Background

The structuring and hiring of a project team, called a project delivery method, is critical to the success of any project. The choice an owner makes at this junction can affect the project's cost, schedule, and quality. In addition, each delivery method has its own benefits and side effects the team must deal with for the duration of the project. As shown in the following diagram taken from B.C. Paulson shows the biggest impact on cost is made from the concept development and contract stages.

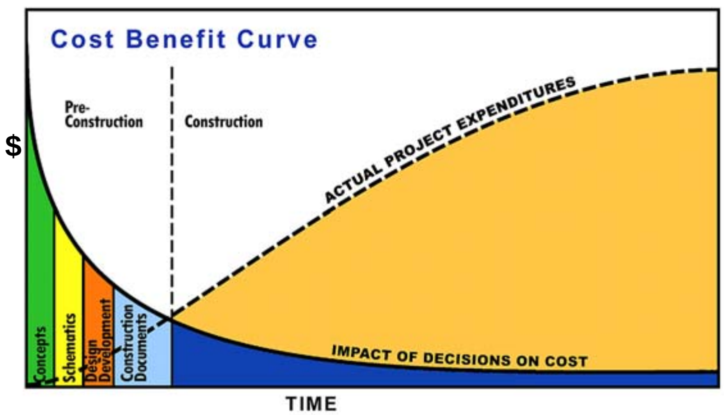


Figure 1: Cost Benefit Curve from B.C. Paulson in "Designing to Reduce Construction Costs." Decisions made at the Concept stage in pre-construction make the largest impact on the overall project cost.

The process of choosing a project delivery method can be difficult for many owners. Unlike the Miranda Rights that are given to every criminal, there is no definitive model that owners could use to choose a delivery method for their specific project. The best model in circulation today is Sanvido and Konchar's Project Delivery System Selection (PDSS) which identifies four project deliveries to choose from: Design-Bid-Build (Traditional), Design-Build, CM Agency, and CM@Risk. In addition, there are six variables in which to choose from: project characteristics, time, owner experience, team experience, quality, and cost. Although this document is quite useful for most owners, it does not reflect the latest advancements in project deliveries, the Design-Build hybrids. In addition, the Design-Build hybrids are difficult to integrate into the PDSS using the existing six variables since the hybrids are quite complicated.

Problem Identification

Currently, the latest state-of-the-art dormitory for Johns Hopkins University (JHU) is going to be late for the Fall '06 grand opening. Two years ago, Charles Commons was a schematic sketch of a facility that would house 600+ students as part of JHU's five-year plan. A fateful program change in Spring '05 permitting a dining commons to be placed on the third floor of the St. Paul building changed the complexion of the project. This addition and steel market fluctuations caused a huge increase in the cost of Charles Commons. The cost-cutting process that followed caused anxiety amongst the project team.

Very little could have been done to prevent JHU's program change. However, a different delivery method could have prepared the project team better for this change and accelerate the design processes. The current project delivery system used is CM@Risk, which is a source of much tension when the steel market fluctuations occurred in early 2005. Using the PDSS model, JHU's only choice for a project delivery method is a CM Agency, which could not have allowed the project team to maintain budget and schedule.

Design-Build has been driving alternative delivery method for a few decades and has just recently begun branching into other hybrid delivery methods. In addition to design and construction, Design-Builders are taking on the risks of the Operations and Maintenance (O&M) and the financing of the project. Thus, the Design-Build hybrids Design-Build-Operate-Maintain (DBOM) and Build-Operate-Transfer (BOT) were born. Could the Charles Commons project team benefit from DBOM or BOT?

Research Goals

- *Analyze issues in case studies in which DBOM/BOT have proved effective and make market comparisons and outlook for future.*
- *Evaluate the advantages/disadvantages from using DBOM/BOT delivery methods at Charles Commons.*
- *Generate an Owner's Guide to DBOM/BOT for use in the Building Construction Industry.*

Project Delivery Definitions

Design-Bid-Build (DBB) is the traditional method of project delivery since the beginning of the Industrial Age. DBB is characterized by the owner having numerous separate contracts with the design team and the construction team. The phasing of the work is sequential: design phase, procurement phase, and construction phase. Typically, the contract is awarded through a low price bid in a lump sum amount. After completion of the project, the owner is responsible for operations and maintenance (O&M).

Construction Management Agency (CM Agent) involves the hiring of a construction manager who then serves to broker the hiring of subcontractors under direct contract with the owner. The CM Agent is frequently a fee-based agreement and this approach can allow for fast-tracking since constructability issues can be

addressed during design. However, the CM Agent is not responsible for O&M and many of the risks associated with the project.

Construction Manager at Risk (CM@Risk) allows owner to contract one construction manager, of whom manages the design professionals and subcontractors at a Guaranteed Maximum Price (GMP) or lump sum. The CM@Risk assumes all of the risk that an owner would control during a CM Agent delivery. This agreement can bring about claims between the design professionals and construction managers. Again, O&M is not included.

Design-Build (DB) involves the owner hiring one entity, a design-builder, to provide both design and construction services. This method requires a clearly defined scope of work and a cost commitment is made early in the design process. Typically, design-build has a fast schedule, best cost control, and least amount of claims. Additional strengths of DB include reduced owner's risks, establishing a fixed price early in the process and this method establishes a fixed schedule. However, there may be little owner control in design and value engineering can potentially impact quality if not properly managed.

Design-Build Hybrids

Design-Build-Operate-Maintain (DBOM) is a Design-Build delivery method in which the owner selects a consortium (project team) that will complete the design, construction, maintenance and a period of operational parameters under one agreement. Upon termination of the operational period, the owner is then responsible for operations and maintenance of the project. Since some experienced owners may or may not have physical plant workers, variations such as **Design-Build-Operate (DBO)** have been used.

Build-Operate-Transfer (BOT) is a project delivery in which the financial services of a bank or developer are used by the project team. The contracted project team acquires ownership of the project under the end of a stipulated time period. A similar method, **Design-Build-Finance-Operate (DBFO)** does not employ the services to transfer ownership, but to defray the expenses of construction into a yearly operations budget. Many Public-Private-Partnerships (PPP's) participate similarly by forming a concession. A **Concession** is a contract arrangement which grants the contract team full responsibility to finance, build, operate, and/or maintain the facility as a franchisee for a specified period of time, whereby the private sector team takes most of the project and financial risks and potential rewards for the term of the concession contract.

The following process chart displays the roles of DBB, DBOM, and DBFO in the delivery of transportation infrastructure as reported by Daniel L. Dornan in a report to the Federal Highway Administration titled "Synthesis of Public-Private Partnership Projects For Roads, Bridges & Tunnels From Around the World 1985-2004."

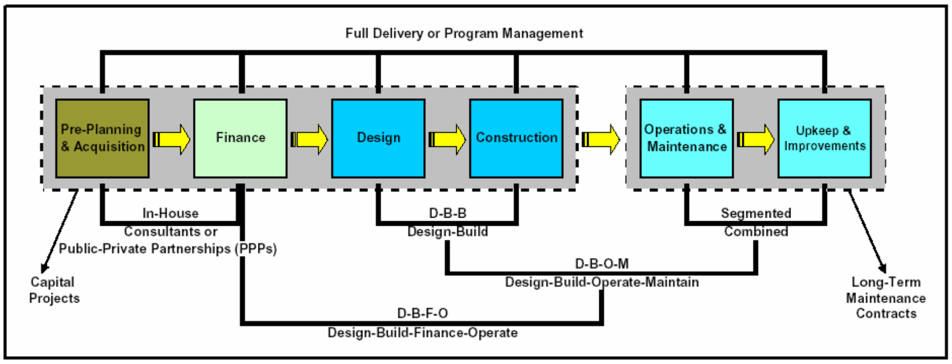


Figure 3.1: Delivery Process Diagram from Daniel L. Dornan in "Synthesis of Public-Private Partnership Projects For Roads, Bridges & Tunnels From Around the World 1985-2004." This distinguishes the roles of DBB, DBOM, and DBFO. It also shows the importance of PPP's to the development of hybrid design-builds.

