproject, are likely to account for a far greater amount. There is a grave risk of the public sector wrongly assuming that it can perform program management on its own.

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[68] Beard, Loulakis, Wundrum, 515.
[69] Loulakis, 575.
[70] Ibid, 562.

6.3 Project Manager

The project manager's role is one much different than that of program manager. The project manager generally takes the lead on management of construction, human resources, and possibly finance. A project manager may work on behalf of either the owner or the private sector. The public agency will often hire a project manager to oversee the construction contractor, but the construction contractor itself may hire its own project manager to assist with the interfaces with subcontractors.

A project manager has control over both work processes and the costs associated with that work. Management of a construction project can be divided into four main components[71]:

- *Final design and construction engineering.* First, developing a 30% conceptual design to a completed 100% design. Then, assembling the proper materials, equipment, and systems, and the selection and utilization of the best construction technologies to complete the tasks.
- *Construction oversight and quality control.* First, establishing the most effective way to implement the construction process, including proper scheduling and control of the flow of labor, materials, and equipment to the jobsite. Then, providing oversight at the site to ensure that the product is being delivered to standard.
- *HR management.* Control over human resources is important since labor productivity and a harmonious work environment are critical elements of a successful project.
- *Financial management.* Construction is a high-risk business with historically low profit margins. Control over costs, cash flow, and adequate project funding is essential.

6.4 Construction Manager

Construction managers (CMs) are similar to project managers and, in fact, a project manager's role may encompass construction management. However, an owner may choose to separately hire a manager solely for the construction stage. This construction manager may be hired for a fixed fee, and be known as an Agency CM, or they may put themselves at financial risk and be known as a Construction Manager At-Risk (CM@Risk.)

A CM@Risk assists the owner and designer in pre-construction activities and becomes at-risk for price and schedule performance[72]. If an owner retains an Agency CM the owner will contract directly with contractors and be responsible for their performance. A CM@Risk will perform the contracting on its own, often with the owner's input, and be responsible for cost overruns, quality deficiencies, and schedule lapses.

Under this strategy, the owner hires a designer under a separate contract, but rather than waiting until design is completed to gain input from the construction entity, the owner instead brings on a construction manager before design decisions have been finalized[73].

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71 Levy, 2006, 9.
72 Ibid, 479.
73 Ibid, 36.

There are several benefits to employing a construction manager[74]:

- earlier involvement of the constructor;
- earlier knowledge of costs;
- more professional relationship with the constructor;
- owner gains more familiarity about the procurement process; and
- projects are usually completed quicker.

Drawbacks to construction management include the fact that there are still both a design contract and a construction contract to manage, as well as operating concerns to integrate[75]. Therefore, although construction management provides certain efficiencies in terms of schedule, it does not ensure focus on performance and commissioning. Finally, especially if the construction manager is not at-risk, there is a likelihood that the constructor's early input may not be incorporated by the designer.

If the owner lacks technical capability, a construction management team can provide such expertise[76]. This role is considered more significant with D-B and other alternative delivery strategies because the normal safeguard of the designer acting in the owner's interests during construction is absent in an ADS model. On a D-B project, the CM can involve a "shadow operator" on behalf of the owner, at least until such time when an operator can be procured. However, there is a high risk that construction issues will dominate over function and performance.

Tasks for a construction manager acting in the owner's interest under D-B include[77]:

- advising the owner on the advantages and disadvantages of various procurement procedures and D-B contract forms and provisions;
- developing preliminary budget and schedule;
- coordinating the activities of independent inspectors and reviewing their work;
- coordinating post-award scope changes and change orders;
- performing general inspections and recording the design-builder's progress;
- certifying the design-builder's periodic payment requests; and
- coordinating post-occupancy performance testing and warranty claims.

Opinions on construction managers vary[78]. Design-builders often note that they are an unnecessary project cost. They claim that construction managers interfere with the design-builder's single point

[74] Ibid, 36.
[75] Ibid, 37.
[76] Ibid, 72.
[77] Ibid, 73.
[78] Ibid, 475.

of responsibility for doing their work, and that they disrupt the close and direct partnering relationship between the owner and the design-builder.

Designers also express concerns that a CM intrudes upon the relationship between owner and designer[79]. They believe that CMs marginalize the designer's role and reduce the designer's profit potential. Designers note that there should only be one prime consultant to the owner on a D-B project and that the designer should be the entity to perform any needed CM services.

Construction managers who are not design professionals are insistent that the owner still requires an independent body to manage certain parts of a D-B project, regardless of who the owner or D-B team may assign to perform these tasks in-house[80]. They claim that their unique management skills can improve the project's success and ensure that the owner is getting what it wants.

6.5 Delivery Partner

In the U.K. the preferred term for managerial roles is "delivery partner" (DP). Delivery partner is a bit of a catch-all phrase that can perhaps best be described as a combination of program manager/technical advisor and project manager[81]. Delivery partners are private consultants to the client, but will not be directly involved in the actual construction.

Many of the firms who generally bid on these roles for megaprojects are among the largest design and engineering firms in the world. Some of them are capable of doing design and/or construction of their own, though will forgo that opportunity on a job for which they want to be a delivery partner. Still other firms were once in the business of design or construction, but have now moved exclusively towards management.

In the case of Crossrail, TfL has chosen to procure a "project" delivery partner and a "program" delivery partner. These roles are expanded upon in Chapter 13, and a synopsis of the experiences with delivery partners on North American rail transit projects can be found in Chapter 8.

6.6 Quality Assurance (QA)/Quality Control (QC)

Quality Control (QC) establishes baseline standards to which the construction or assembly of a component has been incorporated into the project design[82]. Quality Assurance (QA), on the other hand, is the process that verifies whether these standards have been met[83].

Under traditional D-B-B, there is a role for independent oversight initiated by the owner to ensure that the design is incorporated into the construction properly[84]. In D-B, the owner may relinquish that role to the D-B team. The design-builder should be responsible for QA during the construction and testing phases[85]. In a DBOM QA is enhanced further since the design-builder knows it will also

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79 Ibid, 475.
80 Ibid, 475.
81 Interview with Julian Ware.
82 Levy, 2006, 211.
83 Ibid.
84 Beard, Loulakis, Wundram, 78.
85 Ibid.

become the eventual operator and will therefore be incentivized to produce a high-quality, functional product.

The owner's responsibility for QA is in the performance testing of the finished project[86]. All parties should be allowed to observe all tests and obtain copies of all testing reports. Of course, even under D-B or any other alternative delivery strategy, the owner is free to perform any additional QA it chooses, at its own cost. The client will often delegate that task to a construction manager[87].

Beard et al. (2001) contend that quality is usually better on D-B and other alternative delivery strategies[88]. They argue that the combination of design and construction disciplines and their focus on common performance goals leads to improved facility procurement. By contrast, under D-B-B, the designer may conservatively overdesign the facility because they are not aware of true construction costs and do not have a stake in the final outcome of the project[89].

Others argue that because D-B weakens the ethical responsibility of the designer to the client, it is essential to retain the services of an owner's rep who is dedicated to providing QA and QC throughout delivery.

6.7 Client/Management Organization

Key decisions to be made by any public sector agency are:

1. whether it wishes to include outside management; and
2. how it wants to structure such agreements.

These agencies need to have a clear understanding of the marketplace for project delivery.

Client teams may be integrated into the project structure in one of several ways:

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[86] Ibid.
[87] Ibid, 72.
[88] Ibid, 137.
[89] Ibid.

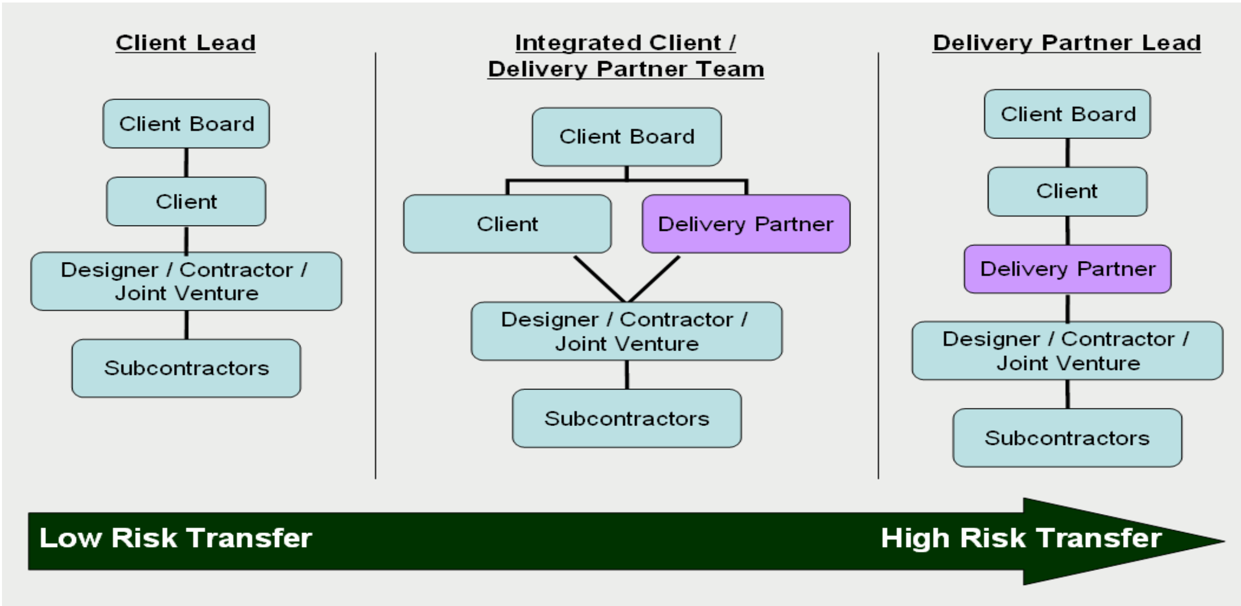

Figure 6.1 – Client/Management Organization Options

- *Client Lead*: In this case there is no outside consultancy present at all. The client hires and manages contractors and subcontractors itself, usually performed by a procurement department within the agency.
- *Integrated Client/Management Team*: The client may wish to have management essentially "attached at the hip" to the client, with the client and managers working in tandem. The delegation of tasks and payment mechanism are the critical issues in this structure.
- *Management Lead*: The client may wish to grant the management team broader powers in the procurement process. This team may be able to structure and negotiate contracts on the owner's behalf with little direct input from the owner itself. This option would entail having a more independent, but strongly incentivized management scheme. The management role would be substantial and require careful definition, since it will be especially difficult to amend tasks and delegation once underway.

These three client structures define a gradation of risk that the owner may or may not be willing or able to transfer. Much depends on the qualifications and experience of each respective party, and the level of trust that exists between them.

Whereas the direct compensation let to a management team may not be of major consequence to the public sector in comparison to the overall project cost, the amount of power and leverage given to that partnership certainly is.

6.8 What Managerial Strategy is Most Appropriate?

Public sector agencies must first assess their strengths and weaknesses before deciding upon the appropriate managerial structure. It may be that the agency has a clear idea of how the asset is to be integrated into a broader-scale program level and can get by without an outside program manager.

But the public sector should rarely keep that responsibility in-house given the high turnover of personnel. Program managers are most successful if involved in the task from the beginning, or at least from an early stage and retained throughout. That is why an outside consultant may be better suited to fulfill this role – to guard against political transition, personnel turnover, and even to mitigate the risk of corruption.

Program managers are even more essential when the client itself is complex, as in the U.S., with substantial federal funding being managed by state or local entities. Crossrail also has a complex client given both its national and local interests. In these cases, a program manager plays an important role in enhancing the level of trust among the client's partners that the program and project will be managed competently.

Critical is the level of autonomy provided to these managers, and the ability and willingness of the public sector owner to set and enforce the terms of these relationships. Effective program and project managers are allowed some latitude to act independently. This requires a great deal of trust.

There must also be open lines of communication and an audit trail that helps to foster a culture of public transparency and professionalism among participants. These factors will lead to effective owner-manager relationships.

Chapter 7: Contracts

The selection of a delivery strategy is one of a lengthy series of decisions that will be made throughout the procurement process. Many of the subsequent decisions relate to the nature of contracts. This chapter identifies key contract-related issues, and examines how laws and regulations governing contracts may either preclude or encourage the use of alternative delivery strategies.

7.1 Pre-qualification

When the contract for a component of a transportation project is put out for a bid, it may be chosen based on the lowest bidder, or be based on a combination of price and other factors. Countless professional associations have been supportive of a two-stage contractor selection process that first has a mechanism in place to determine whether a firm is qualified before price is even considered.

7.2 Low-bid Selection

Low-bid contracting does not always guarantee lowest ultimate price. The owner is susceptible to cost increases that may arise once the full design is implemented, and also because of change orders and contract renegotiations. Another disadvantage of low-bid is that the race-to-the-bottom among bidding contractors can cause them to not focus on exactly what the owner believed it was purchasing and what the contractor thought it was selling in its proposal[90]. There is also the worry that the price of the lowest bid will be insufficient to complete the job properly.

7.2.1 Variations on Low-bid

Renowned economist William Vickrey is credited with another bid selection method in which the contract is awarded to the lowest bidder, but that the buyer actually pays the *second*-lowest price. The theory behind this mechanism is that firms are still likely to bid closer to the true value of the work. If you bid higher than the true value, you only decrease your chances of winning, but you will not influence the price you would have to be paid[91]. The price the winning bidder is paid is determined by the competitors' bids[92].

Another option is to use the median bid, rather than the lowest or second-lowest bid. Those who advocate for the selection of the median bid suggest that the median provides a more accurate test and avoids low-bid outliers that may have strong biases or errors.

7.3 Best Value Selection

A "best value" selection process is a more subjective evaluation system that allows the owner to take reputation and past performance of the bidder into account. The benefit of best value is that it limits the competition to competent firms. However, a risk in this approach occurs when owners develop long-term relationships with contractors preferential treatment may be exhibited, which is

[90] Loulakis, 21.
[91] Turner.
[92] Morrison.

clearly not in the spirit of what best value is intended to achieve. But as long as there is competition among bids, this risk can be mitigated.

7.3.1 Weighted Selection Criteria and Adjusted Low-bid

These contractor selection methods are forms of best value selection that are intended to provide more transparency, though they do not necessarily eliminate subjectivity[93]. Each uses a formula to evaluate price and qualifications to yield an "adjusted bid." The Design-Build Institute of America (DBIA) provides the following example of how adjusted low-bid might work[94]:

Proposer	*Qualitative Score*	*Price Proposal*	*Adjusted Price (price + qual. score)*
Team A	0.85	$1,000,000	$1,176,471
Team B	0.95	$1,300,000	$1,368,421
Team C	0.50	$ 800,000	$1,600,000

Table 7.1 – Design-Build Institute of America Adjusted Low-bid Example

In this example, the low bid is also the lowest qualified team because of its poor qualitative score. Conversely the most qualified firm is also the most expensive. This leaves the middle firm, which was neither the lowest bidder nor the most qualified team, but comes out with the best "adjusted price" and thus gets awarded the contract.

7.3.2 Negotiated Procurement

Negotiated procurement is a variation that enables the owner to negotiate directly with prospective, pre-qualified firms. This allows for an open negotiation period during which the owner may share one firm's bid with another firm, and a bargaining process may ensue. This is also called "bid shopping," and can help increase competition and lower the price of the contract[95].

7.4 Contracting Laws

Although many of these qualifications-based selection methods are proven to lead to a quality project, few public agencies have such broad contracting authority. Laws governing contracts have generally favored low-bid. On the face of it, this would seem to be a prudent strategy for a cash-strapped public agency. In practice, however, low-bid has often led to mixed results in the absence of a thorough qualifications assessment.

7.4.1 Brooks Act of 1972

Congress in 1972 passed the Brooks Act, which prohibits low-bid contracts for design services[96]. Since then, 34 states have enacted similar laws, known as "mini-Brooks Acts."

93 Loulakis, 142-143.
94 Ibid, 143
95 Chris Gordon Lecture, MIT.
96 Loulakis, 64.

Unfortunately, the Brooks Act does not extend to construction contracts, which poses problems for any type of contract that seeks to combine design and construction. In government construction contracts, the public agency generally must use low-bid selection[97].

In D-B, for example, sometimes the public sector agency will first hire a construction firm that will serve as the builder half of a D-B team. When the contract goes to the lowest bidder, the construction firm may then be more interested in choosing the least expensive design firm, rather than the most qualified. As a result, the Brooks Act isn't followed, and D-B may therefore violate state and federal laws. At least one court has found that D-B based on low-bid contracts violates their mini-Brooks Act that governs state contracts[98]. Legislation has since opened the door for limited use of best value on construction contracts.

7.5 Contractor Selection in the U.K.

HM Treasury sought comments from the construction and financial communities in 1993 on how to stimulate private sector involvement and innovation[99]. The results, published in March 1994, show that a number of respondents suggested a two-stage bidding process is one aspect of good practice, with a maximum of three or four firms proceeding past the initial qualifications stage[100].

The results also suggest that firm governmental commitments to a project are essential for the bidder to put forth the most competitive proposal. If a bidder is skeptical about whether or not the project will ever proceed, it may either find it not worth their time and money to bid, or they may not put as much effort into the bid proposal.

7.6 Solicited vs. Unsolicited Project Proposals

All of the above contract selection methods assume that the public sector is the entity that decides what projects are potentially worthwhile. But who's to say that the private sector isn't capable of, or shouldn't even be allowed to propose projects and contract structures?

Several states have adopted legislation that permits consideration of both solicited and unsolicited proposals for projects that use ADSs[101]. If the public sector does wish to proceed with a project that comes out of an unsolicited proposal, it is under no obligation to contract with that firm which submitted the proposal and will likely be required to issue a request for competing proposals. This competition may further lower the price of bids.

There is really no harm in allowing the private sector to submit unsolicited proposals for projects that could be delivered utilizing an alternative delivery strategy. First, the private sector may provide some useful "out-of-the-box" thinking with regards to both project proposals and project financing. Second, the public sector can get a free quote for what any of these projects might end up costing. Finally, projects that are conceived from an unsolicited proposal can, at the very least, be added to the list of priorities for a public sector agency to evaluate against its other options.

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97 Ibid, 115.
98 Ibid, 124.
99 Zhang and Kumaraswamy, 352.
100 Ibid.
101 U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," 28.

Some say it is disadvantageous to the private sector to offer up unsolicited proposals because the public agency that receives the proposal will likely still put the idea out for open bidding[102]. Yescombe (2007) suggests it is not worth the time and effort of the private sector if they will still be in competition for the contract, assuming the public sector is receptive to the general framework of the unsolicited proposal[103].

Even if the proposal is put out for open bidding the private sector entity that came up with the idea will be at an advantage in terms of their prospects for winning the contract. A private sector entity is unlikely to put forth an unsolicited proposal if it did not fit its own business model and skill sets.

7.7 Contract Renegotiation

Regardless of what delivery strategy the public sector chooses, there may be unanticipated disagreements about contract terms that often lead to costly, non-competitive renegotiations. Schur et al. (2006) note that between 1990-2004, 40% of contracts for infrastructure projects were renegotiated[104].

Guasch (2004) found pervasive evidence of renegotiations when he analyzed over 1,000 infrastructure concessions granted in Latin America from 1985-2000[105]. Over half of the transportation projects, 54.7% (151 concessions of the 276 analyzed), had contracts that eventually had substantial changes through renegotiation[106]. The average time that elapsed before the first renegotiation was slightly over three years[107]. In over half of the cases, 57%, it was the operator who initiated the renegotiation. In 27% of the cases it was the government, and in 16% it was both the government and the operator[108].

Guasch identifies three categories of political factors that could determine concession renegotiation and all three tested statistically significant, based on the sample data he used[109]. The first was the affiliation variable (i.e. having a local operator increases the probability of renegotiation). The second was the country's level of corruption – the more widespread the corruption, the higher the probability of renegotiation. The third factor was the election cycle, which mostly explains the government-led renegotiations.

A challenge for the public sector in contract renegotiation is that those in charge of formulating the original contract may move out of their roles eventually, leaving a very weak public agency. The private sector may be the only entity truly paying attention to the contract terms, and will seek to exploit the weak agencies through renegotiations. Anecdotal evidence suggests that firms expect to make most of their profit through change orders and non-competitive renegotiations.

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102 Yescombe, 85.
103 Ibid.
104 Akintoye and Beck, 167.
105 Engel, Fischer, and Galetovic, 14.
106 Checherita and Gifford, 24.
107 Guasch, 14.
108 Ibid.
109 Checherita and Gifford, 24.

In 2006, 82% of the change orders on PFI projects in the U.K. cost £5,000 or less. Although high-value changes in excess of £100,000 were relatively uncommon, they accounted for 90% of total spending on change orders[110]:

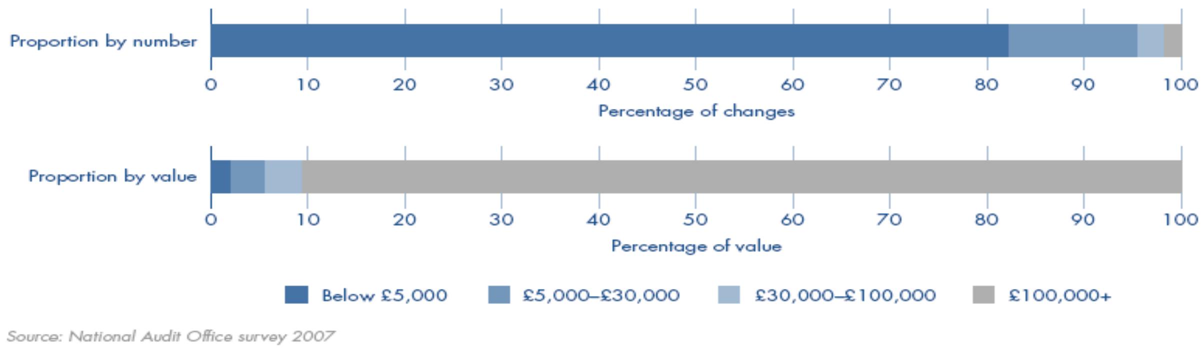

Figure 7.1 – Change Orders in the U.K. in 2006 by Cost

7.8 Contractor Selection Criteria

Whenever a subjective, best value selection method is chosen, the criteria used to evaluate proposals become a paramount concern. In order to retain the integrity of procurement procedures, it is important for the public agency to inform the bidders about the selection process that will be used and the evaluation criteria that will be applied. The more specific the public sector can be in its Requests for Qualifications (RFQs) and Requests for Proposals (RFPs), the more valuable information it will receive in return that can assist in its selection processes.

7.9 Critical Success Factors (CSFs)

Li et al. performed a survey in 2005 of both public and private sector participants in the U.K. to help rank the importance of 18 Critical Success Factors, or CSFs, in partnerships. The following is a summary of their results, ordered in terms of total relative importance[111]:

[110] National Audit Office. "Making Changes in Operational PFI Projects," 10.
[111] Li, Akintoye, Edwards, and Hardcastle.

Critical success factor	Public sector		Private sector		Total			
	Mean	Rank	Mean	Rank	Mean	Rank	F	Sign.
Strong private consortium	3.87	5	4.19	1	4.11	1	1.379	0.245
Appropriate risk allocation and risk sharing	3.73	8	4.17	2	4.05	2	2.011	0.162
Available financial market	3.80	7	4.12	4	4.04	3	1.681	0.200
Commitment/responsibility of public/private sectors	3.60	10	4.12	3	3.98	4	3.107	0.084
Thorough and realistic cost/benefit assessment	3.87	6	3.98	5	3.95	5	0.138	0.711
Project technical feasibility	3.53	11	3.88	6	3.79	6	1.465	0.231
Well-organized public agency	3.93	4	3.67	8	3.74	7	0.567	0.455
Good governance	3.93	2	3.64	9	3.72	8	0.940	0.337
Favourable legal framework	3.47	12	3.69	7	3.63	9	0.748	0.391
Transparency in the procurement process	3.73	9	3.55	10	3.60	10	0.271	0.605
Political support	3.93	3	3.43	11	3.56	11	2.115	0.152
Competitive procurement process	4.00	1	3.14	16	3.37	12	4.694	0.035*
Sound economic policy	3.07	15	3.24	13	3.19	13	0.401	0.529
Multi-benefit objectives	3.13	14	3.21	14	3.19	14	0.058	0.811
Stable macro-economic environment	3.27	13	3.17	15	3.19	15	0.100	0.753
Government involvement by providing guarantees	2.87	18	3.26	12	3.16	16	0.779	0.381
Shared authority between public and private sectors	3.00	17	2.98	17	2.98	17	0.005	0.945
Social support	3.07	16	2.71	18	2.81	18	0.774	0.383

Table 7.2 – Critical Success Factor (CSF) Survey Results

The private sector is relatively indifferent to each of the four CSFs that the public sector ranked as most important: competitive procurement process, good governance, political support, and a well-organized public agency.

This suggests that the private sector is less concerned about *process* than it is about *content*. In one sense that makes sense in a world where traditional D-B-B is still dominant. As the use of alternative delivery strategies continues to grow, it is likely that the process elements begin to be of more concern to the private sector.

7.10 Contract Types

Once the public sector has chosen a contracting strategy and criteria for selecting a particular contractor to assist in delivery of transportation megaprojects, it must then decide how to pay the contract. There are many ways to structure contract payment, generally differentiated by the level of risk the public and private sectors are each willing to assume.

7.10.1 Fixed Fee/Lump Sum Contract

A fixed-fee, or lump sum contract is one in which the contractor agrees to do the specified work for a fixed price. Lump sum works best when both parties are equally knowledgeable about a project[112].

These contracts can be problematic for megaprojects utilizing alternative delivery strategies because of uncertainty. The private sector is unlikely to commit to a set price due to the high number of interfaces and potential hazards beyond its control. If, however, a fixed fee can be negotiated for subsets of a larger project that can be monetized in isolation, then this contract structure is feasible.

[112] Fred Moavenzadeh Lecture, MIT.

A major problem inherent in fixed fee contracts is the lack of incentivization. If the contractor is going to get the same amount of money regardless of its performance, then its goal is to finish the job as quickly as possible. The rush can lead to poor quality.

7.10.2 Unit Price Contract

In a unit price contract, the work to be performed is broken into various parts, usually by trade, and a fixed price is established for each unit of work[113]. Final price of the project is dependent on the quantities of materials used, and their respective unit prices. In general, this type of contract is best suited when both parties can agree on the inputs to a contract but not on their quantities[114]. Unit price contracts are particularly common in construction, and it is not unusual to combine unit price contracts for parts of a project with lump sum contracts for other parts[115].

7.10.3 Cost Plus Contract

There are many variations on this contract type, but the basic premise is that the contractor is paid for all of its costs, including labor and materials, in addition to some extra fee that serves as their profit. This would otherwise be similar to a unit price contract, but is distinguished based on the various incentivization packages[116]:

- *Cost Plus Fixed Percentage* – compensation is a percentage of total costs.
- *Cost Plus Fixed Fee* – compensation is a fixed amount independent of final project costs.
- *Cost Plus Fixed Fee with Guaranteed Maximum Price (GMP)* – compensation is again a fixed fee, but there is a ceiling attached to the final price. This transfers risks to the contractor and provides an incentive to them to avoid escalating costs. The GMP acts as a form of insurance for the owner.
- *Cost Plus Fixed Fee with Bonus* – compensation is a fixed fee, but there are also incentives in place for the contractor to meet certain objectives.
- *Cost Plus Fixed Fee with Guaranteed Maximum Price and Bonus* – compensation is a fixed fee with an upper limit, though again there is an incentivization structure to reward a positive outcome and penalize a negative one. The GMP is a risk to the contractor, but at least this bonus structure may allow the contractor to minimize losses if, say, the project comes in over the maximum price but ahead of schedule.
- *Cost Plus Fixed Fee with Cost Savings Sharing* – compensation is a fixed amount, but the contractor can share with the owner a portion of any cost savings.

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[113] New Hampshire Department of Education. "Construction Contracts and Delivery Methods."
[114] Engineering Toolbox. "Contract Types."
[115] Ibid.
[116] Ibid.

7.10.4 Cost Reimbursement Incentive Contract

This contract structure starts with a negotiated fee, which is later adjusted based on a formula that provides bonuses and instills penalties if actual costs differ significantly from targets. With minimum and maximum fees in place, both sides are protected from targets that are drastically miscalculated. The minimum protects the contractor, while the maximum protects the owner.

7.10.5 Present-Value-of-Revenue (PVR) Contract

Present-Value-of-Revenue (PVR) contracts are increasingly common on projects that have dedicated revenue sources. In a PVR contract, the owner sets the discount rate and user fee schedule[117]. Firms bid the present value of the user fee revenue they desire, and the lowest bid wins. The key distinction on PVR contracts is that the contract terminates once the winning firm collects the present value of user revenue equal to its winning bid.

When demand is less than expected, the franchise period is longer, while the period is shorter if demand is unexpectedly high. The public agency may put into the contract a clause that allows it to buy back the asset at any time if it is willing to pay the difference between the bid price and the amount already paid back to the concessionaire[118]. This is a sufficient estimate for the residual value of the contract, and thus permits the government to decide if and when it wishes to terminate the contract without cutting into the private firm's profit margin[119].

There are several benefits to PVR contracts. First, there is no risk of default; only the risk that the concession period lasts longer than expected. PVR contracts also reduce the likelihood of "bad faith" renegotiations, since scenarios with losses for the concessionaire are less likely under PVR[120]. Because contracts are awarded objectively, PVR also invites new bidders that may be skilled at project delivery and operations but not at gaming the political system[121].

The U.K. has adopted several PVR contracts, including ones on its Queen Elizabeth II and second Severn Bridges. The franchises will last until toll collections pay off the debt issued to finance the bridges and are predicted to do so several years before the maximum franchise period.

PVR contracts reduce demand risk for the public sector, but also provide assurances to the operator since it is guaranteed a specified return. The part that is variable, or risky, from the private sector perspective is how long it will take to recoup that amount. Obviously inflation and other factors make a shorter contract length quite enticing to the operator. It is estimated that PVR contracts lower the amount of risk premium included in a private sector entity's bid by up to one-third[122].

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117 Engel, Fischer, and Galetovic, 23.
118 Eduardo Engel, CTL Speaker Series Lecture, MIT.
119 Ibid.
120 Engel, Fischer, and Galetovic, 24.
121 Eduardo Engel, CTL Speaker Series Lecture, MIT.
122 Engel, Fischer, and Galetovic, 24.

7.11 Shadow Tolls

When the private sector is partially or fully financing the project, it is usually putting a significant amount of its investment at risk based on revenues that would come from a transit project or a toll road. User fees are not the only way the private sector can be reimbursed, however.

Under a shadow toll provision, the government repays the private operator a fixed fee for each user of the infrastructure, rather than having each individual user pay[123]. From the private sector contractor's perspective, this is really no different than if they are paid directly by users. One of the added benefits, however, is that the private operator spends much less on revenue collection. There is no need for toll takers or high-tech license plate-identifying cameras. Sensors at entrypoints are really all that is needed to verify usage, unless the toll varies by distance traveled.

Advocates of shadow tolls claim that the system invites developers to propose desirable highways, thereby attracting vehicular traffic and the revenue source required to create a viable project[124]. Shadow tolls may also be more politically palatable. Even though the road is likely funded through taxes, individual users are not imposed a marginal cost for their usage of the facility.

Critics of shadow tolls say that users feel as though the road is a freeway because they pay no tolls, which leads to congestion. Studies prove that throughput is maximized on a highway without congestion, so the private party would have an incentive to reduce congestion[125].

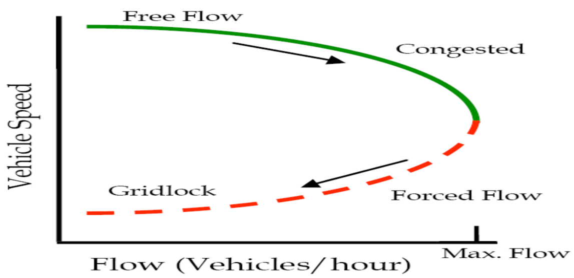

Figure 7.2 – Flow vs. Speed Graph, Indicating Impacts of Congestion

Critics also believe that government will pay more over time with shadow tolls than with user fees because of the increased usage of an untolled freeway[126].

7.11.1 Shadow Tolls in Use in the U.K.

Shadow tolls had been proposed and rejected by the Department for Transport (DfT) for years, but in 1994 Public Transport Minister John Watts suggested that the use of shadow tolls would provide the proper incentive for private investment in new roadway construction[127]. By 2006, the U.K. Highways agency had awarded ten DBFO shadow toll road projects covering 770 km and having a construction value of about $2B[128].

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123 Ibid, 21.
124 Levy, 1996, 211.
125 Antos, 57.
126 Zhang and Kumaraswamy, 352.
127 Levy, 1996, 211.
128 Perez and March, 5.

Chapter 8: Evolution of Alternative Delivery Strategies in Transportation

This chapter will supply the historical context that has led to a paradigm shift towards alternative delivery strategies in recent decades, both in the U.S and in the U.K. It will look at U.S. highway and rail transit projects, and also the U.K. Private Finance Initiative (PFI) movement.

8.1 Early Use of Alternative Delivery Strategies

Alternative delivery strategies date back thousands of years to nearly the beginning of recorded history. The Egyptians used what was then known as the "Master Builder" approach 4500 years ago in the construction of the pyramids, and kings worldwide commissioned Master Builders to construct palaces[129]. It was not until the mid-1800s AD when a distinction was first made between design professionals and builders[130]. By the late 1800s and early 1900s there began to be a clear separation between architects and engineers[131]. Throughout the 1900s these professions grew enormously with little coordination among them. As a result, most public works projects were delivered through a new strategy in which the design was separate from construction.

8.1.1 Alternative Delivery Strategies Through the 1980s

Limitations on alternative delivery strategies, and on design-build specifically, have resulted largely from laws that govern the issuance of contracts. In fact, there has often been an ebb and flow in terms of policy on this issue. Much of this attributes to the mood of the country during wartime and economic depression, as well as subsequent years when public works projects were viewed as a way to emerge triumphant from hard times.

The post-WWII construction boom saw the emergence of D-B among a select few federal agencies. Some of the early uses of D-B were by the Navy in the 1940s on housing projects during and after the War. NASA and HUD also used D-B on occasion. Still, only a few federal agencies used D-B from the 1960s through the 1980s. A major hurdle was the fact that Federal Acquisition Regulations (FAR) didn't explicitly allow D-B[132].

8.1.2 Growth of Alternative Delivery Strategies Since 1980s

It wasn't until the 1990s when D-B became a common delivery strategy for the federal sector. For non-residential design and construction projects, D-B and other non-traditional methods of procurement went from a 17% market share in the mid-1980s to over half of all projects today[133]. The number is expected to continue to rise.

D-B procurement doubled between 1986-1992, and in 1992 Congress lifted restrictions and permitted broader use of D-B[134]. The Clinger-Cohen Act of 1996 explicitly permitted and validated

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129 Levy, 2006, 325.
130 Loulakis, 48.
131 Ibid.
132 Ibid, 78.
133 Design-Build Institute of America. "What is Design-Build?"
134 Loulakis, 78.

D-B as a federal project method in the FAR. The growth in D-B has been more precipitous in other construction-based sectors than in transportation, but this and other legislation in the early 1990s also began to bring D-B front and center in transportation as well.

8.1.3 U.S. States with Design-Build Authority

By 2007, 42 states, as well as the District of Columbia, Puerto Rico, and the U.S. Virgin Islands had proposed, active, or completed design-build transportation projects[135]. This authority sometimes, but not always extends to transit projects as well[136].

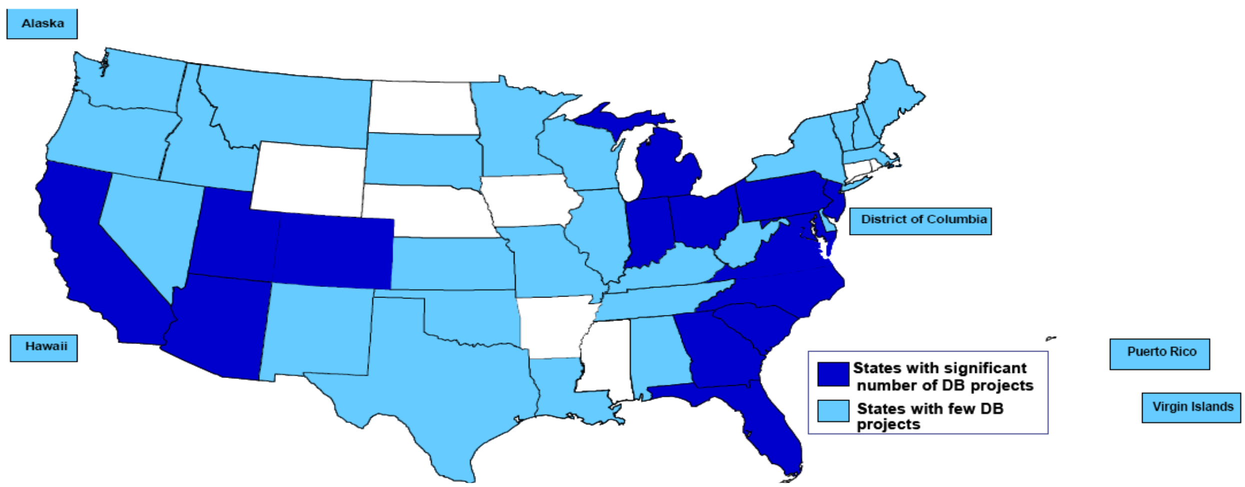

Figure 8.1 – U.S. States with Design-Build Authority

8.2 Historical U.S Highway Funding

When the first modern highways were built in the 1930s and 1940s, they were constructed as public ventures of state and local governments[137]. Tolls were preferred in the eastern U.S., while western states used revenues from a dedicated gasoline tax to finance untolled "freeways."

