

Life Cycle Delivery of Public Infrastructure

Precedents and Opportunities for the Commonwealth

A Pioneer Institute White Paper

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by Dr. John B. Miller



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Executive Summary

Life-cycle delivery of infrastructure projects demands our attention. As the Commonwealth faces the interlocking threats of massive funding deficits, creeping levels of deferred maintenance, and unabated demands for expansion, public-private partnerships (PPPs) offer some potential relief. But, unless properly implemented and monitored, PPPs can also be a hindrance to strategic transportation planning and responsible budgeting. This report summarizes the opportunities and challenges PPPs present and recommends a strategy Massachusetts should follow in the future that adds life-cycle approaches to infrastructure delivery, a strategy based on delivering “value for money” and which demands improved levels of service, durable employment, and decreasing costs to users and taxpayers.

While much recent attention on PPPs has focused on high profile cases of the Chicago Skyway and the Indiana Toll Road, the reality is that life-cycle delivery strategies are not new. They have been used since our country’s earliest days and in significant amounts. In fact, PPPs accounted for over 90% of major public infrastructure projects from 1789 to 1933.

America’s most recent experiences have emphasized “monetization PPPs”, or the generation of large upfront payments to the public sector in exchange for long-term leases of specific toll roads. The Chicago Skyway deal consisted of a \$1.8 billion cash payment to Chicago in exchange for a ninety-nine year lease of the roadway. The Indiana Toll Road deal involved a seventy-five year lease of that roadway, resulting in a \$3.8 billion cash payment to the State of Indiana.

The tremendous cash windfall and strategic logic behind each transaction should not obscure more important lessons about life-cycle procurement. Neither the Chicago Skyway nor the Indiana Toll Road procurements were the result of head-to-head competition over lowest prices and highest

service levels, as evidenced by the \$1 billion spread between the two bids for the Skyway (\$800 million versus \$1.8 billion). Rather than competing to provide specified services – including repairs, maintenance, and operations – at the lowest toll rates over the shortest concession period, the procurements were structured such that the contract was awarded to the bidder offering the highest upfront payment.

As the Commonwealth faces the interlocking threats of massive funding deficits, creeping levels of deferred maintenance, and unabated demands for expansion, public-private partnerships (PPPs) offer some potential relief.

As comparative alternatives, the procurements for the Northumberland Bridge in Prince Edward Island and Toronto’s Highway 407 are also examined. Each demonstrates that competitive integration of design and construction with operations and maintenance can, and does, produce dramatic improvements in the cost of initial delivery, life cycle delivery, and the level of infrastructure service.

A companion to this paper, entitled *Lessons Learned: An Assessment of Select Public-Private Partnerships in Massachusetts*, examines infrastructure projects in Massachusetts in order to assess the level of private sector involvement and to draw lessons about appropriate procurement processes for life-cycle delivery.

The Commonwealth has the opportunity to choose when and where it makes sense to either combine or to segment key elements in the infrastructure delivery process. The first decision point is to determine the level of control the public sector wants over design. This is a complex trade-off between control and flexibility versus construction and life-cycle costs. A segmented approach assures public officials that design will

be largely completed before a decision is made on construction, which lowers risk but increases cost and lengthens project schedules.

Once a decision on the appropriate level of control has been made, the Commonwealth should consider, on a project-by-project basis, whether it makes sense to combine design and construction into a single design-build procurement. Again, depending on the circumstances of each project, this approach allows greater control of scheduling, risk, and costs.

To extend further down the construction value chain, the Commonwealth should consider life-cycle delivery, incorporating design, construction, and operations and maintenance into a single competitive procurement. This approach has the virtue of combining highest service levels over a facility's entire life-cycle, thus lowering overall project delivery costs, and fully funding proper maintenance of public assets.

As part of life-cycle delivery, the project's ability to produce a return, be it through user fees, availability payments, rents, or some other means, should be assessed. Based on this determination, the Commonwealth can evaluate the project's potential ability to attract either direct or indirect funding (that is provided directly by the Commonwealth or indirectly through private sector financing).

Finally, the Commonwealth's thinking about project procurement should be broadened to consider our transportation assets as a portfolio. Do we have the resources to build and properly maintain all the projects we want using just design-bid-build and design-build? Clearly not.

Could we build and properly maintain more using a variety of approaches? Clearly yes. The challenge for the Commonwealth is to plan holistically, determine which projects are most appropriate as design-bid-build or design-build and which projects are most appropriate

for life-cycle delivery, which projects are more appropriately funded directly and which are more appropriately funded indirectly.

To succeed, several actions are needed. First, the operations and maintenance costs of current and planned assets must be known and transparent.

Transparency, head-to-head competition, and a menu of well-understood procurement processes are the most important ingredients to successfully attacking and addressing Massachusetts infrastructure needs.

More importantly, the Commonwealth's procurement system should be revised to permit the full range of basic delivery methods, which would require reconfiguring several of the restrictions in the Pacheco law. A flexible system with access to the full range of methods would attract new participants and establish durable markets. Transparency, head-to-head competition, and a menu of well-understood procurement processes are the most important ingredients to successfully attacking and addressing Massachusetts infrastructure needs.

Based on the foundation of good procurement practices, the Commonwealth should engage in a planning and procurement process that incorporates life-cycle delivery alongside other procurement methods.

Much of our future infrastructure construction will continue to be performed through the traditional means of design-bid-build. But with scarce resources, the creeping malaise of deferred maintenance, and a long list of desired projects, the Commonwealth should use life-cycle delivery methods to expand available resources and create value for taxpayers.

Introduction

Early this decade, public-private partnership agreements for the Chicago Skyway and Indiana Toll Road were reached,¹ creating the sense in the market that a series of privatization deals would follow closely behind. Supporters, primarily in the transportation sector, have been widely promoting PPPs as a “solution” to America’s infrastructure problems. Most of these marketing efforts have failed: a cursory review of recent issues of Public Works Financing, a PPP industry newsletter, seems to indicate that only about 1 in 20 PPP proposals for American infrastructure projects, allegedly modeled on prior British or European successes, have reached financial closure. Intense marketing efforts by financial houses have not yet succeeded in “unlocking the trapped value” in existing infrastructure projects

through “monetization”. Recent events in the world’s financial systems are likely to result in an even more careful and calculating evaluation of public infrastructure projects and facilities before far-reaching decisions are made by public officials to “monetize” existing facilities in exchange for very long term liability. The “PPP” world is likely to move decidedly back toward a transparent, competitive determination of “value for money.” Fortunately, throughout the 1980s and 1990s, that is, before the monetization flurry, American academics supported by the National Science Foundation, the Corps of Engineers, and the U.S. Department of Transportation, had already explored the effective use of alternative project delivery and finance methods, including PPPs, that produce infrastructure facilities and services with better initial and long term cost and schedule performance.

Figure 1

How Are Project Costs Paid?

Government pays for projects with public resources.

Direct

This includes monies obtained by:

- (i) collecting taxes, user fees, or other funds;
- (ii) borrowing funds (typically bonds or bond anticipation notes; and
- (iii) receiving grants of money from other governments.

Funds are borrowed based on the credit-worthiness of the government. Grants received are available through taxes or charges by other governments.

Indirect

Government attracts the private sector to pay for projects with private sector resources. This is typically done by ceding specific, limited, control over a public infrastructure asset to create a revenue stream that the private sector will use to earn a return on capital invested and a profit.

“Indirect” includes monies obtained by:

- (i) charging user fees;
- (ii) borrowing funds; and
- (iii) raising equity.

Funds are typically borrowed for design and construction based on the credit-worthiness of the project to produce sufficient revenue to repay the borrowed funds (with interest), to pay for long term O & M, and a profit.

A. Delivery and Financing of Infrastructure Projects

As the options and approaches for infrastructure delivery and financing grew more complex in the 1990's, researchers began to look carefully into the history of infrastructure project delivery and finance in the United States. They sought to develop a simple, yet useful way to compare project delivery and financing methods, and to create ways for public officials and policy makers to think systemically about how the nation might move from its current focus on initial delivery to a more comprehensive focus on both initial delivery and life cycle delivery of public infrastructure.

Two issues recur in the provision of public infrastructure: who pays for infrastructure services and who contracts with government as it arranges to deliver the three key elements of every infrastructure project – design, construction, and long term operations and maintenance. Two different strategies are described below.²

PPPs accounted for over 90% of major public infrastructure projects from 1789 to 1933.

1. Who pays, at least initially?

Governments can choose one of two basic strategies in answer to “Who pays?” (See Figure 1). The first, described as “direct,” is for government to pay for infrastructure projects with cash that it raises for these purposes. Governments raise their own funds through sales and/or income taxes, user fees, or other charges, and frequently borrow funds in private sector capital markets in order to have sufficient cash on hand to pay for ongoing obligations like health care, education, and public infrastructure. For the purpose of this report, when government assures the private sector that the revenue stream from

tolls, user charges, or government payments will be sufficient to pay for services provided, including a return on investment and profit, this government commitment amounts to “Direct” funding.

Governments may also choose an alternative answer to the financing question. In this approach, described as “Indirect” in Figure 1, a government positions a public infrastructure asset in such a way that the private sector agrees to pay for design, construction, and long term operations and maintenance, in exchange for the opportunity to recover this investment plus a reasonable return through the collection of tolls or user charges. The private sector typically provides these funds through a contribution of equity and by borrowing funds in private sector capital markets. For the purposes of this report, where the timing, amount, and sufficiency of the revenue stream from tolls and/or user charges is at the private sector company's risk, the answer to “Who pays?” is the private sector, and the financing approach is indirect. However, from the consumer's point of view, the consumer is always paying through gasoline, sales, and/or income taxes or tolls paid to government that permit direct financing or through tolls and user fees paid to private sector companies that permit indirect financing. From a practical viewpoint, unless indirect financing from the private sector provides better service and higher value, and/or at lower cost to users, consumers understandably treat indirectly financed projects as an additional tax burden because the government permits the private sector to collect tolls and user fees as the vehicle for substituting private provision for public provision of infrastructure services.

2. Who Contracts With Government to Deliver What?

To a large extent, the structure of the U.S. construction industry determines which professions and firms may contract with the

Figure 2 How Are Project Elements Delivered?

The three (3) key elements of infrastructure projects are delivered separately from each other – “Segmented.”

Distinctions remain between capital budgets for the initial delivery of projects and the operating budgets for long term repair, operations, and maintenance.

Combining Design with Construction (Design-Build) is included here, as is Operations % Maintenance.

Design

Construction

Design-Build

**Operations &
Maintenance**

Segmented

The three (3) key elements of infrastructure projects are delivered together – integrated with each other – “Combined.”

Distinctions are eliminated between capital budgets and operating budgets for these projects.

All “Public Private Partnerships” use combined delivery methods.

Design-Build-Operate-Maintain
(including all combinations of public and private sector funding)

Combined

government to provide public infrastructure. Architects and engineers must be professionally registered under state statutes that require them to play specified roles in the design of public infrastructure facilities. General construction contractors are also licensed under local statutes, and generally provide construction services in accordance with a complex set of local, state, and federal statutes and regulations relating to labor, safety practices, and the environment. Since the Great Depression, government has typically arranged and provided for long term operations and maintenance of infrastructure facilities out of public operating budgets.

Since 1933, the U.S. government and the construction industry have established procurement models to support contracts between the government and separate segments of the industry. Professional designers typically contract directly with governments to provide design through a qualifications-based selection process that balances technical qualifications and cost.

General contractors typically contract directly with governments to build the specified design for a fixed price. Governments then typically maintain and operate the infrastructure facilities at public sector expense.

Governments can choose one of two basic strategies in answer to the “Who contracts with government?” question. In a segmented strategy, government provides for key elements on a piecemeal or segmented basis by separately hiring designers and construction contractors to deliver infrastructure. (For the purposes of this report, the combination of design and construction (design-build) is a segmented process.)

In contrast, governments may also choose a combined approach, whereby a government combines design, construction and long term operations and maintenance in a single contract with a single entity. That single entity performs one or more of these functions itself and sub-contracts with one or more designers, operators,

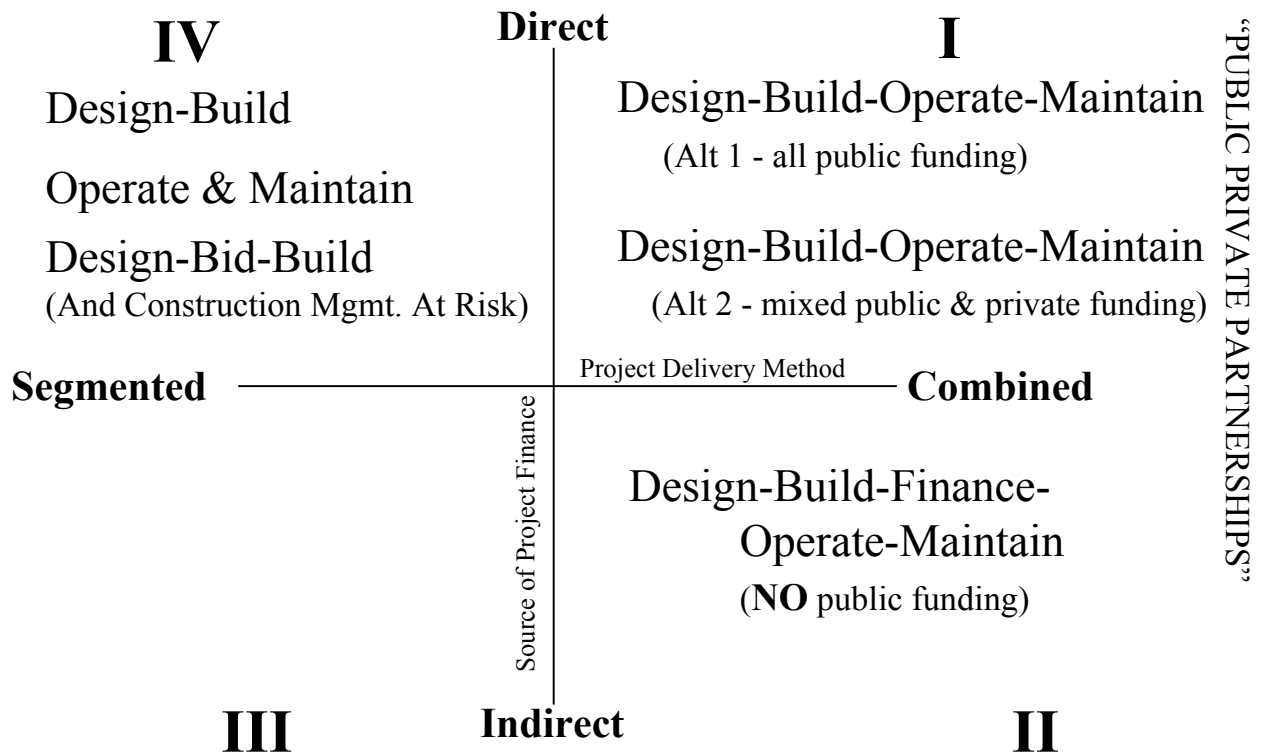
and construction contractors to deliver the completed project over a life-cycle. In this report, projects delivered through a combined or life-cycle strategy may be termed “public-private partnerships” or “PPPs.” Figure 2 illustrates these basic choices.