Figure 3.2: Advantages and Disadvantages of Delivery Methods

Delivery	Advantages	Disadvantages
DBB	Design defined prior to bidding Max Competition Least initial bidding time	Minimal input from contractors/operations Longer schedules Adversarial relationships Owner responsible to Contractor for design errors Many change orders Many interfaces High risk Need for owner's decisions Lack of innovation Least value
CM@Risk	Less Risk Good for owners with insufficient staff	Conflict of interest Many change orders Many interfaces Need for owner's decisions
CM Agency	Less change orders Good for owners with insufficient staff	Many interfaces Need for owner's decisions Risky for owners No CM responsibility to outcome of project
DB	Contractor input early Good for all types of owners Increased quality and shorter durations Single point liability Reduced change orders Less interfaces Less risk Pre-project planning cost savings	Minimal input from operators Owner loses design control Requires team experience Fewer bidders Lengthy initial bidding Financial, O&M, and political risk remains the owner's

DBOM	Contractor and O&M input early Increased quality and shorter durations Increased emphasis on long-term operations costs Owner only responsible for political risk Eliminate gaps in responsibility/coordination Company guarantees instead of bonds Least change orders Less interfaces Innovative Reduces risk of unnoticed items	Owner loses design & operations control Requires additional planning from owner Team needs experience with DB Limited “checks and balances” Almost no bidders to choose from Long initial bidding High initial costs Not for inexperienced owners Politics may change during contract
DBFO	Less interfaces Better net present value Risk elimination Innovative Reduces risk of unnoticed items Lower cost of capital Company guarantees instead of bonds	Almost no bidders to select from Longest initial bidding process Politics may change during contract High initial costs Not for inexperienced owners Limited “checks and balances”
BOT	Company guarantees instead of bonds One interface Risk elimination Reduces risk of unnoticed items Lower cost of capital/better net present value Innovative	Almost no bidders to select from Longest initial bidding process Politics may change during contract High initial costs Not for inexperienced owners Limited “checks and balances”

Market Analysis

Highway Infrastructure Market

Currently, the Design-Build hybrids are not widely used, but their successes have been scrutinized for years in this market. Few design-builders and owners have experience with DBOM/BOT and even fewer consider the option for buildings. However, the highway infrastructure market has recently seen an explosion of projects employing these untested methods. As shown in the following table compiled by Daniel L. Dornan in the aforementioned report to the Federal Highway Administration shows how far the hybrid design-builds have come worldwide.

Contract Type	Number	Percent	$ Billion	Percent	$B/Project
Concession	**245**	**41%**	**$124.2**	**39%**	**$0.507**
DBFO	61	10%	$31.5	10%	$0.516
DBOM	49	8%	$35.7	11%	$0.728
BOT/BTO	**183**	**31%**	**$84.4**	**26%**	**$0.461**
BOO	8	1%	$1.9	1%	$0.239
DB	41	7%	$43.2	13%	$1.054
Mgt Contract	12	2%	$1.5	0%	$0.127
Total	599	100%	$322.4	100%	$0.538

Figure 4: Worldwide Transportation Infrastructure Projects by Contract Type from Daniel L. Dornan in “Synthesis of Public-Private Partnership Projects For Roads, Bridges & Tunnels From Around the World 1985-2004.” This shows that although hybrid design-builds have not become prevalent in the building industry, these methods have become more prevalent than Design-Build projects. Concession and BOT projects are most

frequently chosen worldwide where public entities have much less investment capital for infrastructure than private entities.

On the following page, Mr. Dornan continues to breakdown each of the types of transportation infrastructure in the United States by delivery method. Although Design-Build still reigns supreme in the number of domestic transportation projects, the contract quantities for Design-Build are far behind those planned and completed using DBOM and Concession. The following passage is one conclusion Mr. Dornan uses to explain this growth of design-build hybrids:

[3] On July 29, 2005 Congress passed the "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users" or "SAFETEA–LU". The Act authorizes $286.5 billion in funding for surface transportation projects through FY 2009. It also includes several provisions that will enable public funds to be leveraged with private investment through public-private partnerships, including:

- $15 billion in *private activity bonds (PABs)* for highways and surface freight transfer facilities,
- enhanced authority to use *tolling* to finance construction of interstate highways,
- increased flexibility in using *Design-Build contracting*,
- *streamlined environmental processes*, including a 180-day statute of limitations on actions contesting federal agency approvals for transportation projects, and
- improvements to innovative finance programs, including *Transportation Infrastructure Finance and Innovation Act* (*TIFIA*) and *State Infrastructure Banks (SIBs)*.

In this case, Mr. Dornan believes that government interference has increased the flexibility in using Design-Build contracting and in turn, promoting the innovative hybrid design-builds.

Project Type	Contract Type	Number	Percent	$ Billion	Percent	$B/Project
Non-Toll Highways	Concession	0	0%	$0.0	0%	N/A
	DBFO	0	0%	$0.0	0%	N/A
	DBOM	4	17%	$1.1	13%	$0.264
	BOT/BTO	0	0%	$0.0	0%	N/A
	BOO	0	0%	$0.0	0%	N/A
	DB	12	50%	$6.4	81%	$0.533
	Mgt Contract	8	33%	$0.5	6%	$0.061
	Subtotal	24	100%	$7.9	100%	$0.331
Toll Highways	Concession	5	18%	$5.7	22%	$1.140
	DBFO	2	7%	$1.5	6%	$0.765
	DBOM	5	18%	$10.5	41%	$2.098
	BOT/BTO	3	11%	$1.2	4%	$0.386
	BOO	0	0%	$0.0	0%	N/A
	DB	12	43%	$6.8	26%	$0.565
	Mgt Contract	1	4%	$0.1	0%	N/A
	Subtotal	28	100%	$25.8	100%	$0.920
Toll Bridges	Concession	1	13%	$1.8	57%	$1.800
	DBFO	0	0%	$0.0	0%	N/A
	DBOM	0	0%	$0.0	0%	N/A
	BOT/BTO	2	25%	$0.4	13%	$0.208
	BOO	4	50%	$0.1	3%	$0.021
	DB	1	13%	$0.9	27%	$0.860
	Mgt Contract	0	0%	$0.0	0%	N/A
	Subtotal	8	100%	$3.2	100%	$0.395
Toll Tunnels	Concession	0	0%	$0.0	0%	N/A
	DBFO	0	0%	$0.0	0%	N/A
	DBOM	1	100%	$4.0	100%	$4.000
	BOT/BTO	0	0%	$0.0	0%	N/A
	BOO	0	0%	$0.0	0%	N/A
	DB	0	0%	$0.0	0%	N/A
	Mgt Contract	0	0%	$0.0	0%	N/A
	Subtotal	1	100%	$4.0	100%	$4.000
Toll Bridges & Tunnels	Concession	0	0%	$0.0	0%	N/A
	DBFO	0	0%	$0.0	0%	N/A
	DBOM	0	0%	$0.0	0%	N/A
	BOT/BTO	0	0%	$0.0	0%	N/A
	BOO	1	100%	$0.6	100%	$0.600
	DB	0	0%	$0.0	0%	N/A
	Mgt Contract	0	0%	$0.0	0%	N/A
	Subtotal	1	100%	$0.6	100%	$0.600
Total Road Projects in U.S.	Concession	6	10%	$7.5	18%	$1.250
	DBFO	2	3%	$1.5	4%	$0.765
	DBOM	10	16%	$15.5	37%	$1.555
	BOT/BTO	5	8%	$1.6	4%	$0.315
	BOO	5	8%	$0.7	2%	$0.137
	DB	25	40%	$14.0	34%	$0.562
	Mgt Contract	9	15%	$0.6	1%	$0.066
	Total	62	100%	$41.5	100%	$0.669

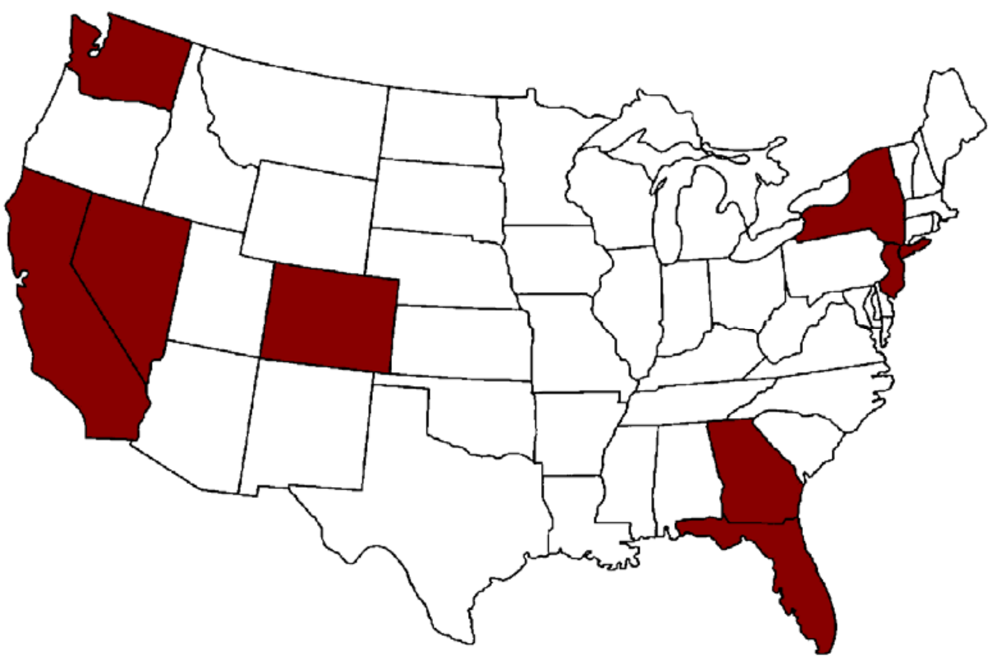
Figure 7: United States Transportation Infrastructure Projects by Contract Type from Daniel L. Dornan in "Synthesis of Public-Private Partnership Projects For Roads, Bridges & Tunnels From Around the World 1985-2004." This shows that although hybrid design-builds do not comprise as many projects as DB, DBOM and Concession projects far out-rank DB in total contract awards.