Following World War II, the U.S. witnessed significant automobile growth and population shift away from urban metropolises towards the emerging suburbs. Recognizing that the nation's highway system was inadequate to meet growing demands, President Dwight Eisenhower called for passage of the Federal-Aid Highway Act of 1956, which appropriated $25B to construct 42,000 miles of interstate highways over a 10-year period[138]. The system, built almost entirely as traditional design-bid-build, ended up costing $114B and took 35 years to complete, but also achieved tremendous success in terms of creating an entirely new nationwide travel network[139].

While existing toll roads were grandfathered into the new system, tolls were not allowed on the new Interstates. Instead, a national fuel tax and a vehicle excise tax were paid into a Highway Trust Fund

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135 U.S. Department of Transportation. Federal Highway Administration. "User Guidebook on Implementing Public-Private Partnerships for Transportation Infrastructure Projects in the United States," 25.
136 Ibid.
137 Perez and March, 9.
138 Ibid.
139 Fox.

that would pay for 90% of interstate construction costs. State governments picked up the remaining 10%[140].

With the "90-10 rule," the construction of toll roads decreased dramatically. From 1960-1980, only about 1,500 miles of toll roads were built in the U.S[141]. Some states even removed existing tolls so that those roads would become eligible for reconstruction and widening funds[142].

The federal fuel tax that is used to fund the majority of the Highway Trust Fund has been increased only four times since 1956. The most recent increase was in 1993 to 18.4 cents per gallon, and since then the real dollar value of the gasoline tax has decreased by over 30% due to inflation[143]. Net revenues supporting the Highway Trust Fund are no longer able to keep pace with growing expenditures.

8.2.1 Federal, State, and Local U.S. Government Infrastructure Investment Trends

Federal sector infrastructure spending over the past half-century has indeed increased dramatically (as demonstrated by the darker line and left axis below), but as a share of total U.S. Federal spending it decreased significantly in the 1980s and is now hovering around 3% (as demonstrated by the lighter line and right axis below)[144]:

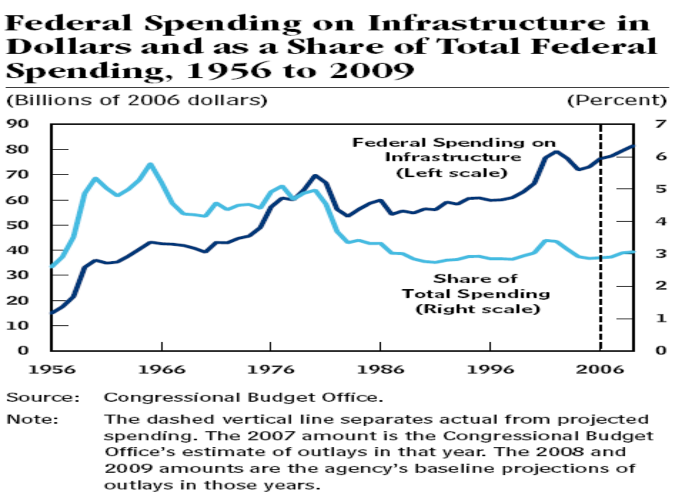

Figure 8.2 – Federal Spending on Infrastructure in Dollars and as a Share of Total Federal Spending, 1956 to 2009

As a share of non-defense spending, federal funding for infrastructure has been about 3.5%-4% since the 1980s. Back in the 1950s and 1960s it was not uncommon for that amount to be well over 10%[145]. Today, the federal government contributes only one-fourth towards the total spending on infrastructure in the U.S., with states and localities picking up the other three-quarters[146].

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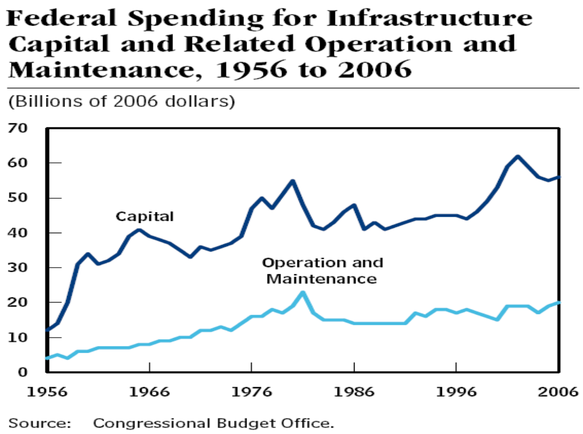
140 Perez and March, 9.
141 Levy, 1996, 27.
142 Ibid.
143 Citizens for Tax Justice. "Gas Taxes: Broken? Antiquated? A Fossil?"
144 Congressional Budget Office. "Trends in Public Spending on Transportation and Water Infrastructure, 1956 to 2004," 5.
145 Ibid, 4.
146 Ibid, 2.

But whereas the federal government may have done the states a favor by paying for 90 cents of every dollar on the Interstate highway infrastructure, it has severely failed states when it comes to the operations and maintenance (O&M) costs of these facilities, especially now that much of our road and rail infrastructure is approaching the end of its life-cycle. Federal government expenditures on capital have increased steadily, but its O&M contribution has remained flat. The O&M burden has fallen heavily on states and localities[147]:



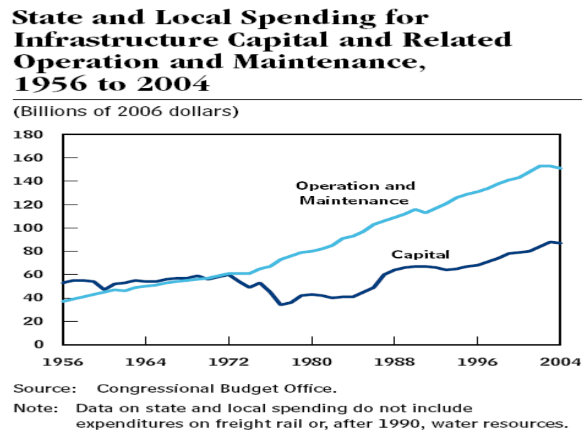


Figure 8.3 – Federal Spending for Infrastructure Capital and Related Operation and Maintenance, 1956 to 2006
Figure 8.4 – State and Local Spending for Infrastructure Capital and Related Operation and Maintenance, 1956 to 2004

O&M accounts for two-thirds of total infrastructure spending by states and localities, but only slightly more than one-fourth of infrastructure spending by the federal government[148]. In fact, when federal government O&M infrastructure expenditures is broken down further by infrastructure type, it is evident that O&M contributions for "Highways, Roads, and Mass Transit" is minimal, and for other Rail investments is non-existent[149]:

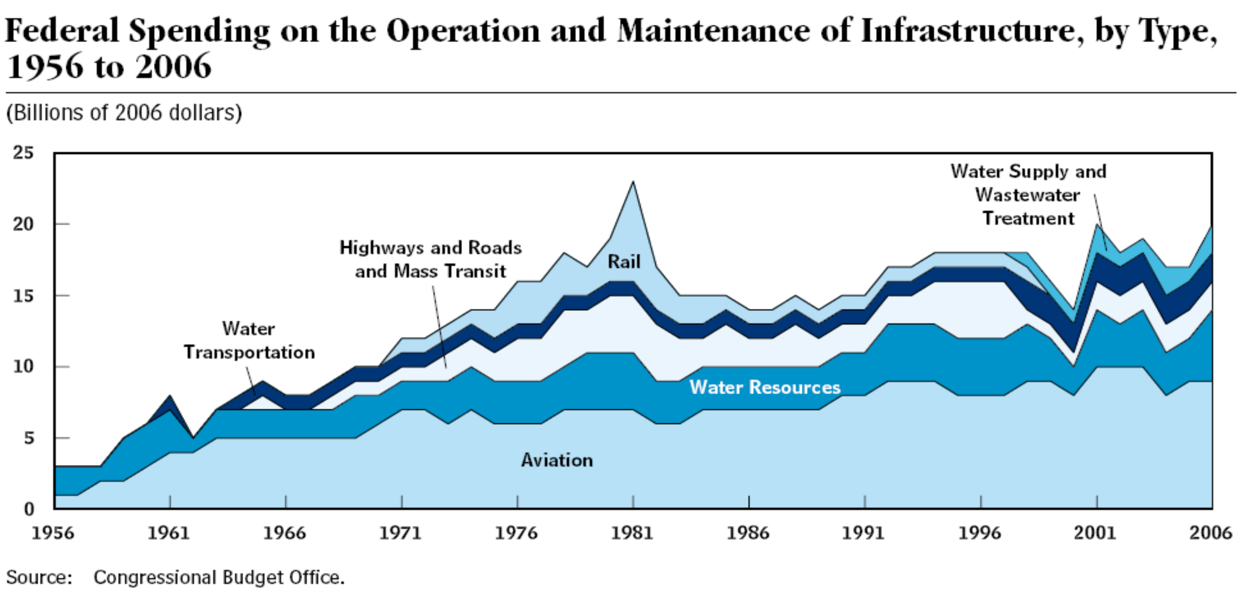


Figure 8.5 – Federal Spending on the Operation and Maintenance of Infrastructure, by Type, 1956 to 2006

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147 Ibid, 7-8.
148 Ibid, 13.
149 Ibid, 11.

It is worth noting that rail was a sizable portion of federal O&M spending from the mid-1970s through the late 1980s, peaking in 1981 following a settlement of litigation related to the government's acquisition of the assets of Conrail[150]. The federal government's main priority for infrastructure O&M has been in the aviation sector, in an effort to maintain our dated air traffic control system[151].

8.2.2 U.S Highway Funding Gaps Create Interest in Alternative Delivery Strategies

In 1991, the Federal Highway Administration (FHWA) enabled state highway agencies to use federal-aid funds to experiment with innovative contracting techniques for selected projects[152]. In return, FHWA asked for reports on outcomes, particularly in terms of the ability to save time, reduce costs, or improve performance. Largely as a result of this initiative, design-build in highway construction grew in the 1990s[153].

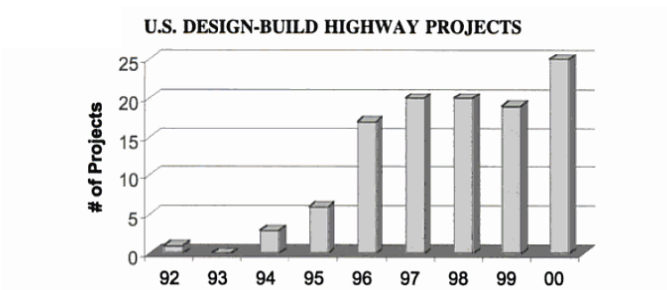

Figure 8.6 – U.S. Design-Build Highway Projects, 1992 to 2000

Congress took note of these successes and in 1998 explicitly endorsed D-B for its "speed, economy, and efficiency[154]." Thereafter, federal aid funding has been allowed to be used for D-B projects contracted for by state DOTs, but only if their state and local laws also permit D-B[155]. This led to a wave of enabling legislation at state and local levels to allow D-B, some of which was done on an experimental basis[156].

8.2.3 Alternative Delivery Strategies on U.S. Highways in 2000s

The latest federal transportation authorization, SAFETEA-LU, eliminates a $50M floor on the size of contracts that can use design-build contracting without special approval. SAFETEA-LU also permits transportation agencies to proceed with certain actions prior to receipt of final National Environmental Policy Act (NEPA) approval, on a case-by-case basis. For example, projects may be eligible to issue RFPs, proceed with awards of D-B contracts, and begin preliminary design work

150 Ibid, 12.
151 Ibid, 11.
152 Loulakis, 93.
153 Ibid.
154 Ibid, 119.
155 Ibid, 68.
156 Ibid, 176.

before final NEPA approval is granted. As of 2004, FHWA had approved over 300 D-B transportation projects worth nearly $14B[157].

8.3 Privatization in the U.S.

A popular trend in the past several years in the U.S. has been the privatization of existing transportation assets. Again, the key difference between a DBFOM and full privatization is that ownership is transferred to the private party in the latter. This has been done at both the city and state levels. These cash-strapped governments are increasingly looking for ways to plug budget gaps by selling capital assets with potential revenue streams such as toll roads. Enter giant private firms with both experience in these types of concessions and strong financial footing, and it is easily understandable why these sorts of deals are enticing to public sector agencies.

The public sector may retain the right to set toll rates on privatization deals. But it is often advantageous to transfer this political risk so that future toll increases are not be subject to legislative votes, the outcome of which may be the equivalent of political suicide. Besides, the private sector concessionaire taking the revenue risk is unlikely to want to leave the toll raising authority in the public sector's hands.

8.3.1 Privatization of New Facilities

When the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 explicitly authorized privately financed toll roads in 1991, 130 years had passed since the last one had been built in the U.S[158][159]. Following the passage of this legislation, a select few public agencies have granted private concessionaires the rights to DBFOM and own a new, previously non-existent facility. Two of the recent examples of U.S. highway privatizations are the Dulles Greenway in Virginia and the SR-91 Express Lanes in California, while the Las Vegas Monorail is a recent example of a transit property privatization.

8.3.1.1 Dulles Greenway

The Dulles Greenway is a 14.5-mile toll road that runs from Dulles International Airport to Leesburg in Virginia[160]. The Toll Road Investors Partnership II, comprised of local interests, the Italian road operator Autostrade SPA and Kellogg, Brown, and Root, raised $360M in private capital to finance the startup[161].

The highway opened in September 1995, six months ahead of schedule[162]. However, ridership forecasts made during the economic boom of the late 1980s proved to be very high, and did not anticipate that it would take four years to obtain approvals, complete preliminary design, and assemble financing[163]. When early ridership was lower than projected, the project went into default

157 Gransberg and Molenaar, 2-3.
158 Vining, 205.
159 Levy, 1996, 50.
160 Vining, 205.
161 Ibid.
162 Ibid.
163 Miller, 2002, 23.

in July 1996, within a year of its opening[164]. The contract was eventually renegotiated and the term extended 20 years[165].

Projections had 1995 usage at 34,000 cars per day at a toll rate of $1.50[166]. Initial usage ended up only being 10,500 cars per day, partly because public pressure led the state of Virginia to widen Route 7; a nearly parallel, untolled alternative[167]. To increase ridership tolls were lowered from an initial $1.75 to $1.00[168]. While trips increased, this had a marginal impact on revenues[169]. Usage did gradually increase over the six-year period following to 60,000 cars per day in 2001[170].

The partnership's losses have been about $30M per year[171]. Engel contends that the concessionaire will still make money in the end, but that it will take closer to 25 years than the anticipated 12 years to become profitable[172].

8.3.1.2 SR-91

Opened in 1995, the SR-91 Express Lanes project is a 10-mile, 4-lane, fully automated toll road running in the median of the existing 8-lane SR-91 freeway in southern California[173]. Vehicles with fewer than three occupants have a choice to drive in the untolled lanes or pay a variable rate, as high as $9.55, to drive congestion-free in the Express Lanes[174][175]. Before the Express Lanes opened, the original untolled freeway carried 230,000 vehicles per day, and was congested more than four hours per day in each direction[176].

The developer and original operator of the project was the California Private Transportation Company (CPTC); a limited partnership that included the construction firm Kiewit, French toll road company Cofiroute, and Granite Construction[177]. CPTC was granted a 35-year concession[178]. Initial private financing amounted to $125M, though only $20M was CPTC's capital[179].

The contract did not regulate toll rates, but it did stipulate that the operator could not earn a return in excess of 17%[180]. To ensure that traffic flow remained fluid, tolls were raised four times in the first three years of the project[181]. Volume on SR-91 increased steadily from 7.3M trips in 1999 to 9.5M trips in 2002, while annual revenue grew over the same time from $19.5M to $29M[182].

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164 Vining, 205.
165 Eduardo Engel, CTL Speaker Series Lecture, MIT.
166 Miller, 2002, 23.
167 Engel, Fischer, and Galetovic, 20.
168 Vining, 205.
169 Ibid.
170 Ibid.
171 Ibid, 206.
172 Eduardo Engel, CTL Speaker Series Lecture, MIT.
173 Vaillancourt Rosenau, 80.
174 91 Express Lanes. http://www.91expresslanes.com/generalinfo/commonquestions.asp#8.
175 91 Express Lanes. http://www.91expresslanes.com/tollschedules.asp.
176 Vining, 206.
177 Ibid.
178 Ibid.
179 Ibid.
180 Ibid.
181 Loulakis, 205.
182 Vining, 206.

The agreement included a non-compete clause which restricted improvements to the freeway or nearby roads until 2035, except for safety reasons[183][184]. With no allowance for additional capacity, SR-91 and adjacent highways became even more congested. The California Department of Transportation (Caltrans) "essentially decided to ignore the non-compete clause" and tried to expand capacity in 1999, claiming that safety was an issue[185]. CPTC won a lawsuit against Caltrans when it was determined there was no critical safety issue present[186]. Other lawsuits and legislative attempts to void the non-compete clause also failed.

In 2002, the Orange County Transportation Authority (OCTA) finally reached an agreement with CPTC to purchase SR-91 for $207.5M[187]. The ultimate sale back to the government was portrayed as a win-win for both sides, though the legal and negotiation costs stemming from the four-year stalemate were substantial[188].

8.3.1.3 Las Vegas Monorail

The Las Vegas Monorail is the only fixed guideway project since the 1920s with financing based in large part on projected farebox revenues and the private sector solely responsible for project risks[189]. This $640M, four-mile, seven-station transit system was developed by a group of local casinos to provide transit links between their properties[190]. Project financing was raised using tax-exempt revenue bonds.

The developer signed a 15-year, $340M contract with the Las Vegas Monorail Company, a consortium led by Granite Construction and Bombardier[191]. Project revenues are required to first account for O&M costs before paying down debt service[192]. The O&M agreement also contains significant financial penalties for failure of the operator to meet specified performance standards[193].

The system opened in July 2004 with an expected daily ridership of 50,000 passengers per day, but actual ridership was closer to 30,000[194]. Operations were halted that September due to the loss of a guide wheel on one of the monorail cars. When service resumed in mid-2005 ridership decreased significantly, and the Monorail has had difficulty attracting riders ever since.

8.3.2 Privatization of Existing Facilities

Cash-hungry states and localities are looking more and more at privatizing existing facilities. These contracts bring with them a large infusion of funds that can be helpful in the short-term, but may end up costing more in the long-term. The most cited examples in the U.S. are the Chicago Skyway

183 Engel, Fischer, and Galetovic, 25.
184 Vining, 206.
185 Ibid.
186 Ibid, 207.
187 Ibid.
188 Ibid, 206.
189 U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," A-2.
190 Perez and March, 12.
191 Loulakis, 203.
192 Ibid.
193 Ibid.
194 Ibid, 195.

and Indiana Toll Road, as well as the Pennsylvania Turnpike as an example of a privatization deal that has initially fallen through.

8.3.2.1 Chicago Skyway

In 2005, the city of Chicago put out for bid the ownership for 99 years of a 7.8-mile stretch of I-90 known as the Chicago Skyway, which until then was generating $45M in annual toll revenues. The Skyway is the main link from Chicago to the southeast. It stretches from the Indiana state line to the merger with I-94 just south of Downtown[195].

Figure 8.7 – Chicago Skyway Map

The bidding generated a lot of attention and attracted ten initial expressions of interest[196]. Five of those consortia were eliminated from bidding on the grounds that they lacked the financial capacity or the experience in operating a tollway[197]. This left five bidders, each of which were provided information about the Skyway's rocky financial history and its vintage engineering and traffic history[198].

The concession went to a Skyway Concession Company (SCC), a joint venture between Macquarie Infrastructure Group and Cintra, for $1.83B. This bid stunned the U.S. financial markets, as it was more than $1B higher than the second-highest bidder[199]. SCC will be responsible operations and maintenance, but has the right to all collected revenue, subject to toll increases stipulated in the contract. Maintenance, snow clearing and policing continue to be performed by the city and SCC billed at cost.

There are no non-compete clauses in the contract, meaning the state has the right to do any transportation upgrades in the vicinity of the Skyway that may impact the Skyway's revenues, though

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195 U.S. Department of Transportation. Federal Highway Administration. "Case Studies of Transportation Public-Private Partnerships in the United States," 3-37.
196 Toll Roads News. "Cintra-Macquarie to Take Over Chicago Skyway for $1.8B."
197 Ibid.
198 Ibid.
199 Perez and March, 13.

new expansion is unlikely given the urban density in the area[200]. Parallel highways are undergoing significant congestion mitigation efforts, however, that could impact the Skyway's usage[201].

Public opinion was mixed, particularly as it pertains to toll rates. Prior to the concession, the toll on the Skyway was $2 and hadn't been raised in 12 years. Immediately following the privatization the toll increased to $2.50 as determined in the contract. Arguably, the Skyway was due for a toll increase anyway.

Tolls were required to stay at $2.50 until 2008, when they went up to $3.00. Tolls will rise to $3.50 in 2011, $4.00 in 2013, $4.50 in 2015, and $5.00 starting in 2017[202]. After 2017, toll increases will be the greater of 2% per year or the rate of inflation.

8.3.2.1.1 Chicago Skyway Benefits

The benefits of the massive financial intake to the city of Chicago as a result of the $1.83B Skyway concession were felt immediately[203]. In a very short period of time, Chicago accomplished three major goals[204]:

1. *Debt repayment*. Chicago spent over $800M to pay down debt, $463M of which was related to the Skyway itself[205].
2. *Rainy Day Fund*. $500M has been placed in a savings account that is currently bearing interest and will be available should the City fall into further financial peril.
3. *Bond rating enhancement*. Chicago has been able to improve its bond rating significantly, which will attract investment for future capital projects. Soon after the deal was struck, Moody's raised the city's bond rating to its highest in 25 years.

8.3.2.2 Indiana Toll Road

The Indiana Toll Road (ITR) concession of 2006 is a very similarly structured deal for a roadway with characteristics much different than the Chicago Skyway. Whereas the Skyway was a fixed-price eight-mile toll road with few interchanges spaced approximately one mile apart, the ITR is a distance-based toll road that is 157 miles long and has 20 interchanges spaced several miles apart. The ITR is the name for the I-90/I-80 east-west roadway that traverses the entire state of Indiana.

As in the Skyway case, the concession went to Macquarie and Cintra, this time for $3.8B and 75 years. Their joint venture is known as the Indiana Toll Road Concession Company (ITRCC). Cintra and Macquarie each put up $374M of their own money, together with loans issued by a consortium of seven European banks in the amount of $3.25B[206].

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200 U.S. Department of Transportation. Federal Highway Administration. "Case Studies of Transportation Public-Private Partnerships in the United States," 3-39.
201 Ibid.
202 Toll Roads News. "Chicago Skyway Handed Over to Cintra-Macquarie After Wiring $1830M."
203 Massachusetts Joint Committee on Transportation Hearing, November 26, 2008.
204 Ibid.
205 Toll Roads News. "Chicago Skyway Handed Over to Cintra-Macquarie After Wiring $1830M."
206 Perez and March, 13.

The toll to drive the ITR from end-to-end is $8 for cash-paying customers. Indiana, like Chicago, hadn't raised tolls in many years. It had been 23 years since the last toll increase in Indiana[207]. The way this contract is structured, an immediate increase of 70% went into effect. The ITR annual revenue was slightly less than $100M per year as of early 2006, and following the toll increases and transfer in ownership is now generating over $160M per year[208][209]. There is a non-compete clause that extends for a ten-mile buffer around the ITR[210].

Proceeds from the $3.8B operating lease will be used to repair and rebuild highways across the state[211]. There is about $794M to fund local transportation improvement projects in each county of the state, and nearly $500M will fund additional transportation upgrades in communities adjacent to the Toll Road corridor[212].

Opponents argued that tolls should be eliminated altogether since they led to excess congestion on the untolled alternatives, particularly at the more densely-populated western end of the route. It is widely held, however, that this toll increase, or one similar, would have gone into effect around this time regardless of whether or not the road was privatized. These current tolls are frozen until 2010, and then will be raised by an inflation-indexed formula thereafter.

8.3.2.2.1 Indiana Toll Road Benefits

The money the state received from the deal has been put towards its ten-year transportation plan[213]. As a result state highway spending will quadruple by 2015[214]. Meanwhile, the money is earning $185,000 per day in interest[215]. The state's bond rating is now AAA, the highest in state history. The state also immediately paid off $300M in debt that it had on the ITR[216].

As part of the agreement, the ITRCC is implementing $770M worth of upgrades to the ITR[217]. The upgrades include an extra lane in each direction for 21 miles from the Illinois state line to the I-80/I-94 interchange, the reconstruction of existing pavement and bridge structures, and implementation of electronic toll collection[218]. With the possible exception of the electronic toll collection, these upgrades likely would not have been possible had the state been continuing to own and operate the tollway itself.

Since the Indiana Toll Road concession went into effect, several states have been considering privatization for their toll roads including Massachusetts, Pennsylvania, and New Jersey. Pennsylvania was very close to signing an extremely lucrative privatization contract in 2008.

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207 Massachusetts Joint Committee on Transportation Hearing, November 26, 2008.
208 Kim, 2.
209 Johnson, Luby, and Kurbanov, 39.
210 U.S. Department of Transportation. Federal Highway Administration. "Case Studies of Transportation Public-Private Partnerships in the United States," 2-23.
211 Ibid, 3-43.
212 Ibid.
213 Massachusetts Joint Committee on Transportation Hearing, November 26, 2008.
214 Ibid.
215 Ibid.
216 Ibid.
217 Ibid.
218 Ibid.

The debate in Massachusetts over the possible privatization of the Massachusetts Turnpike (Mass Pike) is still in its preliminary stages. There is an especially forceful political backlash there for toll increases. This stems largely from the fact that Mass Pike revenues go towards paying down Big Dig debt, even though many of the Pike's drivers rarely utilize the Big Dig. Toll payers argue rightly that this is inequitable.

8.3.2.3 Pennsylvania Turnpike

The main section of the Pennsylvania Turnpike is a 359-mile east-west tollway through Pennsylvania with 30 tolled interchanges and 18 service plazas. There is a proposed privatization that has been held up by financial and legislative concerns. Operating the Pennsylvania Turnpike also poses engineering challenges because of its four separate tunnels running through the Appalachian Mountains. In 2006 the Turnpike generated $607M in revenues, with payments nearly split evenly between cars and trucks.

The state spent over $100M scoping, planning, and evaluating the feasibility of a privatization deal for the Turnpike[219]. In May 2008, a team including Citi and Abertis was preliminarily selected as the concessionaire in a 75-year lease of the Turnpike for $12.8B. The three bidders for the Turnpike secured debt and equity totaling over $30B[220].

The lease would have allowed the state to cap toll increases to inflation, following an initial 25% rate hike. The state planned to retain the right to set standards for maintenance and operations, detail the capital program, and see that the new operators abide by the labor agreements with the unionized workforce of the Turnpike Commission[221]. The Turnpike Commission itself was highly against the deal, as it would have rendered the now quasi-governmental agency obsolete.

Despite strong support from Governor Ed Rendell, the proposed lease faced approval from a skeptical state legislature. The Citi/Abertis team extended its bid through September 2008, but the state legislature had yet to approve any such deal[222]. This coincided with the late-2008 credit crunch and economic recession, and the Citi/Abertis team received word that the value of the concession was now around $11B, and even that may have been optimistic[223]. For now, at least, the Pennsylvania Turnpike concession proposal is on hold.

8.4 U.S. Rail Transit Funding

The mass transit equivalent of the Federal Aid Highway Act was the Urban Mass Transportation Act of 1964 (UMTA), which shifted the policymaking for public transportation from local and state regulation to the federal government[224]. This was particularly inauspicious timing for any mass transit boom in America considering automobile proliferation and the resulting suburban sprawl had become dominant.

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219 Canadian Council on Public-Private Partnerships National Conference, Toronto, Canada, November 24-25, 2008.
220 Massachusetts Joint Committee on Transportation Hearing, November 26, 2008.
221 Toll Roads News. "Abertis/Citi Selected in $12.8 Billion Bid for Pennsylvania Turnpike Lease."
222 Toll Roads News. "Abertis Let $12.8 Billion Offer for Penn Pike Expire."
223 Toll Roads News. "Abertis Better Off Without Penn Pike at $12.8B - $11B Highest Prudent Bid, Analyst."
224 Vaillancourt Rosenau, 83.

Between 1970 and 1980, federal aid to transit increased 16-fold, from $230M to $3.9B, but ridership only increased 18%[225]. Massive subsidies were required to keep our nation's mass transit systems afloat. The overall financial deficit of the transit sector went from $90M in 1968 to $7.8B in 1980, and by then the average transit operation could recover only 41% of its operating expenses through farebox revenues[226]. Generous wage settlements led to transit operating expenses growing more than twice as fast as the Consumer Price Index (CPI)[227].

The President Ronald Reagan administration viewed federal transit aid as one of the many big government programs that was the problem and not the solution. The following chart shows the drastic increase in government funding for highways in the U.S. since the Interstate Highway Act of 1956, and the nominal increase in transit funding that has always lagged well behind[228]:

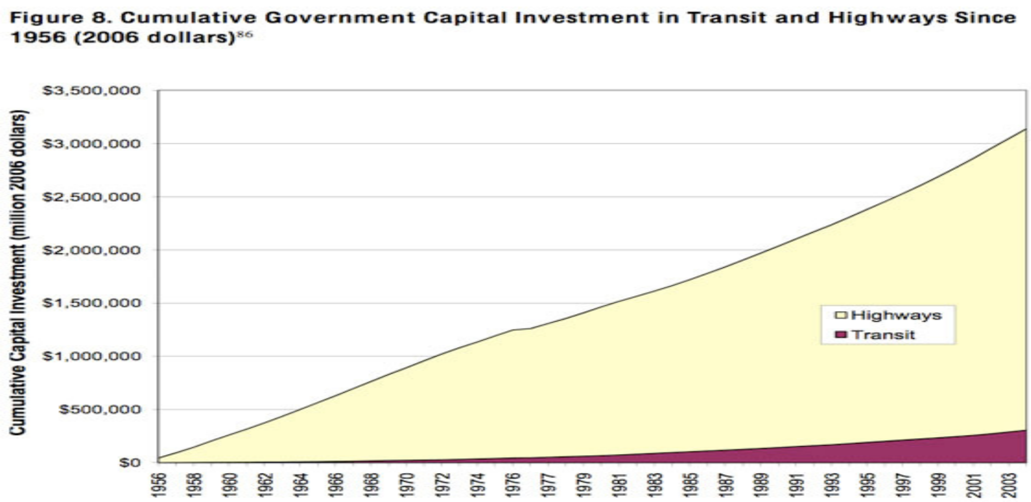

Figure 8.8 – Cumulative Government Capital Investment in Transit and Highways since 1956 (in 2006 Dollars)

A reduction in federal transit spending did convince transit's state and local partners to increase their own transit subsidies significantly. Federal transit spending dropped from $3.9B in 1982 to $3.6B in 1992, while state and local spending rose from $7.4B to $18.4B in the same period[229]. The following two charts from Altshuler and Luberoff (2003) show this increased federal transit commitment in the 1970s and then the growth of state commitment in the 1980s and 1990s[230]:

225 Ibid.
226 Ibid.
227 Ibid.
228 U.S. PIRG Education Fund. "A Better Way to Go: Meeting America's 21st Century Transportation Challenges with Modern Public Transit," 4.
229 Vaillancourt Rosenau, 85
230 Altshuler and Luberoff, 185.

Table 6-2. Transit Spending and Funding Sources, 1950–99[a]
Billions of 2002 dollars

Year	Total spending	Fares	Federal	State and local
1950	3.6	3.0	0.0	0.6
1955	3.3	3.0	0.0	0.3
1960	3.7	2.9	0.0	0.8
1965	4.8	3.6	0.1	1.2
1970	6.1	4.3	0.4	1.4
1975	11.0	3.9	3.0	4.1
1980	14.7	4.6	6.0	4.1
1985	20.7	6.3	4.9	9.4
1990	23.9	6.6	4.7	12.5
1995	28.9	7.3	4.9	16.6
1999	30.0	8.1	4.4	17.5

Table 6-3. Sources of Transit Revenues, 1950–99
Percent

Year[a]	Fares	Federal	State and local
1950	82	0	18
1955	91	0	9
1960	77	0	23
1965	74	1	24
1970	70	6	23
1975	35	28	37
1980	31	41	28
1985	31	24	46
1990	28	20	52
1995	25	17	58
1999	27	15	58

Table 8.1 – Transit Spending and Funding Sources, 1950-1999 (in 2002 dollars)
Table 8.2 – Sources of Transit Revenues, 1950-1999

8.4.1 Alternative Delivery Strategies and Rail Transit

In the face of increasing funding demands and a lack of support from President Reagan in the 1980s, the Federal Transit Administration (FTA) launched several research and technical assistance initiatives to improve management of capital projects, reduce their costs and, perhaps most importantly, explore non-traditional funding sources.

The initial transit forays in alternative delivery strategies were Automated Guideway Transit (AGT) systems in airports and theme parks, and expanded to people mover systems in places like Miami and Detroit[231].

Plans for two extensive projects soon followed: full, urban fixed guideway systems in Honolulu and Houston[232]. Though a lack of political consensus kept these latter two projects from ever being constructed, they are still notable for establishing a procurement strategy that included innovative financing, joint development, advanced technology applications, and contractor-supplied operations and maintenance.

8.4.1.1 Turnkey Demonstration Program

ISTEA in 1991 included provisions for a Turnkey Demonstration Program to "foster advanced technology and the introduction of delivery mechanisms that decrease the developmental costs of new transit systems[233]." The turnkey system was defined by Congress as "a project under which a recipient contracts with a consortium of firms, individual firms, or a vendor to build a transit system that meets specific performance criteria and which is operated by the vendor for a period of time[234]."

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231 U.S. Department of Transportation. Federal Transit Administration. Turnkey Experience in American Public Transit: A Status Report.
232 Ibid.
233 Loulakis, 97.
234 U.S. Department of Transportation. Federal Transit Administration. Turnkey Experience in American Public Transit: A Status Report, xi.

The term "turnkey" is used because, theoretically, once the contract with the vendor is over the public sector takes back the asset and simply has to "turn the key" to keep the system functioning. To be precise, DBOM is often referred to as "Full Turnkey," D-B as "Modified Turnkey," and when private financing is included in the final bid the procurement may be described as "Super Turnkey[235]."

FTA received 17 letters of interest to participate in the program, from which eleven were invited to submit formal requests to participate. Ten formal proposals were submitted, and in April 1993 four projects were selected to participate:

- Baltimore Central Light Rail Transit (LRT) Phase II Extension;
- Bay Area Rapid Transit (BART) SFO Airport Extension;
- Los Angeles El Segundo Del Norte Green Line Station; and
- San Juan Tren Urbano Heavy Rail System.

The L.A. selection was subsequently changed to the Union Station Gateway Project and a fifth demonstration project, New Jersey Transit's Hudson-Bergen LRT system, was added in 1995.

8.4.1.1.1 Successes of Turnkey Demonstration Program

As with most pilot programs, the Turnkey Demonstration Program had its share of both achievements and lessons learned. The following is a list of some of the successes of the program:

1. Reduction in the number of contracts. The Baltimore LRT Phase I expansion, using traditional delivery, required 37 contracts, compared to 3 contracts under the Phase II expansion done via Turnkey. Similarly, the SFO BART extension needed 7 contracts compared to 49 contracts for similarly-priced East Bay extensions.
2. Lower cost per track mile for both heavy rail and light rail projects[236].
3. Reduction in soft costs, including design, project management, insurance, and financing. This is partly attributable to the fewer number of contracts[237].
4. Flexibility in recovering schedules or budgets in response to unforeseen circumstances or changes in market conditions[238]. For example, the Los Angeles Gateway Terminal Project was completed on-time and under budget despite:

    a) The Northridge earthquake of 1994 that necessitated re-welding of the building's steel frame;

    b) The floods which followed shortly thereafter; and

    c) Administrative changes that merged two transit authorities into one.

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[235] Ibid, 4.
[236] Loulakis, 103.
[237] Ibid.
[238] U.S. Department of Transportation. Federal Transit Administration. Turnkey Experience in American Public Transit: A Status Report, 4.