B. Characterizing Infrastructure Projects

The combination of the concepts in Figures 1 and 2 is shown in Figure 3 – a simple framework of quadrants developed within MIT’s Civil and Environmental Engineering Department in the 1990’s (the MIT Framework). The MIT Framework distinguishes between direct and indirect financing strategies, and segmented and

combined delivery strategies. The horizontal axis represents the degree to which the design, construction, and long term operations and maintenance of an infrastructure facility are segmented into multiple contracts or combined in a single contract. The vertical axis represents the degree to which funds to pay for capital and operating costs are direct or indirect. America’s 225 year experience with infrastructure delivery and finance and the six key methods that ultimately produced America’s infrastructure networks have been incorporated into the MIT Framework, as shown in Figure 3.

Figure 3
Six Key Delivery Methods



I. Two Hundred Years of PPPs in the United States

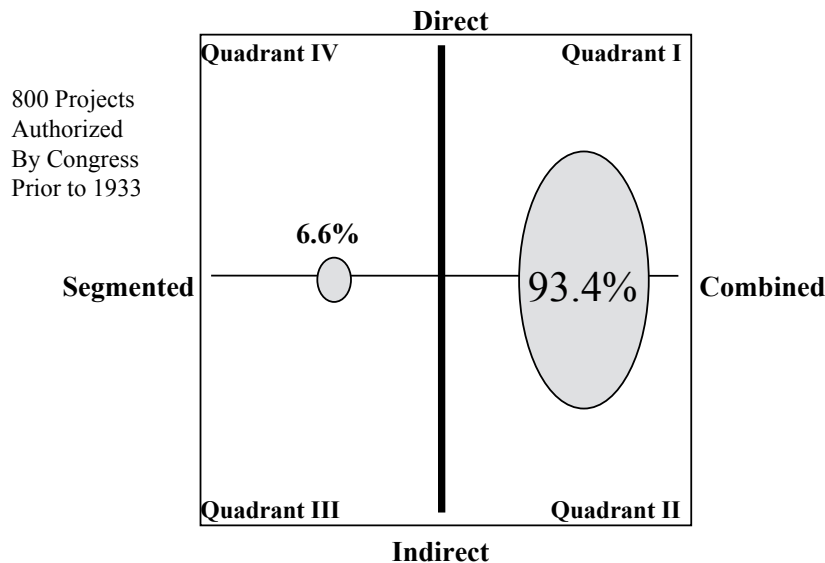
America’s experience with PPPs dates to the period before the adoption of the U.S. Constitution, and confirms that each of the six key delivery methods listed in Figure 3 have been repeatedly and successfully used. Claims by trade associations, marketing firms, investment banks, and interest groups to the effect that one of these methods is inherently new or better are not true. There is no project delivery method that is uniquely and consistently best for the delivery of all of America’s infrastructure projects.

Between 1789 and 1933, federal, state, and local governments faced the same issues currently facing government today – are the costs (both short and long term) of new or refurbished infrastructure projects and facilities justified by the value received? Infrastructure capacity

and level of service were seen then, as now, as fundamental platforms on which local, interstate, and international commerce rely.

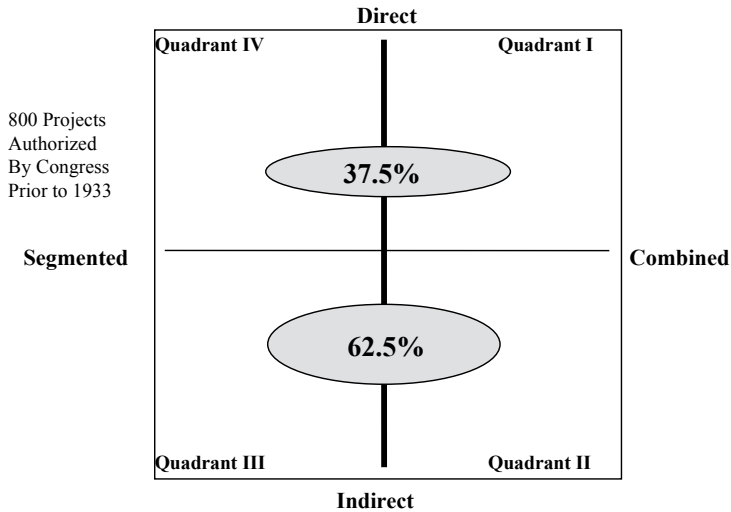
To address pressing infrastructure needs when public budgets were tight and there were competing demands on resources, federal, state and local governments used all of the six key delivery methods listed in Figure 3. Early in this period, most states along the Atlantic seaboard invested public funds in infrastructure development companies in exchange for stock. In general, these investments were failures. The Panic of 1837-39, an economic recession facing the entire country, was caused in part by inappropriate investment of public resources in stock companies promoting infrastructure development. In response, most states amended their constitutions to preclude direct state aid to companies or individuals engaging in infrastructure improvements.³

Figure 4
Early Emphasis by Congress on
Life Cycle Delivery Methods



From *Principles Text*, Miller 2000, Figure 3-3, Kluwer.

Figure 5 Congress' Dual Track Financing Strategy



From *Principles* Text, Miller 2000, Figure 3-2, Kluwer.

Between 1789 and 1933, Congress authorized and promoted many projects, eight hundred of which were incorporated into the MIT Framework, including: canals, roads, railroads, navigation aids, bridges, ferry landings, telegraph networks, cable connections, water supply systems, wastewater treatment facilities, and power generation facilities and distribution networks.⁴ Of these projects, over 90% were delivered using a Combined strategy similar to PPPs. (See Figure 4.) Congress was primarily interested in obtaining infrastructure services over many years and not simply focused on initial delivery of an infrastructure facility, but rather, on life cycle delivery of infrastructure services.

Congress pushed projects directly with its own funds and, at the same time, pulled projects indirectly through concession and lease arrangements which attracted private sector debt and equity financing. During this period, Congress used design-build-finance-operate-maintain as its delivery and finance strategy in five out of every eight (62.5 %) of the projects it promoted through legislation. (See Figure 5.)

Prior to 1933, Congress ran a dual track strategy for infrastructure financing. The logic was practical as well as political. Projects like clearing obstructions and establishing navigation aids such as buoys and lighthouses on navigable rivers were, and still are, a federal obligation under the U.S. Constitution. If Congress didn't push such projects with its own funds, i.e., by direct financing, there was little likelihood that individual states would do so, except on waterways such as the Hudson River where the benefit came solely to the commerce of a single state.

On the other hand, many of the nation's infrastructure needs had to be solved with the assistance of private investment. Federal and state governments simply did not have sufficient resources to pay directly for all projects. In addition, where technology that had been developed in the private sector was unproven or where revenue streams were uncertain, neither Congress nor the States were foolish or impractical in the allocation of scarce public resources. In these situations, Congress and the States put the risk of performance (including design, construction and

Advances in Technology through the Integration of Design with Construction and with O&M.

John A Roebling's Wire Cable technology made the Brooklyn Bridge possible; James B. Eads' diving apparatus and Carnegie's steel made the Eads Railroad Bridge in St. Louis possible; and Eads' system of self scouring mat jetties permanently opened the mouth of the Mississippi River to navigation to the Gulf of Mexico.

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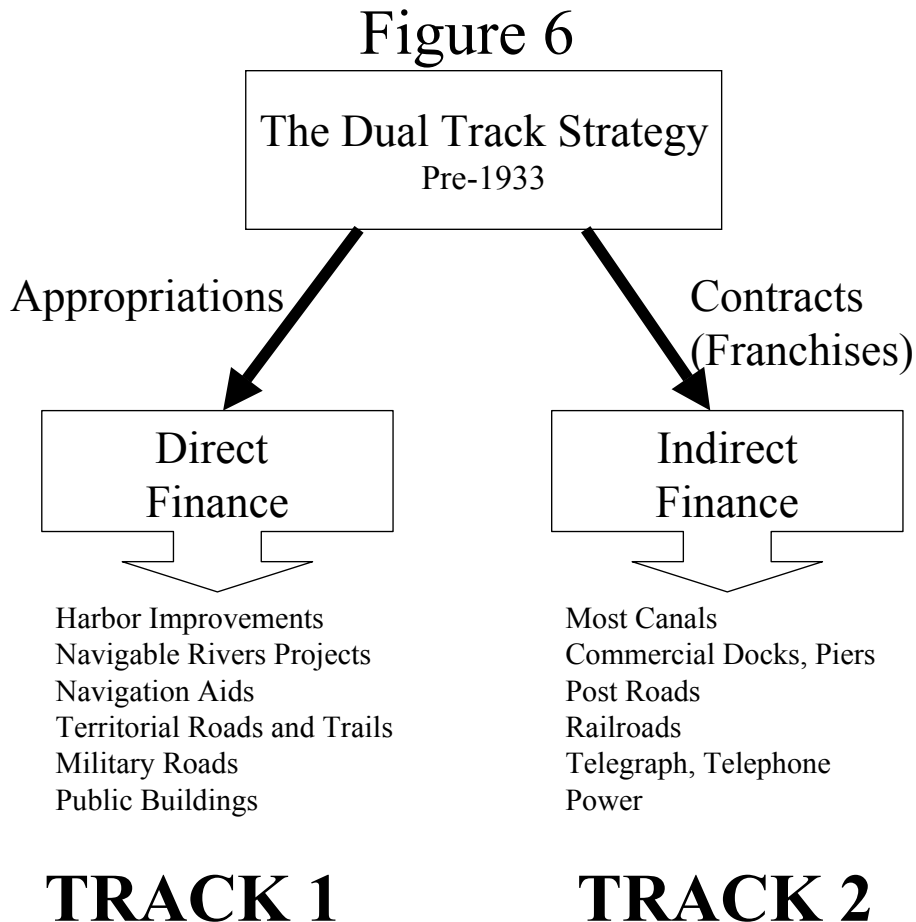
operations), along with the risk of financing, on the private sector, as in Quadrant II. (See inset (p.8) for three well known examples.)

Figure 6 summarizes the basic choices Congress made in this period.

In the twenty-first century, governments are again strapped for cash and the technology needed to improve infrastructure performance is increasingly to be found in the private sector. Governments are again likely to alter their mix of directly and indirectly financed projects toward greater reliance on private sector investment in the infrastructure stock. In January 2008, the National Surface Transportation Policy and Revenue Study Commission reported to Congress on the future transportation service and funding

needs in the U.S.⁵ This report recommends that Congress should provide direct support for the nation's infrastructure networks at about 40% of life cycle costs.

This is a substantial change from the Eisenhower-era strategy of finance one class of infrastructure – the interstate highway network – with 90% federal grant funding and 10% matching state funding. With health care, defense, homeland security, and other funding priorities competing with infrastructure for scarce public dollars, the nation appears to have come almost full circle with respect to its infrastructure strategy, heading back to an equilibrium in which the government pushes infrastructure projects about 40% of the time through direct financing, and pulls infrastructure projects the rest of the time



From *Principles Text*, Miller 2000, Figure 3-1, Kluwer.

through indirect financing and life cycle delivery of services.

With the perspective of history, the provision of public infrastructure facilities and services is best viewed as a dynamic system, in which the infrastructure collection and the population it serves are constantly evolving and changing. What we are now willing to accept as “high quality” transportation, water supply, waste water treatment, telecommunication, and power supply, has constantly changed throughout American history. The very concept of mobility – the movement of people, goods, and information – has undergone dramatic change in even the last decade. Advances in science, modes of communication, engineering, and construction methods not only add to the demand for infrastructure services, but also change the mix of the services in demand. This continues today, in still new and different ways. For example, the emergence of wireless technology is quickly changing how transportation networks work, what governments and users expect in the way of service, and what consumers might be willing to pay for access to internet-based information including email, traffic conditions, weather, news and sports.

There is no project delivery method that is uniquely and consistently best for the delivery of all of America’s infrastructure projects.

Throughout the country’s history, public infrastructure networks have always relied on both government and private sector investment. Advances in science, materials, equipment, engineering methods, and construction practices have generally been the result of private sector investment, in part, to meet changing public demands. It should be expected, rather than be a surprise, that the proportions of direct and indirect government funding have regularly

changed throughout American history, and within particular infrastructure classes. This continues today, and is still evolving. For example, private sector technology advances in computerized control of water and wastewater treatment processes have allowed Combined methods to be effective in improving the quality and cost performance of water and wastewater treatment facilities along with more frequent use of indirect financing methods for the payment of user fees.

Advances in science, materials, equipment, engineering methods, and construction practices have generally been the result of private sector investment, in part, to meet changing public demands.

History confirms that there is no static (or correct) answer in determining whether direct or indirect financing should always be preferred for particular classes of infrastructure projects. Throughout American history, different combinations of available technology, labor, materials, and equipment have mixed with available public and private funds to deliver infrastructure assets in three of the four quadrants of the MIT Framework. Advances in science have combined with improved engineering knowledge, better construction methods, improved O&M techniques, and equally important, skilled labor, to produce and renew America’s infrastructure assets. Recent arguments about who funds, who pays, and what is purchased are not new, and are mostly irrelevant to the re-discovery of workable combinations of technology, equipment, materials, and labor that are focused on delivering better infrastructure value, higher levels of infrastructure service, and a competitive advantage to the American economy in an increasingly international marketplace. As factions push for one or another “public” or “private” result, the incontrovertible fact is that for 200 years, American infrastructure has been “stuck” with both public and private investment.

II. Recent Experience with Public-Private Partnerships

With the historical use of public-private partnerships in mind, the current incarnations of these project delivery methods offer a range of experience. This section will analyze several of the current, high profile monetization PPPs, some alternative strategies, and the Massachusetts experience.

A. Monetization PPPs: Reaching Deep into the Future for Current Cash

1. The Chicago Skyway

In October 2004, the City of Chicago entered into a ninety-nine year lease of the Chicago Skyway with a consortium comprised of Macquarie Bank (Australia) and Cintra Concesiones (now based in Texas, with parent in Spain). The lease began with an up-front \$1.8 billion cash payment to the City of Chicago. The City awarded the lease to Cintra/Macquarie based on the amount of this up-front payment; in fact, its offer was \$1 billion dollars more than the second bidder. The City used the cash infusion to pay down existing debt (improving its credit-worthiness); and to establish an \$800 million rainy day fund for use outside the transportation system.