Commuter Rail Infrastructure Market

The rail infrastructure market has proven to be more supportive of design-build hybrids than highway infrastructure. One reason for lack of DBOM/BOT projects in highway markets can be attributed to the inherent necessity for tolls to make investment profitable. Since ticket fares are standard in the commuter rail industry, investment risks are lessened. In addition, large-scale commuter rail projects are still a tough sell in big cities and most local governments try to shed the risk associated with these projects by implementing design-build hybrid deliveries. However, as will be discussed in the case studies, shedding all risk associated with these types of projects can have its downfalls.

In recent years, very few commuter rail projects are outside of the realm of Design-Build. Since these systems are technologically advanced and the designers of these rail systems are more efficient at building them, Design-Build is a no-brainer. However, a majority of these Design-Build projects in the United States are DBOM. As mentioned by Fred Kessler, partner with Nossaman, Guthner, Knox & Elliott in "Managing Contractural Risk: The Project Owner's Perspective," "nine of the last fourteen contracts awarded in commuter rail are DBOM instead of DB."

Figure 8: The following is a map of the United States depicting where these commuter rail projects have taken place. This shows that DBOM has become most prevalent at the metropolitan areas at the far corners of the country.



One significant problem with forecasting this market is that there currently have been no studies performed like those of Mr. Dornan's for the highway infrastructure market. So far, this market is growing two-fold; owners asking for DBOM bids from the start and owners switching from DB to DBOM contracts (such as in Miami and Denver). More in-depth studies will most likely be published in the next few years documenting this trend.

Utility Infrastructure Market

Utility companies and local governments across the country are on the leading-edge of a construction boom to replace or repair America's aging infrastructure. It has been well-documented in the national news that as England moves to catch-up with its aged utilities, the American government has ear-marked millions of dollars for sorely needed utility upgrades such as canals, sewage facilities, and water treatment facilities. As published by ENR on February 27,2006, concurrent with this report, showed that the strongest sectors of the public construction industry is the power utilities, the highway and street, the sewage and waste disposal, the water supply, and conservation and development industries.

The power utility industry abroad, such as in China and India, are using the benefits of BOT. As shown later, the Shajiao B Power Station in China will be compared to the Tolt River and Cedar Water Treatment Plant in Seattle to weigh the benefits as recognized by these projects.

Building Construction Market

In the building construction market, DBOM is being tested for the first time in the Pacific Northwest region. Two projects in Washington and Oregon are on the cutting-edge of project delivery innovation and are scheduled for completion this Spring. Since DBOM involves long-term contracts during the operations and maintenance terms of these projects, the complete picture will not be reported for decades. However, since the design phases for both of these projects are nearing their end, it is important to study their contributions and the efficiencies attributed to DBOM. Later in this report, these two projects will be the center of a more-detailed case study since their successes will be the most applicable to Charles Commons.

As for the other design-build hybrids, no known building projects are implementing these contracts in the United States. A variation of DBOM/BOT is being tested by the Vancouver Redevelopment Authority in British Columbia, Canada for redevelopment of several urban blocks. Mixed-use buildings and a convention center is planned for Vancouver, where alternative project deliveries were considered due to a lack of funding and an authority that is trying to minimize their risk. It is believed that some future large projects such as stadiums, convention centers, and urban redevelopment initiatives may require these alternatives in the United States. Currently, that remains to be seen.

Civil Infrastructure Case Studies

In this section, case studies were performed in the civil infrastructure markets to make comparisons between the different design-build hybrids and find their advantages and disadvantages. The following projects are used as case studies:

Commuter Rail Infrastructure
- Seattle Monorail Project, DBOM
- Hudson-Bergen LRT, DBOM
- JFK AirTrain, DBOM
- Las Vegas Monorail, DB
- Taiwan High Speed Rail, BOT

Highway Infrastructure
- Dulles Greenway, DBFO
- Route 3 North Improvements, BOT

Utilities Infrastructure
- Tolt River and Cedar Water Treatment, DBOM
- Shajiao B Power Station, BOT

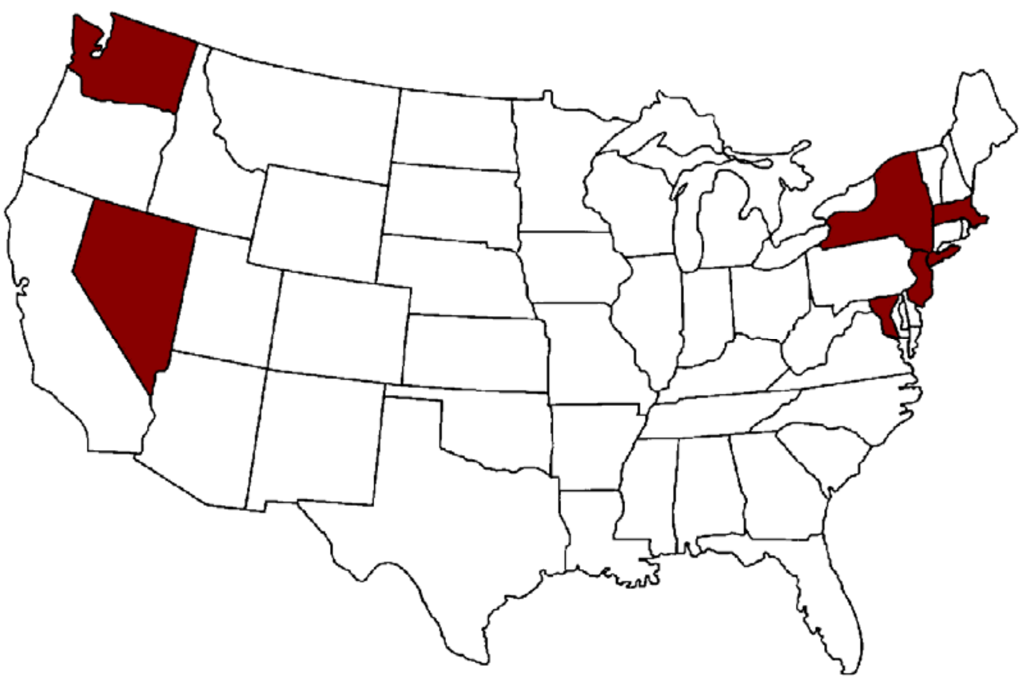
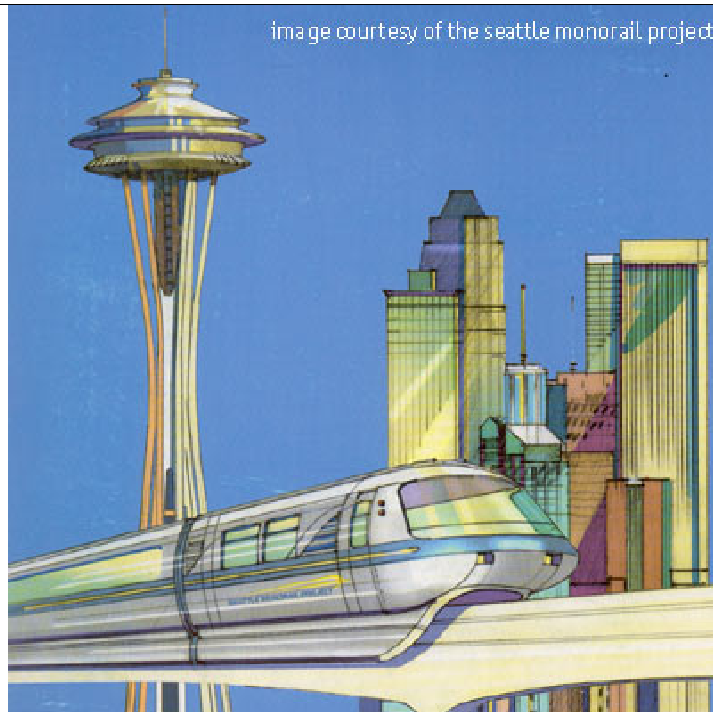


Figure 10: The following is a map of the United States depicting where the civil infrastructure case studies are located. The projects outside the U.S. are located in Taiwan and the Guangdong province in China.