5. Time savings by being able to conduct procurement in parallel with completion of the Final Environmental Impact Statement (FEIS). In the Hudson-Bergen project, the timing worked out such that notice to proceed to the turnkey contractor coincided with the FEIS Record of Decision (ROD). In the Puerto Rico Tren Urbano project, the time lapse was only six months between ROD and notice to proceed with the turnkey contractor[239].

8.4.1.1.2 Lessons Learned From the Turnkey Demonstration Program:

Some Turnkey projects had their fair share of problems. Among the lessons learned from the Program are[240]:

1. Turnkey failed to significantly reduce administrative burden of the owner.
2. There was no shift of administrative costs and responsibility to Turnkey contractors.
3. Excessive reliability on subcontractors led to inferior designs[241]. On the first phase of the Hudson-Bergen LRT – the phase constructed as part of Turnkey – the D-B consortium subcontracted out for the design and the results were not stellar. On the later Phase II, the D-B team did the design itself, and was more responsive to civil and systems needs, which achieved a better product more easily.

8.4.1.1.3 Turnkey Project Comparisons

One of the strengths of these five particular projects having been chosen for the Turnkey Demonstration Program is that a parallel comparison can be performed between these projects and similar projects previously or concurrently constructed in those locations.

In Baltimore, the Phase II D-B project that was completed under Turnkey came in at $11M per route-mile, which was a full $2M less than the Phase I of the system, built as a traditional design-bid-build procurement five years earlier[242]. These amounts are both expressed in year 2000 dollars and represent a cost savings per route-mile of 18%[243].

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239 Interview with Fred Salvucci.
240 Loulakis, 99.
241 U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," 18-19.
242 U.S. Department of Transportation. Federal Transit Administration. Turnkey Experience in American Public Transit: A Status Report.
243 Ibid.

Maryland MTA Central Light Rail Line Comparison of Phases I and II		
	Phase I: Design-Bid-Build	Phase 2: Design-Build
Total Project Value	$360.4M (1991$)	$106.5M (1996$)
Alignment Length	22.5 miles	7.5 miles
Cost per Route-mile	$13.0M (2000$)	$11.0M (2000$)
Number of Contracts	39	5
Average Contract Value	$5.9M	$21.3M
Schedule Duration	5 years	3 years
Change Orders/Claims	>260	26
Total Value	$124.8M	$3.4M
Average Value	$478,000	$131,000

Table 8.3 – Maryland MTA LRT D-B-B vs. D-B Comparison
Note: Measured in route-miles per year, Phase I was 4.5 miles per year and only 2.5 miles per year for Phase II, but FTA notes that the slowdown occurred because of exogenous factors related to right-of-way acquisition issues and interfaces with parallel projects.

In San Francisco, a BART extension to the East Bay and to Colma were completed concurrently with the San Francisco International Airport (SFO) extension that was part of the Turnkey Program[244]. The design-bid-build East Bay and Colma extensions had the same project cost and a longer alignment, meaning a lower cost per route-mile. However, this is partly attributable to the increased difficulty in construction of the SFO extension. Despite these increased difficulties, measured in route-miles per year the airport extension was completed 4% faster than the traditional projects[245].

San Francisco BART Airport Extension Compared to East Bay and Colma Extensions		
	East Bay and Colma Extensions: Design-Bid Build	**SFO Airport Extension: Design-Build**
Total Project Value	$1.5B (2000$)	$1.5B (2000$)
Alignment Length	11.8 miles	8.2 miles
Cost per Route-mile	$129.7M	$184.5M
Number of Contracts	37	6
Average Contract Value	$41.4M	$252.2M
Schedule Duration	6 years	4 years

Table 8.4 – San Francisco BART D-B-B vs. D-B Comparison

On the Hudson-Bergen LRT project, a cost estimate was created for both the traditional design-bid-build and the Turnkey design-build options. Design-build provided a savings of $265M, or 30%, over the cost estimate of the traditional option[246]. D-B was also slated to save half the amount of time, but key issues arose after the D-B contract was underway related to the right-of-way (ROW) not being fully available that slowed the environmental and permitting processes and led to changes in the alignment. These delays, of course, would have also added time to the design-bid-build projection. However, under traditional D-B-B, this would have led to a non-competitive contract renegotiation, under which the contractor could stand to gain more than under the D-B model that had already locked in the contract terms[247].

244 Ibid.
245 Ibid.
246 Ibid.
247 Ibid.

Hudson-Bergen Initial Operating System Comparison of Design-Build Estimates to Original Design-Bid-Build Estimates		
	Design-Bid-Build	**Design-Build**
Total Project Value	$877M (1999$)	$612M (1999$)
Alignment Length	9.5 miles	9.5 miles
Cost per Route-mile	$92.3M (1999$)	$64.4M (1999$)
Number of Contracts	~60	3
Average Contract Value	$14.6M	$193.0M
Schedule Duration	8-10 years	4-5 years
Change Orders/Claims	~250	~5
Total Value	$80M	$11.0M
Average Value	$320,000	$2,200,000

Table 8.5 – Hudson-Bergen LRT D-B-B vs. D-B Comparison

The FTA's interim report on Turnkey confirms that many cost overruns on these projects were not related to D-B[248].

8.4.2 FTA New Starts Program

Since the 1990s, the FTA New Starts program has been the federal government's primary financial resource for locally-planned, implemented, and operated transit guideway capital investments.

The goal of any project being proposed through the New Starts program is to obtain what is known as a Full Funding Grant Agreement (FFGA). An FFGA is the federal government's commitment to support a transit project over the course of several fiscal years, up to a maximum amount, contingent upon the availability of funds. As funds are appropriated, the full funding projects receive priority consideration.

8.4.2.1 Funding Levels Under New Starts

Under New Starts, 80% of a project's capital cost can be covered, and in some unique cases Congress has authorized a full 100% share[249]. In practice, however, the average New Starts project receives about half of its funding from the program. The share has averaged around 50% over the last ten years and has been trending lower due to increasing demand[250].

8.4.2.2 Growth of New Starts since 1990s

Before passage of ISTEA, there were fewer than ten New Starts projects being implemented through active FFGAs[251]. ISTEA broadened the criteria that FTA uses to evaluate projects, perhaps leading more sponsors to believe that they might successfully pursue New Starts funding[252].

248 Loulakis, 222.
249 Emerson, 5.
250 Ibid.
251 Ibid, 2.
252 Ibid, 3.

By 2001, FTA had entered into 32 FFGAs for New Starts projects under ISTEA and its successor, TEA-21, with a total federal commitment for these 32 projects of $10.1B[253]. The total number of projects with existing, pending, and proposed FFGAs grew from 26 in 1994 to 68 in early 2001[254].

SAFETEA-LU authorized $6.6B for New Starts through fiscal year (FY) 2009[255]. It also created new categories for New Starts known as Small Starts and Very Small Starts, intended to provide funding for much smaller projects such as Bus Rapid Transit (BRT).

Funding for New Starts has never been higher, but neither has the demand for such funding. SAFETEA-LU includes funding for over 330 projects that have proposed, pending, or existing FFGAs[256].

8.4.2.3 Environmental Issues Under New Starts

Under NEPA, until the record of decision (ROD) is issued on the EIS, the public sector cannot do anything that would "limit choice of reasonable alternatives[257]." Unless a special exception applies, agencies are precluded from acquiring right-of-way, proceeding to final design, and applying for an FFGA, until issuance of a ROD.

8.4.2.4 New Starts Hurdles to Alternative Delivery Strategies

FTA's process for evaluating projects under its New Starts program does not bode well for fast-tracking and innovative project delivery such as D-B. In practice, significant design detail is required to satisfy FTA's requirements prior to execution of an FFGA. State agencies have noted that there have been proposals requiring as much as 80% design[258]. With D-B the design is generally developed to a maximum of about 30% before issuing the D-B contract[259].

Considering that FFGAs are the primary source of FTA funding for large capital transit projects, it is clear that there is a need to modernize the New Starts program. This is an issue that will hopefully be addressed administratively in the reauthorization of SAFETEA-LU.

8.4.3 Alternative Delivery Strategies in Rail Transit post-Turnkey

These hurdles have not fully prevented ADSs under New Starts. Since 2000, New Starts transit projects that have been procured using D-B include[260]:

- Denver RTD Southeast Corridor LRT;
- South Florida Commuter Rail Upgrades;

253 Ibid, 1.
254 Ibid, 2.
255 U.S. Department of Transportation. Federal Transit Administration. "Introduction to New Starts."
256 Ibid.
257 U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," 34.
258 Ibid, 19.
259 Loulakis, 223.
260 U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," 4.

- Minneapolis Hiawatha LRT;
- NJ Transit Hudson-Bergen LRT Phase II; and
- Washington Metropolitan Area Transit Authority (WMATA) Largo Metrorail Extension.

In total, 28% of the costs of major transit capital projects approved under the FTA New Starts program have been, or are being delivered as alternative delivery strategies since 2000[261].

In addition, two non-New Starts fixed guideway projects funded in part by federally-approved airport Passenger Facility Charges (PFCs) have been delivered using D-B[262]:

- Portland MAX Airport Extension; and
- JFK Airtrain.

A number of local transit agencies have also used D-B since the FTA Turnkey program. Los Angeles did traditional D-B-B for most of its metro, but after its Pasadena extension was transferred from the Los Angeles County Metropolitan Transportation Authority (LACMTA) to the Pasadena Light Rail Authority, the new authority elected D-B[263]. The new authority felt that D-B would help remedy a number of the major problems that plagued LACMTA, including major cost overruns from both owner-directed and contractor-requested change orders[264]. The Authority also appreciated D-B's single point of responsibility for project development and ability to accelerate the project schedule to help reduce the final cost of this project that had been held up for years[265].

8.4.3.1 North American Rail Projects Using Alternative Delivery Strategies

North American rail projects that have utilized alternative delivery strategies have ranged in size and scope from relatively small, at-grade light rail extensions with minimal disruption, to much larger heavy rail projects that involved significant tunneling, risk, and environmental remediation. A summation chart for projects with capital costs over $100M follows. Short synopses of all of these projects may be found in Appendix A.

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[261] U.S. Department of Transportation. Federal Highway Administration. "User Guidebook on Implementing Public-Private Partnerships for Transportation Infrastructure Projects in the United States," 62.

[262] U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," 4.

[263] Loulakis, 192.

[264] Ibid.

[265] Ibid.

Project	Cost ($ million)	Project Type	Procurement Method*	On-time?	Under Budget?
Alameda Freight Corridor	$2,500	Heavy	D-B-B & D-B	Y	Y
Puerto Rico Tren Urbano	$2,250	Heavy	D-B & DBOM	N	N
NJ Hudson-Bergen LRT Phases 1 & 2	$2,200	Light	DBOM	Y	Y
New York City JFK Airport Airtrain	$1,900	Light	D-B-B & DBOM	N	Y
Denver Transportation Expansion (T-REX)	$1,620	Light	D-B	Y	Y
San Francisco BART SFO Extension	$1,500	Heavy	D-B & D-B-B	N	N
Vancouver Skytrain Canada Line	$1,410	Light	DBFOM	Y#	Y#
NJ Transit RiverLine	$998	Light	DBOM	N	N
L.A. Metro Gold Line Eastside Extension	$900	Heavy	D-B-B & D-B	Y#	Y#
Minneapolis Hiawatha LRT	$680	Light	D-B & D-B-B	Y	Y
Las Vegas Monorail	$650	Light	DBFOM	N	Y
Washington, DC Blue Line Extension	$610	Heavy	D-B & D-B-B	Y	Y
Greenbush Commuter Rail	$512	Commuter	D-B	N	N
South Florida Commuter Rail Upgrades	$240	Commuter	D-B	Y	Y
Portland MAX LRT Airport Extension	$125	Light	DBFOM	Y	Y
Baltimore LRT Extension	$110	Light	D-B	Y	Y

Table 8.6 – North American Rail Transit Projects Utilizing Alternative Delivery Strategies
** When more than one contract type was used, the predominant one is listed first*
 # Anticipated

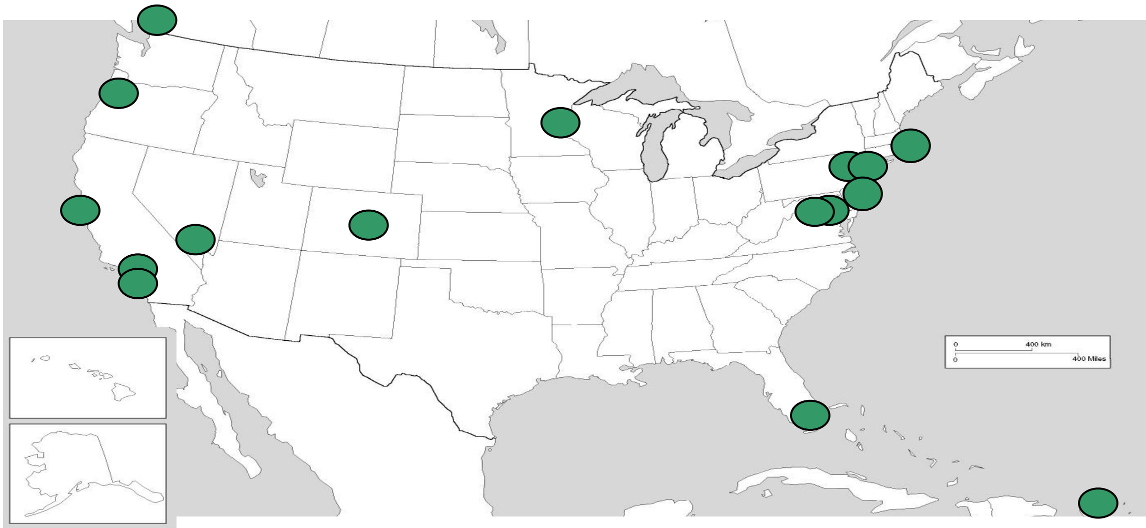

Figure 8.9 – Map of North American Rail Transit Projects Utilizing Alternative Delivery Strategies

8.4.3.1.1 Delivery Partners on North American Rail Projects

Evidence on delivery partners from North American rail projects utilizing alternative delivery strategies is mixed. Slightly less than half of these 16 U.S. and Canadian projects used a designated delivery partner.

Delivery Partner	No Delivery Partner
Alameda Corridor	Vancouver Canada Line
Tren Urbano	Denver T-REX
NJ Hudson-Bergen LRT	San Francisco BART SFO Extension
JFK Airtrain	NJ Transit RiverLine
Las Vegas Monorail	L.A. Metro Gold Line
Washington, DC Blue Line Extension	Minneapolis Hiawatha LRT
Portland MAX LRT Airport Extension	Greenbush Commuter Rail
	South Florida Commuter Rail Upgrade
	Baltimore LRT

Table 8.7 – North American Use of Delivery Partners in Rail Megaprojects

Most significant is the fact that each of the four largest projects in terms of final capital costs – Alameda Corridor, Tren Urbano, Hudson-Bergen LRT, and the JFK Airtrain – had a delivery partner. The U.S. and Canadian cases suggest that delivery partners can be beneficial, and perhaps necessary, on megaprojects with many direct interfaces, like Crossrail.

Among those seven projects to use a delivery partner are three of the six projects that were delivered late and one of the four that was over budget. This evidence is inconclusive to suggest any causal relationship. Although the inclusion of a delivery partner is intended to help streamline procurement and ideally expedite a project's completion, it also adds another layer of personnel and potential bureaucratic hurdles. Those agencies that have hired delivery partners, however, often find that the added expense yields better results.

The following is a synopsis of delivery partner structures from the North American cases:

Alameda Corridor: The Alameda Corridor Transportation Authority (ACTA) created the Alameda Corridor Engineering Team (ACET) as the lead program manager. ACET was a joint venture of four firms: DMJM Harris; Moffatt & Nichol Engineers; Jenkins/Gales & Martinez; and TELACU[266][267].

Tren Urbano: The Puerto Rico Highway and Transportation Authority (PRHTA) moved into project implementation in 1994 by contracting with a General Management and Architectural/Engineering Consultant (GMAEC) to complete the environmental process, develop a 30% design, and manage the bidding and the final design and construction. The GMAEC was led by DMJM Harris, along with two local firms and 22 subcontractors[268].

NJ Hudson-Bergen LRT: Project advisors included Parsons Brinckerhoff (PB), Booz Allen Hamilton, and Nossaman, Guthner, Knox & Elliott, LLP[269]. NJ Transit awarded a $1M contract to Booz Allen Hamilton for consulting services. Nossaman was retained by NJ Transit to assist in structuring procurement and contract documents. PB's role in the project was to serve as the general design consultant. PB developed the preliminary design and bid documents, and served as an extension of NJ Transit staff throughout construction[270][271][272][273].

JFK Airtrain: Parsons Brinckerhoff (PB) provided conceptual and general engineering consultant services. PB prepared the RFQ and RFP documents for the DBOM contract, assisted the Port Authority of New York and New Jersey (PANYNJ) in managing the procurement, and supported the Federal Aviation Administration (FAA) EIS process.[274]

Las Vegas Monorail: The Las Vegas Monorail Company (LVMC) entered into a management contract with Transit Systems Management – a joint venture (JV) of Bombardier Transit and Granite Construction – for the DBOM[275]. Project Advisors included Booz Allen/G.C. Wallace, Public Resources Advisory Group, Orrick Harrington, Broadbent & Walker, Nossaman, Guthner, Knox & Elliott, LLP, Public Financial Management Consultants, URS Greiner, Carter & Burgess, Stradling Yocca Carlson Rauth, and Wilbur Smith[276][277][278].

Washington, DC, Blue Line Extension: WMATA completed the preliminary engineering for the project and prepared the bid documents in conjunction with Capital Transit Consultants (CTC). AECOM was a senior partner in CTC, a JV providing a full array of planning, engineering & construction

266 Parsons. "Alameda Corridor: Project Profile."
267 Alameda Corridor Transportation Authority, http://www.acta.org/about_governance.htm.
268 Middleton, 2000.
269 American Association of State Highway and Transportation Officials. "Hudson-Bergen Light Rail – Hudson/Bergen Counties, NJ."
270 Scarcia.
271 American City and County. "Hudson-Bergen Project is on Track."
272 Railway Technology. "Hudson-Bergen Light Rail System, USA."
273 Ibid.
274 Parsons Brinckerhoff. "Airport Development: Creating Vision, Building Reality."
275 Dunscombe, Cartwright, and Moore.
276 Loulakis, 263.
277 Dunscombe, Cartwright, and Moore.
278 U.S. Department of Transportation. Federal Highway Administration. "PPP Case Studies: Las Vegas Monorail."

services to WMATA[279]. WMATA performed "over the shoulder" reviews of the major structural elements of the project while the design was being advanced. The WMATA reviews helped to identify potential design issues early in the process so that the design team could address the issues prior to making actual design submittals. The rapid resolution of these issues allowed the design team to immediately begin advancing the design while addressing the changes required by the review comments[280].

Portland MAX LRT Airport Extension: Parsons Brinckerhoff (PB) provided program management support to the Port of Portland for the $500M airport capital improvement program, which included the 5.5-mile Portland MAX LRT extension[281][282].

8.4.3.2 FTA PPP Pilot Program (Penta-P)

In January 2007 FTA outlined a new pilot program known as Penta-P, which was authorized by the 2005 SAFETEA-LU federal transportation bill. The pilot program is intended to allow U.S. DOT to study whether, in comparison to conventional procurements, DBFOMs achieve benefits in terms of risk, delivery acceleration, improved cost reliability, and project performance. It is important to note that a project is eligible to be part of Penta-P only if state and local laws permit non-conventional procurement for *all* stages of delivery[283].

As of March 2008, three Penta-P projects had been selected:

- Bay Area Rapid Transit (BART) Oakland Airport (OAK) Connector;
- Houston METRO LRT and bus rapid transit (BRT); and
- Denver Gold Line LRT and East Corridor LRT.

8.4.3.2.1 BART OAK Connector

The BART OAK connector Penta-P project provides a look at how planned projects have suffered as a result of the economic recession that began in 2008[284]. The project calls for a driverless, automated people mover to close a 3.2-mile gap between the airport terminal and the nearest BART station. Currently that trip is served by the AirBART bus route with 20-30 minute headways[285].

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279 AECOM Enterprises/DMJM+Harris. "Who We Are."
280 Korzym, Lark, and Brennan.
281 Parsons Brinckerhoff. "Program Management."
282 Wolinsky.
283 U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," 33.
284 Tom Dunscombe Presentation, BART, Transportation Research Board Annual Meeting, January 13, 2009.
285 Ibid.

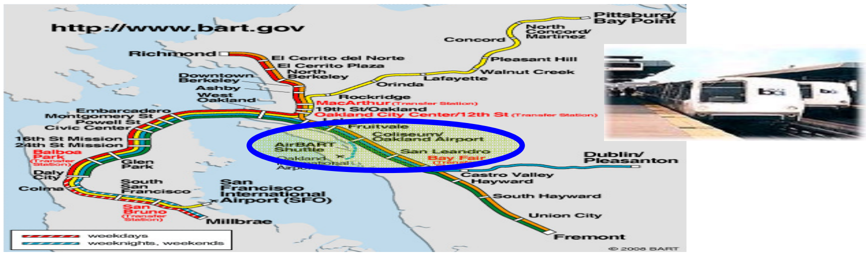

Figure 8.10 – BART OAK Connector Map

The capital cost of the project is $380M. A combination of local bridge tolls, a county sales tax, and a contribution from the Port of Oakland were expected to provide $260M, leaving the project $120M short.

In 2004-2005 the Oakland International Airport (OAK) was experiencing tremendous growth. Two of the nation's largest "low-cost" carriers, Southwest and Jetblue, had set up hubs there, and OAK came to be a viable alternative to the San Francisco International Airport (SFO) across the Bay and Mineta San Jose International Airport south of the Bay. OAK captured 48.5% of the market share in the Bay Area in 2004[286].   Revenue projections were quite strong given the airport's recent growth.

BART hired its own financial advisor, Ernst & Young, to perform a revenue analysis, and based on expected growth it was believed that if the current $3 fare on the AirBART bus was increased to $5-$6 for the new people mover then revenues could fund all of the operations and even some of the capital costs.

This environment was enticing to the private sector, and as such BART investigated DBFOM options in 2004-2005. BART first drafted a concession to procure the people mover system along with a 35-year operations and maintenance contract. The following table shows the key components of the risk allocation in the original RFP[287]:

Concessionaire Risk	BART Risk
Invests approx. **$190M** Design – Construction – Testing - Startup	Invests approx **$190M** 3rd Party delays unforeseen conditions – utilities – hazardous waste
35 YEARS of OPERATION ▪ all defects & flaws • all capital reinvestment & refurbishment costs • 5 years of useful life at handover • Performance Payment based on service availability and performance criteria: • Deductions for less than **99.5%** Availability • Deductions for failure to meet minimum amenity standards (cleanliness, upkeep of facilities, etc.)	Sets and collects fares Obligated to make Performance Payment to Concessionaire (for **35 years**) from fare revenues and Ridership Reserve Fund, for the capital investment + operating expenses + reasonable return on investment (approx **$18M** per yr) Monitors Concessionaire performance and adjusts Performance Payment accordingly Budgeted **$38M** Public funds for Ridership Reserve to cover revenue shortfalls during the ridership ramp up period
10% of Payment is based on actual ridership. Periodic rebasing to limit long-term losses and windfalls.	Revenue surplus shared but capped (no concessionaire windfall)

Table 8.8 – BART OAK Connector Risk Allocation

286 Port of Oakland. "Market Analysis: Oakland International Airport."
287 Tom Dunscombe Presentation, BART, Transportation Research Board Annual Meeting, January 13, 2009.

As the table demonstrates, both the concessionaire and BART were to put up $190M up-front for capital costs. The concessionaire is responsible for all capital reinvestment and refurbishment costs over the life of the 35-year contract, and the concessionaire is repaid its capital investment almost exclusively based on its performance. BART estimated that it could afford approximately $18M in annual payments, of which about $11M was to go to pay back capital costs and $7M to fund O&M. BART insisted that the concessionaire assume a 10% risk for ridership. The prospective bidders balked at the notion of being held even slightly liable for ridership given that they had virtually no control over ridership and didn't trust the ridership projections to begin with. As a compromise, every two years the projections were to be recalculated to limit ridership risk long-term.

In 2006 BART pre-qualified three prospective concessionaire teams. In 2007 BART put the concession out for proposal. One team dropped out early on, and another eventually dropped out as well, citing cost concerns. This left the "Airport Connector Team" joint venture as the sole concessionaire.

While detailed negotiations were ongoing with the Airport Connector Team in advance of a signed final contract, several developments occurred that drastically altered the aviation landscape in the Bay Area and led to legitimate concerns about costs, ridership, and revenue projections.

First, in 2007, Virgin America Airlines announced intentions to move into SFO with 40-50 flights per day. Southwest Airlines, which previously had only been at OAK in the Bay Area decided to move a similar amount of its business to SFO in order to compete with Virgin. SFO benefited from already having a direct BART connection constructed several years prior.

Business at OAK plummeted drastically by 20%. Other issues related to airline consolidation, fuel cost instability, and increased competition completely doomed the project as planned. The Airport Connector Team dropped out in October 2008. The following table shows how dramatically ridership projections have dropped[288]:

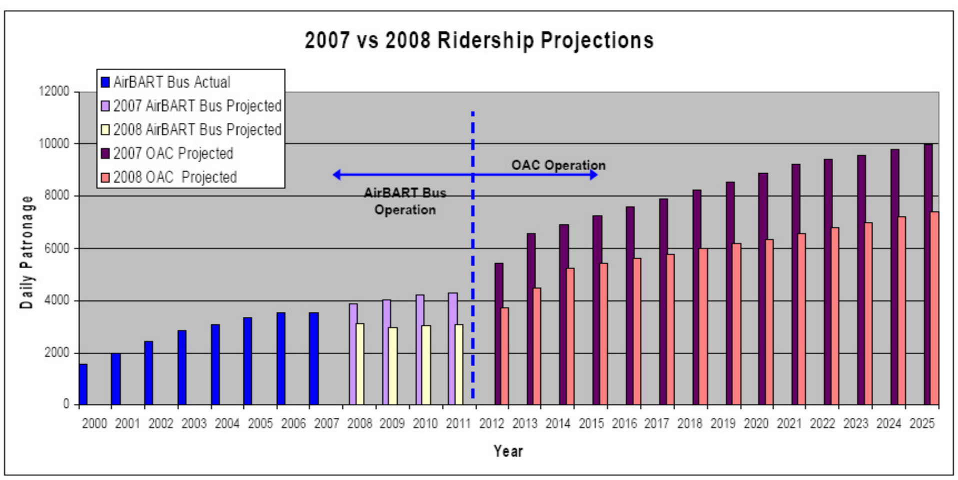

Figure 8.11 – BART OAK Connector 2007 vs. 2008 Ridership Projections

[288] Ibid.

BART, having now admitted that the original cost estimations are no longer accurate, is back to the drawing board. They are hoping to find ways to cut costs to still entice interest in the project as a DBFOM.

8.5 Emergence of the Private Finance Initiative in the U.K.

During the 1980s, the provision of private finance for public projects was governed by the Ryrie Rules. Enacted in 1981, the Ryrie Rules established that public sector projects should be privately financed only if they are demonstrated to provide more value for money over public financing, and that privately financed public investment should still be treated as a public expenditure[289]. The rationale was that there was little economic difference between the government borrowing and private sector borrowing to finance public projects. The Ryrie Rules were seen as an obstacle to the use of private financing and were abolished in 1989.

The Private Finance Initiative (PFI) movement began in the early 1990s amid growing concern for a lack of public investment and maintenance spending[290]. While the generic term PPP has been increasingly adopted in the U.K., PFI still predominates[291]. PFIs transform the government's role in infrastructure provision towards being the purchaser of services from the private sector[292].

There are three types of PFIs: Turnkey, DBFOM, and Joint Venture (JV), the latter of which is when the repayment is made by a combination of user fees and government subsidies to account for beneficial social and economic externalities. The Docklands Light Railway in London is an example of a JV[293].

PFIs were slow to develop, however, due to a complicated institutional structure. A provision known as the Universal Testing Rule (UTR), which required that PFI be considered for all public sector projects, led to significant delays[294].

Labour had generally been opposed to the Margaret Thatcher Conservative government-led privatization movement of the 1980s and 1990s[295]. This perspective changed with the election of Tony Blair's "New" Labour government in 1997[296]. PFIs emerged as a middle ground between the Conservative privatization movement and Labour's socialist policy that has historically promoted public ownership of key industries, including transportation.

New Labour quickly abandoned the UTR, and support of PFIs ultimately became a key distinguishing feature between Old and New Labour[297]. In May 1997, Malcolm Bates, a senior industrialist, was asked to identify the obstacles hindering successful PFI projects and to make specific proposals to streamline the process[298]. This first Bates Review included 29 specific

289 Hemming, 64.
290 Ibid.
291 Broadbent and Laughlin, 335.
292 Zhang and Kumaraswamy, 352.
293 Berg, Pollitt, and Tsuji, 72.
294 Hemming, 64.
295 Osbourne, 43.
296 Ibid, 120.
297 Ibid, 122.
298 Zhang and Kumaraswamy, 353.

recommendations concerning institutional restructuring, improving the PFI process, and measures to reduce bidding costs[299].

The overall experience with PFIs in the U.K. has been extremely positive. Several studies have quantified the average cost savings for PFIs over public provision to be 10%-20%[300]. Mott MacDonald (2002) and the National Audit Office (2003) also found the PFIs are delivered on-time more often than traditional public procurement[301]. It is no surprise, then, that the number of PFIs executed in the U.K. steadily increased in the late 1990s and early 2000s. HM Treasury in 2005 reported that the U.K. government had committed £42.7B for 667 PFIs by the end of 2004[302]. Growth had been particularly significant after 2000 and then stabilized at a still sizable 11% share of total public investment[303].

Transportation, and specifically rail, is one of the major sectors of PFIs, especially as a share of total PFI investment[304]. At the end of 2004, 51% of the total value of PFIs was in the railway sector alone, while the health care sector was second with 11%. Three London Underground (LUL) projects, as well as the Channel Tunnel Rail Link (CTRL), accounted for a significant portion of this railway PFI investment[305].

PFIs are not without their critics. One of the key drawbacks is the high cost of procurement. Tender costs for PFI projects range from 0.48%-0.62% of total project costs, compared to 0.18%-0.32% for design-build projects and only 0.04%-0.15% for traditional projects[306]. The long lead times and high costs associated with the PFI bidding process make PFIs not appropriate for projects with low capital costs, but arguably quite appropriate for megaprojects[307].

8.5.1 PFI Balance Sheet Implications

A key motivation for PFIs in the U.K. is to move large, expensive capital projects off the public sector financial roles, or "off balance sheet." Off balance sheet status represents a type of "back door" financing, as payments under an off balance sheet provision correlate to the year in which they relate, rather than in full upon the signing of the agreement[308]. This allows government to spread the costs of a project across its lifespan, rather than as a lump sum. In so doing, the public sector can preserve its credit rating and expand the number of services it can provide[309].

Getting a project off balance sheet helps ensure compliance with two key U.K. provisions: the Golden Rule and the Sustainable Investment Rule (SIR). The Golden Rule states that government will borrow only to invest and not to fund current spending[310]. Therefore, over the economic cycle the current budget, net of investment, must be in balance or carry a surplus. The SIR is a

299 Ibid.
300 Hodge, 157.
301 Ibid.
302 Priemus, Flyvbjerg, and van Wee, 190.
303 Renda and Schrefler, 4.
304 Ibid.
305 Ibid.
306 Zhang and Kumaraswamy, 352-353.
307 Her Majesty's Treasury. "Value For Money Assessment Guidance," 7.
308 Grimsey and Lewis, 150-151.
309 Ibid, 153.
310 Quiggin, 53.

component of the Golden Rule and restricts aggregate public debt to 40% of GDP[311]. Both of these rules are meant to avoid many potential problems stemming from government borrowing, notably higher debt interest payments and also inflation.

Off balance sheet PFIs do bring higher contract charges than their on balance sheet counterparts, however, since a project done on balance sheet is seen as having a stronger financial footing. A decision to do a large-scale project on balance sheet may provide greater value for money, but it will ultimately reduce delivery options since the PFI option will likely be rejected in favor of an inferior one.

8.6 North American/European Comparison

In many respects, North American and European attitudes towards alternative delivery strategies were similarly aligned in the early 1990s before diverging quite significantly[312]. In 1993, for example, there were 59 transportation infrastructure DBFOMs already under development in the North America versus 50 PFIs under development in Europe. One distinct difference at the time was the sheer size of these projects. The North American projects had a total cost of $23.4B, or $397M per project, while Europe's projects came in at a total cost of $49.2B, or nearly $1B per project. Since then, however, the European investment in PFIs has clearly outpaced the North American investment in alternative delivery strategies, especially the U.S.'s investment.

[311] Ibid.
[312] Levy, 1996, 13.

Chapter 9: Alternative Delivery Strategy Public Funding Mechanisms

Changes in law and innovations in financing have created a wide array of options for transportation projects that complement and enhance existing pay-as-you-go funding sources[313]. These techniques range from fairly modest strategies that permit states greater flexibility in satisfying the standard matching requirements for receipt of federal funds to very ambitious credit enhancement strategies.

Cynics will argue that these funding mechanisms merely offset inadequate funding that has prevailed in the past 15 years, and that it is unclear whether the money would have been better spent if simply distributed in a grant or formula structure.

This chapter identifies several of these new approaches to financing projects that are applicable to alternative delivery strategies[314].

9.1 TIFIA Credit Program

The Transportation Infrastructure Finance and Innovation Act (TIFIA) of 1998 offers three types of credit assistance to large-scale transportation projects of regional or national significance[315]:

1. Direct loans from the government;
2. Federal guarantees for payments on debt service; and
3. Standby lines of credit available to projects should their project revenues fall short of projections.

The fundamental goal of the program is to leverage federal funds by attracting substantial private and other non-federal co-investment[316].

Certain stipulations are included in the legislation[317]:

- funds received cannot exceed one-third of the total capital cost of the project;
- loans must be repaid with user fees or special state and local taxes (as opposed to future federal funds); and
- projects must be expected to cost $50M or more, with the exception of ITS projects, which must be $15M or more.

313 U.S. Department of Transportation. Federal Highway Administration. "Manual for Using Public-Private Partnerships on Highway Projects," 10.
314 Ibid.
315 Jon Bottom Lecture, MIT.
316 U.S. Department of Transportation. Federal Highway Administration. "Manual for Using Public-Private Partnerships on Highway Projects," 10.
317 U.S. Department of Transportation. TIFIA Program.

TIFIA funds are available for both highway and transit projects, and for projects utilizing either traditional or alternative delivery strategies[318][319]. This enables both the public and private sectors to improve their balance sheet situations in procuring transportation projects[320].

To date, the TIFIA program has provided nearly $5.8B in assistance to 18 projects whose total project costs are nearly $21.8B[321].

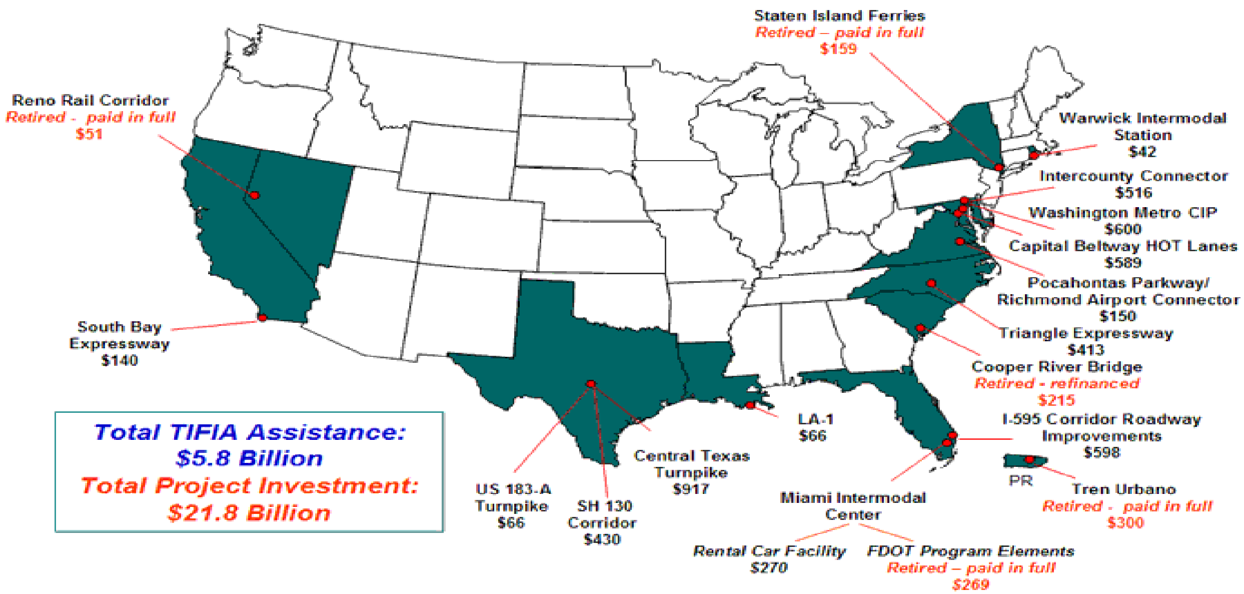

Figure 9.1 – TIFIA Credit Program Project Map

However, the TIFIA program was slow to develop, and as a result Congress rescinded $257M originally allocated to the program[322]. Only $610M was allocated to TIFIA from 2005-2009[323].