2. The Indiana Toll Road

In February 2006, the State of Indiana entered into a seventy-five year lease for the Indiana Toll Road with a consortium comprised of Cintra SA, (Spain), and Macquarie Infrastructure Group (Australia). Cintra won the contract because it offered the highest up-front payment, a \$3.8 billion cash payment to the State. Indiana governor Mitch Daniels committed all proceeds from the lease to transportation improvements and extensions across the State of Indiana.

Two billion dollars of the funds received will pay for the completion of Interstate I-35, a tolled interstate highway to be built across the state from southwest to northeast, part of a longer interstate route connecting at its most southern terminus to Texas and Mexico. One billion dollars were committed to retire existing state highway debt, with the remaining \$800 million slated to fund local transportation improvements along the Indiana toll road corridor.

3. Texas SH 121

In the spring of 2007, a team comprised of Cintra and JP Morgan Fund “won” the procurement competition to build and operate a Greenfield toll-road concession in the Dallas Metroplex. Cintra/JP Morgan was originally selected as the winner following a multi-million dollar competition for the fifty-year franchise for Texas SH 121.

The Cintra/JP Morgan Fund proposal was determined to provide the best value among private sector competitors; it offered \$763+ million in new equity investment to meet the region’s transportation needs; contributed \$2.25 billion dollars in debt financing, and isolated risk by tying tolls on Texas SH 121 to tolls on the region’s publicly owned and managed toll roads.

As a prerequisite to submitting the proposal, the Cintra/JP Morgan Fund team had already managed and dealt with design, construction, and operations risks through the development of conceptual design at its own expense. It also obtained firm fixed pricing to provide these services to the consortium if and when the concession was awarded.

However, after Cintra/JP Morgan won, and the details of its proposal, including prices, were made public, North Texas Toll Authority (NTTA) submitted a post-competition proposal to the Dallas Council of Governments and was allowed, with support from the Texas Legislature, to compete with Cintra for the SH 121 concession.

Table 1

NTTA currently operates sixty-four miles of existing toll road in the Dallas Metroplex. NTTA’s proposal to the Dallas Council of Governments was subsequently judged to be superior to that of Cintra/JP Morgan. It offered an up front payment from one government (NTTA) to another government (Texas DOT) that was slightly larger than the payment the Cintra/JP Morgan Fund team had proposed. The project was awarded to NTTA. NTTA has since closed the transaction, and is proceeding forward with the SH 121 project.⁶

In part because of Texas SH 121, there is now substantial uncertainty about the future of monetization toll road projects in the State of Texas and in the U.S. Table 1 summarizes Cintra’s and NTTA’s toll road expertise, and illustrates some of the reasons that the consequences of the re-competition of the SH 121 project are being monitored closely by both private and public participants in US toll road projects. The Texas legislature has adopted a two year moratorium on most such arrangements pending further investigation, study, and legislative action in the next session.

4. Problems with Monetization PPPs

The Chicago Skyway, Indiana Toll Road, and SH 121 procurements have produced a great deal of uncertainty and fluctuation in policy, political resolve, and logic. Millions of dollars have been spent on transaction costs associated with PPP projects in the U.S. and most projects have not closed successfully.

The consortia that operate the Chicago Skyway and the Indiana TR will do what the previous public owners would not: raise tolls. In each case, the right to raise tolls was set forth in the concession agreement, negotiated after the concession award itself. Future tolls will be computed using whichever of three price escalators produces the highest increase from the prior year – 2%, the increase in CPI, or the increase in per capita GDP.

Experience Comparison for Texas State Highway 121		
Characteristic	NTTA	Cintra
Current Total Miles of Toll Roadway in Operation	64 miles	1,243 miles
Toll Roadway Miles Opened Prior to 1999	22 miles	30 miles
Toll Roadway Miles Opened in 1999 or Later	42 miles	1,213 miles
Rate of Toll Roadway Miles Opened per year, since 1999	5.2 miles	151.7 miles
Construction Cost of Toll Roadways Opened in 1999 or later (with partners)	\$1.192B	\$6.755B
Rate of Construction Cost Expended Per Year on Toll Roadways Opened in 1999 or later (with partners)	\$149M	\$807M
Total Miles of Existing Toll Roadway in North America	63.9 miles	231.5 miles

The Chicago Skyway and Indiana Toll Road deals stand out when compared to infrastructure deals struck between public clients and private producers over the last two hundred years! Rather than competing to provide specified services – including repairs, maintenance, and operations – at the lowest toll rates over the concession period, the procurement was structured such that the contract was awarded to the bidder offering the highest upfront payment. The full amount of these upfront payments must be recovered through tolls.

The Skyway transaction made a great deal of political sense, because Chicago did not want or need to be expert in toll road operations, and most toll-paying users of the road were from out of state. Similarly, the Indiana toll road transaction made sufficient political sense to pass both houses of the legislature, although in the succeeding election, control of both houses in the Indiana legislature switched from Republican to Democrat. And it may be that Indiana is best served by spending its

■ **Life Cycle Delivery of Public Infrastructure**

\$3.8 billion on projects that improve its position as a logistical transportation hub.

Nonetheless, the procurement process associated with each transaction raised intractable questions. Rather than confirm transparency, competitive pricing, and fair treatment of competitors and users – the essential purposes of a good procurement system – the process did none of these things.

The ninety-nine and seventy-five year concession terms were not competitively tested.⁷ In each case, the offers received were far higher than expected, indicating that government could have obtained both the payment it sought and lower tolls or shorter terms. The use of per capita GDP increases as an escalation factor was also not competitively tested through the procurement process. The terms and conditions relating to the Skyway and Indiana Toll Road deals were not finalized until after the winner was chosen, raising the concern that proposers did not compete head-to-head, but rather in a rolling competition where service levels, toll rates, and the length of the concession were not high priorities.

Yet, the deals have created a sea change in thinking about PPP transactions in the U.S. Governors in Pennsylvania and New Jersey are exploring similar arrangements for the Pennsylvania and New Jersey Turnpikes. On the other hand, NW Financial Group analyzed the Skyway and Indiana Toll Road deals, applying historical rates of growth in GDP and the CPI to estimate ranges for the growth in tolls. For the Chicago Skyway, NW Financial Group's analysis suggests that passenger car tolls will rise from \$2.00 to between \$28.00 and \$1,800.00. In Indiana, the analysis suggests that passenger car tolls will rise from \$4.65 to between \$34.00 and \$1,200.00, and for five-axle trucks, tolls will rise from \$14.60 to between \$135.00 and \$4,700.00. The width of these ranges strongly suggests that there was insufficient competitive market pressure on

price when these terms were negotiated after the concession winner was determined.

In retrospect, the Chicago Skyway and Indiana Toll Road transactions are likely to be seen as aberrations in the privately funded delivery of infrastructure services and facilities in the U. S. and not the emerging paradigm claimed by their adherents. There may be other similar transactions, but it is more likely that such transactions will be driven by specific factual circumstances and long term rationalization of the infrastructure market, not by the notion that existing infrastructure services can be productively used as plentiful sources of cash in exchange for a century of higher than necessary user fees.

Likewise, the SH 121 “post-competition” competition was a “cold shower” for potential participants in Texas that were otherwise willing to compete on price and quality. The Texas process was not sufficiently stable to produce transparent competition with predictable results. There is a practical limit to how much bid and proposal preparation costs private sector competitors are willing to incur in pursuit of uncertain PPP agreements. In order to attract reputable participants and competitive pricing, free from unreasonable contingencies, governments must substantially improve their treatment of prospective and actual competitors for PPP or life cycle delivery type projects. If they do not, prices (and tolls) will be higher than would be required in a transparent, fair and competitive process. In the long run, the perception of transparency, fairness, and competitive pricing may be more important than any other factor in the public's acceptance of PPP transactions.

B. Successful Greenfield PPPs – Based on Life Cycle Delivery

Two Canadian projects completed in the 1990s illustrate where many observers thought combined delivery projects were heading in the United States, and where they could still go given sound planning and policy-making. The term PPP caught on, “monetization” followed, and the market has been side-tracked since. These Canadian projects demonstrate that competitive integration of the design and construction with operations and maintenance can and does produce dramatic improvements in the cost of initial delivery, life cycle delivery, and the level of infrastructure service. The projects ought to be used as guideposts for Massachusetts policy-makers as the state considers how to use and apply a Massachusetts version of PPPs based on life cycle delivery of essential infrastructure services.⁸

1. Northumberland Bridge, PEI

The Northumberland Bridge project, subsequently dubbed the “Confederation Bridge,” crosses the Northumberland Strait and connects the Province of Prince Edward Island to the Province of New Brunswick.⁹ The Bridge replaces ferry service previously operated by the federal government.

Figure 7: Location of the Northumberland Strait Bridge



The history of the ferry service and the Canadian federal government’s decision to replace it with a fixed link are inextricably tied to the formation of the Canadian confederation in 1867. A key factor in the development of the Northumberland Bridge project was the constitutional commitment of the federal government of Canada to maintain transportation services across the Strait. When Canada was formed, the federal government agreed to build, open, and maintain the Trans-Canada highway from the east coast to the west coast, including Prince Edward Island. When the Trans-Canada highway crossed the Northumberland Strait between Prince Edward Island and New Brunswick, it used a ferry system operated by the federal government.

These...projects demonstrate that competitive integration of the design and construction with operations and maintenance can and does produce dramatic improvements in the cost of initial delivery, life cycle delivery, and the level of infrastructure service.

From the outset, there were difficulties in maintaining ferry services across the Strait, including interruptions during bad weather and the rising cost of transporting goods and cargo. In winter, the thickness of the ice is measured in meters. For these reasons, keeping the strait open to ferry traffic proved difficult and expensive.

Federal investment in larger ferries capable of transporting large trucks solved some of these problems, but the ongoing cost of ferry operations and the resulting toll charges rose sharply in the 1980s. To understand the problem and its potential solutions, the government prepared a detailed analysis of past capital and operating expenses and revenues, and estimated future capital and operating expenses and revenues (life cycle delivery costs and revenues) over a fifty-year period. The government used this analysis

■ Life Cycle Delivery of Public Infrastructure

to plan and execute a transparent, competitive procurement process. Through this process, the government sought to enable private sector delivery of better infrastructure services across the strait via a new bridge at a substantially lower net cost to the government and toll payers.

With a firm understanding of expected life cycle delivery costs and revenues if it continued the ferry operations (including a needed substantial upgrade in vessels and ferry terminal facilities), the government executed a transparent, competitive procurement strategy that attracted strong proposals from a number of experienced teams. Included in the government's request for proposals to design, build, operate and maintain a fixed crossing over the Strait were minimum design requirements for technical performance, useful life, required condition of road surface, lighting, safety barriers, etc. Proposers had a clear understanding of the size, capacity, and required performance of the crossing (either a bridge or a tunnel) that the government sought, not only initially, but over the thirty-five year concession term.

Having done the homework sufficient to understand its current and future costs for ferry services, the government made two exceptional commitments in the RFP.

First, the federal government committed to pay \$41.9 million dollars annually (in 1992 Canadian dollars)¹⁰ each year over the thirty-five year term of the concession, a cash flow that was substantially less than the anticipated cost of continued ferry services. Second, the federal government committed to begin these payments to the successful bidder in 1997, whether or not the bridge was open to traffic. In exchange for this second commitment, the request for proposals required that the successful bidder would take over and run the ferry service in the event the bridge was not opened to traffic on schedule in 1997. Evaluation factors in the RFP confirmed

that the winner would meet or exceed the design requirements specified by the government and provide the lowest fare structure (evaluated on a common basis by the government) over the thirty-five-year franchise term.

The effect of a well planned competitive procurement process was extraordinary. Teams with designs that were expensive to build and/or to maintain and operate over the thirty-five year franchise would be forced to recover these higher costs through the fare structure they proposed, a strong incentive for teams to design for ease of construction, operation, maintenance and repair, and for long life.

By committing to pay \$41.9 million dollars per year whether or not the bridge was open, the government eliminated concerns about cash flow among private sector lenders. The winning consortium was able to arrange for private financing at a fraction of a point above the borrowing rate available to the federal government itself. The effect of a sound procurement plan was to minimize financing costs, which translated directly into the lowest possible fare structure over the concession term.

By requiring the winner to operate the ferry system in the event of a delay in completing the bridge, the government sent a clear signal that design

Figure 8: The Winning Consortium's Outdoor Factory



and construction risks would be transferred to the concessionaire. Construction industry firms are accustomed to accepting and managing such risks – unlike the political risks generated in projects like Texas’ SH 121.

The winning consortium proposed a pre-cast concrete structure in four basic parts and a construction process that matched the procurement strategy planned by the government. Each element of the proposed bridge was designed with ease of construction, operations and maintenance in mind. The winning proposer planned to build the four basic parts of the bridge in what amounted to an outdoor factory where the components moved as they were being built along an assembly line toward a temporary pier where the world’s largest barge/crane would lift, transport, and assemble the bridge.

Figure 9: Northumberland Bridge Nearing Completion (1997)



The procurement was structured to give the winning consortium powerful incentives to create an innovative design and employ new construction technologies. To minimize its operations and maintenance costs, the bridge was designed to

permit most maintenance to occur from inside the spans, safe and secure from inclement weather. To extend the short construction season in the Strait, DuPont developed and supplied special adhesives for use in cold temperatures. To protect the bridge from structural damage by heavy ice flow, ice shields were designed that force the ice to break upwards. To properly secure the piers to the sea bed, special techniques were developed for the installation of high-strength underwater grout and the transport barge was equipped with systems to place and hold piers within a fraction of an inch of the design location.

When opened (early) in 1997, the Northumberland Bridge provided a year-round fixed link across the Strait. The government’s estimate of its savings in life cycle costs, between paying the yearly fee to the concessionaire and operating the ferry service, was 30% or \$750 Million Cdn over the thirty-five year concession. The concession agreement requires that the bridge be returned to full ownership and control of the federal government at the end of the concession, with a transfer price of \$1. The bridge’s useful life of one hundred years will put the federal government in the position of either operating the bridge as a toll structure itself or re-competing the bridge’s O&M at the end of the initial thirty-five year term.

The procurement plan followed by the federal government successfully achieved what current monetization PPPs cannot. In a transparent, competitive process, it confirmed that a new, well-planned infrastructure service will provide additional value at a fair (in this case lower) cost to the government and/or to users.