Project Name:	SMP Green Line
Team:	The Cascadia Monorail Company: Fluor Enterprises, Inc.; Hitachi Ltd.; Mitsui USA; HDR Engineering, Inc.; Howard S. Wright Construction Co.; Hoffman Construction Company; Atkinson Construction; RCI Construction Group; Concrete Technology Corporation; VANIR Construction Management; David Evans and Associates; Kleinfelder, Inc.; PanGeo; Buckland & Taylor; PB Transit and Rail Systems, Inc.; H.W. Lochner, Inc.; Praha Strategies, Inc. (Patrick Kylen); Alcatel Transport Automation, Inc.; Bear, Stearns & Co., Inc.; Berger/ABAM Engineers, Inc.; EDAW; Hellmuth, Obata & Kassabaum (HOK); Wilson Ihrig & Assoc., Inc.; White Electrical; Holmes Electric, PSI, and Doris Locke & Associates
Owner:	Seattle Monorail Project Authority (SMP)
Contract:	Design-Build-Operate-Maintain
Contract Length:	15 years
Construction Schedule:	2003-2009
Total Project Cost:	$1.5 billion
O&M Cost/year:	$24,530,000
Project Description:	14-mile Green Line that will stretch from north to south and will connect many of Seattle's key destinations

Logic for Using Alternative Delivery Method

The Seattle Monorail Project Authority (SMP) had completed numerous studies detailing the efficiencies of Design-Build-Operate-Maintain over other delivery methods. According to a December 2002 report that is referenced in the DBOM Update published in January 2004 written by Nancy C. Smith and Philip Castellana, DBOM is described as:

• *DBOM acts as an effective "quality hook" in design and construction of projects, incentivizing the project designer to consider enhancements to project quality to reduce operations and maintenance expense and to avoid system failures and resulting decreases in system availability.*
• *DBOM provides significant benefits with regard to system integration and reduces risks relating to system integration by requiring the designer, builder and supplier to work together.*
• *DBOM diminishes the challenges of start-up problems, claims and system integration.*
• *DBOM provides early certainty regarding design, construction and operation and maintenance costs, reduces opportunities for cost growth and increases likelihood of achieving financial targets.*
• *DB/DBOM encourages use of innovative, cost-saving approaches that can be highly beneficial to the project.*
• *DB can greatly accelerate the completion schedule and provide schedule certainty; DBOM enhances the schedule certainty advantages provided by DB.*

To add to the December 2002 report, Smith and Castellana expand on the efficiencies of the DBOM delivery relating to the following aspects: on-time delivery, maintaining budget, break-even by 2020, excellent design, and accountability to the public. These aspects are compiled in the chart on the following page comparing a true DBOM contract with that of separate contracts. Although the results are not completely different, the advantages of DBOM are called out very clearly. In this case, DBOM would clearly allow the SMP to meet all of their goals and have decreased the risk to levels not common on large projects. These advantages will be referenced later when the delivery methods are compared.

ABILITY OF DIFFERENT O&M APPROACHES
TO ACHIEVE SEATTLE MONORAIL PROJECT GOALS AND POLICY OBJECTIVES

GOAL	DBOM	DB WITH O&M CONTRACTED OUT TO THIRD PARTY	DB WITH IN-HOUSE O&M
ON TIME DELIVERY			
• Early certainty re schedule	Yes	Yes	Yes
• Delivery within schedule	High probability	High probability Note: additional interfaces increase risk of delayed opening	High probability Note: additional interfaces increase risk of delayed opening
DELIVERY UNDER BUDGET			
• Early certainty re construction cost	Yes	Yes Note: Price likely to be higher than for DBOM approach due to Contractor uncertainty regarding interfaces with third party operator	Yes Note: Price likely to be higher than for DBOM approach due to Contractor uncertainty regarding interfaces with third party operator
• Avoidance of construction cost growth	Probable	Probable	Probable
BREAK EVEN ON OPERATIONS BY A DATE CERTAIN			
• Early certainty re O&M costs, thus facilitating planning to achieve goal	Base O&M costs are fixed (subject to escalation provisions); pricing provided for 15 years of operations	O&M cost must be estimated for planning purposes; actual amount will be determined only when the contract is awarded; contract will probably be short-term, reducing value of information for planning purposes.	O&M cost must be estimated for planning purposes; little information available for purposes of long-term planning
EXCELLENT DESIGN			
• High quality design/construction • Addressing life-cycle cost • Efficiently managing system integration and transition to operations phase	Probable--DBOM provides incentives for contractor to address O&M issues during design and construction. Due to the complexity of the system and likelihood of glitches during the initial operations period, the system designer and supplier is the best qualified to correct start-up challenges, achieve reliability most quickly and avoid claims and disputes between multiple contractors or contractor and owner.	Since there is no built-in incentive to improve design to reduce life cycle costs, the owner should consider alternative means of achieving that goal. This approach would require owner to manage interface between design/construction and O&M personnel, creating opportunity for contractor claims and allowing arguments that O&M contractor caused problem. Also, owner would need to hire O&M staff/consultants to provide input into design and construction. Note: Third party probably will not be able to perform as well as the system supplier during the initial operations phase. If problems arise during O&M period, contractor may claim they are due to faulty maintenance or operator error.	Since there is no built-in incentive to improve design to reduce life cycle costs, the owner should consider alternative means of achieving that goal. This approach would require owner to manage interface between design/construction and O&M personnel, creating opportunity for contractor claims and allowing arguments that O&M personnel caused problem. Also, owner would need to hire O&M staff/consultants to provide input into design and construction. Note: Owner probably will not be able to perform as well as the system supplier during the initial operations phase. If problems arise during O&M period, contractor may claim they are due to faulty maintenance or operator error.
• Environmental sustainability	Yes (contract performance standards and compliance mechanisms required). Note: SMP's sustainability team believes there is an advantage to DBOM due to built-in incentives to consider life-cycle cost. Many sustainability solutions have higher up-front costs, but cost can be recouped with lower operating costs (e.g. regenerative braking and low voltage lighting) Contract includes provisions incentivizing contractor to minimize power usage.	Yes (contract performance standards and compliance mechanisms required).	Yes (contract performance standards and compliance mechanisms required during DB phase; direct owner control during O&M phase)
TRUE TO GRASSROOTS HISTORY; TRANSPARENCY AND ACCOUNTABILITY TO PUBLIC			
• Social sustainability (family wages/benefits)	Yes (O&M contract performance standards and compliance mechanisms required)	Yes (contract performance standards and compliance mechanisms required)	Yes (direct owner control)
• Diversity (during O&M phase)	Yes (contract performance standards and compliance mechanisms required). Note: DBOM offers long-term opportunity to strategize and collaborate with the contractor. RFP requirement to including up-front proposals on diversity during O&M stage requires proposers to focus on key opportunities over life of project.	Yes (contract performance standards and compliance mechanisms required)	Yes (direct owner control)

Figure 13: The above chart by Smith and Castellana compares DBOM with other variations of O&M in-house and contracted to a third party. In most of these areas of analysis, the risk is consistently minimized and acceptable for the SMP.

Alternative Delivery Performance

Despite its promising attributes, a negative public vote in the city of Seattle on November 8, 2005, the Seattle Monorail Project was shut down. The design and construction services implemented by Cascadia Monorail Company had been terminated and the effects of DBOM on the SMP will never be known. But, the extensive studies performed by the SMP have laid the framework for future projects.

Project Name:	Hudson-Bergen LRT
Team:	21st Century Rail Corporation: Perini/Slattery, STV, Washington Infrastructure Group, Itochu Rail Car, and Kinkisharyo USA
Owner:	New Jersey Transit
Contract:	Design-Build-Operate-Maintain
Contract Length:	15 years
Construction Schedule:	1995-2000
Total Project Cost:	$1.3 billion
O&M Cost/year:	$63 million
Project Description:	15-mile, 16 station, 29 vehicle, manually-operated light rail system

Logic for Using Alternative Delivery Method

Most information regarding DBOM at the Hudson-Bergen LRT was found through the previously cited 2004 report by Smith and Castellana. According to Smith and Castellana in their 2004 report to the SMP:

New Jersey Transit's representatives felt that use of a single procurement for both DB and O&M resulted in a much better product, particularly since the equipment supplier was part of the DBOM consortium. On Hudson-Bergen, there was much better integration than would otherwise be expected. The representative also felt that by using DBOM, New Jersey Transit

avoided disputes between agency operating personnel and the contractor as to whether a problem was due to bad design or bad maintenance.

Once again, a transit authority decided that DBOM could best achieve the goals of the prescriptive specifications and, most importantly, achieve operations and maintenance goals not typically found in construction.

Alternative Delivery Performance

The Hudson-Bergen LRT was found to be quite successful for New Jersey Transit. Since this project was the first of its kind to use a DBOM delivery, it was honored with the American Public Transportation Association's Innovation Award in 2000. As in any project there were a few disputes about the payment structure. Again, as cited in the 2004 report by Smith and Castellana:

The maintenance provided by the O&M contractor is much better than that on agency-operated systems. However, there have been problems in operations, including the contractor's use of a commercial/financial approach to risk management affecting safety issues, and slow response times. For future DBOM contracts, one representative said he would want a different payment structure giving the agency more direct control over operations, i.e. paying on a time and materials basis rather than having a fixed base price. He noted that there is less reason for a large experienced transit agency with substantial in-house resources to use DBOM, but stated that he would recommend DBOM for new small agencies.

In addition to conflicts on payment structure, conflicts may arise from organized labor dealing with the pay rates of the operations staff, since a DBOM contract awarded at the beginning, as with Design-Build. As cited by Smith and Castellana:

New Jersey Transit received union complaints that it was "giving work away" by using DBOM. In fact, the Hudson-Bergen O&M workers were organized one week before commencement of operations. The labor union representative who was interviewed for this survey identified several areas of concern in dealing with the operating company. He recommended that any DBOM contract require the O&M contractor to pay rates comparable to those paid to workers in other systems, and require the contractor to have a labor relations liaison on its management staff.