As interest in alternative delivery strategies has grown, TIFIA has become more popular. As of late November 2008, there were seven TIFIA applications being evaluated by U.S. DOT and six more letters of interest pending[324]. Not all of these projects can be funded. In fact, just two months into FY 2009, all TIFIA funds had been committed for the year.

318 Loulakis, 69.
319 Canadian Council on Public-Private Partnerships National Conference, Toronto, Canada, November 24-25, 2008.
320 Ibid.
321 U.S. Department of Transportation. TIFIA Program.
322 Canadian Council on Public-Private Partnerships National Conference, Toronto, Canada, November 24-25, 2008.
323 Ibid.
324 Ibid.

9.1.1 TIFIA Benefits

TIFIA credit assistance has many features that make it attractive to private investors[325]:

- *Revenue leverage.* TIFIA can leverage revenue streams that otherwise might be considered too risky to obtain needed capital market financing. This is particularly useful for user fee-based projects with uncertain revenues.
- *Interest cost savings.* For projects that must access the taxable debt markets, borrowing rates are typically well above the comparable U.S. Treasury yield. Because the DOT lends TIFIA funds at the U.S. Treasury's borrowing rate, with no premium for credit risk, it can provide an attractive interest cost. Even for projects able to access the tax-exempt municipal market, TIFIA direct loans may prove cost-effective.
- *Payment flexibility.* TIFIA provisions aim to facilitate financings backed by user charges by allowing debt service to be structured according to project cash flows. Often this entails deferral of interest not only during construction but also during the project's ramp-up of operations, which private investors may be hesitant to accept. In addition, the TIFIA program allows borrowers to prepay at any time without penalty. This same flexibility, through the municipal bond market, could add as much as 0.5% to the borrowing cost, depending on market conditions.
- *Project acceleration.* TIFIA can expedite financing and accelerate the public benefits flowing from a completed facility. In many cases, TIFIA assistance is viewed as essential in advancing the project more quickly and at a lower cost.
- *Long terms of maturity.* The final maturity date of TIFIA credit can be as much as 35 years after the date of completion of the project.

9.2 GARVEE Bonds

A Grant Anticipation Revenue Vehicle, or a GARVEE bond, is a debt financing instrument that enables a state to pledge future federal funds for debt service and related financing costs[326]. Costs eligible for reimbursement include interest payments, retirement of principal (including any capitalized interest), issuance costs, and credit enhancement fees, such as bond insurance premiums[327]. Sponsors must be willing to reserve a portion of future Federal-aid highway funds to satisfy debt service requirements.

GARVEEs enable states to generate up-front capital for major highway projects that the state may be unable to construct in the near term using traditional approaches. Transit agencies use a similar mechanism known as a Grant Anticipation Note, or GAN. Candidates for GARVEE or GAN financing are typically projects, or a program of projects, that are large enough to merit borrowing

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325 U.S. Department of Transportation. Federal Highway Administration. "Manual for Using Public-Private Partnerships on Highway Projects," 11-12.
326 U.S. Department of Transportation. GARVEEs.
327 U.S. Department of Transportation. Federal Highway Administration. "Manual for Using Public-Private Partnerships on Highway Projects," 19.

rather than pay-as-you-go grant funding, with the costs of delay outweighing the costs of financing[328].

Between 1997 and November 2005, fourteen states plus Puerto Rico and the U.S. Virgin Islands issued GARVEE bonds, totaling $4.8B[329].

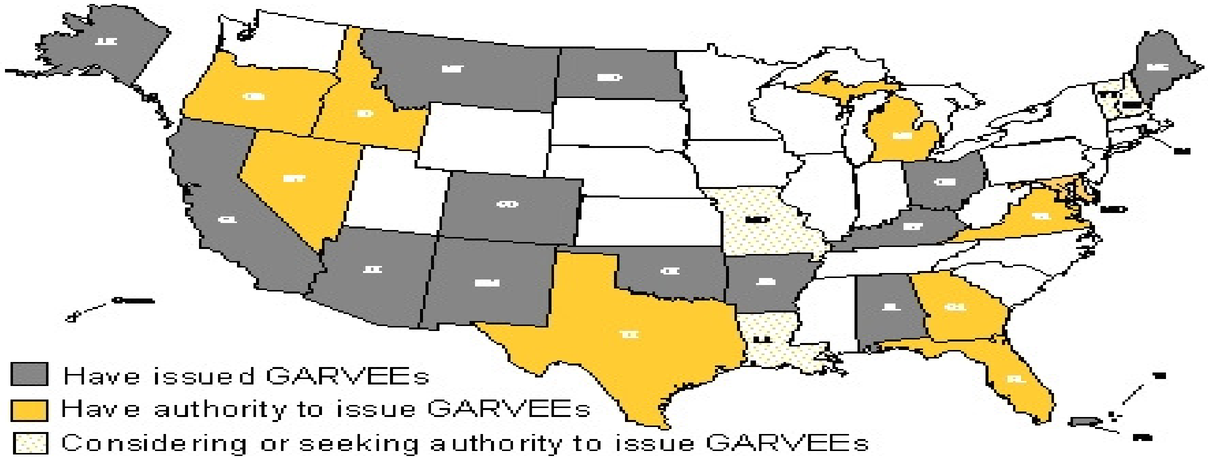

Figure 9.2 – GARVEE Bond Project Map

GARVEEs can be especially helpful for states seeking to fund a local matching requirement for transportation megaprojects.

9.3 Private Activity Bonds (PABs)

The Private Activity Bond (PAB) prevision in SAFETEA-LU allows the private sector to tap into the tax-exempt bond market[330]. Under PABs, the federal government has set aside $15B for surface transportation projects that have private partners, including privately financed toll roads[331]. Funds are allocated based on a review of formal applications by FHWA[332].

Passage of the PAB legislation reflects the government's desire to increase private sector investment in U.S. transportation infrastructure[333]. Providing private developers and operators with access to tax-exempt interest rates lowers the cost of capital significantly, making investment opportunities in transportation infrastructure more attractive for private sector partners.

The impact of PABs has been felt on projects nationwide. In June 2008, nearly $600M worth of PABs were issued for the Capital Beltway High Occupancy Toll (HOT) project in Virginia, along with a TIFIA loan for a similar amount[334]. This accounts for more than half of total project costs,

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328 U.S. Department of Transportation. GARVEEs.
329 Ibid.
330 Massachusetts Joint Committee on Transportation Hearing, November 26, 2008.
331 Canadian Council on Public-Private Partnerships National Conference, Toronto, Canada, November 24-25, 2008.
332 Perez and March, 14.
333 Ibid.
334 Virginia HOT Lanes. "Project Info."

and the interest rate on this senior debt is only 4.97%[335][336]. The proposed privatization of the Pennsylvania Turnpike also secured PABs in the amount of $2B[337].

9.4 Section 129(a) Loans

U.S. tax law allows states to loan some of their Federal-aid funds to pay for projects with dedicated revenue streams[338]. A state may directly lend apportioned Federal-aid funding to projects generating a toll or that have some other dedicated revenue such as excise taxes, sales taxes, property taxes, motor vehicle taxes and other beneficiary fees[339].

The way the loan program works, in theory, is that a state can lend out the money and then recycle that money into future projects later on[340]. Loans can be in any amount, up to 80% of the project cost, provided that a state has sufficient obligation authority to fund the loan.

Borrowers must begin to repay the loans within five years after the project is completed, and the loan must be wholly repaid within 30 years from the date federal funds are authorized for the loan[341]. States have discretion to set interest rates, so long as the rates are at or below market rates and improve the financial feasibility of the project receiving the loan.

335 U.S. Department of Transportation. TIFIA Program.
336 Poole, Robert W. "Cost of Capital for Private-Sector Toll Roads."
337 Canadian Council on Public-Private Partnerships National Conference, Toronto, Canada, November 24-25, 2008.
338 Akintoye and Beck, 205.
339 U.S. Department of Transportation. Federal Highway Administration. "Manual for Using Public-Private Partnerships on Highway Projects," 16.
340 Ibid.
341 Ibid, 17.

Chapter 10: Review of Studies on Alternative Delivery Strategies

Over the past 20 years there have been a number of formal studies, both in the U.S. and U.K., that have sought to achieve consensus on the industry's impressions of alternative delivery strategies, especially design-build. This chapter will convey the major findings of those studies.

10.1 FHWA Design-Build Effectiveness Study

Between 1990-2002, about 300 projects representing $14B were proposed for D-B contracting under Special Experimental Project Number 14 (SEP-14) on Innovative Contracting, which was established by the FHWA to enable state transportation agencies to test and evaluate alternative delivery strategies strictly on highway projects[342]. Of this total, 140 projects representing $5.5B were completed by the end of 2002[343].

10.1.1 Study Participants

The FHWA Design-Build Effectiveness Study included both a "program" survey and a "project" survey. The "program" survey compiled transportation agency managers' impressions of D-B and the extent to which D-B had or had not been successful on agency projects. It sought input from the 32 state agencies (and the District of Columbia) that had administered D-B projects at the time[344]. Of those 32 states, 27 of them, including two local toll agencies as well as the District of Columbia completed the D-B program survey, for an 85% response rate[345].

The "project" survey looked at the results of specific projects, rather than the administration of any of the state programs. A sample of 86 projects out of the 140 that had been completed by 2002 were selected for the project survey, representing 22 states and a broad cross-section of completed projects in terms of type and size[346]. Among the 22 states receiving surveys, 19 states submitted a total of 69 project surveys, representing an 80% response rate[347].

10.1.2 Comparability

Respondents were asked to identify a comparable project using D-B-B for each D-B project surveyed, where a truly comparable project could be identified. This turned out to be a challenging effort due to the difficulty in determining comparability. Seven states submitted surveys for 17 comparable D-B-B projects. This represented 37% of the states and 25% of the D-B projects[348]. Of the 17 returned, eleven contained sufficient data to be included in the detailed analysis[349].

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342 U.S. Department of Transportation. "Design-Build Effectiveness Study – Required by TEA-21 Section 1307(f)," i.
343 Ibid, ii.
344 Ibid, I-7.
345 Ibid, I-7.
346 Ibid, I-7.
347 Ibid, I-7.
348 Ibid, I-8.
349 Ibid, I-8.

10.1.3 D-B Project Type and Cost

Of the 140 projects completed as D-B under SEP-14 by 2002, 49% of them were bridge/tunnel projects, 18% road rehabilitation and reconstruction, and 16% new or widened roads[350]. New and widened roads accounted for over half of total project costs[351].

SEP-14 Design-Build Projects - Completed by 2002					
Project Type	Number	%	Cost $million	%	$million/Project
Road - New/Widen	23	16%	$2,964.0	54%	$128.9
Road - Rehabilitate/Reconstruct	25	18%	$1,847.8	33%	$73.9
Road - Resurface/Renewal	7	5%	$31.3	1%	$4.5
Bridge/Tunnel	68	49%	$456.2	8%	$6.7
ITS	6	4%	$54.9	1%	$9.2
Other	11	8%	$172.0	3%	$15.6
Total	140	100%	$5,526.2	100%	$39.5

Table 10.1 – SEP-14 Design-Build Projects Completed by 2002, by Type

Among the same 140 projects, six were projects with capital costs over $100M[352]. These six projects accounted for 72% of the costs for all projects, or almost $4B out of the $5.5B spent under the program on D-B projects between 1990-2002[353]. The average cost for each of these six projects was $662.4M[354].

SEP-14 Design-Build Projects - Completed by 2002					
Project Size	Number	%	Cost $million	%	$million/Project
<$2 Million	46	33%	$45.3	1%	$1.0
$2-10 Million	48	34%	$209.8	4%	$4.4
$10-50 Million	32	23%	$748.9	14%	$23.4
$50-100 Million	8	6%	$548.0	10%	$68.5
>$100 Million	6	4%	$3,974.2	72%	$662.4
N/A	0	0%	$0.0	0%	$0.0
Total	140	100%	$5,526.2	100%	$39.5

Table 10.2 – SEP-14 Design-Build Projects Completed by 2002, by Size

10.1.4 D-B Program Costs

The responding agencies with D-B programs completed 73 D-B projects in calendar year 2002, representing $1.2B in costs[355]. This compared to 3,034 total projects completed in the same year, at a total cost of $7.4B[356]. Notably, over half of all costs on bridge/tunnel projects were part of D-B contracts[357].

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350 Ibid, D-6.
351 Ibid, D-6.
352 Ibid, D-6.
353 Ibid, D-6.
354 Ibid, D-6.
355 Ibid, IV-2.
356 Ibid, IV-2.
357 Ibid, IV-2.

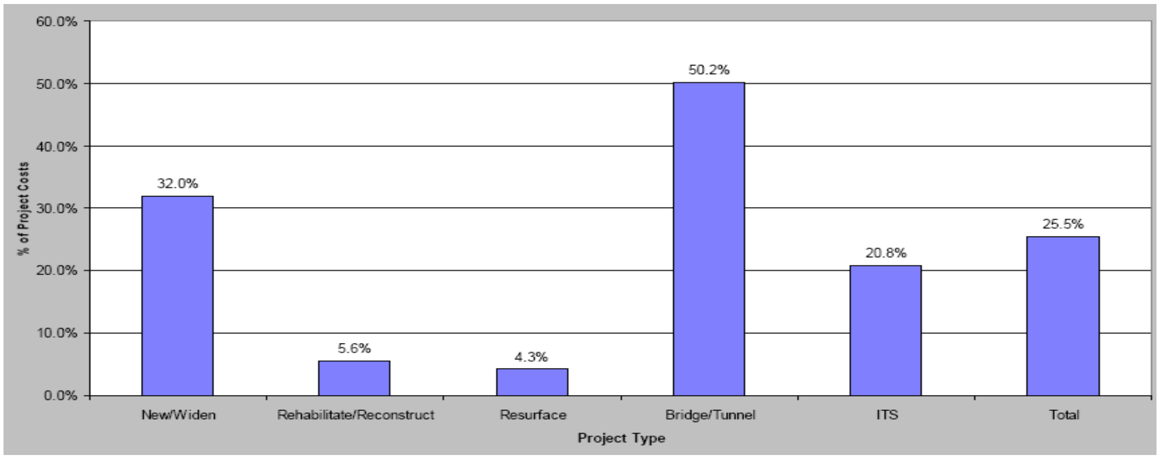

Figure 10.1 – D-B Project Costs as a Proportion of Total Projects Completed in 2002

10.1.5 Amount of Design Before Issuing D-B Contracts

Among the D-B projects surveyed, design averaged 27% completion prior to the awarding of the D-B contract[358]. For 81% of the projects, the percentage completion was 30% or less[359]. An earlier survey of six state agencies found a broad range from 15%-50% design completion before issuance of the D-B contract, with the average being 31%[360].

Results suggest that "no more than 30% of preliminary design (should) be completed before D-B contract award, with lower percentages as the agency gains more experience with D-B[361]."

The following chart shows not only the level of design completed before the issuance of a D-B contract from among the 69 projects surveyed, but also the amount of right-of-way acquisition, permit acquisition, and environmental clearance performed prior to the D-B contract being signed[362].

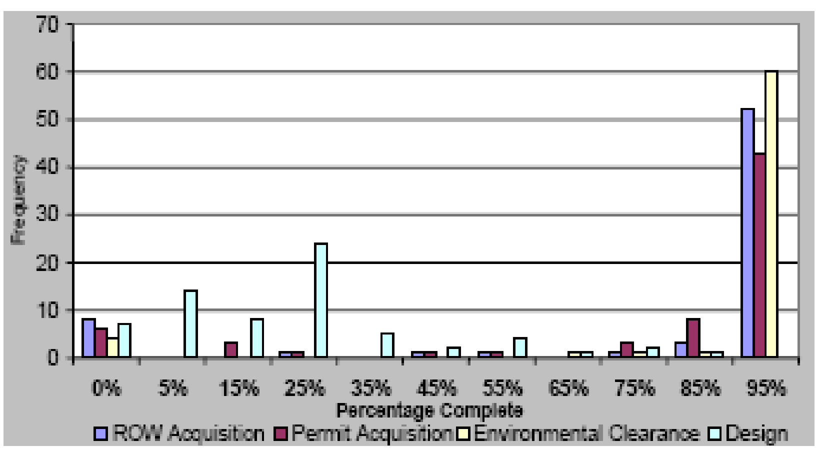

Figure 10.2 – Level of Project Completion at Awarding of D-B Contract

358 Ibid, IV-33.
359 Ibid, IV-33.
360 Ibid, ix.
361 Ibid, IV-34.
362 Ibid, IV-32.

In most cases acquisitions and clearances were nearly complete by the time of the D-B contract, while design generally hovered around the 15%-40% stage. Right-of-way acquisition averaged 89% completion, permit acquisition 83%, and environmental (NEPA) clearance 99%[363]. Under D-B-B, each of these four functions would have to be complete before the tendering of construction contracts.

10.1.6 Contracting Methods Used

For D-B, low-bid procurement still dominates. The design community has been far more receptive to best-value contracting, but the construction industry is often still bound by low-bid as a result of state and local laws[364].

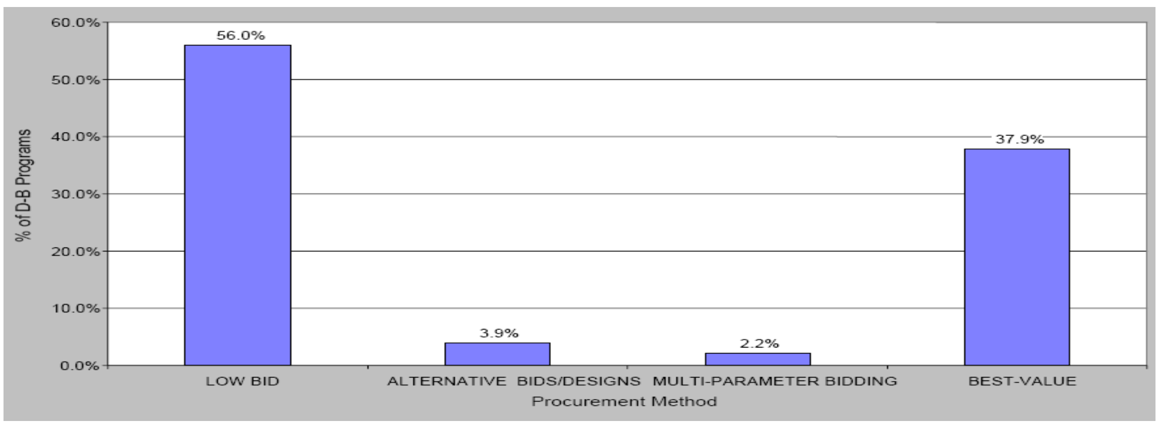

Figure 10.3 – Procurement Methods for D-B Contracts

10.1.7 Impact on Small Businesses

Agency respondents noted that the percentage of D-B project costs going to small businesses was about the same on average as for D-B-B projects, with only a very small reduction for D-B. This suggests that small businesses were not disadvantaged when projects were developed through the D-B process, according to agency D-B program managers. The survey also suggests that D-B spreads more of the work among subcontractors than comparable D-B-B projects[365].

363 Ibid, IV-33.
364 Ibid, IV-6.
365 Ibid, IV-35.

	Design-Build			Design-Bid-Build		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Percent of Project Costs Provided by Small Firms	31.3%	55.0%	5.0%	33.0%	55.0%	15.0%
Percent of Project Costs Provided by Small Firms on Local Competing Teams	32.3%	75.0%	5.0%	32.9%	75.0%	15.0%

Table 10.3 – Impact of Delivery Strategy on Small Businesses

10.1.8 Change Orders and Claims

The subset of D-B projects had fewer change orders than the comparable D-B-B projects. The cost per change order was greater for the D-B projects. However, the study notes that this could be attributed to the greater size of the D-B projects, which is confirmed by the fact that change orders represented roughly the same share of total project costs for both types of projects[366].

The D-B projects also had fewer claims per project. The largest claim among all projects, both D-B and D-B-B, was for $6M on a D-B-B project[367].

Design-Build Projects

Change Order Dimension	Change Orders Per Project	Change Order Costs Per Project ($000)	Cost Per Change Order ($000)	Claims Per Project	Claims Cost Per Project ($000)
Responses	16	16	16	18	17
Average	**16**	**$837**	**$85**	**0**	**$0**
Median	14	$467	$35	0	$0
Mode	17	$400	N/A	0	$0
Maximum	49	$3,355	$472	6	$0
Minimum	4	$14	$1	0	$0
Standard Deviation	**13**	**$890**	**$119**	**1**	**$0**

Table 10.4 – Change Orders and Claims for D-B Projects

Design-Bid-Build Projects

Change Order Dimension	Change Orders Per Project	Change Order Costs Per Project ($000)	Cost Per Change Order ($000)	Claims Per Project	Claims Cost Per Project ($000)
Responses	14	14	13	18	18
Average	**22**	**$588**	**$47**	**0.6**	**$337**
Median	8	$275	$47	0	$0
Mode	5	N/A	$50	0	$0
Maximum	80	$4,000	$180	4	$6,000
Minimum	0	$0	$3	0	$0
Standard Deviation	**27**	**$1,013**	**$49**	**1**	**$1,413**

Table 10.5 – Change Orders and Claims for D-B-B Projects

366 Ibid, IV-25.
367 Ibid, IV-24.

Respondents noted that change orders were the biggest reason that led to cost increases, but that change orders still only represented 5% of the project's total costs[368].

10.1.9 Impact on Project Schedule

D-B had an overall positive impact on project duration. The impacts of delivery strategy on project schedule varied widely, ranging from a 63% reduction to a 50% increase[369]. On the average, D-B resulted in a 14% time savings over D-B-B. Out of the 62 responses, 45 projects came in ahead of schedule and only seven were delivered late[370].

Program survey respondents estimated an average of 15% increased procurement time due to D-B, suggesting that D-B projects take longer to set up, but once awarded require slightly less time for the project to be built[371].

Duration Dimension	Value
Responses	62
Average	**-14.1%**
Median	-10.0%
Mode	-0.1%
Maximum	50.0%
Minimum	-63.0%
Standard Deviation	**24.4%**

Table 10.6 – Impact of D-B on Project Schedule

10.1.10 Impact on Project Cost

D-B had mixed implications for project cost. The results varied from a 62% reduction to a 65% increase relative to D-B-B, with an average cost savings of 2.6%[372]. Out of the 48 responses, 20 respondents believed costs were less under D-B than they would have been under D-B-B, 17 believed there was no difference, and eleven believed costs were higher for D-B than they would have been for D-B-B[373].

368 Ibid, vii.
369 Ibid, IV-12.
370 Ibid, IV-13.
371 Ibid, IV-13.
372 Ibid, IV-18.
373 Ibid, IV-18.

Cost Dimension	Value
Responses	48
Average	**-2.6%**
Median	0.0%
Mode	0.0%
Maximum	65.0%
Minimum	-61.8%
Standard Deviation	**20.5%**

Table 10.7 – Impact of D-B on Project Cost

10.1.10.1 Expected Versus Actual Costs

Costs on the D-B projects, both during the construction phase and in total, were less than expected. On average, total project costs came in 4.2% less than expected, with cost savings as high as 42.5% and cost overruns only as high as 23.1%[374].

Costs on the comparable D-B-B projects, on the other hand, were more than expected. On average, total project costs came in 4.8% above expectations, with cost overruns as high as 30.6% and cost savings only as high as 20.9%[375].

For the construction phase alone, costs averaged 11.6% more under D-B-B, and 1.2% less under D-B[376]. This suggests significant cost savings during construction under D-B[377].

Project Phase	Average	Maximum	Minimum	Standard Deviation
D-B Constuction Phase	**-1.2%**	30.6%	-54.7%	27.3%
D-B-B Construction Phase	**11.6%**	71.7%	-27.2%	28.7%
D-B Total Project	**-4.2%**	23.1%	-42.5%	20.8%
D-B-B Total Project	**4.8%**	30.6%	-20.9%	14.9%

Table 10.8 – Average Percent Change in Expected Versus Actual Project Cost for Similar D-B and D-B-B Projects

10.1.11 Impact on Project Quality

The project surveys indicated that D-B had no differential impact on the quality of the product. Three percent of the surveyed projects noted a small increase in project quality while a similar small percentage noted a small decrease in quality, and 93% of projects noted no discernible difference in project quality[378].

374 Ibid, IV-14.
375 Ibid, IV-14.
376 Ibid, IV-14.
377 Ibid, IV-14.
378 Ibid, IV-26.

Quality Dimension	Value
Responses	61
Average	**0.0%**
Median	0.0%
Mode	0.0%
Maximum	10.0%
Minimum	-10.0%
Standard Deviation	**2.1%**

Table 10.9 – Impact of D-B on Project Quality

However, since D-B is often used on particularly difficult, robust, and risky projects, one may surmise that issues related to quality are more likely to occur on the whole on D-B projects than on D-B-B projects. Therefore, this question may be a bit skewed and may understate the potential quality enhancements that D-B provides.

10.1.12 Perceived Suitability of D-B

Respondents were asked to rank the suitability of D-B for each of the five different highway project types, broken down by size of the project. The ranking was performed on a scale from 1 to 6, with 1 being not suitable and 6 being highly suitable[379].

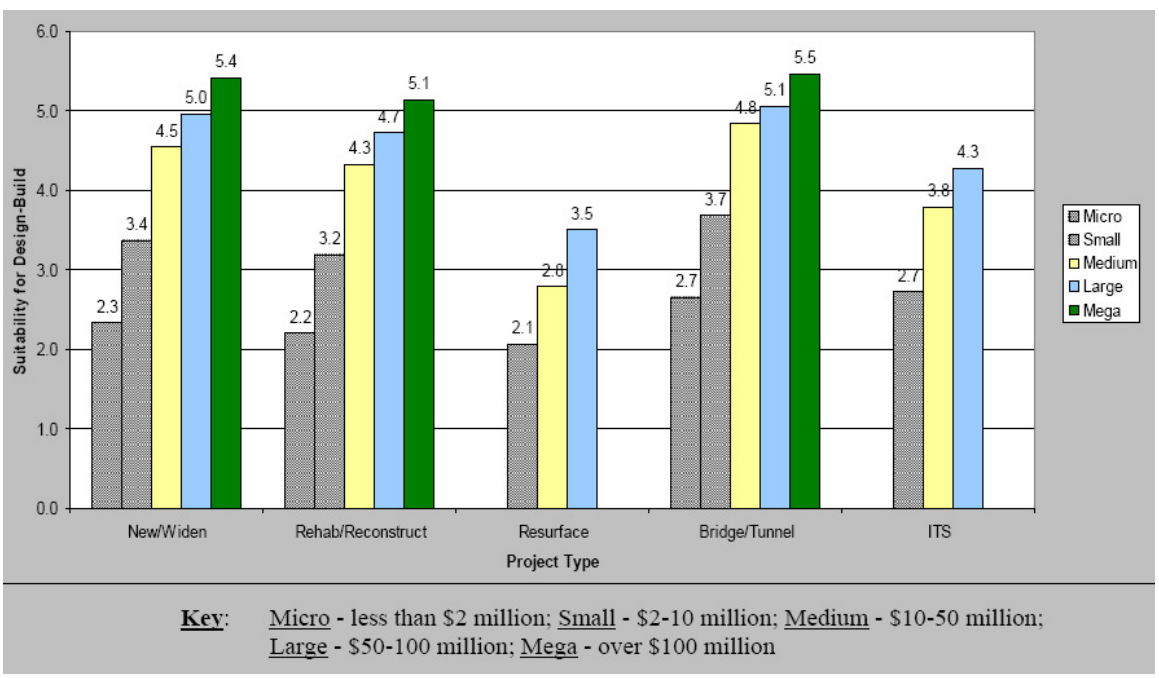

Figure 10.4 – Survey Results on the Suitability of D-B for Various Project Types and Sizes

D-B ranked especially high for large projects. In fact, for each project type, the suitability of D-B grew for each increasing classification of project cost. For projects considered as "mega," or having

379 Ibid, IV-9.

capital costs of $100M or more, D-B got scores ranging from 5.1-5.5; the highest scores for any project type or size.

10.2 New York State DOT D-B Practice Report

In an effort to survey the D-B landscape before considering enabling legislation of its own, the New York State DOT in 2002 drafted a questionnaire that was sent to 18 state agencies that had already implemented or were currently in the process of implementing D-B projects under SEP-14[380]. This was a much more qualitative survey than the FHWA D-B Effectiveness Study, though there was a lot of consensus among the ten respondents. The following lists some of the major findings[381]:

- The majority of respondents use a two-stage process for procurement that first involves a pre-qualifications stage.
- There is no single generally accepted approach to determining "best value." Many agencies adopt formulas, while some prefer descriptive comparison.
- The majority of agencies strongly endorse an industry review process that allows draft RFPs to be shared with industry representatives.
- A number of agencies have offered stipends to bidders as a means of reducing the cost to industry, as well as providing partial compensation for agency ownership of concepts.
- Stipends also tended to increase competition. Compensation ranged from $50,000 on a $22M project in Washington State, to a $1M reimbursement for bids on the T-REX combined LRT-Interstate reconstruction project. The Arizona DOT was the lone respondent that reimburses based on a percentage of bid amount. The reimbursement is 0.2% of the bid amount.
- Appropriate level of design prior to issuing the D-B contract varied, but centered in the 15%-35% range.
- In some cases, the agency hires a program manager. In other cases, the owner provided its own staff to perform that function.
- Regarding incentivization, many agencies provide bonus payments for early completion, and two agencies provide award fee payments at three-month intervals for progress exceeding that shown on the contract schedules.
- Most agencies require submittal of schedules with the proposal, though the amount of detail required in initial schedule submittal varied. Generally, preliminary schedules were requested at proposal and early in the project, with more detail required as work progressed.
- Most agencies had a systematic process for identifying and allocating risks. The majority of these agencies conduct workshops to identify risks, and then often use the industry review process to gather input as to how to best allocate those risks.

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380 New York State Department of Transportation. "Design-Build Practice Report."
381 Ibid.

- The process for change orders is generally the same for D-B and D-B-B, with the one notable difference being that the design firm will usually be involved in implementing the change under D-B.
- Many agencies require 100% payment and performance bonds, but for larger projects agencies are often willing to accept reduced bond amounts, with the amount based on the potential cost overruns resulting from the "worst-case" scenario. The decision to accept a reduced amount is based in part on the surety industry's reluctance to issue 100% bonds for megaprojects, and in part on the fact that only a handful of contractors have sufficient bonding capacity to provide such bonds. Requiring a 100% bond would therefore be likely to reduce the pool of interested contractors and could therefore have a significant impact on the contract price.
- All agencies cited accelerated project delivery as a major factor in the decision to use D-B.
- Almost all of the agencies place quality control (QC) and quality assurance (QA) responsibility with the designers and builders, though agencies will retain a level of QA oversight in the form of small on-site monitor staffs, auditing, and independent testing. The biggest challenge was in transferring quality responsibility by maintaining a "hands-off" approach, while still ensuring public due diligence.
- Cost certainty was another reason to do D-B. The single point of responsibility was cited as the main reason why that is the case. For example, claims against project owner for design defects are eliminated.

10.3 University of Colorado/National Science Foundation Study

This study collected survey data from 108 respondents representing 90 owners and agencies[382]. The respondents had combined experience on 1,683 projects with a value in excess of $12.75B, though a large majority, 83% of the projects, were from the building sector. The survey asked the owners to rank seven primary reasons for choosing D-B. The results are shown below:

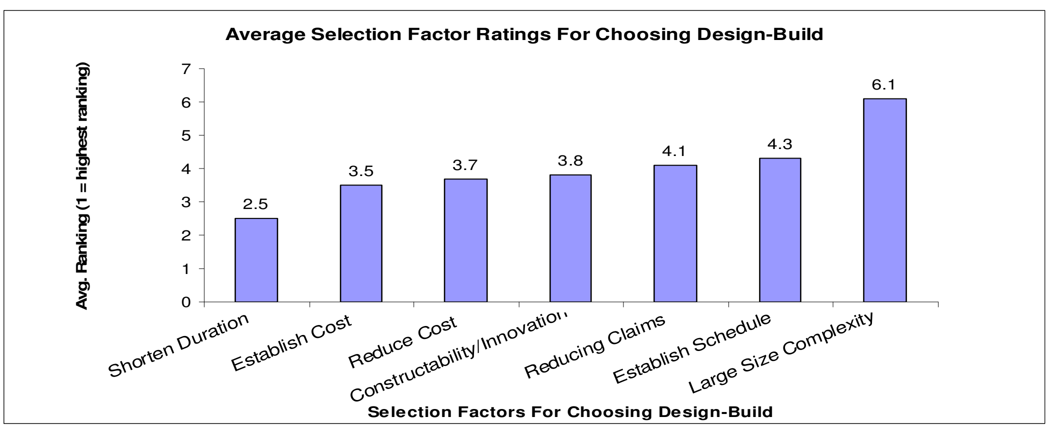

Figure 10.5 – Selection Factors for Choosing Design-Build

Shortening the duration of the project was the overwhelming first choice of all owners. This choice was validated by a survey performed by the Design-Build Institute of America (DBIA) as well. Cost

382 Loulakis, 76-77.

certainty, cost reduction, and constructability/innovation followed. The only major difference noted between the public and private sectors was that private owners were more concerned about shortening duration and public owners more concerned about reducing claims.

In stark contrast to the FHWA survey, very few owners of these mostly vertical projects chose D-B to help manage them. This may suggest an increased willingness to experiment with alternative delivery strategies for transportation and other horizontal infrastructure projects than on vertical building structures.

10.4 ZweigWhite Design/Build Survey of Design and Construction Firms

The architectural, engineering, and environmental consulting firm ZweigWhite has long been conducting industry surveys of design-build. ZweigWhite's 2005 Design/Build Survey of Design and Construction Firms details the responses of a 7-page questionnaire from among 98 architecture, engineering, environmental, consulting, construction, and design-build firms. ZweigWhite makes the following distinction among the firms:

- Integrated D-B: Firm has both design and construction capabilities in-house.
- Design services/Consulting: Firm only does design and consulting, but not construction.
- Construction: Firm only does construction, but not design.

The threshold for inclusion as a candidate in the survey was that each participating firm had to use design-build for at least 10% of its work[383].

10.4.1 Firm Portfolios

Not surprisingly, the integrated design-build firms specialize in design-build construction more so than firms that do only design or only construction. The design community is the one that has the least experience in design-build.

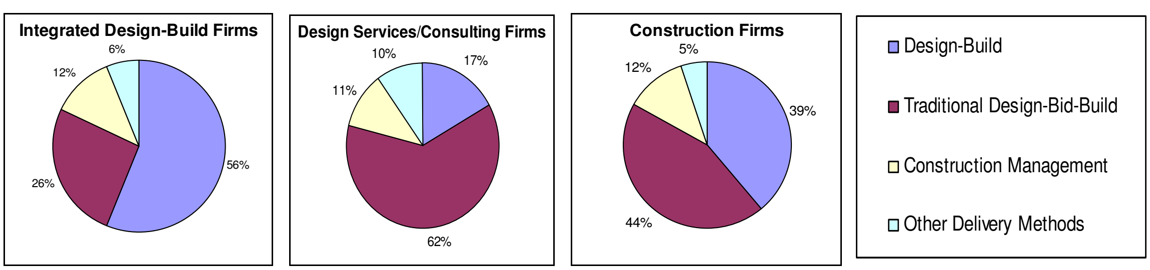

Figure 10.6 – Composition of Firms Participating in ZweigWhite Design/Build Survey

10.4.2 Barriers to Entry into the D-B Marketplace

Each type of firm identified state laws as being the most common barrier to D-B. Interestingly, design firms encounter different obstacles than construction firms and Integrated D-B firms. Design firms are stymied more so by procurement regulations and their firm's size and type than

383 ZweigWhite, 88.

they are by market-related issues. Also, municipal laws were a major barrier to firms that perform construction, but less so for designers.

Question: If your firm has encountered barriers, for which of the following reasons (check all that apply)?

	Integrated D-B	Design services/Consulting	Construction
State laws	64%	63%	53%
Market-related issues	40%	19%	47%
Municipal laws	40%	13%	33%
Procurement regulations	28%	38%	33%
(Our) Firm Size	20%	31%	7%
Client Resistance	16%	6%	13%
Federal laws	8%	6%	7%
(Our) Firm Type	4%	31%	0%
Other	4%	19%	13%

Table 10.10 – Barriers to D-B

The legal barriers were confirmed in a follow-up question that asked whether laws had effectively shut out firms from acquiring D-B work. About half of the firms had reported that they had.

Question: Do procurement laws in your state ever effectively shut you out of acquiring public sector design-build work?