2. Highway 407 ETR

The Highway 407 ETR project is a congestion relief toll road that connects Quebec, Montreal, and Toronto to the I-75 corridor in Detroit, running parallel to Highway 401, north of Toronto. Originally built by the private sector in the mid 1990s and taken back for public operation

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in 1997 following a change in government in Ontario, the road was offered back for private sector operations and maintenance, along with a substantial (Greenfield) extension to the road at both the eastern and western ends, in the year 2000.¹¹

For decades, the need for congestion relief in the Toronto region north of Highway 401 had been evident. Toronto had emerged as the economic and manufacturing center of Canada, and Highway 401 was repeatedly widened and expanded to accommodate heavy truck and passenger vehicle traffic along the Trans-Canada corridor. Near Toronto, Highway 401 is twelve lanes wide, six lanes in each direction, split into express and local lanes, and congested for long periods of time throughout extended morning and evening rush hours

Figure 10 shows the original center section of Highway 407 ETR, plus the road's eastward and westward expansions. When first built in the mid 1990s, Highway 407 ETR was intended to be a design-build-operate concession, but at the end of a competition in which the government organized only two competing teams, government preferred the design and construction (design-build) portion of the proposal of one of the teams but the electronic toll collection system of the other team. The government accepted the design and construction proposal it liked and converted the project to design-build.

The government subsequently hired Hughes Aircraft to design, construct, operate and maintain the world's first, completely seamless Electronic Toll Collection / Automatic Vehicle Identification (ETC/AVI) system to be installed after the design-build portion of the road project.

Hughes' Slotted Aloha (TDMA) protocol for target acquisition technology, originally developed for the F-14 fighter jet, is incorporated into an entirely electronic toll collection system. It either reads transponders on cars traveling the

road at speed, or identifies vehicles by shape, size, and license plate, also at speed. There are no toll booths, no need for traffic to slow down or stop, and no need for extensive additional paved space where vehicles are stacked to wait to pay tolls. Cars and trucks simply drive through at speed. Upon completion, the province had spent \$1.5 billion building the road and installing the ETC/AVI system. Although there were some technical problems with the toll collection system, toll congestion relief was now available for a portion of the trip on Highway 407.

After an election and a change in control, the Ontario government began to explore private operation of both the road and the ETC/AVI system. It recombined the two separate contracts into a single long term DBFOM concession to build the extensions to the east and west, and to consolidate all design, construction and operations and maintenance into a single contract.

Just as in the case of the Northumberland Bridge project, the government prepared a detailed analysis collecting prior capital and operating expenses and revenues and projecting estimated future capital and operating expenses and revenues (life cycle delivery costs and revenues) for the full build-out of Highway 407. In 2000, the government issued a Request for Proposals to

Figure 10: Highway 407 ETR Across the Northern Tier of Toronto, Ontario



operate and maintain the existing Highway 407, including the ETC/AVI function, and to design, build, finance, operate and maintain the east and west extensions. The proposal sought bids to acquire the project from the province for a ninety-nine year term, and included detailed design and operating requirements for both the existing and future road segments, along with parameters for managing toll increases during the concession.

The government took final offers from the two most highly ranked teams and ultimately selected Cintra's¹² bid of \$3.0 billion dollars. After the closing, the province used half of the up-front payment to retire the 1997 debt incurred while building the initial segment of Highway 407, and applied the remaining \$1.5 billion to other transportation projects in the province.

Figure 11 shows the successive strategies employed by the province to build Highway 407 (Part I) and to complete the road as a Design Build Finance Operate Maintain project (Part II). Since

2000, the extensions have been completed and traffic on the road has steadily increased. Capacity north of Toronto has doubled and congestion on Highway 401 has been significantly relieved. By all accounts, the highway is one of the most successful toll roads in North America.

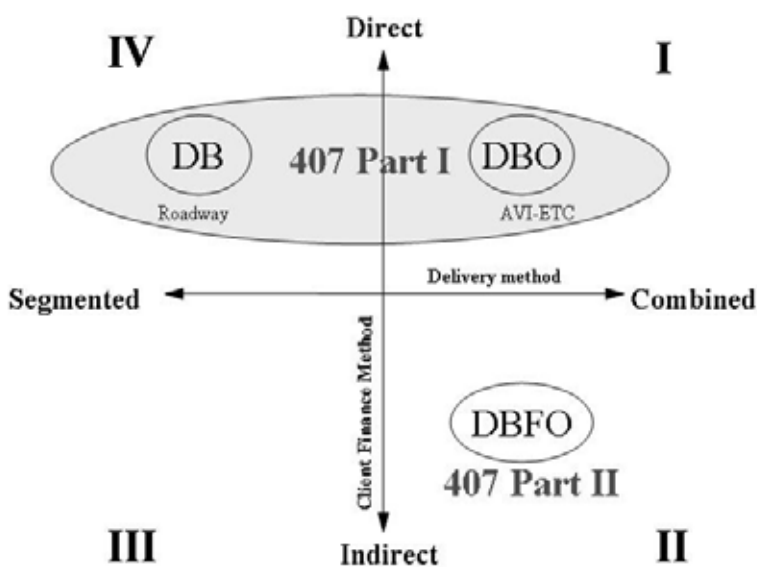
C. Massachusetts' Recent Experiments with Infrastructure Project Delivery

In a separate report, entitled *Lessons Learned: An Assessment of Select Public-Private Partnerships in Massachusetts*, four project case studies reviewed the methods employed for major infrastructure project delivery in Massachusetts. These projects were the Route 3 North reconstruction project from Burlington to the New Hampshire border; the 5 year operations contract between the MBTA and Massachusetts Bay Commuter Rail, Inc. (MBCR), which is to be extended for an additional 3 years; the Big Dig management structure; and the Northeast (MA) Solid Waste Compact (NESWC) for the disposal and recycling of solid waste (a "trash to cash" plant) in North Andover.

Except for the NESWC project, these cases were not based on life cycle delivery and do not meet our definition of a public-private partnership. Only the 20-year NESWC pact involved a contract sufficiently long in duration to permit the private-sector contractor to price and deliver an infrastructure facility on a life cycle delivery basis. Yet, the procurement practices followed on the NESWC facility produced horrific results for its member communities.

The Route 3 North project demonstrates how the combination of design with construction (design-build) in a single procurement, when appropriately used, can produce clear savings in the cost and time of initial delivery.

Figure 11



■ **Life Cycle Delivery of Public Infrastructure**

The agreement between MBTA and MBCR shows how a public entity can contract with the private sector to substantially reduce the amount of deferred maintenance within an infrastructure network, and use a pure operations and maintenance contract approach to position the network for better future technical and life-cycle cost performance.

The Big Dig project, which temporarily added hundreds of private-sector engineers and construction managers to the staff available to manage one of the largest and most complex construction projects in history, is an example of how a public entity can adjust its internal capacity to manage projects over short periods of time.

The effect of a sound procurement plan was to minimize financing costs, which translated directly into the lowest possible fare structure over the concession term.

NESWC provides the clearest lessons for future life cycle delivery (public-private partnerships) in Massachusetts. Because the service agreement contained an unconditional obligation on the part of the member towns to pay all of the contractor's development, financing, operations, repair, and maintenance costs, there was no financial risk transferred to the contractor.

The NESWC project is a classic situation in which the Commonwealth commanded others (the member communities) to take risks with an emerging technology in circumstances where the Commonwealth, rather than the towns, should have done so. The scope of the project had not yet developed to a point that allowed a competitive, transparent competition to take place. Instead, an extremely "soft" competition was conducted to select an entity to build the plant, without obtaining a simultaneous commitment from the bidder as to what precisely would be built and

what precise charges would be paid by member towns. Because the procurement was so poorly planned and executed, the pricing terms were based on recovery of costs, overhead, and profit – essentially a cost-plus arrangement that most public procurement officials would be wary of over a 20-year term. The terms of the service agreement were negotiated by the Commonwealth on behalf of the member towns after the contractor had been selected.

The NESWC project is an example of how poor procurement practices, lack of preparation, and lack of head-to-head competition, can produce unacceptable results with respect to any infrastructure facility.

There are few local success stories in the effective use of life cycle delivery methods, or PPPs, as the Commonwealth considers additional mechanisms to quicken the pace and increase its level of investment in infrastructure renewal. However, legislative models for life-cycle delivery of major infrastructure facilities already exist. These models ensure transparency, head-to-head competition on technical compliance and price, public safety, and fair treatment of competitors,¹³ and policy makers should consider using them to establish a durable market that supports the full range of project delivery and finance mechanisms in the Commonwealth.

III. Framework For Considering and Using Life Cycle Delivery

For a government to properly consider the use of alternative funding and delivery strategies for public infrastructure projects, better, different, and earlier information needs to be collected, assembled, and provided to public decision makers. In addition, appropriate information about upcoming projects should be made public as a first step in attracting the competitive interest of designers, constructors, operators, and financiers. This section of the Report identifies key issues to consider in fashioning the Commonwealth's future infrastructure strategy.

A. Separating Design from Construction

For most public buildings, a primary early focus is design, especially when the building's predominant purpose is occupation by people. For most schools, courts, auditoriums, transportation terminals, office buildings, and other occupied buildings, government officials are likely to conclude that practical control over the initial design is required.

For these projects, DBB (or Construction Manager at Risk) is usually the method chosen to deliver this design. The logic behind this choice usually comes from the conclusion that the most important goal in planning the infrastructure facility is to "get the design right first", before making the decision to move forward with construction. DBB and CM at Risk are viable approaches for nearly all infrastructure facilities, but they frequently lead to higher life cycle costs, which are not commonly part of the evaluation process. Despite this shortcoming, DBB will continue to be the most regularly used delivery method for public infrastructure facilities.

There are several advantages to DBB and CM at Risk. If the public entity is unable to define for itself the features to be included in the design, an architectural firm prepares the program requirements for the public owner. The public entity can review and approve alternative design concepts and details to ensure that it approves all design features. Also, the public entity can stop spending at any time during the design phase, without incurring any liability for construction costs. Also, Construction Manager-at-Risk can facilitate better coordination between the designer and the eventual contractor before the design is finalized and a maximum price is determined.

However, there are some clear disadvantages to the DBB approach. Because the designer typically does not consider the cost of construction, segmenting the design function from the construction function causes the public owner to lose substantial control over the construction price, typically 15-20 times the cost of initial design. And, more importantly, unless it is extraordinarily sophisticated, the public owner has essentially no control over long-term operations and maintenance costs, which are typically 10 times the cost of initial construction, or 150-200 times the cost of initial design.¹⁴

Public owners typically ignore life cycle delivery costs when using design-bid-build. The life cycle obligations a public owner assumes when it approves the design and construction of a public building (O&M, energy, and borrowing costs) are simply passed on to taxpayers or users.

B. Shifting the Focus from Initial Design to Initial Delivery

For some infrastructure facilities, it may be practical and preferable to focus on initial delivery, that is, on both the design and construction functions. Where the combination of design and construction in a single competitive procurement

■ Life Cycle Delivery of Public Infrastructure

makes practical sense, there can be substantial savings in cost and in the time required for initial delivery. In these situations, design-build (DB) is a viable alternative to DBB. In Design-Build (DB), the public entity retains control of both initial design and construction, but through a competition for both in a single contract. Here, the overarching goals of the public entity are to accomplish initial delivery on a fixed price basis, and to transfer the risk of coordinating and managing both the design and construction to a single entity, the design builder.

DB is a viable approach for virtually all engineering projects for which clear design requirements can be established before a competitive procurement process. DB is a possible approach for heavily occupied public spaces, if and only if the public owner can clearly establish design requirements that will remain stable throughout the competitive process and after award.

DB comes with some additional risk. Changes in design requirements initiated after award are much more expensive to the public owner in DB than in DBB. In DB, a late change in design requirements typically delays construction and increases costs. In DBB, most changes in design requirements occur before the construction contractor is hired.

Nevertheless, DB offers significant cost savings advantages over DBB. If a public entity is prepared to establish stable design requirements in a competitive procurement for both design and construction, typical cost savings are 10% over DBB and typical time savings are 12% over DBB. For engineering projects such as pipelines, utility distribution and collection, utility control buildings, stadiums, short span bridges, track, etc., DB is a perfectly viable alternative to DBB.

Disadvantages include lack of control over long-term operations and maintenance costs, unless careful attention has been paid to operations and maintenance characteristics and features in the DB

design requirements. As with DBB, the life cycle obligations (operations and maintenance, energy, and borrowing costs) that a public owner assumes when it approves DB for a public building are simply passed on to taxpayers or users.

An Effective Approach to Design-Build

The ABA 2007 Model Code for Public Infrastructure Procurement establishes a starting gate and a finish gate for delivery methods in which design is integrated with construction. The starting gate is creating design requirements and giving competitors adequate notice of the functional requirements to be met. The finish gate is creating Proposal Development Documents, which must be submitted at the time the proposals are received, and which contain full concept plans, with substantial architectural content, to illustrate how each proposer would aesthetically incorporate design requirements into the facility to be constructed. The 2007 MC PIP requires public owners to do the homework necessary to produce design requirements; in return, it allows substantial competition on aesthetic and architectural bases for evaluation and comparison before a design-builder is selected.

C. Shifting the Focus from Initial Delivery to Life Cycle Delivery

The cost of long-term operations and maintenance on public infrastructure assets is a critical question facing every government in the U.S. We all observe, first hand, the consequences of inadequate maintenance of existing assets each time we ride a bus or subway, or drive a vehicle. Governments need to decide early in a project's development process whether they plan to provide

for initial delivery only, or for life cycle delivery of the proposed infrastructure facility. Figure 12, below lists the six key delivery methods along the bottom, and presents some of the practical consequences of choosing between initial delivery and life cycle delivery.

By choosing initial delivery, as shown on the left side of Figure 12, the options narrow to three of the six possible delivery methods, all in Quadrant IV: DBB, DB and because it is typically available for use only after the first two, Operation and Maintenance (O&M). By choosing life cycle delivery, shown on the right side of Figure 12, government is focusing on the other three possible delivery methods in Quadrants I and II.