The problems with union complaints and operations pay structure can be added as line items in the DBOM contract from the beginning to help with these issues. Overall, the Hudson-Bergen LRT has been a model DBOM project for the Commuter Rail market and will continue to be studied as the O&M contract reaches conclusion.

Project Name:	JFK Airtrain
Team:	Air Rail Transit Consortium: the joint venture of Perini, Bombardier, Slattery/Skanska (USA), Karl Koch Erecting, and STV Group
Owner:	Port Authority of New York and New Jersey (Port Authority)
Contract:	Design-Build-Operate-Maintain
Contract Length:	10 years, with (2) 5-year options
Construction Schedule:	1998-2003
Total Project Cost:	$1.16 billion
O&M Cost/year:	$25 million
Project Description:	8-mile automated transit system, with 3 stations, serving JFK

Logic for Using Alternative Delivery Method

The applied logic for using DBOM on the JFK Airtrain was formed by forming the goals of the owner and contractor, write in provisions in a contract to achieve these goals, and address key areas in which the DBOM process itself must be scoped. First, the goals of the owner and contractor were discussed during the RFP meetings and the following table was created as shown in the following table.

OWNER	CONTRACTOR
Open system on time	Open system on time
Safely meet or exceed passenger service criteria and amenities	Safely meet service criteria (to avoid penalties)
World class system image	Maximize profit during design-build phase
System is maintained within budget to as-new standards	Maximize profit during Operations and Maintenance period
System is serviceable and durable beyond the end of the Operations and Maintenance period	Maintain corporate reputations

Figure 18: As shown in the 2004 report on the JFK Airtrain by Cracchiolo and Simuoli, both the owner and contractor goals were taken into consideration under the DBOM contract written in 1998. It is important for both entities to participate in the DBOM contract to make it a success.

Second, the contract provisions must be agreed upon by the participants of the DBOM contract in order to achieve the goals. The following text is from Cracchiolo and Simuoli from the same 2004 report in which they document the specific contract provisions:

Provisions included in the contract:
• Port Authority standard clauses such as compensation for extra work, time for completion and damages for delay, and provisions for extensions of time.
• Corporate guarantees in place of performance and payment bonds.
• Provisions to limit contractor and owner risks, and incentives to limit claims.
• Contingency Fund covering amounts for:
- Contaminated and hazardous material disposal
- Changed subsurface conditions
- Maintenance and protection of traffic
- Utility relocation
- Idle salaried workers and equipment
- Various delay events not due to Contractor (up to one year)
- Conditions and precautions for construction work on railroad property
• Contingency Fund provision provides the Contractor a 40% contingency fee (bonus) of the amount remaining in the Contingency Fund at the conclusion of the Contract.
• Overruns are Contractor's risk

In DBOM projects, it is typical to see corporate guarantees, risk provisions, and incentives to limit claims since the project is typically one highly scrutinized. Large contingency verbage gives the Design-Builder incentive to carefully calculate the contingency and try to absorb the contingency fee bonus to make the project much more profitable.

Finally, Cracchiolo and Simuoli discuss the important key areas in which the JFK Airtrain addressed to minimize the hardships during the contract:

Key areas in which the DBOM process that must be carefully addressed: scope definition, parties' duties and responsibilities, schedule, payments, change orders and claims, product quality, intellectual property, 3rd-party agreements, dispute resolution, and O&M incentives.

In addition, Smith and Castellana stated in their 2004 report that the "representatives of the Port Authority of New York and New Jersey (Port Authority) stated that the basic reason for using DBOM was to obtain guarantees of the technology. The system provider would not guarantee what another entity operates, and a third-party operator would not provide availability guarantees for a system built by another entity. Particular advantages noted by these representatives were the ability to commence use of discrete systems prior to completion of the entire system, and the quality of employee training provided by the O&M contractor."

Alternative Delivery Performance

The use of Design-Build-Operate-Maintain was crucial to the success of the project, although the project team were faced with their own share of dilemmas. For example, there was a 1-year delay in start of operations due to an accident during manual operations in testing as noted by Smith and Castellana. Accidents happen quite frequently in construction and to have a testing accident before opening allows operations the opportunity to learn. Other lessons learned from the JFK Airtrain project include the following from Cracchiolo and Simouli:

Design and Construction
- *Develop well defined contracts*
- *Develop good performance criteria*
- *Define key roles and responsibilities*

Risk Management
- *Develop a balanced allocation of risk between owner and DBOM contractor*
- *Allow the contractor to proceed "at risk" when appropriate*

Project Management
- *Establish and maintain open communications channels*
- *Allow "fast track" design submittal review to accommodate early construction/building of key project elements*
- *Establish third party agreements early on*
- *Accept innovation*
- *Develop and execute risk mitigation strategies*

Most of these lessons can be attributed to all construction projects, but good performance criteria, balanced allocation of risk, establish third-party agreements, and execute risk mitigation strategies are very important to the success of a DBOM project.

Project Name:	Las Vegas Monorail
Team:	Liaise Corporation, Bombardier Transportation, Granite Construction Company, Gensler & Associates, Carter-Burgess, and Salomon Smith Barney.
Owner:	The Las Vegas Monorail Company
Contract:	Design-Build
Contract Length:	5 years, with (2) 5-year options
Construction Schedule:	2000-2004
Total Project Cost:	$354 million
O&M Cost/year:	$11.2 million, 5 year initial with 5 year options
Project Description:	3 miles of dual-elevated guideway, 7 stations, 9 four-car trains

Logic for Using Alternative Delivery Method

The design-build contract for the Las Vegas monorail is entered into by the owner on one side and the Granite Construction Company and Bombardier on the other. This is what is known as a three-party contract. In addition, the owner entered into a separate O&M contract with Bombardier. The contracts were not bonded, but backed by the parent companies, as done in many DBOM contracts to make the parent companies feel more is at stake in the project.

Alternative Delivery Performance

After many delays, the Las Vegas Monorail opened to the public on July 15, 2004. During testing and commissioning, the monorail suffered several malfunctions that delayed the start of passenger service for almost a year. The most severe of these problems related to parts falling from the monorail to the ground under the tracks. On September 8, 2004, more problems with falling parts led to the closing of the monorail for nearly four months. It reopened on December 24, 2004. A number of repairs were made to the monorail cars during this shutdown. Each time the monorail system requires major engineering changes, it must undergo a lengthy "commissioning" process to confirm the effectiveness and safety of the repairs. The local press reported that each day the monorail was down cost the system approximately $85,000, and that over $8.3 million was lost as a result of this one shutdown.

Despite the problems with start-up, since the two contractors were joint liabilities for the delivery of the project, the owner did not have to determine which of them was at fault for the delay in opening and the subsequent shutdown. Since liquidated damages ensued, the two contractors battled in court over the responsibility to getting the project done in time. Therefore, this type of limited liability approach using Design-Build has proven an effective tool for the owner in escaping litigation.

Project Name:	Taiwan High Speed Rail
Team:	Taiwan Shinkansen Company (TSC), Kawada Industries, AEC, HOCHTIEF, Bilfinger+Berger, and Continental Engineering Corporation
Consortium:	Taiwan High Speed Rail Co., Ltd.
Contract:	Build-Operate-Transfer
Contract Length:	35 years
Construction Schedule:	2000-2006
Total Project Cost:	$16 billion
O&M Cost/year:	n/a
Project Description:	214 mi high speed rail including many miles of viaducts

Logic for Using Alternative Delivery Method

The main reasoning for choosing Build-Operate-Transfer was the inability of the transit authority in Taiwan to fund such a large project, although the need for high-speed rail was great. Thus, the Taiwan High Speed Rail Co., Ltd was born. As mentioned by John E. Schaufelberger in a 2005 ASCE Construction Research Congress paper 7547 titled "Risk Management on Build-Operate-Transfer Projects":

In addition to developing and operating the rail system, the project sponsor was given the right to undertake property development around the ten stations for a period of 50 years. The

Ministry of Transportation and Communications assumed all responsibility for land acquisition and arranged a government loan at a fixed interest rate.

These added stipulations allowed the owner, who is involved in a concession agreement with the Taiwanese government, to use the land benefits of this contract to make up the expenses of the project. However, the relationship with the Ministry of Transportation and Communications, which was responsible for land acquisition, deteriorated as the project wore on.

Alternative Delivery Performance

According to Schaufelberger, the project fell behind schedule early due to delayed land acquisition, but the project sponsor was not compensated for the delay, because a schedule for delivery of the land was not specified in the contract. In addition, the sudden devaluation of the Taiwanese currency in 1997 increased project costs by about $500 million. The effects from delayed land acquisition could have been avoided if a clause was written into the contract allowing the consortium to be reimbursed for delays caused by the government. However, the devaluation of the Taiwanese currency is not a political risk that can be avoided, showing one issue facing BOT's.