	Integrated D-B	Design services/Consulting	Construction
Yes	57%	50%	40%
No	40%	42%	57%

Table 10.11 – Impact of Procurement Laws on Ability to do D-B Work

This makes bi-state and other multi-jurisdictional D-B projects particularly problematic, since all localities will have to explicitly allow D-B for a D-B project to proceed.

10.4.3 Design Development

On projects where the client has retained its own owner's representative, most are only developed to the 0%-10% design stage by the time the project is handed over to the D-B team. Only 7% of projects had been developed beyond 30%.

Question: If the client hires an owner's representative, how much design is developed before it is issued to the D-B team?

0% (pre-design)	8%
1%-10% (program requirements)	45%
11%-20% (conceptual design)	20%
21%-30% (conceptual design)	20%
More than 30% (design/development)	7%

Table 10.12 – Level of Design Completed Before Issuance of D-B Contract

Respondents generally believe this level of design is about right, and only 6% believe that this relatively low-level of design work is too little. In all, D-B teams seem quite satisfied having a project turned over to them early on in the design stage.

Question: In your opinion, is this amount too much, too little, or just right?

Just Right	63%
Too Much	21%
Too Little	6%

Table 10.13 – Firms' Perception of Level of Design Completed Before Issuance of D-B Contract

10.4.4 Project Management/Integration

Integrated design-build firms are more likely than other firms to report that, in their experience, the designer and constructor share project management tasks equally, despite often unequal risks. These integrated firms are also significantly more likely to report that their processes are extremely well-defined.

Question: Do designer and constructor members share equally in management, even though they may not share equally in risks?

	Integrated D-B	Design services/Consulting	Construction
Yes	48%	27%	20%
No	50%	65%	80%

Table 10.14 – Designer and Constructor Management Responsibility

Question: How well are your project management processes for D-B defined?

	Integrated D-B	Design services/Consulting	Construction
Extremely Well	45%	4%	17%
Somewhat Well	50%	65%	70%
Not Very Well	5%	19%	13%

Table 10.15 – D-B Team Program Management Processes

One of the appeals of design-build to the private sector is that it gains more control over how a project is managed. But the survey results suggest that power struggles can arise when construction firms seek to join with a design firm to form a D-B venture, especially when one or both respective firms is relatively inexperienced at delivering D-B projects.

10.4.5 Transportation as a Viable D-B Sector

Question: On scale of 1-5, what markets do you feel are most appropriate for D-B (1 = completely inappropriate, 5 = the best method)?

	Integrated D-B	Design services/Consulting	Construction
Roads, Bridges, Mass Transit, and Rail	3.6	3.4	3.9
Airports	3.4	2.9	3.2

Table 10.16 – Feasibility of Transportation as a Viable D-B Sector

These numbers may seem positive given that they're rated highly on the 1-5 scale. However, among thirteen markets, these two rated 11th and 13th, respectively. Markets rated higher include commercial projects, parking garages, industrial complexes, and power and communications infrastructure.

10.4.6 D-B Advantages

All three types of firms agree that there are three major benefits to D-B: single-source responsibility, shorter schedule, and cost savings. Construction firms are also much more convinced than design firms that quality is better under D-B.

Question: What are the biggest advantages and benefits of D-B (check all that apply)?

	Integrated D-B	Design services/ Consulting	Construction
Single-source responsibility	98%	85%	100%
Shorter schedule	95%	77%	77%
Cost savings/best value	79%	23%	47%
Increased quality	57%	15%	50%
Other	12%	12%	20%
Unspecified	0%	8%	0%

Table 10.17 – D-B Advantages

Designers come from a tradition of ethical identification with the owner. Therefore it is understandable that they may be a bit more reluctant to support D-B since, as a member of a D-B team, the designer is now jointly accountable along with the construction contractor to whom the designer may be forced to cede power.

10.4.6.1 Profitability

Question: Are D-B projects more or less profitable than traditional design-bid-build projects?

More	84%
Less	12%

Table 10.18 – D-B Profitability

It is remarkable that the survey respondents were seven times more likely to suggest that D-B projects were more profitable for them than D-B-B. One of the main reasons firms cite as to *why* design-build is more profitable is because it gives the builder more control over the final product[384].

10.4.7 D-B Disadvantages and Risks

There is strong consensus among each type of firm that risk, generally, is the biggest disadvantage to D-B. Notably, the firms that do D-B exclusively appear to have mitigated risk through experience. While over half of design and construction firms listed risk as a disadvantage, D-B firms were about 20% less likely to do so.

[384] Ibid.

Designers, in stark contrast to constructors, are convinced that the quality is diminished, not enhanced by D-B. This says a lot about the potential for marginalization of the designer in a D-B team, especially when the design and construction entities are either less experienced in D-B and/or haven't worked together on such projects previously. Having an owner's rep present should help mitigate this.

Question: What are the biggest disadvantages and risks of D-B?

	Integrated D-B	Design services/Consulting	Construction
Risk (general)	36%	54%	57%
Decreased Quality	17%	42%	10%
Increased Costs	2%	15%	13%
Less Control	2%	4%	13%
Longer Schedule	2%	8%	7%
Other	26%	23%	23%

Table 10.19 – D-B Disadvantages and Risks

10.4.8 Overall Owner Satisfaction

Owners seem quite pleased with the overall results of D-B, especially results from firms that specialize in D-B. Satisfaction decreases for firms that join D-B teams as designers or construction contractors but do not operate solely as design-builders.

Question: Do owners seem more, less, or equally satisfied w/ D-B vs. other delivery methods?

	Integrated D-B	Design services/Consulting	Construction
More satisfied w/ D-B	88%	31%	67%
Equally satisfied	10%	46%	33%
Less satisfied	2%	15%	0%
Unspecified	0%	8%	0%

Table 10.20 – Owner Satisfaction with D-B

Chapter 11: The Big Dig

The Central Artery/Tunnel (CA/T) project, known worldwide as the Big Dig, was an engineering marvel plagued by extreme cost, schedule, and quality delivery problems. The Big Dig entailed replacing an elevated highway by building a tunnel through Downtown Boston, while reinforcing and continuing to operate the elevated highway during tunnel construction. It also included the construction of a third Boston Harbor Tunnel to Logan Airport. The project was procured entirely as traditional D-B-B, as alternative delivery strategies such as D-B were prohibited by law in Massachusetts until 2004[385][386][387].

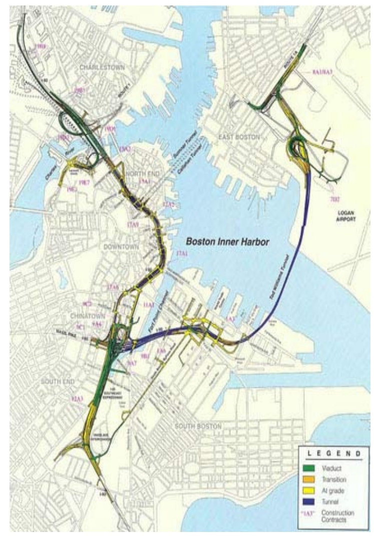

Figure 11.1 – Big Dig Before and After Photos
Figure 11.2 – Big Dig Map

No discussion on the genesis of the Big Dig is complete without a brief look back at the original Central Artery itself and the climate that led to its elimination.

11.1 Central Artery

The Central Artery construction began in 1949, and was well ahead of its time[388]. The Interstate Highway System had yet to even be adopted, so Massachusetts spent its own money to build a six-lane superstructure through Downtown. The Artery was intended to improve mobility and allow Boston commuters to live further away from Downtown.

Financial failure of the Old Colony commuter rail system and generally inadequate transit service quickly led to the roadway becoming overburdened[389]. The projected 75,000 vehicles per day

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385 Tufts University. "Practical Visions."
386 Massachusetts Turnpike Authority. Big Dig. "Project Maps & Plans."
387 Peterson, 910.
388 Gelinas, 1.
389 Interview with Fred Salvucci.

became 150,000 per day, and extreme congestion set in[390]. By 2003 the Central Artery was accommodating 200,000 cars daily[391].

11.2 Highway Revolt

Partly in reaction to the social isolation created by the elevated Central Artery, there grew in Boston a powerful movement to prevent the growth and expansion of the region's highway system that became known as the Highway Revolt. In 1970, Governor Frank Sargent ordered the Boston Transportation Planning Review, a review of all proposed freeways around Boston. Once the Review was complete and the public backlash against highway expansion had grown into a sizable coalition, several highway projects were cancelled[392]:

1. The Inner Belt was a proposed 7.3-mile loop around the city that would have cut huge swaths of land and required many takings in the neighborhoods of Roxbury, Brookline, Cambridge, and Somerville.
2. The proposed Northwest Expressway to Burlington was replaced by the MBTA Red Line extension to Alewife station.
3. The Southwest Expressway was a proposed extension of Interstate 95 through Downtown Boston, which was replaced by the relocated and upgraded MBTA Orange Line and improved commuter rail.

11.3 Dukakis Administration

The first priority of new Governor Michael Dukakis in 1974 was implementation of transit and commuter rail improvements. Dukakis was also supportive of depressing the Central Artery, but not keen on building the third Harbor Tunnel which, at the time, was a completely separate project. Dukakis was concerned about the impacts of a third Harbor Tunnel on the residents of East Boston. Four years later, Dukakis lost his re-election campaign to Ed King, who wanted to shelve the Central Artery depression, but proceed with the third Harbor Tunnel.

It was during this time when Dukakis's once and future Secretary of Transportation, Fred Salvucci, became convinced that not only could the Central Artery and third Harbor Tunnel projects be combined into a single project, but also that there was an alignment for the Harbor Tunnel that would both alleviate impacts to East Boston and provide opportunities for significant economic development in South Boston as well. In 1982, Governor Dukakis returned to the State House and proceeded to work in earnest on getting both approvals and funding for the CA/T.

11.4 Federal Funding

Massachusetts has long had powerful allies in Washington, perhaps none more so at the time than House of Representatives speaker Thomas P. "Tip" O'Neill, who was originally skeptical of the

390 Vanderwarker, 9.
391 National Research Council. Transportation Research Board. "Completing the Big Dig: Managing the Final Stages of Boston's Central Artery/Tunnel Project," 7.
392 Public Broadcasting Service. "Interview with Fred Salvucci, former Massachusetts Secretary of Transportation, for Program Four: The Big Dig."

tunnel to East Boston because of impacts on his constituents there. But as early as 1976, Rep. O'Neill began advocating for statutory language that clarified the Central Artery depression's eligibility for 90% federal funds under the Interstate Highway Act[393]. Rep. O'Neill eventually became an even stronger advocate for the CA/T once the East Boston issues were resolved. Beginning in 1983 the Reagan administration withheld funding on the project, but Tip O'Neill planned to re-enact the 1976 statutory language and get Massachusetts its federal funding for the project before his retirement in 1986[394].

However, reauthorization of the Transportation bill that included the CA/T's funding was delayed until 1987. Rep. O'Neill had since retired, and although the reauthorization overwhelmingly passed through Congress, President Reagan vetoed the bill, identifying his concerns about the CA/T. In a very close vote, and thanks in large part to the arm-twisting of Massachusetts' senior senator, Edward M. "Ted" Kennedy, the U.S. Senate voted to override the President's veto. The bill became law in April 1987, and the CA/T finally had its funding[395].

In a parallel administrative effort, Massachusetts had filed a Final Environmental Impact Statement (FEIS) on the CA/T in September 1983[396]. Unfortunately, the Federal Highway Administration (FHWA) held up its comments for two years, and then required further environmental studies. These studies resulted in further expansion of the project, so that by the time the FEIS was approved in 1991, the cost of the Big Dig was estimated at $6B. It was over the next decade when costs escalated, or at least became publicly disclosed to be closer to the final cost of roughly $14.6B.

11.5 Weld Administration and Scheme Z

Among the most contentious debates surrounding the Big Dig focused on the design of off-ramps and on-ramps north of the Big Dig tunnel in Cambridge. Shortly before leaving office, Salvucci settled on one of the 29 proposals known as Scheme Z[397][398]. With Final EIS approval coinciding with a change in state government, the Governor William Weld administration began construction on the third Harbor Tunnel, but re-opened the environmental process on the Charles River bridge section connecting Boston to Cambridge and Charlestown. Salvucci pleaded with Governor Weld not to reopen the EIS, not only because he was convinced Scheme Z was the best option, but also because reopening the EIS would set the project back years[399]. By reopening the EIS, not only would work on the bridges over the river be halted, but so would much additional enabling work as much as a half-mile away.

The record of decision on the new EIS wouldn't come until more than three years later. Salvucci notes that for every month construction was delayed, the project incurred $18M in costs as a result of inflation alone[400]. In the end, the modified Scheme Z was not even too dissimilar from the original design. It continued to include the signature cable-stayed bridge, which has become an icon of the city, and park esplanades on both sides of the river. But it also required substantial additional

393 Gelinas, 3.
394 Ibid.
395 Ibid.
396 Interview with Fred Salvucci.
397 McNichol and Ryan, 200.
398 Interview with Fred Salvucci.
399 Ibid.
400 McNichol and Ryan, 43.

tunneling under rail tracks at North Station to make ramp connections to I-93 more direct, which caused traffic weaving conflicts and congestion on some of the redesigned ramps[401].

Not coincidentally, on the same day that Weld's Secretary of Transportation James Kerasiotes declared the Scheme Z issue resolved, he announced that Big Dig costs had increased $1.3B[402].

Considering the ripple effect the reopening of the EIS had on the rest of the project, the cost increases as a result were likely much more than publicly stated. Contractors were allowed to begin work on some parts of the Big Dig before design for other key parts was complete[403]. This approach was part of the project's philosophy of "getting things done now and asking questions later[404]." This fast-track strategy is perfectly logical when there is no direct interface among these various elements and when there are very few unknowns. But in the case of the Big Dig, interfaces were quite prevalent and no one knew how the Charles River crossing would be modified. Paradoxically, the much less complex work to be done in East Boston had no engineering relationship to Scheme Z and the Charles River crossing, and yet was also held up while the EIS was being revised, leading to unnecessary inflation costs[405].

11.6 Delivery Partner Bechtel/Parsons Brinckerhoff (B/PB) Role

Back in 1985, a full two years before federal funding was approved for the Big Dig, the state already began to form the team that would eventually deliver the project. The planning and engineering that led to the earlier EIS had been underway since 1978, but the next phase, which was expected to be final design and construction maintenance, required a new selection process. Five groups competed for the first Big Dig contract; a 4-month, $1.3M consulting contract[406]. Nine highway officials unanimously chose the joint venture of Bechtel and Parsons Brinckerhoff (B/PB).

The choice was a rather easy one. Bechtel was the largest construction firm in the world, and Parsons Brinckerhoff was the 17th-largest design firm. The two companies had worked together on several megaprojects previously, including the San Francisco Bay Area BART metro and Atlanta's MARTA metro system.

The Big Dig included the largest use of slurry walls anywhere in North America. Slurry is a clay-water mixture pumped into an excavation to give a structure stability until concrete can be poured[407]. Up to that point, B/PB had done 90% of all slurry wall construction in the U.S., and the state perceived them to be well suited to implement the many new and innovative technologies that the Big Dig required[408].

The B/PB contracts were short-term but oft-renewed. In 1993, the 12th contract with B/PB was in effect, and by now B/PB was the manager of design and construction on the Big Dig[409]. By

401 Interview with Fred Salvucci.
402 McNichol and Ryan, 202.
403 Gelinas, 4.
404 Ibid.
405 Interview with Fred Salvucci.
406 McNichol and Ryan, 40.
407 Massachusetts Turnpike Authority. "Slurry Walls."
408 McNichol and Ryan, 42.
409 Hughes, 212.

project's end, the sum of B/PB's contracts was over $2.2B[410]. B/PB's total profit from the Big Dig is estimated at $150M[411]. However, due to settlement agreements with the Commonwealth in excess of $450M, B/PB actually lost their entire profit and $300M more (see section 11.16).

B/PB was to develop basic design, oversee other companies completing the final design, oversee selection of contractors, and manage and inspect the construction to be sure bid documents were followed and specifications met[412].

Over the years, B/PB's role continued to expand, particularly during periods of political transition when turnover of key public employees led to a loss of institutional memory and increased reliance on B/PB. The perception was that B/PB's 1,000-plus employees dwarfed their few dozen public counterparts and effectively ran the Big Dig itself[413]. The state even went so far as to designate B/PB as its own representative in some areas[414]. B/PB did ultimately provide essential continuity throughout the project, but the lack of oversight capacity created a vacuum, and led to B/PB being excessively in control of designers, contractors, and information.

11.7 B/PB Obligation to the Client

The state made a major blunder in allocating much responsibility to B/PB and expecting B/PB to act solely on behalf of the state's interests without adequate public sector oversight. In 1994, Massachusetts Turnpike Authority (MTA) director and Big Dig project manager James Kerasiotes said that B/PB's incentive in the Big Dig was its reputation[415]. One could argue that, as two of the most successful engineering and design firms in the world, respectively, Bechtel and Parsons Brinckerhoff had already established a reputation that even some major errors on the Big Dig would not significantly harm. The state may have overstated the reputational risk being assumed by B/PB. B/PB, as a multinational construction conglomerate is, first and foremost, out to protect its own corporate interests, including its business volume and profit. The fact that Bechtel has now won the Project Delivery Partner role for Crossrail (see Chapter 13), and that PB was a finalist is clear evidence that the reputational risk theory was overstated.

As B/PB's longtime Big Dig director Keith Sibley stated, "Our responsibility as management consultant was to deliver a standard of professional care, not to guarantee the contractor's work[416]." This is a critical distinction, that B/PB was not out to promise perfect results, but to be professional in its advisory and management work.

In 1994, B/PB compiled analysis that the Big Dig would cost roughly $14B in completion year dollars[417]. They brought their findings to the state, but the state kept this information hidden from the public. This alarmed Bechtel executives so much so that they flew to Boston to see Governor Weld. According to a 2001 report by the Office of the Inspector General, the Weld administration

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410 Commonwealth of Massachusetts. Office of the Inspector General. "Inspector General's Investigation Leads to $146 million Big Dig Lawsuit."
411 "Big Dig Contractors Settle Tunnel Collapse Lawsuit for Nearly $450 Million." The Associated Press.
412 Salvucci.
413 Gelinas, 2.
414 Ibid, 6.
415 Ibid, 6.
416 Ibid, 6.
417 Ibid, 4.

directed state and B/PB staff to maintain "the fiction" of an $8B project, despite the warnings from Bechtel[418].

Subsequent to B/PB performing this due diligence, one could argue that it would have been unreasonable for B/PB to attempt to override the policy direction of its client and assume the role of defining the public interest. As a result of the state's stubbornness and inaction, several years would pass before the numbers became public that cost was indeed $14B. In the meantime, the state still approved costly additions, including the rebuilding of the tunnel section under Dewey Square to increase the speed limit there from 35 mph to 45 mph[419].

Even after becoming aware of the $14B estimate, the state effectively took no action to reduce cost through a serious value engineering approach, nor did the state increase its direct funding. Instead, the state relied on increased borrowing.

11.8 Big Dig Privatization Option

The Dukakis administration back in 1988 commissioned a report by the firm Lazard Freres that looked at the financial feasibility of delivering the Big Dig as a fully private venture[420]. The privatization option was based in theory on the notion that the owner could potentially "capture" some of the real estate value from being able to develop the air rights above the Big Dig tunnel.

The Lazard Freres report ultimately suggested that the project was too big to be privatized, and that there was too much risk involved[421]. Since the Big Dig air rights would not be available for another 10 years or so, the potential fluctuations in real estate values made privatization risky. Ultimately, the Boston Redevelopment Authority (BRA), the city planning agency of the city of Boston, argued successfully for the air rights to be primarily open space, which meant that the increased real estate value would occur on privately owned adjacent land, not over the actual air rights above the tunnel.

11.9 Delay in Ownership and Operations Designation

When the Weld administration took over from Dukakis in January 1991, the record of decision (ROD) on the Big Dig's Environmental Impact Statement (EIS) had just been delivered, and logically it would have made sense to anoint an official owner and eventual operator of the soon-to-be-constructed roadway[422]. This was in fact a major recommendation emerging from the Lazard Freres finance study.

Despite MassHighway (MHD) being the conduit through which federal funds for the Big Dig arrived in Massachusetts, few people thought that MassHighway was the appropriate entity to be the owner. This created the inauspicious situation of an agency that knew it would not be accountable for the maintenance presiding over the design and construction of the facility[423].

Logical candidates for Big Dig owners included:

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[418] Ibid, 5.
[419] Interview with Fred Salvucci.
[420] Ibid.
[421] Ibid.
[422] Ibid.
[423] Pioneer Institute. "Driving Questions: A Forum on Transportation Strategy in Massachusetts," 12.

- the Massachusetts Port Authority (MassPort), which was already in charge of Logan Airport, its parking facilities, the seaport, South Boston real estate, and the Tobin Bridge; and
- the Massachusetts Turnpike Authority (MTA), which owned and operated the Massachusetts Turnpike (Mass Pike), as well as the first two Boston Harbor Tunnels and the tunnel under Boston's Prudential Center.

In Secretary of Transportation Fred Salvucci's lone transition meeting with Weld's staff, he advocated for immediate selection of the operating agency. Salvucci feared that, without operator oversight, the engineers assigned to the project design and construction might embed numerous mistakes and inoperable features, so as to simplify construction and cut costs[424].

But instead, the project languished for several years without an operating agency looking out for the project's well-being. The MTA, which was finally designated in 1997, had no role in reviewing the B/PB design or in providing construction oversight during the critical early years of engineering and construction[425].

11.10 Federal Funding Cap

In multiple statutes in the 1970s and 1980s, the administration had successfully argued that since Massachusetts built the Central Artery itself, without federal funds, that the state should be eligible for "90-10" on CA/T, which consists of two Interstate highways, I-90 and I-93. This victory for Massachusetts meant that the federal government was essentially accepting the risk for 90% of the cost of the Big Dig[426].

Unfortunately for Massachusetts, that all changed in November 1991. With the Interstate Highway System nearly complete, the federal law changed and the federal government officially limited funding for the Big Dig in 1991 to the then-current estimate of $6B. Subsequent costs would be borne solely by the state without Interstate highway funds. As a result, Massachusetts' share of the costs in the Big Dig, which were originally at 10%, will end up at closer to 50%[427]. With the eventual addition of some formula-based funds (which were eligible to be used on other projects in Massachusetts) the total federal contribution on the Big Dig ended up being $8.6B[428].

The shift of cost risk from the federal government to the state government also significantly altered the federal government's view on the project. When the federal government was reimbursing 90% of the final cost it was focused on cost control, but once the federal guarantee was lifted, the federal government turned into a strong advocate for additional costly features. With the federal government already invested for several billions of dollars, but with no risk beyond that amount, it began to push for bigger and more expensive designs to be employed.

424 Interview with Fred Salvucci.
425 McNichol and Ryan, 221-222.
426 Gelinas, 3.
427 McNichol and Ryan, 222.
428 Davidson and Lusk-Brooke, 826.

The following chart from Altshuler and Luberoff shows the evolution of Big Dig cost estimates over the years, including the precipitous drop in the federal government's share[429]:

Year	Current dollars (billions)	Constant 2002 dollars (billions)	Overall federal share (percent)	Federal interstate program share (percent)
1983	2.3	3.7	85	85
1985	2.6	3.9	85	69
1987	3.2	4.5	85	69
1989	4.4	5.8	85	69
1991	5.2	6.4	85	69
1992	6.4	7.7	85	65
1993	7.7	9.0	85	54
1995	7.8	8.7	85	52
1996	10.4	11.4	85	40
1998	10.8	11.5	79	39
2000 (March)	12.2	12.6	70	34
2000 (April)	13.5	13.9	63	31
2000 (October)	14.1	14.5	61	30
2001	14.5	14.6	59	29
2002	14.6	14.6	58	29

Table 11.1 – Big Dig Historical Cost Estimates

11.11 Ownership, Operations, and Maintenance

Whatever federal funding the Big Dig was eligible to receive, one caveat to the 90-10 rule was that it only provided for construction, not operations funding. A key justification for transferring the Big Dig to the MTA was that it would provide a guaranteed, user-based revenue stream for operations and maintenance that did not require legislative approval[430]. The legislative angle is an important one because Massachusetts legislators from outside the Boston area, and particularly those from western Massachusetts whose constituents pay taxes but rarely use the Boston facilities, would be unlikely to support taxes for maintaining a tunnel that they would rarely utilize.

In 1990, a toll increase on the Mass Pike was justified based on its own deferred maintenance. The timing seemed to work out well for the Big Dig, since those Mass Pike repairs were set to be paid off by the time the Big Dig was complete, and the excess revenues could go towards the Big Dig's expected annual operations and maintenance tab estimated at $80M-$100M per year[431].

The 1991 capping of federal funds clearly dealt a huge increase in risk to the financial plan for the Big Dig given that the state would now be paying closer to all of the increased project costs, not even accounting for O&M. Moreover, when the legislation was presented in 1997 to transfer oversight of the Big Dig to the MTA, the anticipated operations and maintenance costs were publicly stated to only be $25M per year and were left to the annual appropriation legislative process, while the Mass Pike tolls were dedicated to bonds to help deal with the cost increases[432]. Back during the Dukakis administration, in 1990, the O&M costs were projected to be at least three times more than the later $25M annual estimate, and that 1990 estimate has proven to be accurate[433].

429 Altshuler and Luberoff, 116.
430 Interview with Fred Salvucci.
431 Ibid.
432 Ibid.
433 Ibid.

11.12 Management Structure

As early as 1991, the Massachusetts Office of the Inspector General (OIG) warned of long-term dependency on a consultant whose contract had an open-ended structure and inadequate monitoring. Later OIG reports noted that B/PB essentially played the following roles[434]:

- Preliminary designer and oversight of final designer;
- Design coordinator;
- Construction manager, including packaging the bids and overseeing construction contracts;
- Contract administrator;
- Claims negotiator; and
- Change order negotiator.

The state OIG was consistently critical of the multiple roles B/PB was playing. This structure theoretically helped keep B/PB accountable for the outcome, but the risk of schedule slippage and cost increases was to the state, so it was the state's responsibility to vigilantly review these aspects.

The state should have known that it was going to be in a vulnerable position considering that B/PB was perhaps the only consortium capable of delivering the Big Dig given its size, scope, and innovative technologies used. The state would have been wise to have included the operations entity early, so as to provide some checks and balances along the way in a transparent system, rather than cede full control to B/PB and hide information from the public.

11.13 Managing Project Risks

An alternative way to manage the risks would have been for the state to split up the work of B/PB into smaller parts. One way to do this is to have separate consultants for preliminary design and for project management work[435]. The preliminary designers would have had primary responsibility at the beginning of the project, with the project management team providing oversight and working to integrate preliminary design with future stages that were dependent on the design outcome.

Another option is to keep some or all of the project management in-house, though this is generally infeasible and to be discouraged for megaprojects. Though this would have meant that the state retained all risk, at least it would have forced the state to be more aware of the risks and their implications.

In hindsight, perhaps the biggest failure of the state was not in risk allocation, but in ineffectively monitoring the risks for which B/PB was meant to be held to account.

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434 Haynes, 77.
435 Gelinas, 5.

11.14 Independent Project Organization (IPO)

By the late 1990s it finally became apparent to all parties that the Big Dig was suffering from a severe lack of transparency. The solution to this problem came in the form of an Integrated Project Organization (IPO), comprised of both MTA and B/PB staff mixed in at various levels into one single organization[436]. Upon creation of the IPO, the position of project director was designated to be an employee of the MTA who reports directly to the MTA Chairman[437].

The IPO gave the impression of transparency and cooperation, but this ultimately weakened the long-term planning, legal, financial, and contractual obligations of B/PB, and left B/PB with little consequence for their actions[438]. Combining the roles of oversight and management resulted in a lack of cost recovery and accountability on the project. The IPO ultimately reinforced the responsibility of the state for the entire outcome. On the positive side, the coverup of cost overruns had poisoned relationships, so the IPO did help reestablish collaboration, though perhaps too little too late.

A Massachusetts Senate Committee on Post Audit and Oversight report of December 2004 was critical of the IPO[439]. The Committee noted in the report that the benefits of IPOs had been seen in the private sector, but never realized on a public project that rivaled the scope or the cost of the Big Dig.

This was a criticism aimed at the wrong body. The Big Dig problems arose well prior to the creation of the IPO. For the IPO to have even had a chance to work, it needed to be implemented from the start of the project. The IPO structure certainly would not have prevented each of the mistakes on the Big Dig, but certainly it would have created a mechanism through which problems could have been identified and rectified much sooner. The state had the authority to establish transparency many years earlier, but only did so once the project had already incurred significant problems, and by then had passed the point of no return on expensive changes made in the early 1990s.

11.15 Cost Recovery

The Boston Globe conducted an investigation in February 2003 that detailed the mismanagement of the Big Dig to date. The Globe alleged that B/PB had profited from design mistakes and poor decisions to the tune of $1.6B[440]. The Inspector General would later concur.

Following these revelations, the MTA Chairman announced the creation of an Independent Cost Recovery team in 2003[441]. Between 2003 and 2004 the team secured $3.5M in settlements, but had

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436 National Research Council. Transportation Research Board. "Completing the Big Dig: Managing the Final Stages of Boston's Central Artery/Tunnel Project," 31.
437 Ibid.
438 Commonwealth of Massachusetts. "Road Blocks to Cost Recovery: Key Findings and Recommendations on the Big Dig Cost Recovery Process: A Report of the Senate Committee on Post Audit and Oversight," 12.
439 Ibid.
440 Commonwealth of Massachusetts. Office of the Inspector General. "Analysis of Bechtel/Parsons Brinckerhoff's Reply to *The Boston Globe*'s Investigative News Series Concerning the Big Dig." 1.
441 Commonwealth of Massachusetts. "Road Blocks to Cost Recovery: Key Findings and Recommendations on the Big Dig Cost Recovery Process: A Report of the Senate Committee on Post Audit and Oversight," 3.

several larger lawsuits pending. The team ultimately pursued 300 claims against Big Dig contractors[442].

B/PB should not be exonerated for its efforts on the Big Dig which, at times, were lackluster. But what must be underscored is the lack of oversight that led to a culture of corruption, scope creep, and mission creep on the Big Dig. That is what ultimately led to the major cost overruns.

Because responsibility and accountability was so poorly defined on the Big Dig, the state has recovered very little money as a result of change orders. The Massachusetts Senate Committee on Post Audit and Oversight report notes that the Big Dig had incurred over 11,000 change orders, but the state had only recovered $35,707 from those changes[443].

This limited cost recovery highlights the fact that it is a trap to believe that the public sector will be triumphant at recovering costs in the long run. Cost recovery should certainly never be an objective of the public sector; it should be a last resort. The objective is to get the project done correctly, so as to not require a laborious and often unsuccessful cost recovery effort.

11.16 Ceiling Collapse

These claims preceded a horrific tragedy in 2006 when a ceiling collapse led to the death of Milena Del Valle. In that case, B/PB and project designers settled with the state for $458M. The deal with the state and the U.S. Justice Department enabled the firms to avoid possible prosecution and debarment from federal and state contracts. Under the deal, Bechtel paid $352M, PB $47.2M, and about 24 design firms $51M collectively[444].

The ceiling collapse and the subsequent legal battle over liability should serve as caution for private consultants and construction managers[445]. Massachusetts threatened B/PB with indictments in order to get B/PB to settle with the state. The public sector, with its power to indict, may use the criminal justice system to deflect its own accountability. The subpoena power is armor for the public sector to pull out of its back pocket if and when mistakes are made.

The lack of clear accountability in the IPO structure undermined B/PB's legal liability for the ceiling collapse, but the state's criminal accusation forced B/PB to settle for a much larger amount. Just prior to the ceiling collapse, a settlement of $100M was under discussion[446].

The National Transportation Safety Board (NTSB) concluded that there was plenty of blame to go around. First, the epoxy used wasn't suitable for long-term loads of any type, and the company that made the glue, Powers Fasteners, didn't warn clearly that the epoxy wasn't interchangeable with another epoxy that it made[447]. The state subsequently sued Powers for criminal negligence.

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442 Commonwealth of Massachusetts. Office of the Inspector General. "Analysis of Bechtel/Parsons Brinckerhoff's Reply to *The Boston Globe*'s Investigative News Series Concerning the Big Dig," 1.
443 Commonwealth of Massachusetts. "Road Blocks to Cost Recovery: Key Findings and Recommendations on the Big Dig Cost Recovery Process: A Report of the Senate Committee on Post Audit and Oversight," 3.
444 Rubin, 1.
445 Gelinas.
446 Interview with Fred Salvucci.
447 Gelinas, 6.

The NTSB's report also noted that neither the ceiling's designer, Gannett Fleming, nor B/PB had thought about the ceiling's long-term performance[448].

However, it was the state of Massachusetts, annoyed by cost overruns and cleanliness problems on a similar ceiling, that chose to fit this section of tunnel with a cheaper ceiling, which turned out to be heavier[449]. What's worse is that it would later become public that the ceiling was only installed in the first place for aesthetic purposes and served no real function[450]. The NTSB report points out that, once the tunnel opened in 2003, Massachusetts was supposed to conduct regular inspections, which likely would have revealed the ceiling panels' displacement long before the collapse. This tragedy highlights the failure to shift to a culture that was adequately cognizant of O&M issues.

11.17 Non-Delivery of Transit Commitments

The Big Dig was part of a much larger citywide movement to curb congestion and gridlock, started in the 1970s. Among the transit commitments that were to be completed as part of that plan are:

- Connection from the MBTA Blue Line to the Red Line at the Charles/MGH station;
- Extension of the MBTA Green Line north to Medford;
- Third phase of the MBTA Silver Line bus service to Logan Airport and Dudley Square;
- Restoration of the commuter rail line to Scituate, MA;
- Restoration of the Arborway branch of the MBTA Green Line; and
- Increased frequency of bus service.

Also among the commitments that were part of a Memorandum of Understanding (MOU) Salvucci signed with the Conservation Law Foundation (CLF) in 1990, just before leaving office, were 20,000 new parking spaces at commuter rail and rapid transit stations, a regional system of high-occupancy vehicle (HOV) lanes, a limit on transit fare increases to the rate of inflation, and more stringent limits on the number of parking spaces in Downtown Boston[451].

To date, very few of these commitments have been fulfilled as promised. On the rail capital side, only the commuter rail restoration to Scituate has been completed, and even that took until 2007 to complete.

There is a strong constituency of transit advocates in the Boston area for these projects, but the arguments are often couched in language that suggests the commitments are serving the purpose of "mitigating" the impacts of the Big Dig. This mitigation argument has a negative connotation, as if to suggest that these projects are to correct a problem caused by the Big Dig. In actuality, they are part of the same package of commitments that are intended to complement the Big Dig to achieve the congestion reduction projected in the EIS.

448 Ibid.
449 Ibid.
450 Interview with Fred Salvucci.
451 Altshuler and Luberoff, 109-110.

These transit projects have also suffered from a narrow, short-term viewpoint that often plagues these megaprojects. Seldom are these commitments considered as part of the broader program of transportation improvements that included the Big Dig and were intended to help retain the economic vitality of the Boston region over the long-term.

11.18 CM@Risk as a Possible Management Alternative

When B/PB was hired as an Agency CM rather than a CM@Risk, it reduced B/PB's accountability and left B/PB with less incentive to do a stellar job beyond its ethical responsibility to act in good faith. Of course, this begs the question of how much of a risk premium B/PB would have included in its bid if it were bidding as a CM@Risk rather than as an Agency CM.

The state was ultimately in a weak bargaining position given the fact that B/PB was among very few consortia with the skills necessary to deliver the Big Dig. B/PB very well could have recognized this weakness and leveraged it in order to avoid having to accept project risks. This is a way in which the public sector is put at a significant disadvantage when procuring a highly specialized project, and the potential for risk transfer may be illusive.

11.19 The Big Dig as a Design-Build Project

Though the Big Dig was conceived, planned, and built in an environment that did not allow alternative delivery strategies at the time, it is worth considering whether the project would have turned out any differently were those options available. It is generally agreed upon that the Big Dig, much like Crossrail, was too big to be delivered under any single D-B contract. Therefore any discussion of D-B needs to take into account the fact that multiple contracts would have been necessary.

If the Big Dig had been managed with early involvement of the operator and in a transparent manner, the outcome might also have been much better. However, the comparison of D-B to D-B-B on the Big Dig may be misleading because of a poisonous culture of secrecy that would likely have prevailed regardless. On balance, it appears D-B could have helped, but it is difficult to "prove" that based on the observation of this one case.

11.19.1 Potential Advantages of Design-Build for the Big Dig

B/PB performed 30% design and then approved the final design that had been contracted out to section designers. This put B/PB in the strong position of approving designs that were of its own conception, but completed by other design entities. It gave B/PB the leverage to not sign off on changes made to its conceptual design that it did not approve of and allowed B/PB to blame section designers for mistakes.

Under D-B, there still may have been a structure in place by which the state's consultant, B/PB, would sign off on final design completed by a design-builder. In this case there would have been clear accountability of the design-builder to B/PB, and of B/PB to the state of Massachusetts.