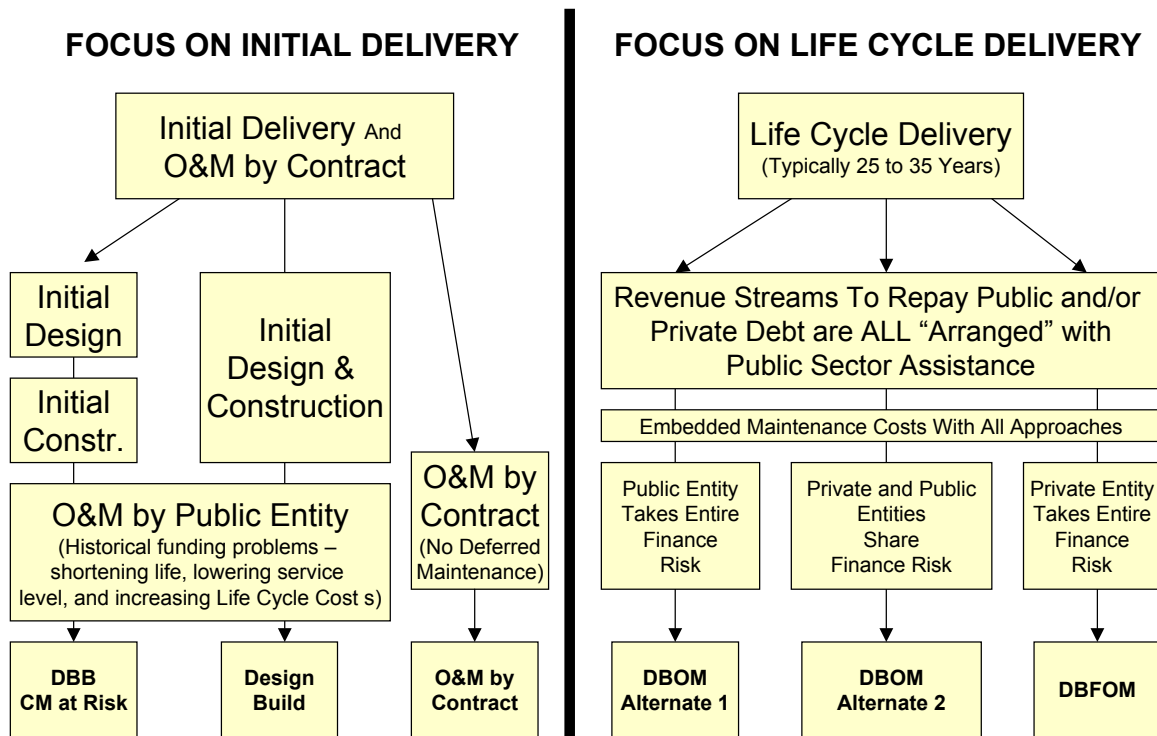
This basic choice has important consequences. If the choice is initial delivery, decision-makers should immediately face the question of how the government will provide and pay for long-term operations and maintenance. Unfortunately,

when choosing initial delivery, governments have historically avoided questions about ongoing expenditures for operation and maintenance.

The vast majority of public buildings are operated with underfunded maintenance budgets. Inadequate operations and maintenance budgeting is largely invisible, encouraging the continuing cycle of deferred maintenance, until much higher than necessary capital replacement costs become necessary. Failure to properly perform operations and maintenance services throughout the life cycle results in substantial additional overall expense, lower levels of service, damage to existing equipment, additional energy consumption and shortened useful life of existing facilities.

Over the past several decades, federal, state, and local governments across the U.S. have seen the effects of failing to properly operate, inspect and maintain important infrastructure facilities. Bridge collapses on the interstate

Figure 12
Basic Project Delivery Choices



■ Life Cycle Delivery of Public Infrastructure

highway network in Connecticut (1983, Mianus River), New York (1987, Schoharie Creek), and Minnesota (2007, Mississippi River) provide potent reminders of the impact of deferred inspection and proper maintenance. Years of research at the US Army Corps of Engineers have confirmed that when proper maintenance is not performed (i.e. regularly deferred), the rate of degradation in the value and the useful life of road structures is significantly higher. Deferral of maintenance essentially guarantees significantly higher capital replacement costs throughout transportation infrastructure networks.

Where an existing facility is being poorly operated and maintained, and where necessary maintenance has been regularly deferred, it may be practical to focus on managing the operations and maintenance responsibility through a fixed-price, competitively bid contract. Such an approach to long-term O&M may also make sense for a new facility that requires separate design and where long-term operations and maintenance is a priority.

Deferral of maintenance essentially guarantees significantly higher capital replacement costs throughout transportation infrastructure networks.

Cleaning, routine maintenance (filter replacement, motor servicing, cleaning of roof and bridge drains, cleanout of storm drains, etc.), and, on occasion, operation of infrastructure stock have been successfully contracted out through competitively awarded contracts. Contract operations and maintenance have been used in public infrastructure facilities for occupied spaces – schools, courthouses, public office buildings, public transit stations, intermodal terminals, and other heavily occupied and used space.

The principal advantage of operation and maintenance by contract is that a mechanism is established by which operations and maintenance services that are not otherwise being performed are listed, measured, and verified on a daily or regular basis. The addition of an operations and maintenance contract typically results in higher O&M expenditures, but lower public expenditures, because maintenance is performed timely and prevents damage to existing equipment, conserves energy, and extends the useful life of existing facilities. Proper maintenance, either through contract or by public owners themselves, usually results in substantial reduction of life cycle costs.

Where an existing facility is being poorly operated and maintained...it may be practical to focus on managing the operations and maintenance responsibility through a fixed-price, competitively bid contract.

Competitive pricing for long term operations and maintenance can typically produce savings of 10 to 20% of life cycle costs. Some years ago, the MBTA moved to contract cleaning operations in downtown subway stations, a change which dramatically improved results, because cleaning standards contained in the competitively bid contracts were checked and enforced on a daily basis as a condition for payment.

Another advantage of long term operation and maintenance contracts is that they establish the actual costs for maintaining an infrastructure facility. With a solid factual understanding of long term O&M costs, governments can properly analyze the technical and financial feasibility of substituting a Quadrant IV (segmented) delivery strategy with either a Quadrant I or II (combined, or life cycle delivery) approach.

A good example of this is the MBCR, Inc. contract with MBTA to operate and maintain the commuter

railroad network. With proper accounting and reporting from the MBCR, the MBTA should be in a better position to estimate ongoing capital and maintenance costs over long periods of time, enabling it to develop better strategies to operate, maintain, replace, and upgrade the entire commuter rail network through a steady program over many years.

D. Whether a Project Can Produce a Return on Investment for a Private Entity

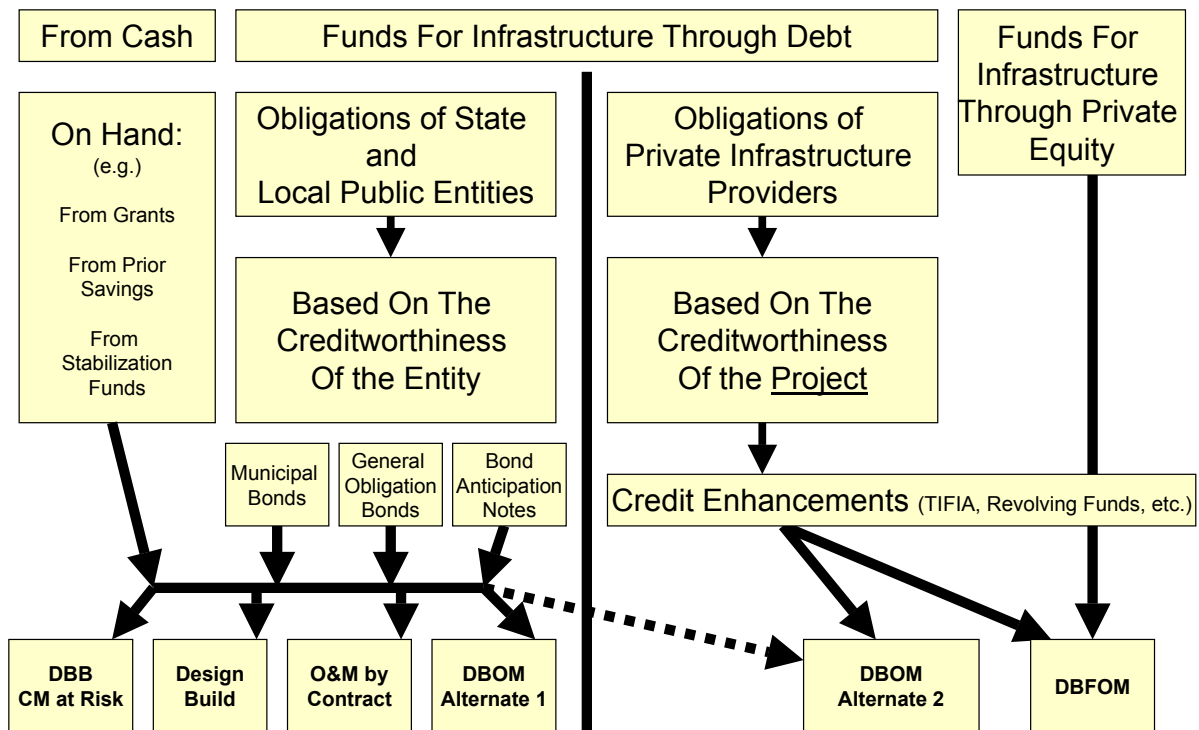
Before considering whether public funds are (or should be made) available to fund one or more projects, government officials should also consider whether an infrastructure project can be positioned for private financing, in whole or in part. Figure 13 shows the three basic sources

of funding for public infrastructure facilities – cash, funds obtained through debt (both public and private) and equity funds contributed by the private sector. Typical obligations of state and local governments in the Commonwealth are municipal bonds, general obligation bonds and bond anticipation notes (BANs), as shown on the left side of Figure 13. Four of the six basic delivery methods rely exclusively on public sector sources of financing. Projects that are funded through these types of public obligations do not include either of the two basic delivery methods on the far right – DBOM Alt. 2 (Mixed Funding) or DBFOM.

Figure 14 presents a summary of characteristics that make infrastructure projects suitable for financing on the right hand side of Figure 13, or, in many more situations, a combination of both public and private sources of debt and equity.

Figure 13

Sources of Funding For Public Infrastructure Facilities



■ Life Cycle Delivery of Public Infrastructure

Figure 14 was developed based on a series of interviews conducted in Hong Kong in the early 1990s, when the colony was fully engaged in using private funding to support an aggressive program of infrastructure improvements.

Investors, unlike governments, can choose to invest elsewhere (geographically or out of the infrastructure sector), so the logic followed by governments in assessing public sector investments simply does not apply in the same way. Before investors agree with producers (developers) to invest significant cash to build an infrastructure project, they need to become comfortable along three basic themes.

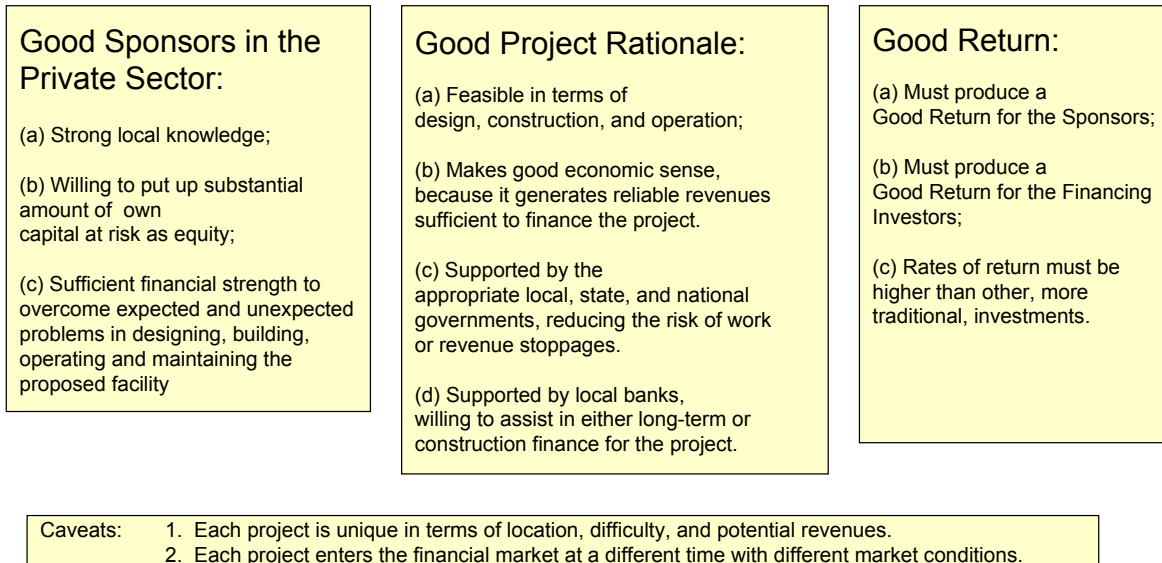
First, investors want good sponsors in the private sector. Therefore, governments have to structure infrastructure competitions transparently, competitively, and in a way that allows strong local producers to participate, and that allows producers to find good investors with whom to team. To a banker, a key indicator of a good

sponsor is its willingness to put up substantial equity that doesn't get repaid until after investors are repaid in full.¹⁵ Investors want to have confidence that sponsors have sufficient strength and local experience to overcome expected and unexpected problems in providing and operating the facility.

Second, investors want to be assured that a project has a strong rationale. Economic and technical feasibility has to be clearly shown.¹⁶ Another key ingredient is strong government support for the project.

Third, investors want a good return on their investment in a public sector infrastructure project. In fact, they seek a higher return than on traditional investments in the private sector. Government officials have the most difficulty with this third theme, which is the source of most of the confusion surrounding the use of life cycle delivery (PPP) approaches around the world.

Figure 14
Characteristics of Infrastructure Projects Suitable for Financing Through Private Debt and Private Equity



Adapted from "Aligning Infrastructure Development Strategy to Meet Current Public Needs", PhD Dissertation, MIT, by John B. Miller, May, 1995, pp. 41-2.

In the Texas SH 121 procurement, NTTA's argument was that it would be folly for the state to allow a "plum" toll-road project to go to the private sector for funding. NTTA argued that it was better for the public entity to incur the debt. Essentially, NTTA argued that if Cintra was willing to put up \$760 million in equity and \$2.25 billion dollars in private debt to fund SH 121, the asset was "too valuable" to put into the private sector.¹⁷

However, history should confirm to public officials that public sector resources have never been and will never be sufficient to provide for all infrastructure needs in the United States.¹⁸ Therefore, judicious, competitive, transparent use of private sector resources to close the gap between the level of resources governments can provide and the level needed to compete in world markets is all to the good. Two hundred years of experience confirms that it is unwise to reject private sector resources in the face of a significant shortfall in public sector funding.

But in the case of Dallas, this logic was in fact backwards. The Metroplex master plan estimated that tens of billions of dollars in private infrastructure investment were required to complete the plan. Dallas Metroplex governments were attempting to accelerate a substantial upgrade in the region's infrastructure portfolio to a pace much faster than public investment alone could ever support. Turning down an equity investment by Cintra of \$763 million in favor of the \$3 billion plus in public sector debt by NTTA widened, rather than narrowed, the gap.