Project Name:	Dulles Greenway
Team:	Brown & Root, Autostrade International of Virginia, O/M, Inc.
Consortium:	Toll Road Investors Partnership II (TRIP II): Bryant/Crane family, AIE, L.L.C., and Kellogg Brown & Root, Inc.
Contract:	Design-Build-Finance-Operate
Contract Length:	42.5 years
Construction Schedule:	1988-1995
Total Project Cost:	$385 million
O&M Cost/year:	$7.1 million
Project Description:	14-mile extension of the Dulles Toll Road, connects Dulles International Airport with Leesburg, Virginia.

Logic for Using Alternative Delivery Method

Enabled by the 1988 action of Virginia 's General Assembly, authorizing private development of toll roads, TRIP II constructed a 14 mile extension of the Dulles Toll Road. The Virginia Corporation Commission limits the rate of return on the project to 18 percent, but profits appear unlikely to approach which will be explained later. As stated by Schaufelberger in his 2005 paper, "As a result of the Design-Build-Finance-Operate delivery, the project completed six months ahead of schedule."

Alternative Delivery Performance

Although design and construction amounted to a success, the profitability of the Dulles Greenway has continuously been an issue. When traffic fell short of projected levels one year after completion, TRIP II defaulted on their loans. After toll decreases and still facing financial challenges, TRIP II restructured its debt in 1999 and agreed to an extension of the project.

Project Name:	Route 3 North Improvements
Team:	Modern Continental Construction Company
Consortium:	Route 3 North Transportation Improvements Association, a tax-exempt 63-20 corporation whom issued 30-yr bonds
Contract:	Build-Operate-Transfer
Contract Length:	30 years
Construction Schedule:	2001-2004
Total Project Cost:	$385.1 million
O&M Cost/year:	N/A
Project Description:	Lane addition along 21-mile stretch, 40 bridge replacements, and improvements to 13 interchanges

Logic for Using Alternative Delivery Method

According to the Route 3 website, there are four major reasons for choosing a design-build hybrid: demand for quick completion, limit cost and schedule risk, complete the project during an adjoining project, and take advantage of financing innovation to reduce project costs. The demand for quick completion and advantage from the financing innovation are not "sure" results as shown previously with projects like the Las Vegas Monorail. However, they understand the lessened liability they face if the project was to suffer delays or cost overruns.

Alternative Delivery Performance

On October 2004, three travel lanes were open in each direction on the full 21-mile length of the highway. The additional work on roadway overpasses and interchanges have been delayed and should complete by Spring 2006. So far, there are no cost overruns or litigation on the project.

Project Name:	Tolt River and Cedar Water Treatment
Team:	Camp Dresser &McKee/Azurix/Dillingham
Owner:	Seattle Public Utilities
Contract:	Design-Build-Operate-Maintain
Contract Length:	15 years with (2) 5-year options
Construction Schedule:	Tolt: 1997-2000 Cedar: 2001-2004
Total Project Cost:	Tolt: $101 million Cedar: $109 million
O&M Cost/year:	Tolt: unknown Cedar: $1.25 million/year
Project Description:	300-million gallon per day drinking water treatment plants

Logic for Using Alternative Delivery Method

The logic for Seattle Public Utilities for choosing Design-Build-Operate-Maintain was the ability to control costs and allow a private entity to operate and maintain the remote facility. In addition, Seattle Public Utilities wanted to guarantee the O&M costs for the next fifteen years despite fluctuations in the economy.

Alternative Delivery Performance

Seattle Public Utilities completed the Tolt River Water Treatment Plant in 2000, on schedule and within budget, and completed the Cedar Water

Treatment Plant months ahead of schedule and under budget. According to Smith and Castellana:

The agency representatives interviewed strongly believe that these results are tied to the fact that the contracts include operations. They also believe that the capital cost savings are tied to the high level of industry interest in the O&M work. (Contracting out operations is widely used in the public water industry and is very competitive.) They particularly cited contractual incentives and liquidated damages for a number of factors (e.g., water quality) as effectively motivating the contractor to perform to a high standard during the 24-month operation period to date. The agency also had strong goals regarding diversity and sustainability and wages that they achieved using DBOM.

Project Name:	Shajiao B Power Station
Team:	Modern Continental Construction Company
Consortium:	Hopewell Power (China) Ltd.: Hopewell Holding, Kamematsu Gosho, HK
Contract:	Build-Operate-Transfer
Contract Length:	10 years
Construction Schedule:	1984-1987
Total Project Cost:	$530 million
O&M Cost/year:	N/A
Project Description:	(2) 360 MW coal-fired plants

Logic for Using Alternative Delivery Method

As the first Build-Operate-Transfer project in China, the Shajiao B Power Station was on the leading edge of innovative delivery practices. Frequent blackouts in the Guangzhou province in China lead to the Shenzen Special Economic Zone Power Development Co. to be formed. This group of prominent government and business professionals decided that the urgency called for an immediate bidding process inviting concessions to build two coal-fired power plants as soon as possible. A BOT contract was awarded to Hopewell Power (China) Ltd. and to promote early completion, a major incentive was built into the agreement between Shenzen and Hopewell that any proceeds from electricity sold before March 31, 1988, less the agreed costs, would be credited to Hopewell.

Alternative Delivery Performance

The incentive program and delivery method decision proved successful. Shajiao B was tested, commissioned, and in full commercial operation within 33 months, while the synchronization of power-generating Unit 1 was completed within 2 years (11 months ahead of schedule) from the handover of the construction site. According to Schaufelberger, the project was a complete success:

"The power plant construction not only set a world record in speed, but was done with high quality. One party to the joint venture, Hopewell, later received an award for Superior Civil Engineering from the United Kingdom in performing the project," said Eddie Ho, director of Hopewell Power (China) Ltd.

Up to July 31, 1999, it had sold 42.2 billion kwh of electricity, an enormous contribution to the stability and peak loading of the provincial power system. In its initial stage, the station produced 3.7 billion kwh of electricity each year, which was nearly one fourth of the generation total of the province's power system. The power shortage was to some extent alleviated and the investment environment of Guangdong Province was greatly improved.

It is surprising to find that the first BOT project completed was a total success. The power station was transferred to Chinese control in 1997.

Building Construction Case Studies

In this section, case studies were performed in the building construction market to investigate how the design-build hybrids can be used for Charles Commons and future building projects. However, there are only two building projects in the United States using design-build hybrids. All two are located in the Pacific Northwest region and implement Design-Build-Operate-Maintain as their chosen delivery method.

Since these projects were the closest match to Charles Commons, a more-detailed case study analysis needed to be performed. A project delivery questionnaire was distributed amongst the professionals on each project, including the owner representative for Charles Commons to find more-detailed first-hand information. More questions were asked when the professionals submitted their questionnaires to understand the idiosyncracies of the projects, instead of the generalities. Only at the completion of this analysis, design-build hybrids can be compared for the Charles Commons project.

The projects that are analyzed in this section are the Clackamas County Public Services Building in Oregon City, Oregon and the University of Washington Research & Technology Building in Seattle, Washington.

Clackamas County Public Services Building

Team:	Hoffman Construction, Group Mackenzie, Johnson Controls
Owner:	Clackamas County Public Services
Contract:	Design-Build-Operate-Maintain
Contract Length:	30 years
Design Schedule:	July 2003 – February 2004
Construction Schedule:	July 2003 – July 2004
Total Project Cost:	$16.9 million
O&M Cost/year:	$96,408/year
Use:	110,000 sf administrative space

Logic for Using Alternative Delivery Method

Clackamas County is a growing Oregon community of 362,000 in an area of urban and rural mixes. County workers have outgrown their existing space in 17 offices spread out around the county and running lease costs of $154,000. The overall goal of the county government was to consolidate all of the facilities into one campus to make the smallest impact on the environment and save on facilities cost. As the concept of the Public Services Building was discussed in the county government, three major issues required a streamlined construction process:

- Lease Deadlines – 17 local offices needed to move out of their leases at an exact time

- Financing – with funding secured at a low 4.11% interest rate for 30 years, construction needed to begin immediately
- Steel Prices – using DBOM allowed the project the ability to secure steel prices before the steeper rises.

In order to conquer these issues, Clackamas County had to act as soon as possible. The county decided to solicit bids for a Design-Build-Operate-Maintain contract.

Project Description

The four-floor building is approximately 110,000 SF and located on a 6.52-acre parcel of the Red Soils site in Oregon City. The building's systems include fire alarms, sprinklers, electrical, cable, telecom and data, lighting, audio-visual, security, and automation. A 450-ton chilled water HVAC system heats and cools the building. The facility also features bioswales for stormwater run-off and a series of trails and educational signs designed for public use throughout wetlands on the property. Other technology includes a low-temperature HVAC system and a Web-based Metasys® building management system used to tie together many intelligent systems that improve operations and management. Indoor environmental quality measures such as carbon dioxide monitoring and use of low-emitting materials complemented an environmental quality management plan during construction and a two-week flush-out before occupancy.

Additional sustainable features include lights that sense the amount of daylight entering the building and adjust to maintain optimum levels (and save energy at the same time), and a cooling tower that is electro-statically cleaned so chemicals are not released into the drainage water Reflective panels and louvers work in concert with light harvesters to automatically control lighting based on the amount of available natural light, and the building is zoned into variable air volume boxes.