Value engineering changes after 100% design almost never were accepted on the Big Dig because it implicitly criticized B/PB's design. In D-B the design-builder would have been entitled to propose value engineering solutions, but they also would have been responsible for delivering value for money on their own final design at the contract price.

In the actual traditional D-B-B process, the initial market tests for construction did not come until after all of the engineering had been performed, which occurred several years later than they may have under D-B. If D-B contract approval came at or prior to 30% design, with requirements for review and approval at 50%, 75%, and 100%, there would be early feedback not only on cost but also constructability. The B/PB $14B cost estimate in the early 1990s that was ultimately sequestered by the state for several years surely would have been forced to become public much sooner under D-B. D-B allows for course corrections, fast-tracking, and more realistic management of contingency funds.

D-B would have required and allowed for B/PB to focus on its core responsibilities for which it was most qualified, such as managing the many interfaces involved in the project. Instead, because of the latitude provided to them by the state, B/PB was responsible for each and every decision. D-B would have ensured that B/PB was not excessively micromanaging the project.

The eventual owner and operator would also have likely been selected much earlier than 1997 under D-B, and therefore could have had influence in reviewing and overseeing the B/PB design and construction during the critical early years.

Finally, D-B would have eliminated the need to create the Independent Project Organization (IPO) in 1998, which let B/PB off the hook for many of the mistakes and cost overruns it may have been at least partially responsible for prior to the IPO's creation. Under D-B the state would have understood better its relationship with its consultant B/PB and would likely not have had to perform a complete restructuring halfway through construction.

11.19.2 Potential Disadvantages of Design-Build for the Big Dig

D-B implemented on a project as large as the Big Dig, and in a region where D-B was and still today is not commonplace, would have significantly reduced competition for D-B contracts. This would have led to a few number of large firms inflating their price quotes to cover the many risks posed simply by the inexperience in doing D-B, let alone the risk of substantial design changes.

Since Massachusetts found itself unable to provide oversight over its partners and contractors under a traditional D-B-B structure, it arguably would have been even more difficult under an alternative delivery model. At least traditional D-B-B was familiar. D-B relies heavily on the contractor's own quality control, and though B/PB had the capacity to perform that function, transferring that responsibility does not ensure it is being handled properly. This applies even more pressure on the public sector to hold their design-builders accountable for quality deficiencies, and there is no guarantee that Massachusetts could have handled that task properly on the Big Dig.

Lastly, the best value approach to letting D-B contracts raises issues about the potential subjectivity of contract awarding. Under traditional D-B-B's predominant low-bid rules there is a clear, if imperfect, rubric by which contractors are selected. "Best value" only provides better value in theory, but it is a highly subjective selection method sometimes accompanied by biased selection criteria.

Chapter 12: Tren Urbano

Tren Urbano is a 10.7-mile (17.2-km) heavy-rail metro system in San Juan, Puerto Rico, which opened in December 2004. It has 16 stations, 10 of which are elevated, four at-grade or in open cuttings, and two underground. This chapter describes how the project evolved throughout procurement, and how alternative delivery strategies used on this project impacted the final result.

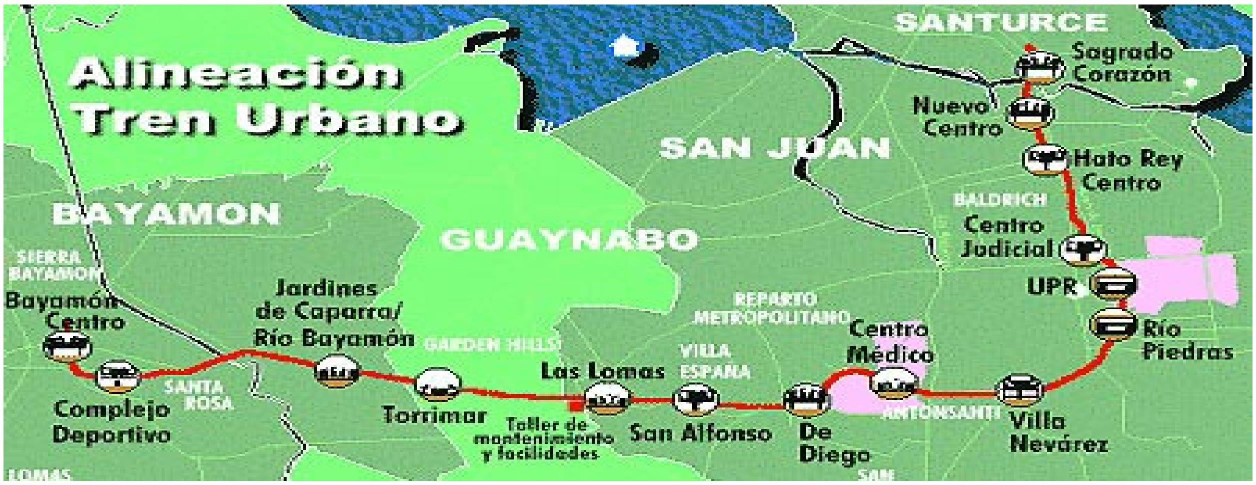

Figure 12.1 – Tren Urbano Map

12.1 Purpose and Need

The San Juan Metropolitan Area (SJMA) alone has 1.3M inhabitants, which is over one-third of the population on the island[452]. Population densities in central San Juan are among the highest in the U.S., rivaling even New York City[453]. While the average density in San Juan is 8,500 persons per square km, in some areas it exceeds 20,000 per square km[454].

As this chart of journey-to-work behavior of Puerto Ricans from the 2000 census indicates, transportation in Puerto Rico had long favored the automobile much like in the rest of the U.S. Nearly 87% of journeys to work are in single-occupancy vehicles[455]:

452 Agarwal, 40.
453 Nigel Wilson Lecture, MIT.
454 Agarwal, 40.
455 U.S. Census Bureau. "Population Density for States and Puerto Rico."

Total:	**908,386**
Car, truck, or van:	790,157
Drove alone	626,578
Carpooled	163,579
Public transportation:	48,322
Bus or trolley bus	15,749
Streetcar or trolley car (publico in Puerto Rico)	31,131
Subway or elevated	117
Railroad	9
Ferryboat	269
Taxicab	1,047
Motorcycle	970
Bicycle	2,249
Walked	36,834
Other means	13,890
Worked at home	15,964

Table 12.1 – Puerto Rico Journey-to-work Census Data, 2000

Based on the dramatic growth rates in and around San Juan, and the capacity issues on existing roadways, Puerto Rico decided to construct Tren Urbano; the first rail system built on the island in over 50 years[456].

12.2 Shift to Transit Mindset

In March 1991, the Puerto Rico Highway Authority (PRHA) was officially renamed the Puerto Rico Highway and Transit Authority (PRHTA) to reflect this new focus on mass transit. The fact that Tren Urbano was the first modern transit project in Puerto Rico, coupled with a concerted effort to include local contractors caused significant problems. Years later, while the project was under construction, highway specialists who did not have a stellar performance record of their own became responsible for inspection of major portions of transit infrastructure.

12.3 Procurement

Tren Urbano was procured as a design-build-operate-maintain (DBOM) project, but with many elements that were strictly design-build (D-B). The civil work, comprising the permanent right-of-way and building acquisition was split into seven "alignment sections." A D-B contract was let for each of the seven sections. One of the seven contracts includes the overall operations and maintenance (O&M) function for five years, with a government option for a five-year renewal. Five years was the maximum contract length allowed at that time under U.S. tax regulation[457].

In 1994, PRHTA signed a $42M contract with a General Management and Architectural and Engineering Consultant (GMAEC), led by the firm DMJM Harris[458]. The GMAEC was an Agency

456 Lewis, 3.
457 Interview with Fred Salvucci.
458 Peña-Mora, Sosa, and McCone, 230.

CM, not at-risk, set up to develop the 30% design and be the first point of accountability and owner's representative on implementation[459]. It was to be responsible for the EIS, procurement documents, and selection and oversight of the eventual DBOM partner[460].

The entire systems portion, comprising track, signaling, vehicles, and communications, was awarded to the single DBOM contractor, Siemens Transportation Partnership Puerto Rico. PRHTA was not required by law to choose the lowest bidder, but the bid eventually chosen was also the lowest cost[461].

The Siemens joint venture included three partners[462]:

- Siemens Transportation Systems, Inc., of Delaware, USA;
- Juan R. Requena y Asociados of Puerto Rico; and
- Alternate Concepts, Inc., of Massachusetts, USA.

Siemens was also responsible for coordinating the work of the remaining alignment section corridors to ensure adequate integration with Siemens's system design[463].

Siemens is paid an inflation-indexed base compensation ranging from $27.3M to $34.4M per year for operating the system[464]. Compensation is also dependent on the quality of service, with a deduction for service shortfalls and a bonus for improved performance and high ridership. PRHTA sets the level of service and the fares, though they are collected by Siemens[465]. PRHTA may require changes in the level of service with appropriate adjustments in compensation paid to Siemens.

Long-term functionality is a key reason for procuring a DBOM contract since it shifts much of the performance risk to the private operator. PRHTA believed Siemens's O&M responsibility would lead to a better quality product. However, Siemens had only a short-term perspective since the DBOM contract was only for five years with the one five-year renewal option. Because much of the infrastructure has a lifespan well in excess of five or ten years, Siemens was not properly incentivized to be cognizant of the whole life-cycle costs of the asset.

12.4 Revenue Risk

PRHTA's EIS predicted 110,000 rides per day, but the agency agreed that a prudent bidder would probably discount that number in its bid[466]. The final contract stipulated that all fares from the first 100,000 rides per day go to PRHTA and any extra would be shared between PRHTA and Siemens.

Ridership was significantly less than expected, largely because an extensive bus feeder system plan was never implemented nor was there a university ridership program to help capture the large

459 Lewis, 3.
460 Ibid.
461 Ibid, 4.
462 Agarwal, 47.
463 Interview with Jim Whalen and Chip Dewitt.
464 Agarwal, 48.
465 Ibid.
466 Lewis, 4.

student population in the areas surrounding Tren Urbano stations. Tren Urbano averaged only 24,000 trips per day after nearly a year of operation[467]. If Siemens thought the ridership estimate was optimistic from the start, the incentivization package likely did not lower its bid price as intended.

12.5 Tren Urbano Construction Management

Because Tren Urbano was a completely new type of project in Puerto Rico, coordination among the owner, contractors, and subcontractors was critical. In a transit project, there are many systemwide elements being delivered by contractors at different intervals.

The GMAEC was tasked with developing the design and providing oversight during the construction period. Unfortunately, the GMAEC was consistently undermined by the PRHTA[468]. PRHTA put their own highway specialists in key roles that only people with a background in transit could perform adequately. This left the GMAEC to perform only residual QA/QC functions rather than full construction oversight.

PRHTA also neglected to properly oversee the Siemens operations contract. Transferring construction risk to Siemens backfired because PRHTA attempted to manage Siemens's subcontractors directly, violating the contract and weakening Siemens's accountability[469].

Many of these consequences came to light on contracts with one Puerto Rican-based contractor in particular. This contractor was granted work on four of the seven design-build contracts and frequently extracted escalation fees to fast-track task completion[470]. This may have been a contributing factor in the deaths of three workers during Tren Urbano construction[471]. Siemens never performed extensive reviews of the contractor's work and acted as though the contractor was accountable to PRHTA[472]. PRHTA, however, should have challenged this claim and should have been holding Siemens accountable for the shoddy work of its subcontractors.

PRHTA made a fundamental error in transferring a risk for which it did not hold its private sector partner accountable. Perhaps in deference to the fact that the contractor was local and provided lots of jobs to native Puerto Ricans, PRHTA consistently relented.

Given PRHTA's unwillingness or inability to hold Siemens accountable for the work of its subcontractors, PRHTA had two options. It could either let the subcontractors continue to deliver poor work that was often late, or it could perform its own oversight and inspection of the subcontractors. Either way, the accountability always fell on PRHTA.

PRHTA inspectors were also quite blatant in their disregard for any input provided by the GMAEC on construction management and quality control. The oversight that was to be provided by the GMAEC and by Siemens was disregarded when PRHTA dealt directly with subcontractors.

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[467] Toll Roads News. "Tren Urbano PR Another Way Low Transit Ridership Forecast."
[468] Dieterich, 88.
[469] Interview with Fred Salvucci.
[470] Nigel Wilson Lecture, MIT.
[471] Interview with Fred Salvucci.
[472] Ibid.

12.6 Benefits of Early Operator Involvement

This is not to say that Siemens's early involvement was all not worthwhile. One example came in the development of the Tren Urbano maintenance facility. The delivery partner GMAEC had partially designed the facility prior to Siemens being selected as the operator. Since Siemens was hired as the operator early enough in the design phase of the facility so that their input could be incorporated into the final design, Siemens was able to work with the GMAEC on the final plans. The maintenance facility has proven to be one of the most successful elements of Tren Urbano[473].

12.7 Inclusion in the Turnkey Demonstration Program

The PRHTA was opportunistic in its approach to securing funding for Tren Urbano. FTA was encouraging experimentation with design-build techniques, so Puerto Rico applied to become part of FTA's blue-ribbon Turnkey Demonstration Program design-build initiative as a means to attract favorable consideration from FTA for federal funding[474]. The FTA executed a Full Funding Grant Agreement (FFGA) for the construction of Tren Urbano with PRHTA in March 1996. At the time, Tren Urbano was originally scheduled to open in July 2001 and at a cost of $1.25B.

PRHTA also sold bonds that would eventually amount to $2B and received substantial funding from local sources including gas taxes, diesel oil taxes, motor vehicle license fees, and highway tolls[475][476].

12.8 Scope Changes, Delays, and Amended Federal Commitment

The cost of Tren Urbano grew to $1.68B by August 2000[477]. Through an amended FTA FFGA signed in 1999, the federal government's financial contribution to the project grew from about $300M to $700M.

Notably, the additional funds were formula-based and did not come directly from the New Starts program. Therefore, these funds could have been used to fund other transportation improvements not related to Tren Urbano. In essence, the gap funding being filled by formula funds meant that Puerto Rico had to divert funds away from its highway improvements to make up for shortfalls on Tren Urbano.

The amended FFGA reflected several scope changes – the addition of two stations, additional vehicles, and enhancements to station finishes and community facilities – as well as some cost increases[478]. The schedule in the amended FFGA projected a revenue operating date of 2002; 10 months later than estimated when the original FFGA was signed in 1996[479].

By 2003 the project had not yet been completed and its cost had risen to $2.25B. In May of that year the FTA approved yet another amendment to the FFGA. Again, the federal commitment increased without any additional New Starts contributions. This time, the formula-based funds

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473 Ibid.
474 Bennett, Desai, and Mevawala, 1.
475 U.S. General Accounting Office. "Mass Transit: Review of the Tren Urbano Finance Plan," 3.
476 Ibid.
477 Middleton, 2000.
478 Ibid.
479 U.S. General Accounting Office. "Mass Transit: Review of the Tren Urbano Finance Plan," 2.

added to Tren Urbano were $125M, bringing the federal government's total contribution to $833.3M. The following chart shows the amount and source of funding, as well as the scheduled date of completion at the time each of the three FFGAs were signed[480]:

Tren Urbano Historical Cost, Funding, and Schedule Estimates ($ millions)			
	March 1996 FFGA	**July 1999 Amended FFGA**	**May 2003 Amended FFGA**
Federal Funding			
New Starts	$307.4	$307.4	$307.4
Capital Funds	$0	$0	$5
Formula Funds	$0	$141	$181
Federal High Flex Funds	$0	$259.9	$339.9
Subtotal Federal	$307.4	$708.3	$833.3
Local Funding	$942.9	$945.3	$1,416.7
Total Funding	$1,250.3	$1,653.6	$2,250
Scheduled Project Completion	July 1, 2001	May 31, 2002	June 30, 2004

Table 12.2 – Tren Urbano Historical Cost, Funding, and Schedule Estimates

12.9 D-B-B Cost Estimates Versus D-B

The National Transit Institute (NTI) D-B Project Development training course performed a comparison study between Tren Urbano D-B-B cost estimates versus D-B cost estimates[481]:

Tren Urbano Comparison of D-B-B Estimates to D-B Estimates		
	Design-Bid-Build	**Design-Build**
Total Project Value	$2.0B (1999$)	$1.7B (1999$)
Alignment Length	10.7 miles	10.7 miles
Cost per Route Mile	$186.9M	$158.9M
Number of Contracts	~75	8
Average Contract Value	$26.7M	$212.5M
Schedule Duration	8-10 years	5.5 years
Change Orders/Claims	~250	~15
Total Value	$750M	$450M
Average Value	$3.0M	$30.0M

Table 12.3 – Tren Urbano D-B-B vs. D-B Cost Estimate Comparison

Despite the project eventually having come in at $2.25M due to scope increases and market conditions, PRHTA's data predicted that D-B still saved 15% in costs per route mile, 30% in overall project duration, and took two years off the project's timeline[482][483].

480 U.S. Department of Transportation. Federal Transit Administration. "Audit of Tren Urbano Rail Transit Project," 2.
481 Loulakis, 102.
482 Ibid.
483 Dieterich, 83.

12.10 Federal Audit

The Federal Transit Administration (FTA) kept a close eye on the project and performed several audits, the third of which was released in September 2004. According to FTA, 40% of the cost increase is due to scope changes, such as the addition of rail vehicles and two stations[484]. The remaining 60% is attributed to rising costs, schedule slippages, and construction quality problems.

12.10.1 False Inflation Assumptions

The FTA audits exposed PRHTA for using an arbitrarily low inflation adjustment. PRHTA accounted for inflation simply by adding $200,000 per year[485]. For example, it determined the amount of capitalized expenditures for 2008 by taking the figure from 2007, $85M, and increasing it to $85.2M. This is equivalent to an annual inflation rate of less than 0.25%. By comparison, for the 10-year period from 1995-2004, inflation in Puerto Rico had never been below 1.33% and was as high as 6.36%[486].

This may have been the result of a careless inaccuracy, or may be an egregious example of optimism bias. Regardless, as a result of this extremely low inflation projection, it is estimated that PRHTA understated capitalized expenditures by approximately $378M in 2003 present value terms[487].

12.10.2 Bus Feeder System Abandonment

Perhaps the most notable omission was the elimination of not one, but two bus feeder system plans which were intended to provide the access to Tren Urbano for a large majority of its intended ridership. Roughly 55% of Tren Urbano's riders were expected to arrive at metro stations by bus[488]. The FTA review noted that the cost of this single omission alone could reach $1.269B in 2003 present value terms[489].

This elimination of the bus system plan represented an explicit neglect for the long-term functionality of Tren Urbano as a whole. Political posturing may have had a lot to do with this, as Puerto Rico had just undergone a transition of political parties. The new administration may not have wanted to proceed with a bus plan developed by the previous administration[490].

On megaprojects, especially, it is important that the owner or its designated manager or representative is consistently looking out for the project's long-term viability. In the case of Tren Urbano, both political transition and also the weakening of the GMAEC role led to an excessive focus on short-term interests.

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484 U.S. Department of Transportation. Federal Transit Administration. "Audit of Tren Urbano Rail Transit Project," 3.
485 Ibid, 20.
486 Ibid, 20.
487 Ibid, 6-7.
488 Peña-Mora, Sosa, and McCone, 231.
489 U.S. Department of Transportation. Federal Transit Administration. "Audit of Tren Urbano Rail Transit Project," 21.
490 Interview with Fred Salvucci.

12.11 Costly Change Orders and Inadequate Cost Recovery Plan

The "fast-tracking" strategy in Tren Urbano that allowed work to start on certain elements while the final designs and plans for seemingly unrelated elements were still being conceived had unintended consequences. It allowed contractors to claim that previously completed work hindered their ability to fulfill their responsibilities, even though this was a risk that was legally theirs to manage. This led to numerous and costly claims, change orders, and renegotiations.

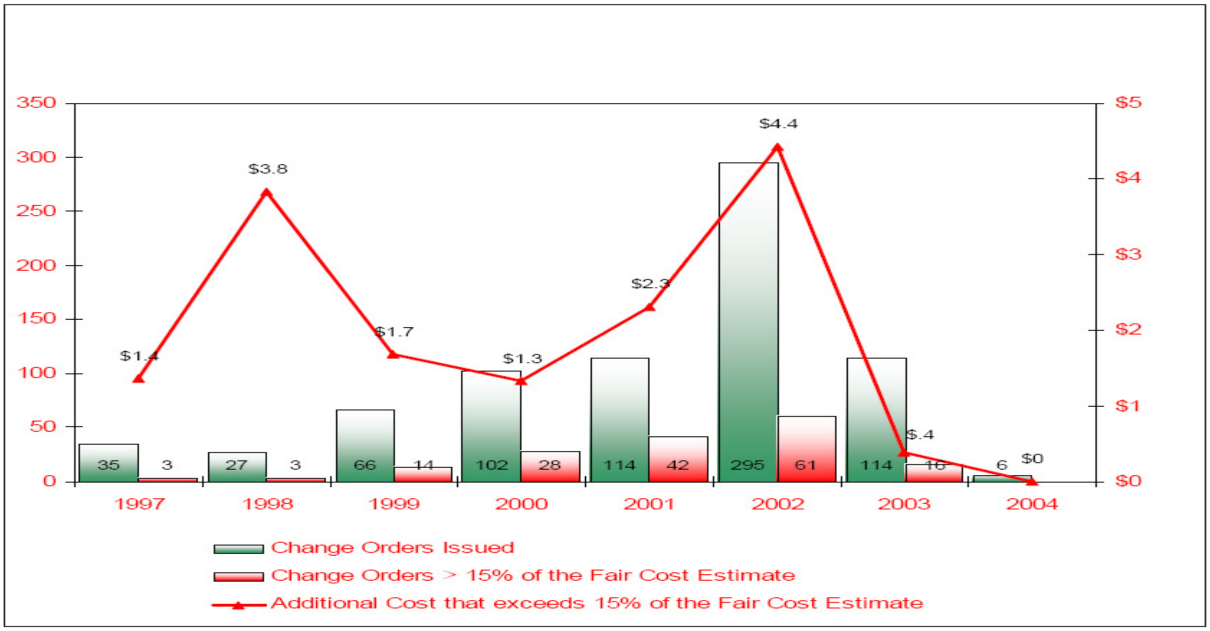
Since PRHTA lacked in-house expertise to determine whether or not their contractors were telling the truth and not trying to extrapolate additional funds, there was little recourse but to take the contractors at their word. Someone has to determine when to fast-track and when there genuinely isn't enough information to do so. PRHTA did not adequately analyze the interfaces of the contracts and identify which elements had too many dependencies to be fast-tracked, nor did PRHTA legally enforce contractors' risks.

From 1997 through 2004, PRHTA executed 759 contract change orders[491]. FTA's audit found that 377, or nearly half of these change orders were irregular, suggesting that contractors may have been overpaid for their work. The irregularities in the change orders were of three types[492]:

1. 207 change orders valued at $186.1M were executed without PRHTA first obtaining a fair cost estimate, as was required by the FTA. For example, a 2002 change order to redesign and relocate utilities for the Hato Rey contract had a contractor-proposed value of $281,162 and was settled for $888,000.
2. 167 change orders were executed for more than 15% above the value of their fair cost estimates. In the most extreme case, one change order was settled for 2189% above its cost estimate. The amounts paid above 15% over the fair cost estimate totaled $15.3M[493].

[491] U.S. Department of Transportation. Federal Transit Administration. "Audit of Tren Urbano Rail Transit Project," 5.
[492] Ibid.
[493] Ibid, 17.

Number and Additional Cost of Change Orders Issued Above 15 Percent of Fair Cost Estimates ($ in Millions)



Source: OIG analysis of the project's change order log as of May 7, 2004.

Figure 12.2 – Tren Urbano Change Order Costs

3. 8 change orders were executed for accelerating construction, even though FTA warned PRHTA that the dates were not achievable.

FTA noted that PRHTA showed a "flagrant disregard" for its requests[494]. As a result, these 377 change orders added $226.5M to the cost of the project.

In November 2003, FTA completed a review of 167 of these change orders and declared 52 of them, valued at $130M, ineligible for federal funds because supporting documentation was missing to validate the rationality for the contractors' proposals and the value of the work performed[495]. PRHTA had not provided the documentation related to the 52 change orders a full ten months after the request by FTA was made.

12.12 Safety Delays

With 93% of the project complete, PRHTA had identified 241 safety and performance issues yet to be resolved[496]. In July 2004, PRHTA and FTA determined that 77 of these issues were safety-critical and PRHTA submitted a plan to FTA for resolving these issues. However, the plan did not establish timeframes or identify actions to address all safety-critical issues prior to the start of passenger service. By September 2004, only seven of the 77 issues had been resolved.

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494 Ibid, 5.
495 Ibid, 5.
496 Ibid, 8.

12.13 Litigation

Delays in construction led to a bitter dispute between Siemens and PRHTA. Originally scheduled for a September 2003 completion date, Tren Urbano was still not operational several months later. PRHTA fined Siemens $3M and imposed a penalty of $100,000 per day in damages for not completing the project on-time[497].

Siemens claimed that it had no control over their contractors since it believed that they were to be supervised by PRHTA. Also, Siemens noted that PRHTA granted extensions to these other civil contractors without granting the same extensions to Siemens.

Siemens contended that the delays were not its fault, but rather that of other contractors whose own failures meant that Siemens couldn't complete its work on-time. Again, these other contractors were actually subcontractors to Siemens for whom Siemens should have been held accountable.

In February 2004, the Siemens Partnership sued PRHTA seeking a 284-day extension to complete Tren Urbano and $50M[498]. Siemens arrived at the $50M amount based on $10M for work already undertaken to accelerate the project, a $3M judgment against PRHTA for not complying with a change order request, and $37M in damages[499]. Siemens and PRHTA are still in litigation[500].

12.14 D-B Contract Success Story: Rio Piedras

Despite many of the problems in the procurement and delivery of Tren Urbano, there was one contract in particular that, by all accounts, was a resounding success. It just so happens that this contract also included the lone subterranean sections of the project and hence had the most difficult engineering and logistical hurdles to navigate. This one of the seven alignment section-based design-build contracts for Tren Urbano was the Rio Piedras contract. Rio Piedras consists of a 1.5-km tunnel with two underground stations: University of Puerto Rico and Rio Piedras.

The contract was advertised in June 1996 and awarded in April 1997 to the KKZ/CMA joint venture, which comprises three construction contractors: Kiewit Construction Company, Kenny Construction, and H.B. Zachry Company[501]. The managing designer was the Puerto Rican firm CMA Architects & Engineers. The bid of $225.6M was the highest of the three bidders, but was deemed to be of the best value, in part because of the consortium's stellar health and safety record[502].

The KKZ/CMA JV had to assume more risk for their alternative design, which was quite different than the one PRHTA had been developing in-house[503].

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497 Buckner Powers, Mary. "Siemens Sues Puerto Rico Over Tren Urbano Completion."
498 Ibid.
499 Ibid.
500 Interview with Jim Whalen and Chip Dewitt.
501 Gay, Rippentrop, Hansmire, and Romero, 623.
502 Interview with Fred Salvucci.
503 Ibid.

Sections of the guideway and the University of Puerto Rico station were constructed by cut-and-cover methods. The remainder was done by various tunneling methods, including the use of an earth pressure balance tunnel boring machine for both guideway tunnels.

12.14.1 Risks Specific to Rio Piedras

For the Rio Piedras subterranean contract, the owner did a significant amount of geotechnical research prior to requesting proposals for the design-build contract[504]. Subsequently, this research was shared with prospective bidders and helped to foster an open dialogue about these delicate engineering obstacles.

First, a geotechnical data report was generated by the owner and shared with bidding teams. Second, bidding teams were allowed to submit requests for additional geotechnical information prior to them submitting their best and final offer. Finally, bidding teams were invited to meet with the owner's team members to discuss their interpretation of the data.

In urban areas, especially *old* urban areas, there are always many unknowns when it comes to existing utilities. This causes delays and disputes and is considered a high risk for a contractor. To eliminate this risk in Tren Urbano, the owner decided to provide a "stipulated lump sum" amount as a bid item[505]. All utility work was paid for under this item, eliminating the risk to the contractor, and the D-B contractor was paid a fee for administering the utility subcontractor's work. This created a very proactive environment for the project team.

The amount of design performed before issuing a contract, design-build or otherwise, should depend on the amount of uncertainty that can be eliminated through a more thorough preliminary analysis. Utility relocation is one such element that should be executed to a higher level of design than others due to the potential delays and additional costs associated with this type of work. Ideally, utility companies are involved actively in the design and scheduling of major construction work, but this is difficult to achieve. In Rio Piedras, because leaks from water and sewer pipes could weaken soil stability during tunneling, an early action renewed and repaired most utilities in the area.

12.15 Lessons Learned from Tren Urbano as a DBOM Project

Tren Urbano perhaps suffered most from the "cultural" shift in mindset that it required. There had not been a transit project built in Puerto Rico in 50 years, so the PRHTA experience was solely in road projects. In addition, because of the scarcity of competitive contractors, a culture of accepting poor quality work and paying extra for remediation had developed. The PRHTA was therefore poorly prepared to oversee construction of a transit project with much higher quality requirements than most highway projects.

Under D-B-B the project likely would never have happened or would have resulted in an inferior asset. Given the extremely close relationship between PRHTA and local contractors, none of whom had experience in rail transit, the project likely would have been very poorly constructed. At least with DBOM, the civil contractors were to be held accountable to future operator Siemens.

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504 Bennett, Desai, and Mevawala, 5.
505 Ibid.

With one contractor having been given the majority of D-B alignment section contracts (four of seven), however, the project exhibited many of the same characteristics of D-B-B. This strategy provided greater opportunity for the contractor to extract additional funds by causing delay on one contract and then claiming that the delay had an adverse impact on its other contracts, which led to costly claims and change orders.

The culture of low quality and safety standards that existed in the Puerto Rican procurement and construction communities made the project management function so critical in DBOM all the more difficult to perform. The GMAEC/delivery partner structure was probably the proper one considering the large number of interfaces that the multiple D-B contracts created. Unfortunately, an ineffectual client in PRHTA usurped the GMAEC's role and also chose to manage the operator Siemens's contractors rather than hold Siemens itself accountable.

The broad scope of PRHTA's role partially undermined both the project and program management efforts. As a result of this failure in management there was virtually no one looking out for the long-term viability of the program. This led to the eventual abandonment of the plan to integrate bus feeder systems and plans to attract university students, which contributed significantly to low ridership.

Tren Urbano may have ended up as a DBOM partly because of the funding streams that the Turnkey Demonstration Program provided. But the substantive reason for choosing DBOM, rather than simple D-B, which would have been adequate to be included in the FTA Turnkey Program, was to have the operator, with a stake in high quality, in charge.

Siemens was involved early, but perhaps not early enough. Contributing to some of the failure was the fact that the Siemens O&M contract was only for five years. This was well short of what was needed to entice Siemens to play a proactive role in quality enhancement and also to account for whole life-cycle costs. Although tax law initially prevented longer contracts, this law was eventually overturned to allow for early extension of the contract, but no extension was ever executed. Siemens's contract is set to expire in late 2009, and it has not yet been renewed, nor is there any indication of a successor.

Despite all of the hurdles that needed to be overcome in order to bring Tren Urbano to completion as a DBOM, it is still believed that DBOM saved two years over D-B-B, and there is no evidence to suggest that the project would have turned out any better if it had been delivered traditionally[506].

[506] Dieterich, 83.

Chapter 13: Crossrail

This chapter will introduce the reader to Crossrail, including the business case to support its development, and its funding and governance structures.

13.1 Crossrail

Crossrail is a proposed east-west rail line spanning nearly 120 km and traversing central London via a 21-km tunnel through the heart of the city[507].

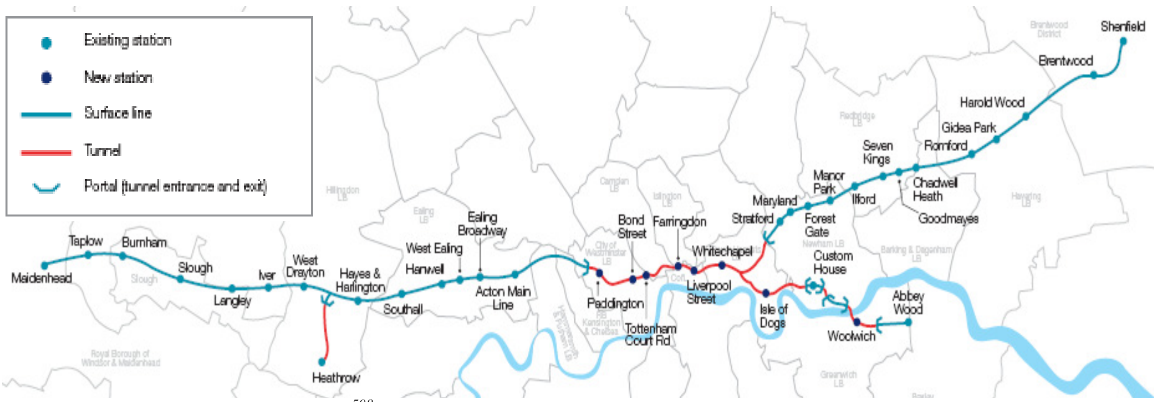

Figure 13.1 – Crossrail Regional Map[508]

Crossrail will support economic growth, reduce congestion into and within London, improve intermodal connections, and provide regeneration opportunities throughout the region[509].

13.2 Crossrail Timeline

Crossrail obtained the key parliamentary approval known as Royal Assent in 2008, and with a £15.9B funding package in place is set to proceed with procurement and construction, to commence in 2009. Crossrail is expected to open for passenger service in 2017. The following diagram indicates the projected timeline of key benchmarks[510]:

507 Crossrail. "Major Boost for Crossrail as BAA Agrees £230 million Funding - Joint DfT & BAA Release."
508 Crossrail. "Regional Map."
509 Crossrail. "Environmental Statement." Volume 1. Chapter 1, page 4.
510 Crossrail. "Freedom of Information Act – Guide to Publications."

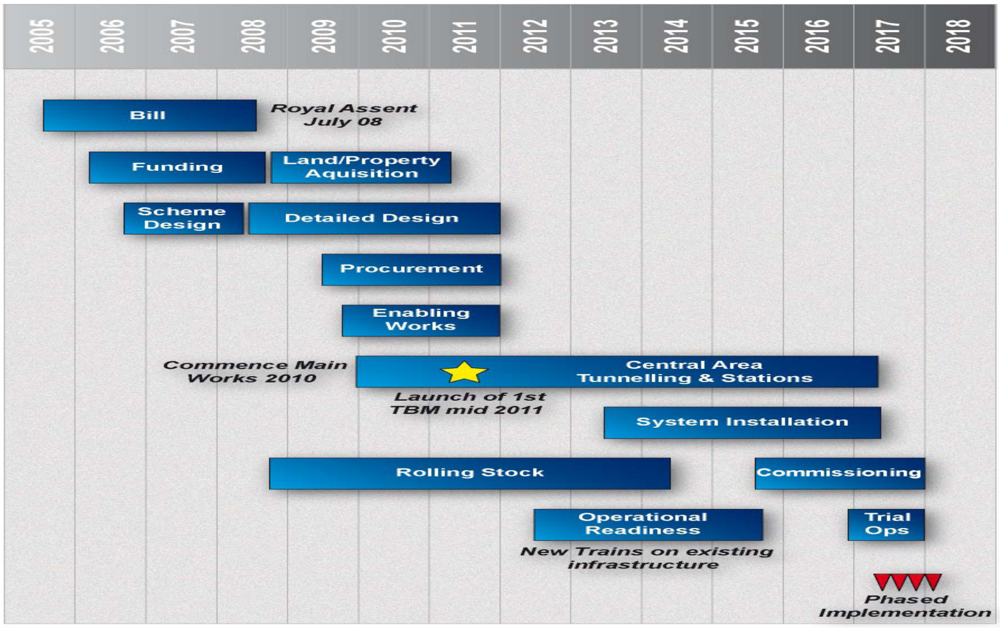

Figure 13.2 – Crossrail Timeline

13.3 Crossrail Route

Crossrail's route has four distinct sections: a central tunnel section (CTS) and western, northeastern, and southeastern branches. In the west, Crossrail will use the existing Great Western Main Line rail corridor to its terminus in Maidenhead[511]. The CTS will consist of a twin-bore tunnel beneath central London. On the northeast route section, Crossrail will use the existing Great Eastern Main Line to Shenfield. Crossrail will emerge from the central tunnel to serve a reconstructed station at Custom House, as well as stations at Woolwich and at its southeastern terminus at Abbey Wood.