The SH 121 project represents the classic example where governments' long-term interest was to attract private sector investment at the portfolio level in "good" projects. This seems counterintuitive to many in the public sector, and "monetization" deals like SH 121 breed suspicion within stakeholder groups who are never quite sure that the thirst for more and more money up-

Moving the Line between Public and Private: Opportunities Small and Large

Depending on where the line between private and public sector activity is drawn, our view of what should be "public" and what should be "private" should continue to evolve for the benefit of everyone. We are accustomed to the notion, for example, that the road network to and from the Burlington Mall should be in the public sector, and that the road network within the mall itself should be firmly in the private sector. But could a similar distinction be applied to the space not directly connected to transportation at MBTA stations? How far away from the subway platform should the line of private space be drawn? In Toronto and Hong Kong, and in isolated situations in Washington and Atlanta, for example, within a few feet of the subway doors, transit passengers are in privately financed and developed commercial space – dramatically "streamlining" the public sector's responsibility for initial delivery and life cycle delivery costs of a mass-transit system. When the new Boston Garden was built on top of a new North Station, and on top of a private sector parking garage, this "streamlining" was accomplished. Could a series of smaller, mid-course corrections throughout the Commonwealth serve to substantially improve how public and private sector dollars finance, operate, and maintain the collection of public infrastructure assets?

front isn't unnecessarily raising tolls and the rate of toll increases on drivers. But, it is reasonably clear that the public sector's long-term goals to stretch public dollars through competition over the life cycle, and to attract additional private sector dollars to the infrastructure sector can only be achieved if all the features set forth in Figure 14 hold true.

■ **Life Cycle Delivery of Public Infrastructure**

In a few cases, private sector funds have been attracted to infrastructure projects through very long, very large, concessions based on the amount of upfront money paid. In the long run, this approach is not sustainable. The better practice with respect to such large projects is to allocate to the private sector a typically small percentage of the most expensive, most desirable, infrastructure projects where a strong return on investment appears likely within a period of twenty-five to thirty-five years. By eliminating substantial upfront payments, which tempt government to reap cash today at the expense of future generations, the focus of these projects can and should be efficiency, improved technology, reduced energy use, and low prices to users. Allowing a “good return” on this category of projects has the added benefit of shortening concession periods, and permitting facilities to either be “re-concessioned” at competitive pricing or converted from tolled facilities to non-tolled facilities.

E. Understanding the Portfolio Approach to Project Delivery

Consider thinking about collections of projects when deciding how to deliver and finance multiple projects. In such an approach, one reason to push one of the projects in a collection toward life cycle delivery might be that the resulting savings in cost on that project will allow another project in the collection – one that can’t be delivered in that way – to proceed at all. In this Section, the “portfolio approach” to project delivery is outlined.

First, establish a preliminary infrastructure project list looking several years (the suggested period is ten years) into the future. To be prepared to properly consider the use of different funding and delivery strategies for public infrastructure projects, better, different, and earlier information needs to be collected, assembled, and provided to public decision makers.¹⁹ This includes a

basic description of each project, its features and performance requirements; its technical and economic feasibility; current estimates of the cost of initial delivery (design and construction); expected start, duration, and completion; estimated annual O&M costs; and whether the project might be supported in whole or in part by tolls or user fees.

One reason to push one of the projects in a collection toward life cycle delivery might be that the resulting savings in cost on that project will allow another project in the collection...to proceed.

Second, establish actual constraints on public contributions to these projects through an analysis of “practically available” public funds over the same planning period. By “practically available”, we mean that the willingness of legislators, city councilors, selectmen, town meeting members, and voters to authorize increased public debt for infrastructure has practical limits. “Practically available” resources (that is, cash on hand or cash available through borrowing) are those that governments will vote to make available in support of an infrastructure project.²⁰ If sufficient cash to pay for all the projects on the preliminary infrastructure projects list is on hand,²¹ or if cash is available from state or federal grants, it can be appropriated to fund selected projects.

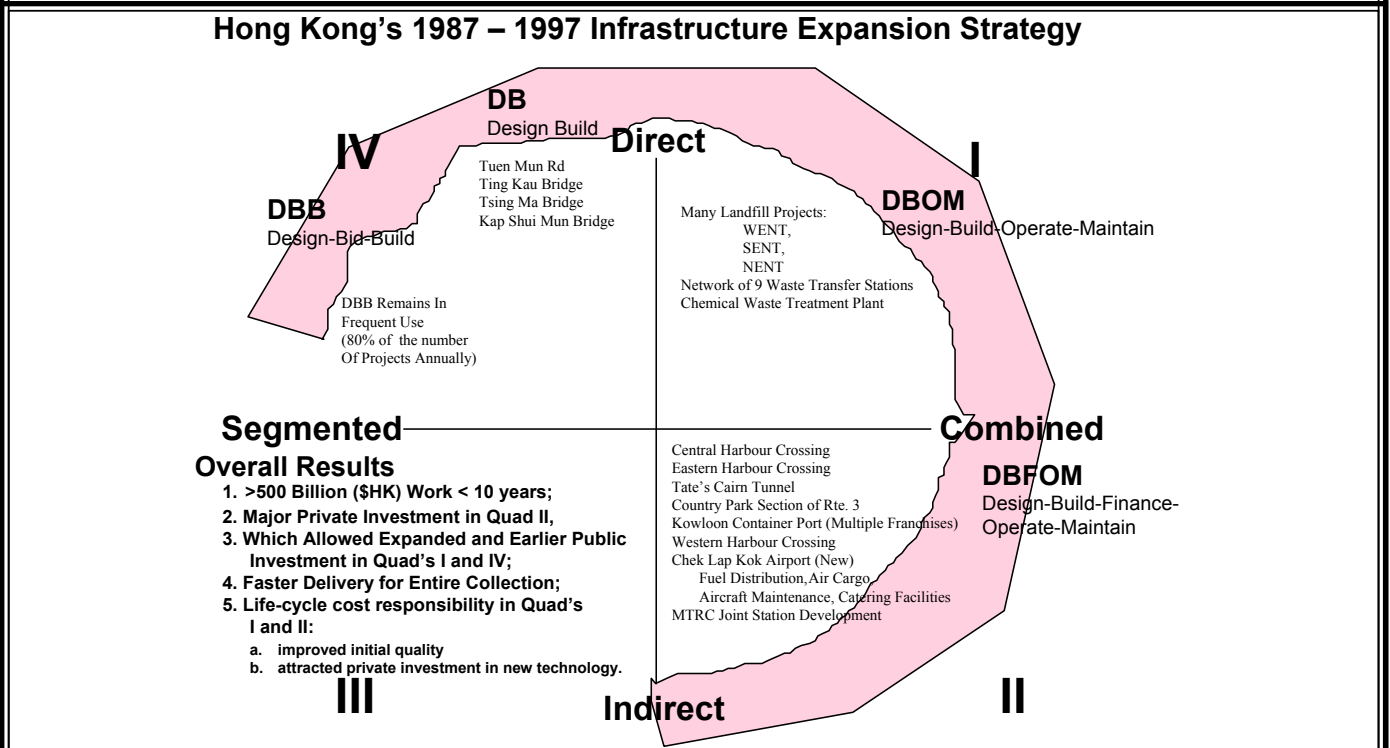
In most situations, however, governments rely on their ability to borrow cash, typically in exchange for a commitment to repay the debt through the issuance of bonds or notes. Most cities and towns in the Commonwealth, as well as the Commonwealth itself, can choose to borrow money for infrastructure expenditures at progressively higher rates of interest, limited only by their ultimate credit-worthiness, as judged by independent rating agencies and the financial markets.

Third, if public resources are insufficient, test different combinations of the six key delivery methods against projects on the preliminary project list. Where available funds are not sufficient to fund all projects, the scope of individual projects must either be revised, additional funds found, or life cycle delivery methods applied to some projects. Life cycle delivery options generally offer two different ways for public officials to approve

projects that are further down the preliminary list of infrastructure projects.²² Economies of scale, efficiency through the integration of design with construction, and the implementation of innovative technologies, designs and construction techniques are typical ways in which a portfolio approach permits public officials to proceed with more infrastructure projects at a faster pace.

Hong Kong: The Portfolio Approach in Practice

Between 1987 and 1997, the Crown Colony of Hong Kong used the portfolio approach to accelerate and complete an aggressive program of infrastructure renewal and expansion, as Hong Kong sought to ensure its economic future in South China in the years following the return of Hong Kong and Kowloon to the PRC. The project delivery and finance strategy employed by the Colony (with the assent of both the British and Chinese governments) is represented in the Figure below.



Approximately 80% of the projects were delivered by DBB using only public funds. A few signature bridge projects were delivered using DB, but they followed design concept competitions. The majority of environmental projects for water, wastewater, and solid waste, were delivered through competitive award of twenty-five to thirty-five year DBOM concession agreements. In these projects, the need for efficiency and quality performance of stable, predictable public infrastructure services made DBOM a logical fit. A few large transportation projects where demand was strong and revenue was predictable were positioned as DBFOM projects in Quadrant II, also through competitively awarded concessions of twenty-five to thirty-five years.

■ Life Cycle Delivery of Public Infrastructure

In situations where there are opportunities to be more efficient either through reduced costs or higher levels of service or both, it is often practical for government to focus on long-term efficiency in the design, construction, and operation of an infrastructure facility.²³ For government to conclude that design-build-operate-maintain (DBOM) is a viable approach, efficiency across a facility's entire life cycle is typically the overarching goal.

DBOM has proven viable for virtually all engineering projects where clear, stable design requirements are included at the start of a competitive procurement. The DBOM approach may also be suitable for heavily occupied public spaces, with the same concerns expressed above with respect to DB.²⁴ In any case, the public owner must have clearly established and stable design requirements as a basis for competition.

The principal advantage of DBOM should be that when government obtains competitive pricing, private sector participants are in head-to-head competition as to which has most efficiently and effectively designed for ease of construction and for ease of operations and maintenance. Provided that the evaluation factors reward proposers that best achieve this integration through the most technically and commercially advantageous proposals, life cycle delivery can be obtained with typical cost savings of 30% to 40% over DBB, and typical time for delivery of 25% over DBB. Life cycle costs incurred by the public entity (including operations and maintenance, energy and borrowing costs) must be competitively tested before being passed on to taxpayers or users.

Sometimes, situations arise in which new technologies and/or innovations²⁵ present opportunities, beyond operational efficiency, for government to realize long term improvement in the design, construction, and operation of an infrastructure facility. Where such technologies or innovations are obtainable from the private

sector at private sector risk, design-build-finance-operate-maintain (DBFOM) can be a practical alternative for government.

As defined in this report, DBFOM is a delivery strategy in which the private sector takes all financing risk.²⁶ While rare, governments have opportunities to incorporate breakthrough technologies, design, and construction techniques into public infrastructure networks, and the use of private sector finance at private sector risk, with higher than usual returns, has attracted technology and innovation to infrastructure networks throughout American history. This strategy invites innovation across the entire life cycle, including design, construction, and operations and maintenance, with competitively determined charges to users, and pre-established cost escalators.

Figure 15 summarizes the essential elements of the process described in this section for identifying which of the six basic delivery methods are viable options for each project under consideration.

F. How the Quadrants in the MIT Framework Differ

Effective use of the MIT Framework will help public officials improve cost and service performance. Research conducted at MIT demonstrated repeatedly that delivery strategies positioned in each of the quadrants produce predictable results. While no single delivery method will be appropriate for all infrastructure needs, public officials and their consultants can quickly learn and take advantage of the attributes of each quadrant (see Figure 16).

1. Quadrant IV: Segmented, deliberately-paced approach; Isolated technology; Least risk.

For many years, public officials have been comfortable with Quadrant IV, in particular

with design-bid-build (DBB). DBB’s segmented approach assures public officials that design will be complete, or nearly so, before a decision is made on construction. DBB is the slowest and most expensive of the options, but has the least associated risk. It is the “isolated technology” quadrant; the only path for innovation in technology is through the designer. Design-build (DB) offers opportunities for better integration of design with construction, fewer disputes along this divide, faster delivery, and savings in initial delivery costs.

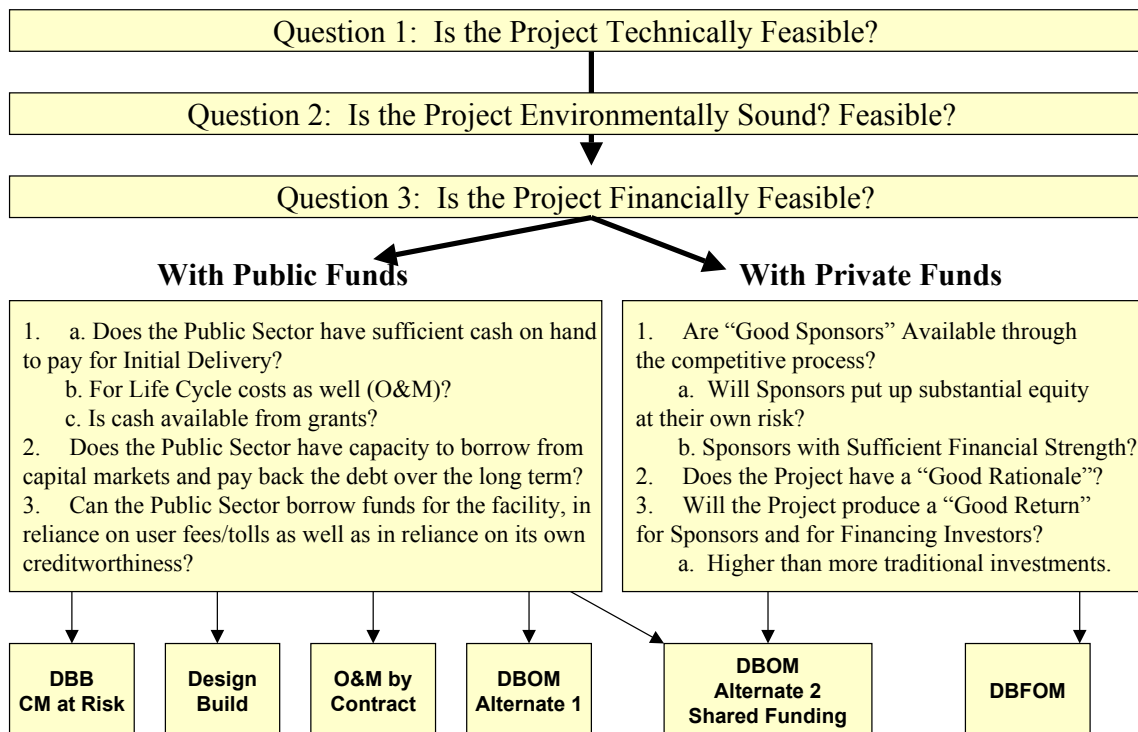
A measured increase in the number of stand alone O&M contracts, in appropriate situations, where current O&M costs are either unknown, or, alternatively, are known to be unacceptably high, is another tool that public officials may find useful in managing a collection of infrastructure facilities. The five-year operations contract

between the MBTA and Massachusetts Bay Commuter Rail, Inc., due to be renewed for three more years, demonstrates that such contracts can be helpful in managing deferred maintenance and in understanding the true level of funding required to maintain and operate a complex network of infrastructure assets.