Design and Construction

After selecting the team of Hoffman Construction, Johnson Controls, and Group Mackenzie by way of best-value, the design and construction got underway immediately. At the beginning of design, Hoffman Construction and Johnson Controls project management staff were present to offer constructability reviews, value engineering, lifecycle advice, and sustainability advice. Clackamas County had decided to achieve LEED Certified Silver status for the project and this was taken into considerations in all aspects of design.

Upon Group Mackenzie's preliminary design, Johnson Controls designed and worked as a single-source for MEP Coordination for the project. Allowing Johnson Controls design and coordinate the MEP systems helps shorten the commissioning process and allows the building to be turned-over quicker. In addition, the entity with the greatest familiarity with the installed systems stays on to operate the systems, which is very efficient. In addition, County officials signed an energy performance contract with Johnson Controls. The contract guarantees the county will realize energy savings for 15 to 20 years. Johnson Controls will monitor, operate and maintain the systems for the 20-year period. If the systems don't deliver the energy savings promised, Johnson Controls is obligated to pay for the difference and correct the system. These types of guarantees are what separates DBOM from all other deliveries, where in other projects distrust and litigation clauses reign.

Almost immediately after ground was broken, Hoffman Construction began excavation and foundation work on the 6.52 acre site. Since the site is large, very few problems with sequencing, deliveries, and coordination developed. Otherwise, the steel building was construction like any other office building construction.

The MEP system components were installed on the heels of the structural contractors. Since MEP was coordinated through Johnson Controls, all of the systems were installed prior to wall construction. Some aspects of green design, such as the two-week system flush-out, added to the schedule, but the savings in commission more than compensated for the lost time. The building was turned over to Clackamas County exactly one year after breaking ground, which Johnson Controls attributes to be a savings of seven months.

Operations and Results

According to Johnson Controls, the project saved in two areas:

Lifecycle Costs — Because Johnson Controls installed and guaranteed the performance of high-grade equipment over 20 years, the building is estimated to avoid $1.8 million in repair, maintenance and energy expenses as compared to a building constructed at minimum code compliance. By focusing on lifecycle cost as opposed to first cost, the building also is 40% more efficient than ASHRAE 90.1. The project gathered approximately $346,000 in energy rebates and tax credits.
Operating Costs — The county's costs are expected to be reduced by nearly $64,000 per year compared to a typical office building. For instance, by having county offices share resources and

equipment such as copiers and printers, the county will save in equipment leasing and renewal costs. Most importantly, the co-location of services helps Clackamas County provide a higher level of customer service. Citizens needing services and information can quickly and easily have a variety of their needs met through the professional services centrally located at the PSB.

In addition, the county received $206,684 from the State of Oregon by reselling the available Business Energy Tax Credit, and $47,370 from the Energy Trust of Oregon's New Building Efficiency program. The project received an award for excellence by the DBIA-Northwest region.

University of Washington Research & Technology Building

Team:	CollinsWoerman, M.A. Mortenson, Johnson Controls
Owner:	University of Washington
Contract:	Design-Build-Operate-Maintain
Contract Length:	30 years
Design Schedule:	November 2003 – February 2005
Construction Schedule:	July 2004 – March 2006
Total Project Cost:	$29,850,000
O&M Cost/year:	$125,000/year
Project Use:	Six floors and 122,000 sf of research space 65-parking space garage

Logic for Using Alternative Delivery Method

The Research &Technology (R&T) Building project was conceived to help meet the growing need for flexible, cost-effective facilities to support multi-disciplinary research initiatives at the University. The project will provide space for physical science laboratory research in the general areas of nanotechnology, photonics, genome technology, information technology, energy, biometrics, and others. The space is intended for research projects that need to be on the Seattle campus and are subject to the on-campus indirect cost recovery rate. While being owned by the University, the building cost and rent must be competitive with the private sector and should provide predictable occupancy and life-cycle costs over 30 years.

Project Description

The six-floor, 122,000 sf UW Research & Technology Building is carved out of the side of a steep incline. Its structure is comprised of cast-in-place concrete flat plate slabs and its façade is glass and masonry. The building is located the closest of all on-campus buildings to downtown Seattle. There is close proximity to the Puget Sound, in which dewatering wells were required to excavate for the building's foundation. There are also 65 parking stalls located in the lower two stories of the building.

Design and Construction

The Mortenson/CollinsWoerman/Johnson Controls team won an intense competition to design, construct, operate, and maintain the UW Research & Technology building. The following table shows how the team faired with schedule early-on:

Schedule (start – finish)	Planned	Actual
Conceptual Planning	12/10/02 – 9/23/03	12/10/02 – 9/23/03
Design	10/14/03 – 12/14/04	11/17/03 – 4/17/05
Procurement	5/21/04 – 7/9/04	5/21/04 – 6/29/04
Construction	7/9/04 – 3/21/06	7/9/04 – not complete
Close-out	3/21/06 – 1/20/07	3/9/06 – not complete

As shown above, the only delay thus far is the delay in design. From correspondence with CollinsWoerman, a 3-D modeling process was used to coordinate building systems. This digital modeling process, which is not frequently used in the Pacific Northwest, was implemented at the middle part of preparing construction documents.

The process of identifying system conflicts continued floor to floor starting in the CD process through MEP coordination phases of construction. Each of these "processes" were performed in meetings in which all trades were involved.

In addition to design for the base building project, each leased space will require a tenant fit-out, which has been coordinated to use the services of Mortenson/CollinsWoerman/Johnson Controls through University of Washington. So far, three research tenants are spending at least $6 million to lease space in the UW Research & Technology Building before it is complete.

The 19-month schedule of the UW Research & Technology building is on-track. Thus far, the structure has been complete and the interior finishes are wrapping-up. The most important aspect, the commissioning process is about to begin and the true test of the added O&M input has yet to begin.

Interview with CollinsWoerman

Two respondents with the architect on the project, CollinsWoerman, gave important information about the processes of the project. In a phone interview with John Whitlow, the project architect, he discussed the overall design and its challenges. First, he stated that the design delays that were incurred on the project were not due to the inefficiencies of the design process. Since the project lies on the outskirts of the University of Washington campus, permitting with the City of Seattle was required. The building permit was delayed several times by the City of Seattle due to problems with the site design, since the building is on such a tight site. These problems were rectified after being delayed for months.

In addition, the owner and contractor were very involved in the design process. They both took on the responsibility of managing design and design decisions could be answered quite quickly. During construction, two owner representatives would visit and get daily construction reports from the superintendents. The owner and architect were inexperienced with DBOM prior to this project and the contractor was the least experienced with high-technology laboratories. Mortenson's experience was derived from the Clackamas County Public Services Building project that was previously described. There was not a formal value engineering process during design since the contractor was present to weigh-in at real-time on the best-value.

The first respondent, Jon Szczesniak, worked on the digital modeling required for the coordination of the high-tech laboratory. The floor-to-floor height was reduced from 15' to 13'-6" as a result of the digital modeling. The introduction of digital modeling was described by Mr. Szczesniak in the following:

It's important to realize that out here, in Seattle, the idea of digital coordination is fairly fresh. There have only been a handful of projects that have used this to it's fullest capacity. I believe it was Mortenson who had originally brought up the idea of modeling the building in three dimensions for the explicit purpose of coordinating the different trades that were to make up this Research & Tech. building. They have done similar processes on the Disney Concert Hall, and it is becoming their standard way to work with architects and all subs.

The primary purpose of the 3D modeling was for MEP coordination, which began in the middle of the construction document phase. It was Jon Szczeniak's opinion that if the 3D modeling was started earlier, at the beginning of the design development phase, the design could have been coordinated between the professional engineers and not require the added coordination costs incurred by the subcontractors. Nevertheless, Mr. Szczeniak went on to describe the process:

… the design sequence/timeframe was from the CD phase through construction. We got together every other Tuesday and went through the project. Each floor was separated out and coordinated by itself. We used specialized software that would allow us to view the building stereoscopically in real-time so that we could see that when plumbing had a collision with electrical, we could zoom right to it and see how to best resolve the issue. Each coordination meeting had parties from all trades.

Mr. Szczeniak and Mr. Whitlow believed that this MEP coordination process was a success that saved the UW Research & Technology Building in lower building height, construction conflicts, and access issues. Without the project team cooperation that results from a DBOM delivery, the UW Research & Technology Building may not have achieved the cost and schedule benefits from 3-D MEP Coordination.

Johns Hopkins University – Charles Commons
Analysis of Alternative Delivery Methods

The Charles Commons project is part of the Johns Hopkins University plan to expand their residential services to allow their students more options while attending the Homewood Campus. When students reach sophomore, junior, or senior status, they had typically left the on-campus housing and found off-campus apartments to share with their friends. Since the 1990's, there has been a trend to supply suite apartments to upperclassmen who still want to remain in touch with the on-campus crowd. JHU's most recent master-plan had called for thousands of beds of capacity to be constructed over the next ten years. Johns Hopkins University will not meet this goal with the traditional methods being used on Charles Commons.