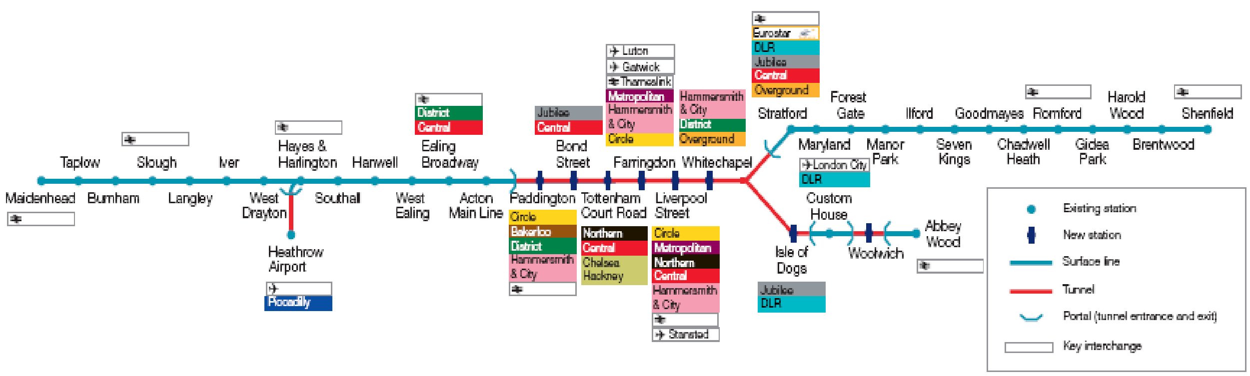

Figure 13.3 – Crossrail Route Connections Map[512]

Crossrail includes the construction of seven central area stations – providing interchange with London Underground (LUL), Network Rail (NR), and London bus services – and the upgrading or renewal of existing stations outside central London. Crossrail is designed to connect to various

511 Crossrail. "Environmental Statement." Volume 1. Chapter 2, pages 12-13.
512 Crossrail. "Route Connections Map."

other elements of the London transport network, thus providing a more seamless and more reliable transportation system[513].

13.4 Crossrail Operations

Crossrail's rolling stock will be reminiscent of a commuter rail or intercity rail service, but with frequencies through the central section comparable to the London Underground or any other Metro system. Though still susceptible to change, the expected frequencies are 24 trains per hour in each direction during peak periods[514]. Fourteen of the 24 peak-hour trains will terminate at Paddington Station in the west. Two trains will terminate in West Drayton, four at Heathrow Airport, and four at Maidenhead. Eastbound trains will be split evenly between the Shenfield and Abbey Wood branches[515][516]:

Figure 13.4 – Crossrail Trains Per Hour Per Direction in the Peak Period

Station platforms will be designed to accommodate 10-car trains that are 200 meters long[517]. Each 10-car train will have a capacity of at least 1,500 passengers. However, the tunnels will be constructed to allow for a future upgrade of platforms to 245 meters to be able to handle 12-car trains[518].

When Crossrail opens, joint sponsors Transport for London (TfL) and the Department for Transport (DfT) expect 160,000 daily rush-hour passengers between 7:00-10:00 in the morning[519]. Sections of the central tunnel will carry up to 55,000 passengers hourly in a single direction[520]. The

513 Crossrail. "Image Library."
514 Crossrail. "Environmental Statement." Volume 1. Chapter 2, page 24.
515 Ibid.
516 Crossrail. "Environmental Statement: Non-technical Summary," 9.
517 Ibid, 7.
518 Ibid, 7.
519 Ibid, 9.
520 Ibid, 9.

following diagram shows projected passenger loadings in the central area during the morning peak period[521]:

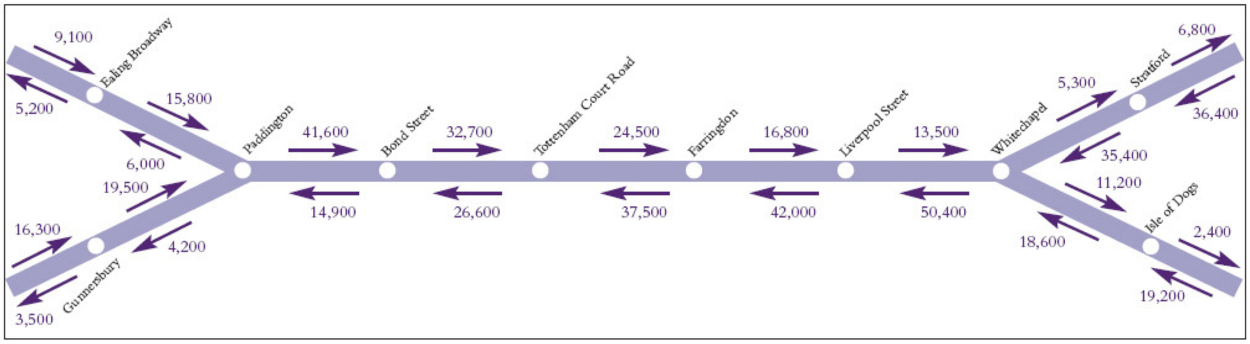

Figure 13.5 – Crossrail Projected Passenger Loadings Along Select Segments in the AM Peak

Crossrail will provide significant reductions in journey times between many key destinations currently underserved by the London Underground[522]. Journeys that may previously have required at least one, if not multiple transfers, will now be able to be made in a single-ride, thus reducing congestion at many Underground stations.

Journey Times and Time Savings with Crossrail (in minutes)			
	Before Crossrail	**After Crossrail**	**Savings**
Abbey Wood to Isle of Dogs	30	9	21
Isle of Dogs to Paddington	29	18	11
Ealing Broadway to Farringdon	25	17	8
Hayes to Tottenham Court Road	34	24	10
Southall to Custom House	58	36	22
Paddington to Liverpool Street	17	11	6

Table 13.1 – Time Savings Associated with Crossrail

Crossrail's Business Case determined that 58% of its user benefits come in the form of time savings. Other benefits include crowding relief and highway decongestion[523]:

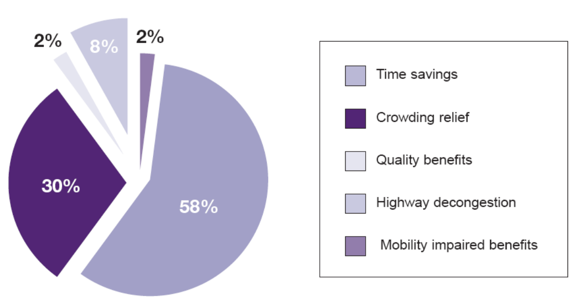

Figure 13.6 – Crossrail User Benefits

[521] Crossrail. "Business Case – Summary," 11.
[522] Crossrail. "Environmental Statement." Volume 1. Chapter 4, page 79.
[523] Crossrail. "Business Case – Summary," 16.

13.4.1 Crossrail Operator Involvement

Rail for London (RfL), a TfL subsidiary, has been selected as the "shadow operator" for Crossrail, meaning that it will assume the operator role until such time when a full-time operator can be procured. RfL has experience in rail operations as the operator of the relatively new London Overground services. RfL also manages the operations of the Docklands Light Railway (DLR) and the Croydon Tramlink.

Though RfL's qualifications are unquestioned, it is still unclear whether RfL will be the Crossrail train operating company (TOC). Presumably, when the current Network Rail concessions are re-bid, the new structure may incorporate the new Crossrail operation. These sorts of issues surrounding the integration of existing Network Rail services into Crossrail are yet to be fully resolved.

It would be in TfL's best interests to procure the operator as soon as possible. This way, there can be an early market test of the operating costs, and the operator can have input during construction. The lack of early operator involvement proved to be disastrous on the Big Dig. Tren Urbano achieved moderate success from the early involvement of the operator Siemens, at least in terms of Siemens being able to provide input into the asset's final design.

13.5 London Transport2025 Vision

London businesses consistently rank transport constraints among their greatest concerns. There are extreme cost implications associated with people being late for work and missing meetings due to crowding, uncertainty, and delays[524]. With expected growth comes new challenges for an already overburdened system. The City's transport vision and investment strategy is intended to help accommodate 900,000 more jobs and 800,000 more people by 2025[525]. Transport for London (TfL) is preparing to move 1.4M people a day in and out of the central area by 2025; an increase in rail demand of 40%[526].

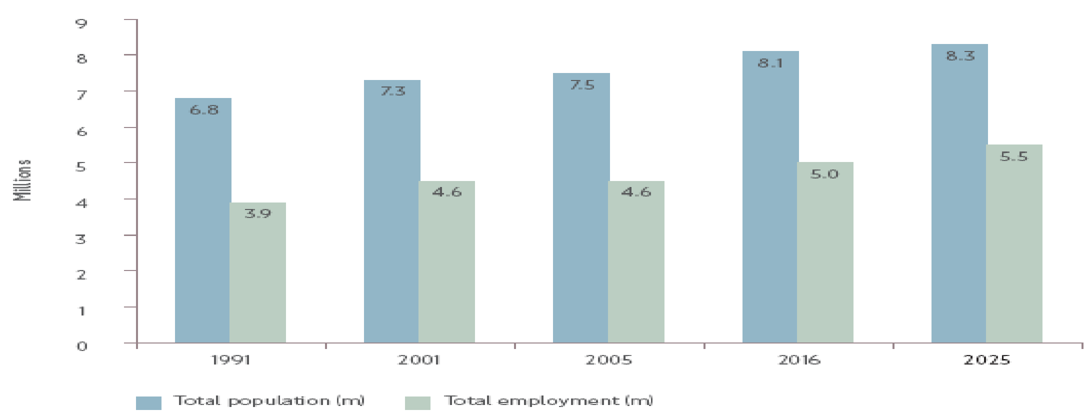

Figure 13.7 – Projected Growth of London Population and Employment Through 2025

524 Mayor of London, and Transport for London. "Transport2025: Transport Vision for a Growing World City," 30.
525 Ibid, 8.
526 Ibid, 28.

Job growth is expected to concentrate in an east-west corridor stretching from White City through the City of London to the Isle of Dogs and Thames Gateway, including Paddington and King's Cross[527]. The current transport network in London is lacking in east-west thoroughfares. As the following diagrams from TfL's Transport2025 Vision indicate, two-thirds of the expected development hotspots are outside the central City, and are mostly concentrated east of London in areas poorly served by public transit currently, but will have improved and direct links to and through London via Crossrail[528]:

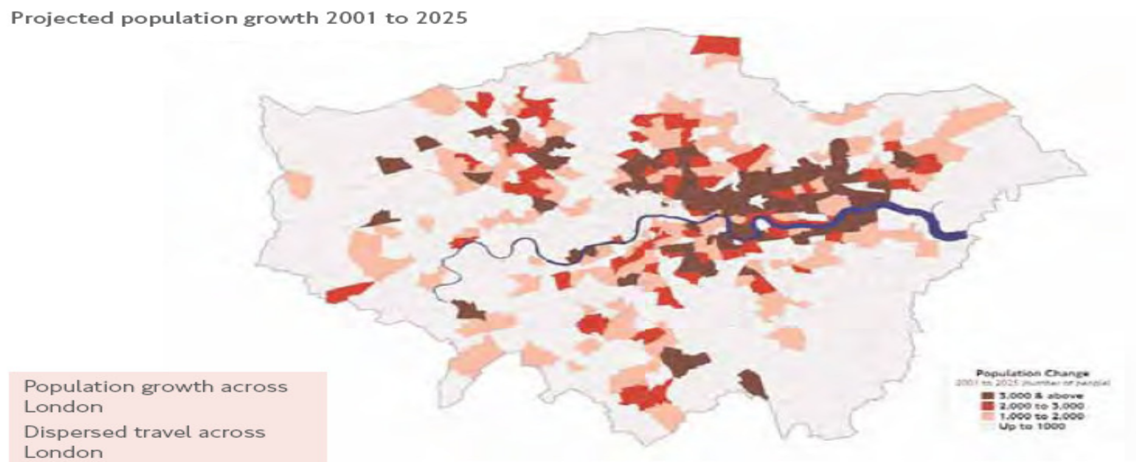

Figure 13.8 – Map of Projected London Population Growth Through 2025

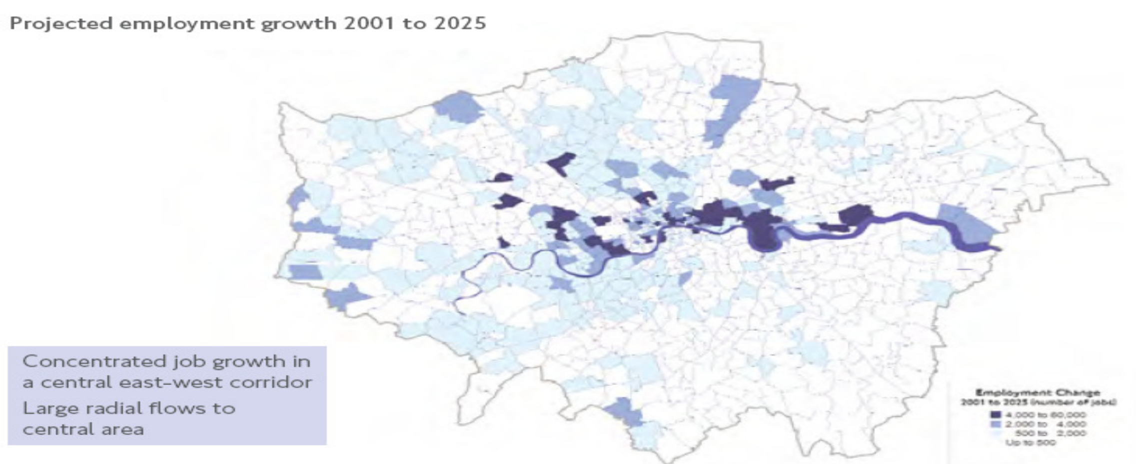

Figure 13.9 – Map of Projected London Employment Growth Through 2025

13.6 Crossrail Role in London Transport2025 Vision

Crowding is projected to increase on the Underground ("Tube") and Network Rail by about 40% during peak hours by 2025[529]. This is on top of 2006 levels, when over one-third of the network was already overcrowded, defined on the Tube as there being more than one person standing for each

[527] Ibid, 29.
[528] Ibid, 35.
[529] Ibid, 48.

person seated. Bus demand could also grow by around 30%. This increase in demand will significantly outpace capacity improvements absent Crossrail[530]:

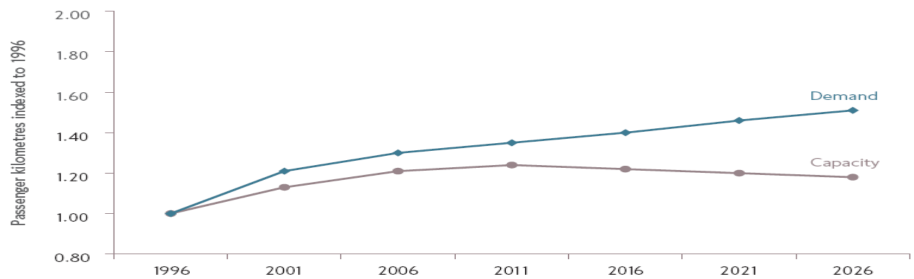

Figure 13.10 – London Public Transport Demand and Capacity Gap

Crossrail is the key mass transit link to deliver the capacity needed. Crossrail is expected to provide a 10% boost to capacity in some of the most congested parts of the network[531]. It adds 5.8M passenger-km to peak capacity, and when combined with the full London Underground system upgrades will be able to reduce crowding on the Tube and DLR by 45% as compared to the base case scenario of the completion of TfL's Investment Program through 2010[532][533][534].

Changes in London Underground Boardings and Crowding with Crossrail		
Line	**% Change in Boardings**	**% Change in Crowding**
Bakerloo	-8	-29
Central	-9	-27
District	-4	-21
Metropolitan/Hammersmith & City/Circle	-8	-25
Jubilee	-6	-18
Northern	+2	-2
Piccadilly	-3	-12
Victoria	-3	-8
Waterloo & City	-14	-31
London Underground Total	**-5**	**-17**
Docklands Light Rail Total	**-8**	**-30**

Table 13.2 – Changes in London Underground Boardings and Crowding with Crossrail

Changes in National Rail Boardings and Crowding with Crossrail		
Service Group	**% Change in Boardings**	**% Change in Crowding**
Paddington	-10	-9
Liverpool Street (Great Eastern)	-35	-36
Liverpool Street (West Anglia)	15	-12
Total National Rail (excluding Crossrail)	**-5**	**-11**

Table 13.3 – Changes in National Rail Boardings and Crowding with Crossrail

530 Ibid, 50.
531 Ibid, 74.
532 Ibid, 80.
533 Crossrail. "Business Case – Summary," 12.
534 Ibid, 14.

Crossrail supports development potential in excess of 260,000 jobs and 70,000 people within the opportunity areas of the Isle of Dogs, Lower Lea Valley, and Paddington. Crossrail is vital if the Isle of Dogs is going to support 200,000 jobs by 2026[535]. Employment accessibility is significantly enhanced by Crossrail, with an additional 90,000 people now able to access jobs within 45 minutes by public transport[536]. Crossrail alone would help generate net benefits of nearly £20B to U.K. GDP over 60 years[537].

Crossrail will also serve no fewer than eleven designated regeneration areas[538]:

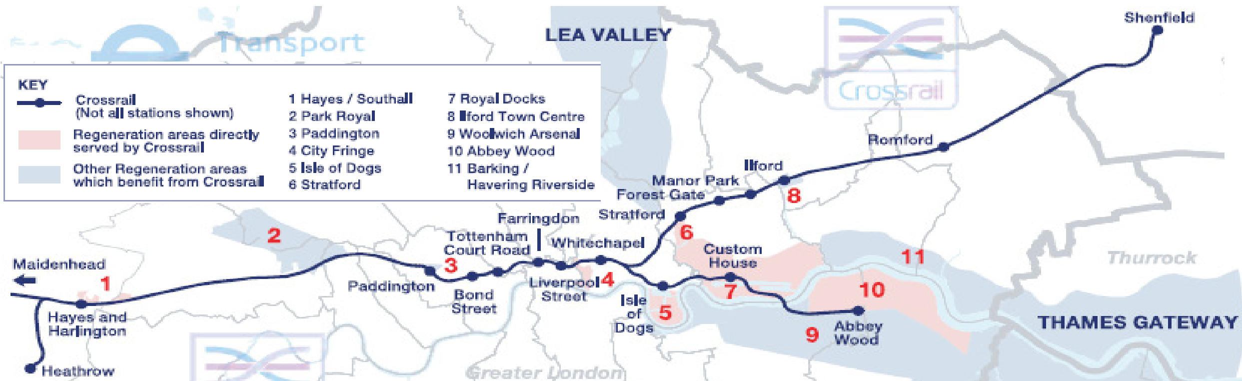

Figure 13.11 – Map of Crossrail's Role in London's Regeneration Efforts

13.7 Crossrail History

Crossrail was among three new projects proposed in the Central London Rail Study of 1989, along with a line from Wimbledon to Hackney via Chelsea (known as Crossrail Line 2), and the Jubilee Line Extension[539]. Crossrail was initially rejected by Parliament in 1991 following the start of the early 1990s recession. In 2000, the London East-West Study brought Crossrail back to the forefront of discussion, and development funding was allocated in the 2002 Government Spending Review. Following extensive lobbying by TfL and the business community, funding was finally agreed in the 2007 Comprehensive Spending Review as part of a ten-year funding settlement for both the Department for Transport (DfT) and TfL.

13.8 Crossrail Cost and the Montague Review

In July 2003, an expert team set up by the Secretary of State for Transport and led by Adrian Montague was asked to review Crossrail's business case[540]. This review came to be known as the Montague Review, and found that Crossrail's cost at the time was roughly £10B in 2002 prices, which included £3B in contingency. When adjusted for inflation the Montague £10B estimate from 2002 is only slightly shy of today's £15.9B estimate.

535 Mayor of London, and Transport for London. "Transport2025: Transport Vision for a Growing World City," 80.
536 Ibid, 83.
537 Ibid, 83.
538 Crossrail. "Environmental Statement: Non-technical Summary," 26.
539 Crossrail. "History of the Projects."
540 Department for Transport. "Review of the Crossrail Business Case," 118.

Montague found understatements and overstatements that largely cancelled each other out. Montague concluded that Crossrail's business case represented "acceptable" value-for-money[541]. The following chart outlines the £7B cost allocation noted in the Montague Review[542]:

	£ million
Land and property	695
Tunnels	1,680
Surface route infrastructure	314
Trackwork	298
Stations	2,201
Railway systems	919
Stabling, depots and maintenance	283
Project team and commissioning	496
Total	6,886

Table 13.4 – Crossrail Business Case Capital Cost Estimate

Project management costs were assumed to be around £500M, which Montague found to be grossly underestimated by up to £1B, or 200%. In fact, project management was the area in which Montague found the biggest underestimation[543].

The Crossrail Heads of Terms (HoT), which was released several years after Montague, was more comfortable with the current £15.9B estimate. The HoT considered this estimate to have "appropriate" allowances for contingency and expected inflation.

The £15.9B present day cost estimate equates to about US$23B as of April 2009. A current breakdown of Crossrail capital expenditures is outlined below:

Crossrail Capital Costs	**(£ million)**
On-Network Works	2,309
Isle of Dogs Station	496
Old Oak Common Depot	502
Tunneling	3,361
Stations	4,973
Systems	619
Land & Property	1,426
Indirect Delivery & Programme Level Contingency	1,846
Others	376
Total	**15,907**

Table 13.5 – Crossrail 2008 Capital Cost Estimate

541 Ibid, 7.
542 Ibid, 23.
543 Ibid, 30.

13.9 *Crossrail Funding*

DfT is responsible for £5.6B of funding with the Greater London Authority (GLA), via TfL, responsible for £7.8B. Canary Wharf Group (CWG) and Berkeley Homes (BH) will also contribute towards the construction of new stations at the Isle of Dogs and Woolwich, respectively. A £230M funding package with the British Airports Authority (BAA), the owner of seven British airports, was confirmed on November 4, 2008[544]. The contribution will be paid by Heathrow Airport Limited, a wholly owned subsidiary of BAA which owns and operates Heathrow. Network Rail is also delivering £2.3B of upgrades across the rail network.

A Business Rate Supplement levied on London largest businesses will support another £3.5B of Crossrail funding. The Government is introducing legislation to enable top-tier local authorities to introduce these Business Rate Supplements[545].

Additionally, a portion of Crossrail's financial support will be supplied by developer contributions in the amount of £350M. London Mayor Boris Johnson commenced consultation with stakeholders on an amendment to the Mayor's London Plan planning framework that will enable this funding stream to be realized. On December 4, 2008, a deal with the City of London Corporation confirmed this full contribution[546]. The Corporation will provide £200M directly and will seek contributions of businesses of £150M.

A breakdown of funding, including contingency, as noted in the Crossrail Heads of Terms (HoT), is outlined below[547]:

Funding Source	**£ billion**	**Notes**
DfT Underwritten	5.6	Includes contributions from BAA and City of London Corporation.
TfL Underwritten	7.8	Includes proceeds of £3.5B of borrowing by the Greater London Authority against Supplementary Business Rates (underwritten by DfT if necessary legislation not in place).
Other	2.5	Includes Network Rail contribution towards On Network Works (ONW), a depot operating lease, and an additional City Corporation contribution.
Total Available Funding	15.9	

Table 13.6 – Crossrail Funding Contributions

The private sector funding element stems largely from the fact that Crossrail is too large to be put in the ordinary budget[548]. Cost with inflation will average about $2B per year over an eight-year delivery stage[549]. Debt levels in the U.K. have recently threatened to violate the Sustainable Investment Rule, which stipulates that public debt cannot exceed 40% of GDP. If entirely debt financed, Crossrail's debt would have peaked at about 0.8% of GDP[550].

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544 Crossrail. "Major Boost for Crossrail as BAA Agrees £230 million Funding - Joint DfT & BAA Release."
545 Crossrail. "Full Speed Ahead for Crossrail."
546 Ibid.
547 Crossrail. "Heads of Terms in Relation to the Crossrail Project." Section 4.1.3.
548 Gomez-Ibanez, Jose. "Crossrail (A): The Business Case," 9. Cited with permission from the author.
549 Ibid.
550 Ibid.

13.10 Crossrail Expense Schedule

The following table provides an estimation of when the main DfT and TfL contributions will be spent over the next decade[551]:

Year ended 31 March	DfT Contribution	TfL Base Contribution	TfL Contingency Contribution	TFL LUL Contingency Contribution	Total TFL Contribution
2,008	**120**				
2,009		500			**500**
2,010	**172**	522			**522**
2,011	**220**	832			**832**
2,012	**622**	788			**788**
2,013	**1,250**	799			**799**
2,014	**1,313**	1,124		100	**1,224**
2,015	**1,142**	920		150	**1,070**
2,016	**800**	681		150	**831**
2,017		549			**549**
2,018		22	600		**622**
	5,639	6,737	600	400	7,737

Table 13.7 – Crossrail Expense Schedule

According to the current schedule, costs will ramp up throughout the early part of the 2010s and will dissipate towards construction completion.

13.11 Crossrail Government Stakeholders

On a project of Crossrail's size, there are bound to be many stakeholders. The governance structure in the U.K. and in London pertaining to transportation is such that Transport for London and all its subsidiaries play a role that is on par with even the national government. Crossrail, being both a national project and a project for London, has joint and equal sponsorship by TfL and by the national DfT. Specific roles of these entities and several others with direct involvement during the Crossrail procurement process are described in the following table[552]:

551 Crossrail. "Heads of Terms in Relation to the Crossrail Project." Section 4.1.3.
552 Ibid.

Stakeholder	Role
Department for Transport (DfT)	Co-sponsor. Main interface to national government and HM Treasury
Transport for London (TfL)	Co-sponsor. Main interfaces to local government, the Greater London Authority (GLA), and the Mayor of London's office. Owner of the central section.
Crossrail Limited (CRL); previously Cross-London Rail Links Limited (CLRL)	Delivery agent. Formerly a 50/50 joint venture of TfL and DfT, now a wholly-owned subsidiary of TfL. Main interface to the delivery supply chain, including both the Project and Program Delivery Partners (DPs).
Network Rail (NR)	Industry Partner. Responsible for the operations, maintenance, and renewal of the National Rail network. Infrastructure manager of Crossrail end-to-end rail systems. Main interfaces to Train Operating Companies (TOCs) and Freight Operating Companies (FOCs).
London Underground (LUL); a TfL subsidiary	Industry Partner. Responsible for the operations, maintenance, and renewal of the London Underground transport system. Infrastructure manager of the central section stations, except Paddington. Main interface to the PPP and PFI LUL contractors.
Rail for London (RfL); a TfL subsidiary	Operator franchising authority, or "shadow operator," of Crossrail. Infrastructure manager of Crossrail stations at Paddington, Isle of Dogs, and Woolwich.
Docklands Light Railway (DLR); a TfL subsidiary	Industry Partner. Responsible for the operations, maintenance, and renewal of the Docklands Light Railway transport system, and for providing Crossrail Limited (CRL) with access for proposed modifications of the DLR.
British Airports Authority	Owner of the Heathrow Spur.
Canary Wharf Group (CWG) and Berkeley Homes Group (BH)	Developers that have agreed to make contributions towards the cost of stations at the Isle of Dogs and Woolwich, respectively.

Table 13.8 – Crossrail Stakeholders and Roles

13.12 Crossrail Limited (CRL)

Crossrail Limited (CRL), until January 2009 named Cross-London Rail Links Limited (occasionally noted in charts and diagrams as CLRL), is Crossrail's delivery agent and is jointly owned by TfL and DfT. Established in January 2002, CRL's role is to design, procure, and deliver Crossrail according to the sponsor's requirements[553]. In meeting these ambitious goals, CRL is expected to:

- Develop an organization, management, and delivery strategy for executing the design and construction of Crossrail;
- Work with the Program Delivery Partner (DP) to define and manage program interfaces with industry partners and third parties;
- Take full responsibility for railway requirements and systems integration;
- Manage communications with stakeholders and the public;

553 Ibid, Section 3.3.

- Develop management incentive arrangements, based on the model used in the Channel Tunnel Rail Link (CTRL) project, but compatible with TfL's chosen processes; and
- Take the lead on bill compliance, technology, legal issues, finances, and human resources.

CRL will control part of the delivery of Crossrail but only influence other parts. In particular:

- Network Rail will have a separate budget for the On Network Works (allocated from within the £15.9B total) and will have considerable freedom over how those works are procured and delivered.
- Canary Wharf and Berkeley Homes will have contracts negotiated by the sponsors to construct the Isle of Dogs and Woolwich stations.
- TfL, through Rail for London (RfL), will have a major role in supporting CRL procuring rolling stock and operations contracts.
- TfL, through LUL, will also have a significant role over how station works are procured and delivered.

CRL will be downsized in phases. A small core team is expected to remain throughout construction and until the project is completed and handed over to the eventual operator.

13.13 Crossrail Board Structure

DfT and TfL appointed a new CRL Board in July 2008. The Board is chaired by a non-executive Chairman and includes three executive directors: the CEO, Finance Director, and Program Director. There are also four non-executive directors, and TfL and DfT each have the option of appointing an additional non-executive director. CRL requires the approval of both sponsors to change the composition of its Board.

The non-executive Chairman and CEO have six key areas of management: resources and talent, development, finance, program, legal services, and corporate affairs.

There is also a separate Executive Committee (ExCom), which includes CRL executive directors, chaired by the CEO. Even though CRL is now a subsidiary of TfL, DfT retains the right to appoint a project representative and will have access to all information, but has no executive authority on the ExCom. The ExCom is beneath the Board and does day-to-day management.

CRL is coordinating delivery of its wider program role through a Program Board (also known as the Programme Board). The principal function of the Program Board is to provide a forum for interface management. The Program Board is chaired by the CRL CEO with NR, LUL, RfL and CRL members. CWG and BH will attend when necessary. The Program Board will be supported by various specialist panels and groups.

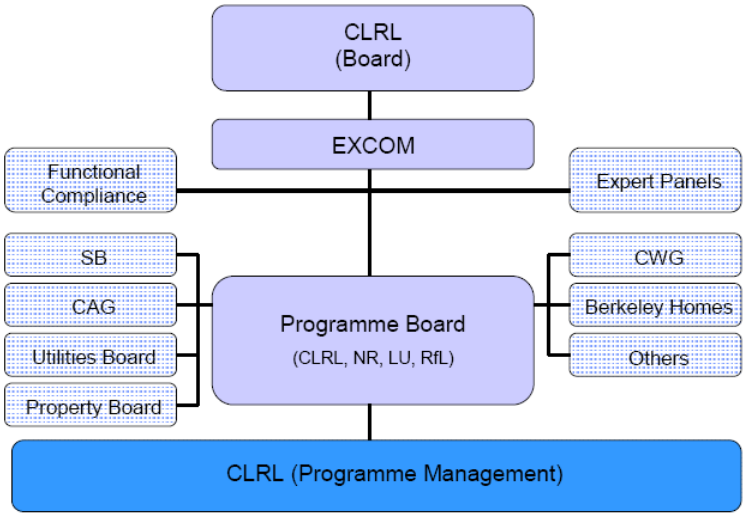

Figure 13.12 – Crossrail Board Structure

13.14 Crossrail Contracting Strategy

Crossrail's draft contracting approach includes four generalized options:

- Option A – Large Geographical Contracts, CRL Transfers Risk;
- Option B – Large Functional Contracts, CRL Transfers Risk;
- Option C – Mixed Size Functional Contracts, CRL Shares Risk; and
- Option D – Mixed Size Functional Contracts, CRL Retains Risk

One final sub-option is to separate signaling from other rail systems elements and transfer signaling responsibility to NR so that Crossrail can more easily be integrated with other railway projects in the region.

These options revolve around three main features: contract value, risk transfer, and whether to divide up contracts by location or function. The tradeoffs among these various options are outlined in the following chart:

Key Criteria for Developing Options		
Perspective	**Choices available and their Characteristics**	
1. **Scope of Work**	**Geographical** (where contractors are responsible for all works within their allocated area) • Contractor manages interfaces within the area • CRL manages interfaces between areas	**Functional** (where contractors are responsible for their work element within an allocated area) • Contractor manages the interfaces within the function • CRL manages the interfaces between functions
2. **Contract Value**	**One/few large value contract(s)** • Potential for increased leverage and better value • Will attract major international contractors • Requires high level contract definition from the outset • Trade interfaces are managed by contractor • Moves control from CRL to contractor • Increases the risks (CRL and supplier) associated with contract failure	**Many smaller value contracts** • Provides more opportunities for small companies • Will attract wide range of contractors • Can spread procurement to suit programme • Requires a high degree of management, including interface risks • Retains a high degree of control with CRL management • Minimizes the risks arising from individual contract failure
3. **Risk Allocation**	**CRL transfers risks as far as possible to contractors** • Private finance contracts • Lump sum fixed price contracts • Target price contracts • CRL design warranted by contractors; some ability to prepare own design	**CRL accepts risks as far as possible and introduces management and incentive mechanisms to assure efficient working** • Cost reimbursable contract with incentives

Table 13.9 – Key Criteria for Developing Crossrail Procurement Options

13.14.1 Geographical Versus Functional Contract Packaging

Geographical packaging would combine all of the works in a given area for delivery by a single supplier. For the Crossrail central area this would require packaging together the tunnels, stations, station systems, and possibly the railway systems. Geographical packaging introduces a high degree of risk and complexity at the interfaces between packages. Therefore, the most practical approach to geographical packaging would be to create a very limited number of large contracts.

Functional packaging may include separating:

- tunnels from stations;
- tunnels from railway systems;
- the railway systems into their components (signaling, track, power);
- stations from station systems; or

- the rolling stock and depot from everything else.

The advantage of functional packages is that it is much easier to create contracts of the right size for particular supplier markets and for suppliers to achieve economies of scale within their specialized area. The main disadvantage is that each division creates another interface for CRL and the delivery partners to manage.

13.14.2 Evaluating Crossrail's Contracting and Risk Allocation Options

Large geographical contracts would include some level of design responsibility and may also include some maintenance obligations. The main advantage is that it minimizes complex interfaces at site boundaries. There would probably be between 3-5 large contracts under this option.

Large functional contracts would include packaging all of the railway systems elements (signaling, track, communications, ventilation, etc.) together, or breaking them down by individual system. There would be consideration to doing these contracts as D-B. The number of contracts can vary depending on whether the systems elements are packaged together or separately.

Larger contracts will attract major contractors that can deliver excellent value. They can also reduce overhead costs and provide efficiencies in terms of contract management and administration processes. However, larger contracts will also limit competition as the number of prospective bidders will be reduced. Another drawback is that CRL will have to relinquish much control to large contractors who will be unlikely to bid on such a risky project if they feel as though the final outcome is largely out of their hands.

Mixed size functional contracts that include risk sharing would include a range of contract packages valued anywhere from around £25M to £800M. This would allow both small and large contractors to penetrate the market. For the main civil work (utilities, portals, tunnels, shafts), contractors will be working with an engineer's design, but they will also provide their own design input. D-B will be considered for non-civil work. Smaller contracts will increase CRL's level of control over each contractor, but the more contracts needed increases the number of interfaces to be managed.

Mixed size functional contracts with CRL retaining risk would have the same characteristics as above, except that contractor will be paid on a cost-plus basis with a heavily incentive-laden compensation scheme.

The sub-option that isolates signaling is compatible with each of the four options listed above, although it would make risk transfer more difficult, particularly in large geographical contracts. Signaling proved to be a major headache in delivering the Jubilee Line Extension; the last major extension to the London Underground network.

13.14.3 Design-Build Options for Crossrail

Crossrail has long weighed the D-B option for at least part of its delivery. If contracts are divided up into several alignment sections, for example, there will be consideration to completing at least one of the sections as D-B. There is a tremendous amount of both support and skepticism for D-B on such a large project, especially given the enormous level of uncertainty surrounding so many of Crossrail's key elements.

The most relevant lesson learned in both the Big Dig and Tren Urbano case studies is that the early market test provided by D-B can be tremendously valuable in verifying technical feasibility and cost. Especially in combination with early operator designation and participation, D-B can substantially improve transparency, leading to better outcomes. D-B plus early operator involvement may provide timely collaboration while it is still particularly opportune for Crossrail.

If D-B is to have a solid future in the U.K. it would be an incredibly valuable test case to do at least one of these alignments as D-B, which will allow for any number of comparisons once the project is complete. This requires a long-term perspective for which it is difficult to gain political support. The risk is significant, but so is the potential reward if D-B can be shown to be a success story as part of such an important and visible project as Crossrail.