2. Quadrant I: Efficiency; Innovation in operation

Public officials will increasingly grow comfortable with Quadrant I. When projects are properly structured and competitively bid, and in situations where existing operations and maintenance costs are well known, transparent use of Quadrant I has regularly produced life cycle cost savings between 20% and 40%. Ideal candidates for DBOM Alternates 1 and 2 include water treatment plants, wastewater treatment

**Figure 15
Project Viability Of Basic Delivery Methods**



■ Life Cycle Delivery of Public Infrastructure

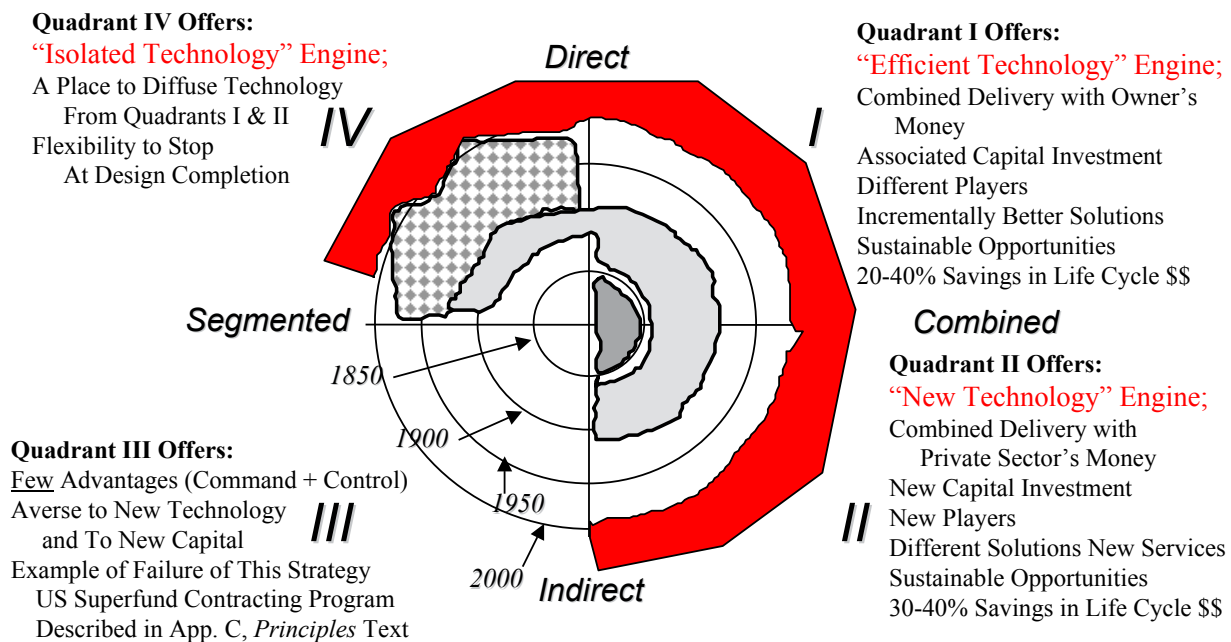
plants, and highway projects involving critical infrastructure services. This approach is also ideal for projects that require private sector economies of scale in purchasing chemicals and equipment, and/or in projects that require private sector innovation in equipment and in operations. Where “availability payments” or “shadow tolls” are being considered by the government in exchange for services, Quadrant I will generally provide the most effective procurement solution.

3. Quadrant II: Innovation, new technology, high capital cost; High risk.

In some situations, a major upgrade in technology or practice can significantly increase infrastructure capacity, materially extend facility life, produce significant cost savings or dramatically lower user charges. This kind of private sector innovation may require high initial capital costs with relatively high risk. A government decision

to take on an expensive project usually has strong adverse consequences elsewhere in the network.²⁷ In these situations, a determined effort to position such large, risky, complex, high technology, infrastructure projects in Quadrant II makes a lot of sense. The question to be asked is whether there is an acceptable way to attract a combination of good producers, good project rationale, and good return to enable government to finance the project entirely in Quadrant II.

Figure 16
The Quadrants Behave Differently



IV. Recommendations

Infrastructure is the platform on which both the American economy and the economy of the Commonwealth run. Skyrocketing costs associated with health care and public education will continue to consume a larger percentage of general public revenues. With a substantial shortfall in practically available public resources, state departments, local governments, and public authorities have few options when faced with expanding infrastructure needs and rising O&M costs due to decaying existing infrastructure. However, the pressure for better infrastructure services and better value for money across entire collections of projects will only intensify. In this climate, the integration of design with construction (Design Build) and the integration of design with both construction and O&M (Life Cycle Delivery or PPP approaches) can play a vital role.

Infrastructure is the platform on which both the American economy and the economy of the Commonwealth run.

Every infrastructure project requires government to plan, maintain and arrange for financing over the project's entire life cycle. To discharge these obligations, governments need accurate information about ongoing facility costs; a flexible procurement system that establishes attractive, durable markets; an openness to "new" modes of designing, building, operating and financing facilities, as illustrated in the MIT Framework; and an understanding of future trends in infrastructure procurement. Massachusetts citizens have the skills, the experience, and the necessary technology to assist the Commonwealth in meeting its infrastructure needs, on a competitive and transparent basis. Three basic recommendations are offered as the Commonwealth moves forward to tackle infrastructure issues.

A. A Better Understanding of the Current Condition of Existing Assets

State and local governments can and must acquire and maintain accurate knowledge of physical condition, rates of degradation, and current and expected O&M costs, and expected replacement costs of existing infrastructure assets. With detailed information of this nature, governments can make effective use of current cost information to establish competitive baselines for confirming that the Commonwealth's investments in infrastructure in fact produce better levels of service and better value for money as the infrastructure stock is rebuilt, replaced, and extended.

Technology is available today to permit government to gather detailed and accurate answers to the questions that support more effective decisions and better performance:

- *What is the current actual cost to operate and maintain individual facilities within infrastructure networks? What is their current estimated replacement cost?*
- *What is a facility's O&M cost over the past five years, and projected O&M cost over the next five years?*
- *What is the current capacity of existing infrastructure facilities? What are the current and projected revenue streams associated with those facilities?*

With a clear understanding of ongoing infrastructure costs, governments throughout the Commonwealth can shift their focus away from specific projects. Procurement strategy can improve to address both individual projects as well as the impact of each on the entire collection of infrastructure projects. Through a "portfolio" approach to entire networks of projects, government's focus can shift upward

■ Life Cycle Delivery of Public Infrastructure

to improving the cost and performance of public infrastructure at both the project and portfolio levels, and to more effectively use competition to confirm that high quality infrastructure services have been obtained at low, competitively verified prices.

B. Developing a Flexible Procurement System for the 21st Century

The Commonwealth's lack of a flexible procurement system constitutes the most serious obstacle to the effective use of the six basic delivery methods to improve public infrastructure assets. The Commonwealth's procurement system should be revised to permit each of the six basic delivery methods. A flexible system with access to each of the basic methods would attract new participants and establish durable markets.

The procurement laws should specifically permit the three basic methods for initial delivery: design-bid-build (DBB) and Construction Manager at Risk; Design-Build (DB); operations and maintenance (by contract); and the three basic methods for life cycle delivery: design-build-operate-maintain alternate 1 (all public funding); design-build-operate-maintain alternate 2 (mixed public and private funding); and design-build-finance-operate-maintain (all private funding).²⁸

The procurement laws should insist on transparency, fair treatment of potential and actual competitors and the competitive award of contracts based on pre-disclosed evaluation criteria and head-to-head competition. A new procurement strategy should incorporate evaluation factors that focus on higher levels of service for better value to governments and to users. Specifically, evaluation criteria should focus on:

· *Better future performance on the cost of both initial delivery and life cycle delivery when compared to known current performance;*

· *Higher levels of service when compared to known current conditions and levels of performance; and*

· *Improved environmental performance when compared to known levels of current performance.*

Adjusting the Pacheco Law

The "Pacheco law", found at MGL Ch. 7 Sections 52 through 55, is often cited as a significant barrier to "privatization" in Massachusetts. The thrust of the statute is generally to discourage the transfer of public sector functions to the private sector solely for savings in the wages of employees – a purpose which makes practical sense. While it may be a barrier to "privatization", it need not be a barrier to competitively awarded, life cycle delivery projects that improve service levels and reduce life cycle costs by 40-45%. With some clarifications for "Life-Cycle" delivery, including that Design-Build-Operate-Maintain contracts could typically extend for the world-wide standard of 25–35 years, the requirements of the law could be readily adapted to establish a pre-procurement process, and a pre-procurement ruling of compliance by the State Auditor. Such an advance ruling would prove to be quite useful in focusing both the private and public sectors on projects, designs, methods, and approaches that improve the life-cycle cost performance of infrastructure networks – goals that produce durable employment in public infrastructure and extend the infrastructure base on which the state's economy rests.

C. Expanding the Use of Life Cycle Delivery

With continuing pressures for better infrastructure and better value for money, governments can make effective use of the three basic life cycle delivery approaches – Design–Build–Operate–Maintain (Alternate 1, all public funding); Design–Build–Operate–Maintain (Alternate 2, Mixed public and private funding); and Design–Build–Finance–Operate–Maintain (all private funding). As MIT’s Hong Kong case study illustrates, a wise use of indirect financing for appropriate projects makes it possible to leverage government and private funds to achieve a program of infrastructure renewal and expansion beyond the capacity of government funds alone.

The Commonwealth’s lack of a flexible procurement system constitutes the most serious obstacle to the effective use of the six basic delivery methods to improve public infrastructure assets.

These contracts hold much promise for governments when they incorporate a number of important elements. The public sector must expand its expertise in identifying infrastructure projects suitable for financing through private debt and private equity. Once a project is determined to be a strong candidate for indirect financing, the government must make use of transparent, competitive procurement methods in the award of life cycle delivery contracts. Finally, the government must identify and create relationships with good private sponsors that work towards ensuring that a given project features both a good project rationale along with a good return to private investors.

V. Conclusion

If our perspective were limited to the last few years, the infrastructure sector seems to be in an incredible state of flux. But, from the perspective of more than two centuries of experience, the U.S. infrastructure industry and the public procurement market it generates are simply going through another cycle. There have been many such cycles since 1789. Throughout these cycles, previous generations have contributed technologies and equipment as infrastructure networks have been entirely replaced and upgraded – the barge, the train, the car, the plane, the radio, the phone, the computer, and the Internet. The Commonwealth and the nation are headed toward the latest reincarnation of the dual track strategy described previously in this report.²⁹

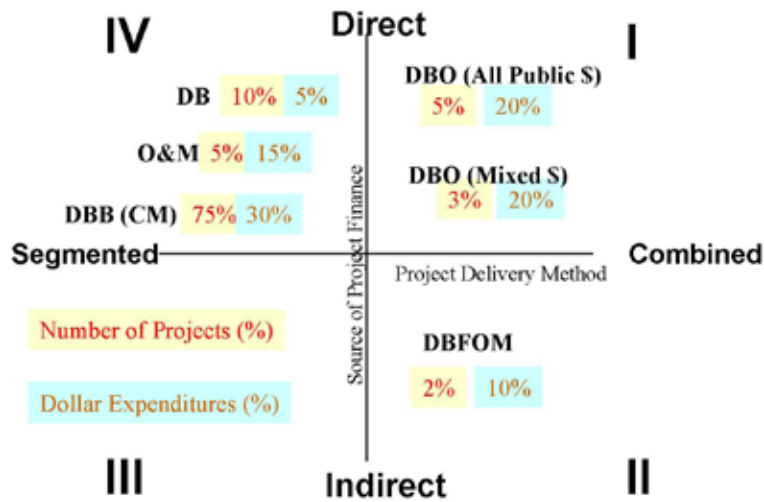
A wise use of indirect financing for appropriate projects makes it possible to leverage government and private funds to achieve a program of infrastructure renewal and expansion beyond the capacity of government funds alone.

Figure 17 (p. 35) represents the author’s prediction of how public infrastructure delivery strategy will evolve over the next thirty years in the Commonwealth and in the United States. The six basic delivery methods are shown in Figure 17, along with the author’s predictions of the number of projects using each method (by percentage) and the percentage of public (direct) dollars expended using each method.

A relatively small percentage (10%) of the total number of infrastructure projects will use the life cycle delivery methods in Quadrants I and II, but the life cycle cash flow through these projects will be quite large (50% of expenditures), creating durable, additional employment. The vast majority of public infrastructure projects

Figure 17

Predicted Steady State



Adapted From *Principles Text*, Miller 2000, Kluwer.

(75%) will continue to use design-bid-build (and Construction Management at Risk) for initial delivery because of the essential need in these projects for extensive review, approval, and control of the initial design. The use of design-build will continue to expand (to 10% of all projects and approximately 5% of all expenditures). Operations and maintenance (by contract) will expand slightly in situations where governments need to better understand ongoing O&M costs.

The current cycle is best compared to the transformation of the U.S. defense industry and its products over the last thirty years. In this time period, the defense industry has evolved from the mass production of relatively “dumb” items of military equipment to the incorporation of highly sophisticated “smart” information technologies such as GPS, GIS, stealth technology, unmanned

drones, and computer guided and controlled machines.

The next incarnation of America’s infrastructure networks is now underway. The relative contributions of technologies, techniques, finance, equipment, labor, and materials are once again being shuffled and dealt in ways unique to our new circumstances.

What has not changed is the need for transparency, the requirement for head-to-head competition in the award of public sector resources and concession rights, and the important organizing role that governments (at all levels) must play in coordinating infrastructure projects at the network level. The capacity of the Commonwealth, its citizens, its educational institutions, and its construction industry firms to address its infrastructure needs is also clear.

While the Commonwealth has yet to substantially participate in the emerging paradigm in which life cycle delivery plays an important new role, the conceptual tools, the legislative frameworks, and the planning capacity to use these methods are effectively available for ready application to infrastructure problems and issues in Massachusetts.

Glossary of Terms

A. General Terms

ARCHITECTURAL PROJECTS. For purposes of this report, projects predominantly involving design by architects, typically buildings, passenger terminals, multi-modal terminals (sometimes called “vertical projects” in the construction industry), where there is significant design focus on inhabited space. The distinction from Engineering Projects is for convenience only.

CLIENT/OWNER. Public or private client procuring facilities or services.

CONTRACTOR/PRODUCER. The successful bidder or proposer that emerges as the winner of the procurement process.

DESIGN REQUIREMENTS. The written description of the infrastructure facility to be procured, including: required features, functions, characteristics, qualities, and properties that are required by the client; the anticipated schedule, including start, duration, and completion; and estimated budgets for design, construction, operation and maintenance. These may include drawings and other documents illustrating the scale and relationship of the features, functions, and characteristics of the project.

ENGINEERING PROJECTS. Projects predominantly involving design by engineers – typically roads, water, sewer, transportation projects (sometimes called “horizontal projects” in the construction industry – where there is less design focus on inhabited space. The distinction from ARCHITECTURAL PROJECTS is for convenience only.

INFRASTRUCTURE. Used in a broad sense to refer to capital facilities such as building, housing factories, and other structures which provide shelter; the transportation of people, goods, and

■ **Life Cycle Delivery of Public Infrastructure**

information; the provision of public services and utilities such as water, power, waste removal, minimization, and control; and environmental restoration.

INFRASTRUCTURE FACILITY. A building; structure; or networks of building, structure, pipes, controls, and equipment that provide transportation, utilities, public education, or public safety services. This includes government office buildings; public schools; courthouses; jails; prisons; water treatment plants, distribution systems, and pumping stations; wastewater treatment plants, collection systems, and pumping stations; solid waste disposal plants, incinerators, landfills, and related facilities; public roads and streets; highways; public parking facilities; public transportation systems, terminals, and rolling stock; rail, air, and water port structures, terminals, and equipment.

PORTFOLIO OF PROJECTS. The collection of infrastructure facilities and services owned, leased, operated, or controlled by a single client.

PROJECT. Discrete tasks performed in connection with part, or all, of an infrastructure facility or service.

PROJECT VIABILITY. A combination of technical, financial, and environmental feasibility measures, the key ingredient for effective use of all the project delivery methods.

B. Terms Relating to Delivery Methods

INITIAL DELIVERY. The design and construction phases of an infrastructure facility, that is, the production of the initial facility itself. Long term operations and maintenance is not included in this phase.

LIFE-CYCLE DELIVERY. All phases of an infrastructure facility, that is, both the initial delivery of the initial facility and its operations

and maintenance of the facility throughout its useful life.

DESIGN-BID-BUILD (DBB). A segmented delivery strategy in which the design of an infrastructure facility is fully separated from construction, both of which are, in turn separated from maintenance and operation of the facility. In the DBB model, the client separately provides project planning and financing. The DBB model focuses on initial delivery only, and does not include long term operations and maintenance. Included in DBB is an important variant known as Construction Management at Risk, CM at Risk, in which the client procures the services of a construction manager before the design is completed. CM at Risk assists the client and the designer during the completion of the design process and commits to a Guaranteed Maximum Price to construct the project before construction commences.

DESIGN-BUILD (DB). A delivery strategy in which the client procures both design and construction of an infrastructure facility from a single producer.

DESIGN-BUILD-OPERATE-MAINTAIN (DBOM). Delivery method in which the client procures design, construction, maintenance, and operation of an infrastructure facility as an integrated whole over a contractually defined period from a single producer. The client provides initial planning and the functional design for the infrastructure facility in sufficient detail to permit private sector producers to compete for the project on pre-established evaluation criteria. The DBOM model, as defined in this report, requires that the client directly provide either

all of the cash flow required by the producer to finance the tasks assigned by the client; or the client shares the obligation with the producer to finance the cash flow required. The client typically provides this cash flow: by direct cash payments to the producer (sometimes referred to as “availability payments” or “shadow tolls”) in exchange for services; by transferring user fees collected from operation of the infrastructure facility; or by combinations of both. In short, all or a portion of the funds required to pay for the services provided by the producer during the contract period are either appropriated by the client prior to award of the contract or secured by the client through commitments of fare, toll, or user charges.

DESIGN-BUILD-FINANCE-OPERATE-MAINTAIN (DBFOM). Also known as build-operate-transfer (BOT): A delivery method in which the client procures, from a single producer, an infrastructure facility’s design, construction, financing, maintenance, and operation as an integrated whole over a contractually defined period. The client provides initial planning and functional design in sufficient detail to permit private sector producers to compete for the project on pre-established evaluation criteria. In the DBFOM model as defined here, the risk that project receipts will be insufficient to cover all project costs, debt service, and a return on equity is placed squarely on the producer. No client funds are appropriated to pay for any part of the services provided by the producer during the contract period.

BUILD-OPERATE-TRANSFER (BOT). The popular name in the 1980’s and 1990’s in the Far East and in the Middle East for DBFOM. Operations and maintenance: A project delivery method in which the client enters into a single contract for the routine operation, repair and maintenance of an infrastructure facility.

C. Terms relating to the MIT Framework

QUADRANT I. The portion of the MIT Framework defined by combined project delivery methods and direct project finance methods. There are two key delivery methods in this quadrant, including two variations of DBOM: DBOM Alternative 1, which includes projects fully financed by the public sector, and DBOM Alternative 2, which involves shared financing by the public and private sectors.

QUADRANT II. The portion of the MIT Framework defined by combined project delivery methods and indirect project finance methods. The key delivery method in this quadrant is DBFOM.

QUADRANT III. The portion of the MIT Framework defined by segmented project delivery methods and indirect project finance methods.

QUADRANT IV. The portion of the MIT Framework defined by segmented project delivery methods and direct project finance methods. There are three key delivery methods in this quadrant, each of which is a segmented delivery strategy: DBB, DB and O&M. DBB and DB are initial delivery methods only, and do not address long term operations and maintenance. All three delivery methods in Quadrant IV are typically fully financed by the public sector.

About The Author

Dr. John B. Miller's career has spanned the legal and academic worlds, focusing on practical business, legislative, and contractual solutions to the world's burgeoning infrastructure needs. He graduated from MIT in 1974 with a bachelor's degree in Civil Engineering and a Master's degree in Soil Mechanics. In 1977, Dr. Miller received his J.D. from the Boston University School of Law and Master's in Law in Taxation from the same school in 1982.

After serving as Associate General Counsel and Patent Counsel to a Cambridge high tech firm for three years, Dr. Miller joined the Boston office of Gadsby & Hannah in 1981, where he built a national practice in construction law and government contracts. Dr. Miller was elected to the American College of Construction Lawyers in the Fall of 2005. In August, 2006, Dr. Miller joined Patton Boggs LLP as Of Counsel in its Construction Projects, Infrastructure, and Finance groups. In over 30 years of practice, Dr. Miller has represented clients with the full range of construction industry interests, including cities, towns, designers, contractors, suppliers, subcontractors, and construction managers. After Dr. Miller resigned his partnership at Gadsby & Hannah, the firm represented the Big Dig.

In 1992, Dr. Miller accepted a three-year fellowship in the Center for Construction Research and Education in MIT's Civil Engineering Department. He received his PhD in Infrastructure Systems in 1995, and joined MIT's Construction Management Faculty. At MIT, Dr. Miller was awarded a four-year NSF CAREERS grant to explore and develop the logic for a new area of engineering practice that applies the array of project delivery methods to American infrastructure networks. The goal of this research was to promote and attract new technology and more effectively deliver complex collections

of infrastructure assets – i.e., buildings, water, wastewater, and transportation.

His research at MIT produced a comprehensive history of America's 200 year experience with public-private partnerships. Miller's work with industry groups produced the 2007 ABA Model Code for Public Infrastructure Procurement, the intent of which is to re-establish a broad, competitive US marketplace for infrastructure and to balance public policy requirements of transparency and fairness. While at MIT, Dr. Miller taught several undergraduate and graduate level courses, including Law and the Construction Industry, Public Infrastructure Development Systems, and The History of American Infrastructure.

Dr. Miller's work at MIT produced theory, evidence, and practical new approaches for addressing long term infrastructure problems. He authored two textbooks on public-private partnerships, *Principles of Public and Private Infrastructure Delivery* and *Case Studies in Infrastructure Delivery*. His contributions to the ABA 2000 Model Procurement Code and the ABA 2002 Model Regulations produced a new project delivery model for state, district, and local governments. A condensed version of this model – the Model Code for Public Infrastructure Procurement (MC PIP) – was issued by the ABA Sections of Public Contract Law and State and Local Government Law in 2007.

About Pioneer

Pioneer Institute is an independent, non-partisan, privately funded research organization that seeks to change the intellectual climate in the Commonwealth by supporting scholarship that challenges the "conventional wisdom" on Massachusetts public policy issues.

Endnotes

¹ These transactions are discussed in more detail below.

² See Engineering Systems Integration for Civil Infrastructure Projects, John B. Miller, *Journal of Management in Engineering*, September/October 1997, pp. 61 to 69 for background on this research.

³ Miller, John B., PhD Dissertation, at page 167.

⁴ The results of this research are presented in *Principles of Public and Private Infrastructure Delivery*, *Ibid*, Chapter 3, pp. 79 thru 170.

⁵ The National Surface Transportation Policy and Revenue Study Commission was created under Section 1909 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (P.L. 109–59) to investigate and make recommendations to Congress on the future federal role in surface transportation policy. To examine the Finance Commission’s Report, go to www.transportationfortomorrow.org.

⁶ Proposal preparation costs (transaction costs) spent by all proposers are estimated to be in excess of \$30 million.

⁷ The present value of one dollar (\$1.00) ninety-nine (99) years from now is \$0.008 (eight tenths of one penny – assuming an interest rate or discount rate of 5%). The present value of one dollar (\$1.00) 75 years from now is \$0.026 (between 2 and 3 pennies -- at the same discount rate). Put another way, when a public entity includes that ninety-ninth year at the end of a lease – it is worth almost nothing to the private sector. Does it make practical sense for governments to do so?

⁸ Life Cycle Delivery would be a more descriptive term than PPP, which is almost meaningless in today’s environment.

⁹ A complete case study of the Northumberland Bridge Project, with cash flow analysis, and

teaching aids, is contained in *Case Studies in Infrastructure Delivery*, John B. Miller, Kluwer Academic Publisher, 2002.

¹⁰ In other words, escalated by the CPI each year over a thirty five year period of the concession.

¹¹ Two case studies on Highway 407 ETR are included in separate chapters of the *Case Studies* book, *supra*.

¹² The same firm that subsequently participated in the Chicago Skyway and Indiana Toll Road transactions.

¹³ See, for example, the ABA 2007 Model Code for Public Infrastructure Procurement, and the ABA 2000 Model Procurement Code for State and Local Governments. Both are available from the ABA Web Store.

2007 MC PIP: <http://www.abanet.org/abastore/index.cfm?section=main&fm=Product.AddToCart&pid=5390260>

2000 MC: <http://www.abanet.org/abastore/index.cfm?section=main&fm=Product.AddToCart&pid=5390244>

¹⁴ For example, a facility that cost \$100 million to build will likely cost between 6% and 10% to design separately. After delivery, the public owner will likely spend between \$800 Million and \$1B on operations and maintenance, repair, utilities, and refurbishment over a 50 – 70 year life. A good rule of thumb to estimate annual operations and maintenance costs is to assume 7% to 9% of initial delivery costs (design and construction) per year, with inflation. The better practice is to collect actual data.

¹⁵ The concept is similar to a 10% or 20% down payment on a house, which is an equity contribution by an owner that gives comfort to the bank that the borrower believes it will pay the debt in full. The borrower’s equity is fully at risk, if the bank isn’t repaid. The borrower has strong incentives to make the project work.

■ Life Cycle Delivery of Public Infrastructure

¹⁶ For example, before each one of Hong Kong's three (3) tunnel crossings to Kowloon were authorized, there were extremely strong indicators that the demand from motorists was more than sufficient to pay for design, construction, long-term O&M, and the cost of borrowing.

¹⁷ The very long terms of monetization transactions (407 ETR – 99 years, Chicago Skyway – 99 years, Indiana TR – 75 years, and SH 121 – 50 years) with substantial up-front payments are creating substantial concern in the public sector as to the fairness of these transactions – including the projected rate of returns on private investment.

¹⁸ A proposition fully supported by the research at MIT, as described above.

¹⁹ Public disclosure of appropriate information about upcoming projects, as it is being collected, should be made as a first step in attracting the competitive interest of designers, constructors, operators, and financiers.

²⁰ All levels of governments throughout the Commonwealth have commitments other than infrastructure that also require borrowing. Health care and education are primary examples of needs that compete with public infrastructure.

²¹ This is rare for cities and towns in the Commonwealth, unless “sinking” or “rainy day” funds have been established in prior years.

²² A good, current “rule of thumb” for quickly evaluating whether an annual net revenue stream from an existing or proposed Infrastructure Facility might be sufficient to support both Initial Delivery and Life Cycle Delivery is to divide the projected income stream by discount rates of 8% and 10%. The result provides a preliminary range for the Initial Delivery costs that could be supported by that revenue stream. So, for example, the annual revenue stream of \$42 Million dollars promised as a minimum payment by the Canadian government on the Northumberland Bridge project, when divided by a range of discount rates

of 7% and 10%, provides a preliminary indication that the revenue stream may be sufficient to fully support the bridge IF the bridge can be designed and constructed in the range between \$420 million dollars (\$42 million divided by 10%) and \$525 million dollars (\$42 million divided by 8%). Trial discount rates should only be used for ball-parking purposes. The actual cost of capital is more appropriately used as projects move from first concept to competitive phases.

²³ Both alternatives of Design Build Operate Maintain are considered together in this section.

²⁴ The ABA 2007 Model Code for Public Infrastructure Procurement provides practical solutions for DBOM, and for DBFOM. Competitors must meet all Design Requirements, and compete head-to-head over design concepts, aesthetics, and life cycle costs.

²⁵ An example Bay Staters will recognize is the technology behind the Ted Williams Tunnel, sunken tube technology with self sealing tube to tube connections, which was first introduced on the Western Harbor Crossing in Hong Kong, at private sector risk. Parsons Brinckerhoff's experience with the technology helped move it to Boston.

²⁶ DBFOM has also been successful used where the economics of the proposed concession are so strong that the government need not assume any of the financing risk. The Western Harbor Crossing, the Eastern Harbor Crossing, and the Tate's Cairn Tunnels in Hong Kong are examples of this.

²⁷ The Big Dig was perceived by many in the Commonwealth as “draining the moat dry” with respect to other infrastructure needs across the state.

²⁸ The ABA 2007 Model Code for Public Infrastructure Procurement (MC PIP) published in March, 2008, consists of a legislative blueprint meeting all of these goals. The competitive

processes employed in the 2007 MC PIP are well known in the Commonwealth, having been substantially adopted for procurement of supplies and services in the 1980's.

²⁹ See Figure 6, supra.