13.15 Crossrail Delivery Strategy

Crossrail has procured both a "project" delivery partner (DP) and a "program" delivery partner. The Project Delivery Partner will manage the delivery of the central tunnel section (CTS). CRL awarded the £400M Project Partner contract to Bechtel in April 2009[554]. The Program Delivery Partner will handle non-CTS elements and macro-level management. CRL awarded the £100M Program Partner Contract in March 2009 to Transcend – a joint venture comprising AECOM, CH2M Hill, and Nichols Group[555]. The following is the strategic framework for the two delivery partner strategy:

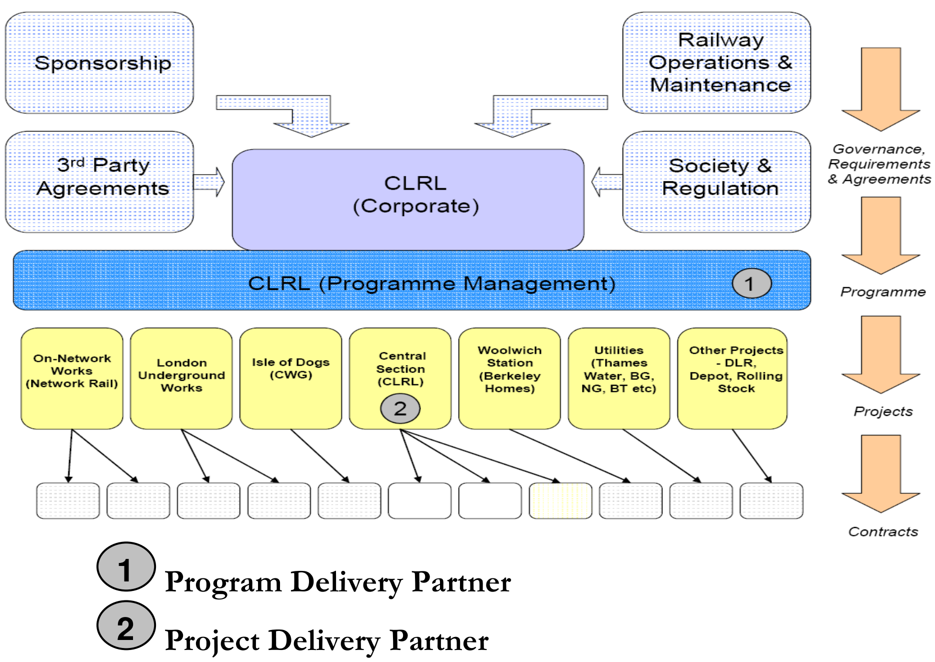

Figure 13.13 – Crossrail Delivery Strategy

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[554] Crossrail. "Up to 14,000 Jobs Anticipated as Key Crossrail Contract Awarded."
[555] Crossrail. "Transcend confirmed as Crossrail Programme Partner."

13.15.1 Crossrail Program Delivery Partner

The Program Delivery Partner's role is mostly one of coordination and outreach. It will help to resolve interface issues in merging many different components into a single railway. For this task, the Program Partner will work very closely with NR, RfL and LUL. The Program Partner will also oversee the development of stations being funded by private developers Canary Wharf Group and Berkeley Homes.

The Program Partner will work alongside CRL staff in an integrated Program Delivery Team, comprised of both CRL and Program DP staff. The best individual will be chosen for each role regardless of employer. The integration of the Program Partner and CRL early in the delivery process will provide a critical safeguard for CRL and its owners, TfL and DfT.

CRL will evaluate the possibility of hiring its own staff to reduce the size of the Program DP contract in later years, and to bring more control in-house. Once construction begins, however, the Program Partner role is expected to be scaled down, as long as all is going well.

Managing the overall program requires flexibility, adaptability, effective negotiation, and wide-ranging professional experience. The Program Partner's role is less clearly defined than the Project Partner, and is influenced largely by factors beyond its own control. Therefore, it will be more difficult to create an incentivization package for repayment, and risk transfer will be less appealing to the Program Partner than for the Project Partner.

13.15.2 Crossrail Project Delivery Partner

The Project Delivery Partner will manage the safe delivery of the central tunnel section (CTS), including stations and systems. They will manage procurement of the substantial number of contracts required to build the CTS. The contracts, however, will be between CRL and the contractors, with the Project Delivery Partner acting on CRL's behalf.

The CTS is reasonably well-defined and self-contained, so it will require more traditional project management skills. These characteristics make risk transfer more practical and desirable, and allow for the Project DP to be incentivized through common metrics, such as time, cost and quality.

Specifically, the Project DP will handle:

- engineering and design implementation;
- interface management within the CTS;
- procurement;
- construction management and administration; and
- infrastructure testing and commissioning.

Both DPs are expected to have input on the final procurement strategy. Both will have experience and views on how procurement should be organized, what the ideal contract sizes and packages are, and what incentivization structure would maximize quality and output.

The two-DP strategy has both advantages and disadvantages. CRL can control most of the project but only influence the program, so having a Program DP will ensure better program management. However, some of the efficiency gains in having a single point of responsibility with a one-DP strategy are lost.

There are alternatives to the use of a DP:

- for CRL to take on the core DP role itself;
- for CRL to employ different firms for different functions, and to coordinate overall program management work itself; or
- for CRL to pass most of the DP role down to a major contractor, while employing its own adviser.

The temporary nature of CRL is a strong argument against having it perform these management tasks itself. Also, DPs have people already available, while CRL would have to recruit personnel and develop its own processes.

While there is limited scope for transferring risks to DPs on a project the size of Crossrail, it would be possible to make a significant part of repayment based on overall performance to time and budget.

13.15.3 Crossrail Staffing Levels

The Program DP could have 100 staff members at its peak in the early-2010s, and the Project DP as many as 500, which would make their combined labor forces to be even larger than CRL's expected peak personnel level of 500:

Table of Staffing Numbers										
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
CRL staff	366	400	450	480	500	500	500	500	400	200
Two DPs combined staff	120	200	410	600	600	600	600	320	200	50
Design Contractors	260	390	450	350	220	50	50	50	0	0
Industry Partner staff	90	165	165	175	300	400	390	90	70	0

Table 13.10 – Crossrail Staffing Numbers

13.16 Crossrail Overall Governance Structure

The full extent of Crossrail's governance structure is outlined in the diagram below:

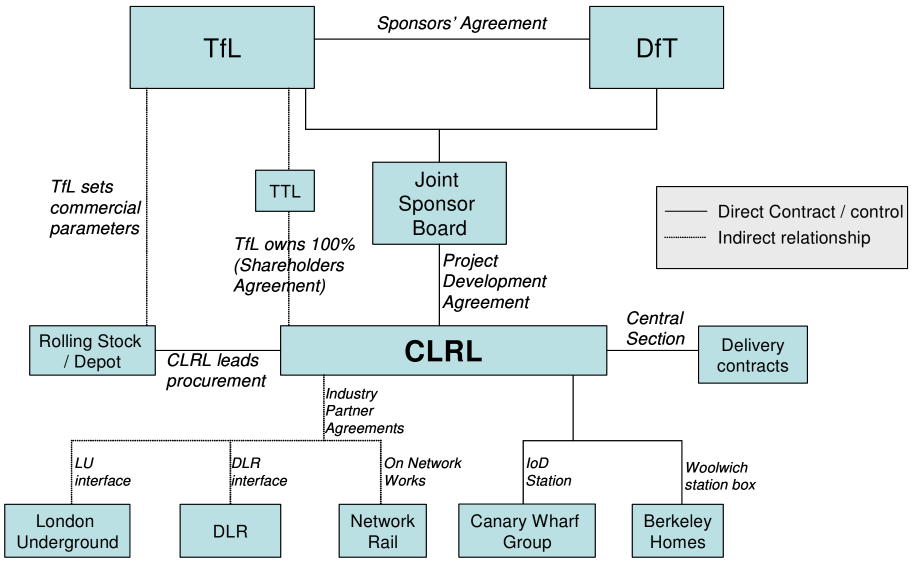

Figure 13.14 – Crossrail Governance Structure

13.17 Review Points (RPs)

There are four specific opportunities for the Crossrail sponsors to review the project and decide whether or not to continue, two of which remain. The first remaining opportunity, Review Point 3 (RP3), is September 30, 2009. By this time, DfT is expected to have contributed £206M towards Crossrail, and TfL £761M. The second and final opportunity, Review Point 4 (RP4), is December 30, 2010. By RP4 DfT will have spent about £457M and TfL £1.65B. The RPs may still change in both scope and timing.

The sponsors retain much control over the Crossrail project until after RP4. They can authorize CRL's expenditures and manage risk with greater certainty. For example, CRL may not release tender documents to contractors until after RP3, and may not award any contract for any task other than design or survey works until after RP4.

Once the sponsors have agreed to proceed beyond RP4, however, they will then be committed to their combined contribution of £13.4B. CRL will acquire a large degree of flexibility in the manner in which it delivers Crossrail post-RP4. Provided that CRL stays within the constraints of the delivery strategy it will be empowered to conduct most of its business without having to seek sponsor approval.

13.18 Intervention Points (IPs)

If, however, Crossrail project costs are forecast to exceed target prices, the sponsors (in the first instance TfL, and then subsequently DfT) have increased intervention rights and the ability to direct CRL. These "Intervention Points" (IPs), of which there are three, are the sponsors' main protection against cost overruns.

The IP mechanism becomes effective at RP4 and ceases to be effective when Crossrail passenger services commence. Each IP is calibrated according to available sources of funds. The IP thresholds can fluctuate, but are tested on a semi-annual basis by referencing CRL's semi-annual construction report, which forecasts costs to completion.

The first Intervention Point, IP0, is breached if CRL's direct costs exceed roughly £12.2B. This is considered a "P50" event, meaning there is a 50% likelihood of it happening. TfL can then require CRL to prepare an action plan to remedy the problems that led to the cost overruns. The only restriction under IP0 is that TfL requires DfT consent for certain actions.

IP1 comes into effect when CRL's direct costs exceed roughly £12.8B, which is believed to have a probability of occurring of 15%-20%. Notably, this is after TfL has contributed its £600M in contingency funding. After this point, TfL can take direct control of CRL and make whatever changes it deems necessary to deliver Crossrail. TfL still has to gain DfT's consent for certain actions, but under IP1 TfL can amend the Delivery Strategy to reflect a new direction. TfL cannot, however, unilaterally change either DP or make any material change to the incentivization package for either DP contract.

At IP1 DfT can also step in and require TfL to prepare a Project Completion Plan, and subsequently a Handover Plan setting out TfL's proposal for transition of control of CRL from TfL to DfT should either the Put or Call Option be exercised, which can happen after RP2.

13.19 Put and Call Options

Once CRL's costs get to roughly £13.3B, which has a 5%-10% probability, IP2 comes into effect unless TfL commits further funding to CRL. At this point, DfT can exercise a "Call Option" whereby ownership and control of CRL transfers from TfL to DfT. TfL will only have limited rights to influence Crossrail thereafter, but would retain the right to transfer operating responsibility to DfT if it wishes.

TfL also has the right to exercise the "Put Option" whereby DfT is obliged to acquire CRL, and TfL is released from further funding obligations. Within 60 days of CRL being transferred to DfT, DfT must announce its intention to proceed or abandon the Crossrail project. This announcement does not restrict DfT's ability to abandon at a later date. If IP2 is breached and neither the Put nor Call Option is exercised the sponsors would then have to determine together how to complete Crossrail.

DfT or TfL have the right to exercise the Call or Put Option, respectively, if the other party is in violation of its obligations under the Core Agreements or if there is a funding failure that is not remedied within nine months.

Chapter 14: Conclusions and Recommendations

This thesis has evaluated alternative delivery strategies from several angles, including their respective advantages and disadvantages for transportation megaprojects in:

- establishing the business case;
- reducing and allocating risk;
- providing management; and
- writing and enforcing contracts.

Because of their inherent uniqueness and reliance on exogenous factors, the appropriate use of alternative delivery strategies (ADSs) on transportation megaprojects must be tailored to each specific situation. Yet there are several broadly applicable conclusions and recommendations that come out of the research in the following areas:

- policy;
- management, transparency and oversight;
- process and procurement; and
- contracts and contract structures.

14.1 Policy Conclusions

- *Alternative delivery strategies (ADSs) require policy alignment at multiple levels of government.* A major barrier for alternative delivery strategies (ADSs) to be able to penetrate the market is that they require all levels of government to permit their use. Greater consensus that, at the very least, explicitly *allows* ADSs would increase the likelihood of ADSs being considered on future transportation megaprojects. Several countries, including Canada, require an ADS screening process on projects over a certain monetary threshold, and have also established a federal agency to handle procurement issues. These have been effective steps in the right direction.

- *Experimentation with ADSs should continue to allow for further comparison and analysis.* Public agencies fall into a trap of experimenting with an ADS model and then abandoning that strategy long-term if growing pains are felt initially. In order for there to be sufficient reflection, public sector agencies wishing to incorporate ADSs should do so on multiple projects of multiple scales. The fact that these ADSs are fairly new and are providing modest benefits means there is a strong likelihood that public sector agencies will be able to build upon the lessons already learned from their initial forays into the ADS market.

- *Federal Transit Administration (FTA) policy should be more receptive to ADS models.* Many state and local agencies report that, on average, 60%-65% design is required before FTA will issue a Full Funding Grant Agreement (FFGA) under the New Starts program. This high level of specificity generally precludes the use of ADSs. A 10%-30% design is more appropriate to capture the inflation avoidance and other benefits provided by ADSs. Given the relative success of the Turnkey Demonstration Program and other select New Starts projects that have used ADSs, FTA should encourage their continued experimentation by allowing for FFGAs to be granted at an earlier design stage.

- *ADS models and environmental policy should be better streamlined.* While NEPA does not involve design beyond the 25% design level, many environmental permits require a higher level of design to be completed prior to construction commencement. This can inhibit the use of ADS models which may provide ancillary environmental benefits. The transportation and environmental sectors can work together to establish benchmarks that may allow for innovative procurement when it can be proven to meet mutual goals.

14.2 Management, Transparency, and Oversight Conclusions

- *Transportation megaproject development requires a greater focus on long-term functionality.* When there is pressure to keep capital costs down and to complete projects on schedule, function may ultimately be sacrificed, which has a major impact on long-term benefits. Strong management, focused on end-state functionality and early operator involvement, ensures that long-term benefits of a project are not sacrificed by the short-term interests of contractors and partners under pressure to deliver to time and schedule.

- *Particularly if it is an owner's first use of an ADS, it is helpful to have a program manager (i.e. owner's rep) employed from the start of the project.* A dedicated consultant whose sole purpose it is to act on behalf of the owner's interests during procurement will help guide the owner though sometimes difficult decision making and contract execution.

- *Integrated project organizations (IPO) need to be incorporated from the start of a project in order to be effective.* On the Big Dig, the decision to merge B/PB and state of Massachusetts personnel into an IPO was not made until 1998. This was well after construction began and, more importantly, came after a decade during which B/PB should have been held accountable for their actions. Once the entities were essentially merged, the state's ability to hold B/PB accountable was undermined, but by this point the primary objective was to reduce adversarial pressure that had built up and get the job completed.

- *Collocation of partners leads to open dialogue.* By almost all accounts, efforts made to locate project partners in close proximity lead to better collaboration and increased transparency. Conflicts and differences of opinion can be discussed and ameliorated more quickly, without excess delay and misunderstanding.

14.3 Process and Procurement Conclusions

- *Projects using alternative delivery strategies benefit from earlier market tests.* The opportunity to take a project to the marketplace at 30% design rather than final design allows the public sector to much earlier assess project costs and risks. These market tests will surely include a large amount of contingency in contract bids given the level of uncertainty that exists at 30%

design. However, public sector agencies are aided because the contingency helps them to price project risks accordingly and determine which risks it may wish to manage themselves rather than attempt to transfer to the private sector.

- *Early operator involvement leads to better quality and functionality.* Unless appropriately incentivized, designers and builders will tend to focus more on constructability than on functionality and performance. It helps to have operators procured early in the development process so that they can influence final design and also better understand the system that will ultimately be handed over to them upon project completion.

- *Even if ADS models are infeasible as a single contract for an entire project, they may be appropriate for smaller subsections of projects.* The level and number of interfaces that exist in a project should ultimately determine the delivery strategy, and the Puerto Rico and Boston examples each demonstrate the difficulty of interface management. For projects with unique, yet independent sections (i.e. a change on one section will not significantly impact other sections), an approach that allows for traditional D-B-B for parts of the project and an ADS model for others may provide added benefit. ADS models allow for the design flexibility that many sections of projects require and stand to benefit from, but this requires that all interfaces can be identified and managed well.

- *Independent, unbiased cost estimation and forecasting is essential for establishing a prudent business case.* Reference Class Forecasting, sensitivity and Monte Carlo analysis, and Public Sector Comparator (PSC) generation by independent bodies are all worthwhile tools that help to support value for money arguments. Such early analysis helps public sector agencies better understand the delivery marketplace before committing to a particular project or delivery strategy.

- *Information exchanges and industry workshops are beneficial.* It is advantageous for the client to seek knowledge and guidance throughout planning and procurement. This helps the client to more clearly outline its objectives, which can then be shared with prospective bidders before final contract proposal submission.

14.4 Contracts and Contract Structure Conclusions

- *Designers should be retained in an oversight capacity throughout construction.* Whether or not an ADS is strictly employed, having the designer acting on the client's behalf to ensure proper design implementation serves two key functions. First, it limits the construction contractor's ability to cut corners in order to reduce cost. Second, it ensures that the designer does not overdesign the facility since it will have some accountability in implementing it.

- *Repayment structures should incentivize contractors and partners to deliver on the owner's expectations.* Ideally, there is an incentive package that rewards good performance both at select intervals throughout the project (i.e. every three months), and also at project completion. Contractors therefore are not only looking towards the final completion date but are also attempting to meet deadlines throughout, which should help the project maintain schedule.

- *Hiring construction managers willing to put themselves at-risk generally provides better value for money.* A construction manager not at-risk will usually seek to obtain its maximum fee with minimum effort. On the other hand, if a construction manager puts itself at-risk and stands to gain from good performance it will lead to better outcomes. Of course, the public sector will pay a premium to retain a CM@Risk, though the incentive for the CM to perform well will usually make the investment worthwhile.

- *Bidders should be reimbursed for their proposal fees.* Proposal costs are relatively small in comparison to overall project costs. If stipends are granted, owners should retain ownership of all proposals for possible incorporation later on. There is much value added, and the ideas in the proposals not chosen may still be able to be incorporated into the final contract. This allows bidders new to the ADS market to assume minimal risk in putting forth a bid proposal, leading to increased competition and improved quality.

- *Unsolicited project proposals from the private sector should be allowed and even encouraged.* The public sector, being under no obligation to accept the proposal, at the very least receives some free and calculated advice that can be incorporated into its broad transportation policy goals. The benefit from the private sector perspective is that it can hope to win contracts on proposals it submits, which will likely showcase that private firm's skills and specializations.

14.5 Crossrail Conclusions and Recommendations

- *Delivery partners need to be complementary, not adversarial.* As the delivery partner (DP) contracts are implemented, it is still quite unclear what level of integration will exist among many of the key stakeholders involved in Crossrail: TfL, CRL, DfT, the Project DP, and the Program DP. These relationships will surely continue to form and evolve as the final delivery and contracting strategies are developed throughout 2009 and 2010. But it should be reinforced to the DPs in their contracts that they are to be complimenting one another and that they are working to achieve mutual goals.

- *Interfaces on the central tunnel section will need to be very carefully managed.* The Project DP will take the lead on the Central Tunnel Section (CTS), but the work will have a major effect on the overall Crossrail "program." It would be shortsighted to assume that the Project DP can fully manage the CTS without also having significant involvement of the Program DP as well. Collaborative relationships between the DPs will not occur naturally. The responsibility falls on TfL and CRL, in particular, to ensure that the two-DP model as implemented instills healthy partnership between the DPs. Incentive-based repayment structures in which each DP benefits from overall performance and outcomes will increase the likelihood that the DPs are motivated to work together. Since the final completion date of 2017 is still far away, interim targets and rewards will be needed.

- *For Crossrail's business case to hold up during economic downturn, the arguments for its existence need to be tailored to the times.* In a good economy, Crossrail serves the region by reducing congestion. In a bad economy, Crossrail serves the region by stimulating reinvestment. If the congestion argument continually weakens, stakeholders will need to unite around other benefits that will endure. This public relations aspect is one that the Program DP will be instrumental in facilitating.

- *Crossrail is not yet "too big to fail," but soon will be.* TfL and DfT have two remaining opportunities to abandon the Crossrail project entirely; Review Point 3 (RP3) in 2009 and Review Point 4 (RP4) in 2010, though these dates may change. TfL has invested significant time and money into Crossrail, and would take a public relations hit if it were to withdraw support. However, the public will be receptive to such an effort to "trim the fat" during economic hardship. The fact remains that the amount already invested is minimal compared to the total expected public sector contribution, and after 2010 both TfL and DfT have very little recourse to back out, barring a blatant breach of contract that would trigger one of the Intervention Points (IPs). This is not to suggest, by any means, that TfL abandon Crossrail. But TfL needs to work diligently over the next year to ensure that the financial package, ridership projections, and other business case factors still hold up. TfL should also require much more detail from CRL on the final delivery strategy and the development of CRL's own organizational capacity.

- *A shift in mindset from risk transfer to risk reduction may be most cost-effective.* There is already fairly strong consensus at TfL that risk transfer on Crossrail will be difficult given the many interfaces and high degree of uncertainty. Still, risk transfer is among the goals in the delivery strategy. While those limited opportunities for risk transfer may exist, it will be more cost-effective in the long-term to do further preliminary analysis that reduces uncertainty. This will ultimately reduce risk and contingency put into the very large design and construction contracts soon to be procured. Also, risk transfer should only be sought for elements on which TfL is willing to relinquish much control. There are many risks too important to leave to chance that TfL and DfT should strategically retain. It will be up to TfL and DfT to jointly determine which risks these are.

- *Securing an operator should be a near-term goal rather than medium- or long-term.* The current plan is to have Rail for London (RfL) act as a "shadow operator" for a period of time, perhaps years. Now that the Project DP and Program DP are in place, Network Rail (NR) will begin to be engaged. There may be tensions between NR and RfL if NR has an overarching interest in having one of the existing train operating companies (TOCs) already operating on Crossrail right-of-way (First Great Western, National Express) selected as the Crossrail TOC. Another issue to be reconciled is the contract structures and expiration dates for the TOCs already operating on the eventual Crossrail right-of-way outside of central London. This is an matter best managed by the Program DP.

- *Delivery partners should be strategic partners rather than simply an extension of CRL staff.* There is a danger in having the DPs too far integrated into CRL such that it blurs the critical distinction in their roles. This was a flaw in the Big Dig's IPO structure. Specifically, if CRL and the Project DP don't agree on certain issues related to the construction of the CTS, then the Program DP may be called in to provide a second opinion. This collaboration is definitely worthwhile, but Crossrail would suffer if the Program DP were roped in too far to project-specific conflicts such that for any extended period of time there is essentially no entity focusing on the critical programmatic elements. In other words, the DPs should certainly work together on overlapping issues, but not at the expense of their core responsibilities.

14.6 Further Research

There is undoubtedly much research still to be done on this subject. Assuming continued public sector funding shortages, experimentation with alternative delivery strategies will surely grow. Some of the ways in which this research may be built upon include:

- *FTA New Starts project analysis*. This thesis has noted a handful of rail transit projects that have both utilized ADSs and also qualified for New Starts funding. A comparison between those projects and other New Starts projects that have used traditional delivery methods may identify trends, positive and negative, that can be attributed to delivery strategies.

- *ADS financial analysis*. The private sector's ability to secure financing is a major catalyst for seeking its involvement in transportation megaprojects. While this thesis acknowledges this to be the case, it does not delve much into the specifics of how private financing is secured and what its implications are.

- *Big Dig comparison to Boston Harbor Cleanup.* While the Big Dig was being conceived and constructed, another infrastructure megaproject was also being delivered: the Boston Harbor Cleanup. The Harbor Cleanup has widely been heralded as a major success. In the late-1980s both the Cleanup and the Big Dig were essentially at the same stage of development. An in-depth look into why one turned out so much differently than the other could prove telling.

- *Crossrail comparison to Channel Tunnel Rail Link or Jubilee Line Extension.* As Crossrail gets off the ground and closer to completion in the coming years, more opportunities will emerge to compare its development to any of several other major rail infrastructure projects that have been delivered in the U.K. in recent years.

Appendix A: North American Rail Projects Utilizing Alternative Delivery Strategies

Appendix A provides short synopses on 16 rail transit projects in North America with capital costs of $100M or more that have utilized alternative delivery strategies.

A.1 Synopses of North American Rail Projects Utilizing Alternative Delivery Strategies

Alameda Freight Corridor: The Alameda Corridor is a 20-mile rail cargo route linking the Ports of Los Angeles and Long Beach to Downtown Los Angeles and connections to cross-country freight lines[556]. Opened on-time and under budget in April 2002, the Corridor now handles over 7,200 containers per day, many of which would otherwise have had to be transferred onto trucks which would sit in, and contribute to the notorious Los Angeles traffic, and would also exacerbate air quality issues in the Los Angeles basin[557][558]. This $2.5B project was completed with 24 construction contracts. All but one were procured under traditional D-B-B, but the centerpiece of the project, a 10-mile-long, 50-feet-wide, 30-feet deep trench was bid as a D-B contract valued at $712M to a joint venture led by California-based construction firm Tutor-Saliba[559].

Puerto Rico Tren Urbano: Tren Urbano is a 17.2-km heavy rail metro system in San Juan, Puerto Rico, with 16 stations[560]. Tren Urbano was procured with six D-B contracts and one DBOM contract awarded to the Siemens Transit Team for $500M[561]. It was the first DBOM contract sponsored by the FTA, and gave operations and maintenance responsibilities to the Siemens Team for five years, with the option for a five-year renewal[562][563]. Largely because of major scope changes, poor management and oversight, and shifts in political ideologies, Tren Urbano was delivered three years late in 2005 at a cost of $2.25B; $1B over its original budget[564].

New Jersey Hudson-Bergen Light Rail (HBLRT): The HBLRT is a $2.2B light rail system that serves dense New Jersey communities and provides them with links to the rail networks that connect to New York City via tunnels under the Hudson River[565]. Originally opened in April 2000 with 16 stations, the HBLRT has been incrementally extended and now has 23 stations[566]. At full build-out, the HBLRT will have 32 stations in total[567]. The 21st Century Rail Corporation was awarded a 15-year DBOM contract for the line, after which time it will be transferred back to the local transit authority, New Jersey Transit (NJ Transit)[568]. NJ Transit had initially sought private sector financing for the project, but once it became apparent that the cost of private financing would

556 Alameda Corridor Transportation Authority, http://www.acta.org/projects/projects_completed_alameda.asp.
557 Alameda Corridor Transportation Authority, http://www.acta.org/newsroom/Releases/releases_041202.html.
558 Alameda Corridor Transportation Authority, http://www.acta.org/newsroom/Releases/REL_ACTA_Sixth_Ann.pdf.
559 Alameda Corridor Transportation Authority, http://www.acta.org/newsroom/Releases/releases_18.html.
560 Railway Technology. "San Juan Tren Urbano Light Rail System, Puerto Rico."
561 Perini Corporation. "Operations."
562 Alternativa de Transporte Integrado. "Tren Urbano."
563 Middleton, 2000.
564 U.S. Department of Transportation. Federal Transit Administration. "Audit of the Tren Urbano Rail Transit Project."
565 Railway Technology. "Hudson-Bergen Light Rail System, USA."
566 New Jersey Transit. "Hudson-Bergen Light Rail."
567 Miller, 2002, 135.
568 Hoboken Terminal. "Governor Whitman Officially Launches New Jersey's First Modern Light Rail System."

be far greater than public financing, it removed that component from the contract[569]. The transit authority retained full farebox revenue risk and rate-setting authority[570].

New York City JFK Airtrain: The Airtrain is an elevated, automated light rail service directly linking New York City's John F. Kennedy International Airport to the New York City subway system and the Long Island Railroad commuter rail network. Funded by a $3 passenger facility charge (PFC) tacked on to the price of each ticket for outbound JFK flights, the Airtrain was procured through a DBOM contract with Air Rail Transit Consortium for five years with two possible five-year extensions[571]. The 13-km system opened in December 2003[572].

Denver Transportation Expansion (T-REX): T-REX is a 19-mile light rail extension combined with a 17-mile interstate highway reconstruction[573]. As two existing interstate highway in the Denver Metropolitan area approached capacity in the 1990s and were expected to have to serve nearly twice as many vehicles within 20 years, the Colorado DOT entered into an agreement with the Regional Transportation District (RTD) to combine a major road widening effort with two new light rail corridors. The $1.67B project included the largest D-B ever awarded in the U.S. at $1.2B to Southeast Corridor Constructors[574]. T-REX was delivered on-budget and 22 months ahead of schedule[575].

San Francisco Bay Area Rapid Transit (BART) San Francisco International Airport (SFO) Extension: This 14-km, $1.55B project extended the BART heavy rail system to SFO Airport and also included three new stations to the south[576]. The project was procured with two traditional D-B-B contracts and four D-B contracts[577]. The project was delivered 16 months late and nearly $500M over budget[578][579][580]. This extension is part of plans to eventually connect the BART system down to the burgeoning communities at the south end of San Francisco Bay.

Vancouver Canada Line: The Canada Line is a C$1.9B, 19-km, north-south extension of Vancouver's Skytrain automated light rail system that will connect Downtown to the 2010 Olympic Village, Vancouver International Airport, and the city of Richmond upon completion in 2009[581]. The project includes an underground tunnel from Waterfront Station in Downtown Vancouver to south of 64th Avenue in Richmond, then will proceed on an elevated guideway for the rest of the route[582]. It is a critical transportation link for the 2010 Winter Olympic Games. InTransitBC is the company contracted to design, build, partially finance, operate and maintain (DBFOM) the Canada Line for a 35-year period in return for a share of the operating revenue. InTransitBC is also

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569 Loulakis, 193.
570 Ibid, 194.
571 Port Authority of New York and New Jersey. "Port Authority's Airtrain JFK Nears Completion as Airtrain Newark Ridership Continues to Rise."
572 Port Authority of New York and New Jersey. "All Aboard! Governor Pataki Dedicates Airtrain JFK on 100th Anniversary of Wright Brothers' First Flight."
573 U.S. Department of Transportation. Federal Highway Administration. "Colorado's T-REX: Mega, Multi-modal, Design-Build."
574 Ibid.
575 Ibid.
576 Parsons Brinckerhoff. "BART San Francisco Airport Extension."
577 Parsons Brinckerhoff. "BART San Francisco Airport Extension, Constructed Project of the Year, 2003."
578 Business Wire. "BART Information Managers Select ReviewIt AEC for BART-SFO Extension Project."
579 Bay Area Rapid Transit, "BART to SFO ridership jumps 65%."
580 Wilson, 2.
581 Canada Line. "About the Canada Line." http://www.canadaline.ca/about.asp.
582 "Vancouver Celebrates as Canada Line Tunnel Completed." The Canadian Press.

contributing roughly C$700M towards capital costs[583]. This is a performance-based contract with some volume incentive. Adjustments to monthly payments made to InTransitBC will be made based on system performance and asset condition[584]. Canada Line Rapid Transit, Inc. (CLCO) was created by the agencies funding the transit line specifically to oversee the procurement, design, construction and implementation of the project.

NJ Transit RiverLine: The RiverLine is a 34.5-mile diesel light rail system that runs from Trenton to Camden along the Delaware River[585]. The best-value DBOM contract for this project was awarded in June 1999 to Southern New Jersey Rail Group, LLC, a consortium led by Bechtel and Adtranz[586]. The system came in several hundred million dollars over budget at $998M and opened fourteen months behind schedule in March 2004[587].

Los Angeles Metro Gold Line Eastside Extension: This 6-mile extension of the Los-Angeles-to-Pasadena Gold Line to East Los Angeles will feature 2 underground and 6 at-grade stations[588]. It is being procured with one $400M D-B contract for the 1.8-mile tunnel portion and one $200M conventional D-B-B contract for the at-grade portion[589]. Construction was more than 80% complete as of May 2008, and the line is scheduled to open on-time and on-budget in mid-2009[590].

Minneapolis Hiawatha LRT: The Hiawatha Line is an 11.6-mile, 17-station light rail line connecting Minneapolis and St. Paul to Minneapolis-St. Paul International Airport (MSP) and the Mall of America[591]. The majority of the project was procured utilizing a D-B approach. Due to concerns about constructing two 1.4-mile long tunnels below two airport runways, the Metropolitan Airport Commission opted for a traditional D-B-B approach to the two airport stations[592]. It is estimated by the FTA that $25M-$38M and one year was saved due to the innovative D-B strategy[593].

Las Vegas Monorail: The Monorail is an extension of the original one-mile route that opened in 1993 and connected the MGM Grand and Bally's hotels. The full line opened in July 2004 and has seven stations spanning four miles. The sponsoring hotels invested a total of $30M in the project, and the Las Vegas Monorail Company, led by Bombardier and Granite Construction, invested an additional $18.5M for a total private sector cash investment of $48.5M into this DBFOM project.

Washington Metropolitan Area Transit Authority (WMATA) Blue Line Extension: The extension of WMATA's Blue Line east to Prince George's County, MD, was awarded with two D-B contracts and one D-B-B contract[594]. A contract for both site preparation and a crossing over the Washington Beltway were included in the D-B-B contract, while all systems, stations, and parking

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583 Canada Line. "Financing." http://www.canadaline.ca/aboutFinancing.asp.
584 Partnerships British Columbia. "Canada Line."
585 New Jersey Transit. "River LINE."
586 Loulakis, 203.
587 Pearsall.
588 U.S. Department of Transportation. Federal Transit Administration. "New Starts Program Assessment, Appendix A: Case Study Report."
589 Ibid.
590 Ubaldo, Jose, and Littman, Marc. "Metro Gold Line Eastside Extension is More Than 80 Percent Complete."
591 U.S. Department of Transportation. Federal Highway Administration. "PPP Case Studies: Hiawatha Light Rail Transit."
592 Ibid.
593 U.S. Department of Transportation. Federal Transit Administration. "Report to Congress on the Costs, Benefits, and Efficiencies of Public-Private Partnerships for Fixed Guideway Capital Projects," 9.
594 Ghosh, Korzym, Mester, and Rosenbaum.

facility work fell within the boundaries of the two D-B contracts. The 3.1-mile alignment includes both tunnel and surface segments and includes two new stations[595].

Greenbush Commuter Rail: The Greenbush line involved the restoration of an 18-mile commuter rail line to the South Shore of Massachusetts, outside Boston. This D-B contract was awarded in March 2002 to the joint venture of Jay Cashman, Inc., and Atlanta-based Balfour Beatty Construction, Inc. (CBB), for $252M[596]. When the contract was awarded, the Massachusetts Bay Transportation Authority (MBTA) provided CBB with a conceptual design developed to approximately 15%[597]. Greenbush was scheduled to begin operation in 2005 at a cost of $470M, but was delayed two years and increased in cost by roughly $35M[598]. Environmental regulatory agencies required 60% design in some areas before permits could be issued, and this requirement was not included in the D-B RFP package[599]. This was partly to blame for the delays and cost increases, as were issues pertaining to the acquisition of the right-of-way from the private freight company CSX, then Conrail[600].

Portland MAX LRT Airport Extension: The creation of the Red Line expanded the highly successful MAX LRT system to Portland International Airport. It was procured with a unique design-build-finance (DBF) contract by which the design-builder, Bechtel, agreed to finance $25M of the $125M project in exchange for development rights to a 120-acre lot adjacent to one of the stations along the route[601].

South Florida Commuter Rail Upgrades: This commuter rail enhancement provided for the double-tracking of a 45-mile segment of the 72-mile South Florida Rail Corridor[602]. This corridor supports Tri-Rail commuter rail service connecting Palm Beach to Miami, as well as Amtrak and CSX freight operations. Tri-County Rail Constructors - a joint venture between Herzog Contracting Corp., Granite Construction Co., and Washington Group International - won the design-build contract.

Baltimore LRT Extension: The Maryland Mass Transit Administration used a design-build procurement on its $110M light rail extension completed in 1997[603]. This was one of the projects developed as part of the FTA's Design-build Demonstration Program and was the first linear transit project completed in the U.S. under a design-build procedure.

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595 Ibid.
596 Jay Cashman, Inc. "Greenbush Commuter Rail."
597 Ibid.
598 Daniel.
599 Massachusetts Executive Office of Transportation. Massachusetts Bay Transportation Authority. "South Coast Rail Plan for Action," 39
600 Interview with Fred Salvucci.
601 Malone, 2.
602 Judy, 1.
603 Light Rail Central. "Status of North American Light Rail Projects."

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91 Express Lanes. http://www.91expresslanes.com/.

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Interviews:

Fred Salvucci, Senior Lecturer, MIT.
Julian Ware, Principal, Corporate Finance, Transport for London.
Jim Whalen and Chip Dewitt, Edwards, Angell, Palmer & Dodge.

Lectures:

Jon Bottom, MIT, Fall 2008.
Eduardo Engel, MIT CTL Speaker Series, December 5, 2008.
Chris Gordon, MIT, Spring 2009.
Fred Moavenzadeh, MIT, Spring 2009.
Nigel Wilson, MIT, Fall 2007.

Conferences:

Transportation Research Board Annual Meeting, Washington, DC, January 11-15, 2009.
Canadian Council on Public-Private Partnerships National Conference, Toronto, Ontario, Canada, November 24-25, 2008.

Legislative Hearings:

Massachusetts Joint Committee on Transportation Hearing, November 26, 2008.