Existing Project Delivery Method

The project delivery method on Charles Commons is best described as ever-changing and all-encompassing. The project began with the intentions of using the traditional Design-Bid-Build method. However, as the development teams were introduced to the project, the method used changed to CM@Risk under a GMP contract. However, as the cost of the project increased, the dining hall component was added, and the design schedule lengthened, the developers decided to employ SBER under a CM Agency agreement in a lump sum contract. Currently, the project is a CM Agency.

Analysis Criteria

Using the information compiled from the case studies, questionnaires, and interviews, I will investigate the advantages and disadvantages for using the following alternative project delivery methods at Charles Commons:

1. A Design-Build contract awarded through best-value and employing the O&M services of JHU Office of Facilities Management.
2. A Design-Build-Operate-Maintain contract awarded through best-value and employing the services of a full-service O&M contractor in all parts of the project at a length of 15 years with options up to 30 years.
3. A Build-Operate-Transfer contract awarded to a consortium consisting of a development firm, financier, contractor, designer, and an operations & maintenance contractor. Ownership can be transferred to JHU after 30 years.

At this time, these alternatives could not be implemented because of the policies of the JHU Board of Regents. The Board of Regents require CM@Risk, CM Agency, and Design-Bid-Build contracts only. It is the ultimate goal of this report to introduce owners to the benefits of design-build hybrids and hope that they consider them in their decision-making processes for the future.

Interview with JHU Facilities Management

On February 1, 2006, I interviewed Mike DiProspero, a senior project manager with the Johns Hopkins University Office of Facilities Management about the project he is closely involved with, Charles Commons. In addition to the walkthrough interview at the jobsite, he completed my Project Delivery Questionnaire, whose comments are listed below. I want to take this time to thank him again for all of his help.

At this time, the project is under a Design-Bid-Build delivery with Lump Sum payment terms. The University is a private entity and has earmarked money from personal donations to make capital improvements such as Charles Commons. Mr. DiProspero has much experience outside of this project with other project deliveries and feels that the delivery system is adequate for its use on Charles Commons.

The schedule began to slip in October of 2004 when design needed more time to complete the newly added Dining Hall component. This one month day translated into a two month delay (from June 2004 to August 2004) in construction when difficulties arose in negotiations with an existing tenant that refused to leave early. Specialized abatement was needed for the demolition of Ivy Hall, diminishing the opportunity to make-up time. Excavation for St. Paul proved difficult since rock was found sooner than expected. An inability to contract the caisson subcontractor delayed the beginning of caissons on St. Paul. In addition, relocation of utility lines on the corner of the site by BG&E caused an enormous delay in utility work. All of these troubles minimally delayed the superstructure of St. Paul. More delays were yet to come.

The additions to the program, such as the Dining Hall component and Conference/Banquet Facility and scope changes contributed to a $600,000 design increase and a $10 million construction increase. Increased material escalation, such as steel and concrete, at bid time also added to the unexpected cost increases. Cost cutting processes, called value engineering by the team, were implemented during the changes in a failed attempt to maintain the original budget.

The overall project experience for all parties involved has been quite stressful, but Mike DiProspero attributes most of the headaches to unforeseen conditions and typical problems in design and construction. He commented about the excellent relationship that team has with him. In addition, he commented about the excellent experience the contractor and designer has with similar facilities and the project delivery system. Although there were many lessons to be learned from this project, Mr. Prospero noted that he would not have changed the team or the project delivery method.

1. Design-Build

A Design-Build contract was first considered when analyzing the inefficiencies in the schedule (without mentioning unforeseen conditions). Demolition, utility and foundation excavation, and mobilization needed to occur before design was approximately 50% for the greatest overlap of the design and construction activities. Contractor input can be facilitated from the beginning of the project and could perform constructability reviews, value engineering, and MEP coordination during the entire design process.

In addition, the Design-Build contract would protect the developers from the negative effects of unforeseen conditions and maintain the controlling hand in negotiation or litigation. The risk-limiting attributes of Design-Build is what attracts many saavy owners to this delivery method. The owner could facilitate design with less staff using performance specifications.

The bidding process would need to be changed to a best-value evaluation process, which may require more investigation of the program and bidding requirements, increasing the initial bidding process approximately 50%. In addition, the contract would be written on fixed lump sum terms where the Design-Builder takes on most of the risks associated with the project. The Design-Builder could very well be a joint-venture between SBER and Design Collective, especially since they have worked together well many times before.

2. Design-Build-Operate-Maintain

A DBOM contract was considered when discussions were held regarding value engineering at the past year's S:PACE Roundtable meetings dealing with Design Management. DBOM would work to improve the design and construction processes as in Design-Build, with the added improvements in lifecycle value engineering. Not only would the owner use performance specifications to make sure he experiences the best value, but the entire project's focus will be on what amounts to 75% of the project's cost, its operations and maintenance.

The O&M contractor can be integral during design to facilitate energy savings concepts and sustainability. A quality O&M contractor such as Johnson Controls or Siemens could operate and maintain the off-campus building as well as JHU's Office of Facilities Management at a controlled cost. This control allows the developers to not be liable when expensive equipment malfunctions, as it may be prone to do under conventional contract terms. Incentivizing design and construction to concentrate on "getting it right" will promote the quality standards expected from Johns Hopkins University facilities.

The bidding process would need to be a best-value evaluation on fixed lump sum basis as discussed with Design-Build. In addition to a joint-venture between SBER and Design Collective, an O&M contractor would need to be partner as well.

3. Build-Operate-Transfer

A BOT contract was considered soon after discussing the development taking place in the vicinity of the project. The existing Owner-Developer-Contractor structure allows itself well to an integration with other projects in the area. The $90 million student apartment development taking place near by is spear-headed by a team made up of the developers Canyon-Johnson and SBER under a loan from the Citibank Community Development Fund. Capstone and SBER are developing $64 million Charles Commons. The integration of these two development teams would create a strong BOT team capable of $154 million in development of 863,000 sf of dormitories and apartments for Johns Hopkins University.

The most important benefit of this structure for Johns Hopkins University is its risk allocation. All risk, including political risk, are handed over to the BOT partners. This would allow the team to use economies of scale to design, construction, finance, operate, and maintain Charles Commons, Charles Village East, Charles Village West, Village Commons, and the Village Lofts.

The bidding process would need to be a best-value evaluation as discussed with the previous two delivery methods. In addition to the two development teams, the integration of an O&M contractor would be preferable.

Comparison of Delivery Methods

On Charles Commons, an experienced owner and team allows the possibilities of using alternative delivery methods. Although the existing team experience using Design-Build is not a strength, the team does have experience with one another. The risks associated with DBB are high in comparison with all of the other delivery methods. Problems such as steel prices, unforeseen conditions, and subcontractor woes would be the responsibility of the design-build team, not the responsibility of the developers. Below is an estimate of the schedule for Charles Commons if the alternate delivery methods were used.

To secure a reasonable estimate as to the schedule benefits of one delivery method over another, the schedule of the UW Research & Technology building and JHU Charles Commons were compared. The overall complexity of both projects

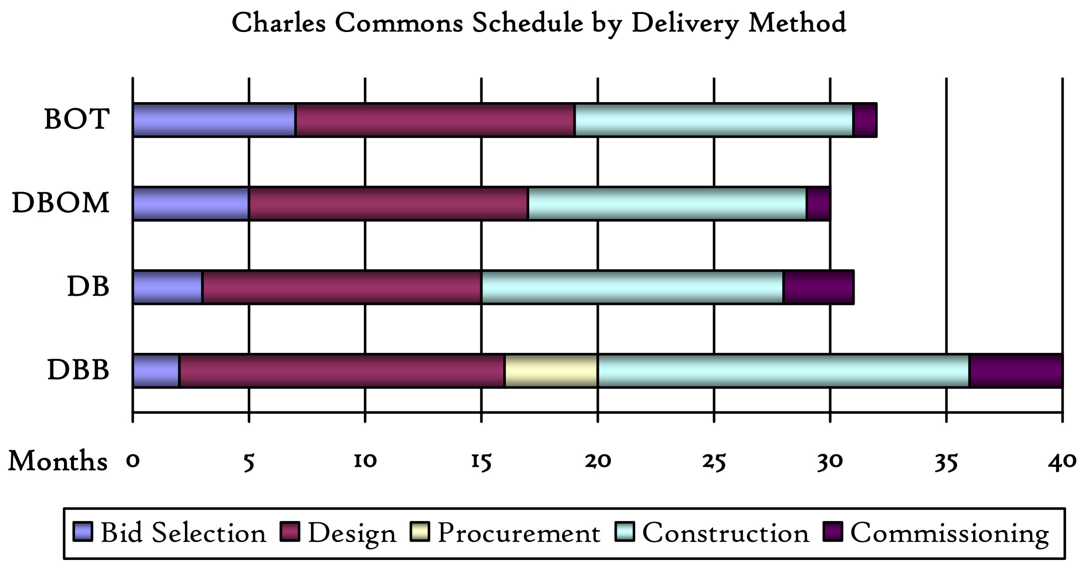


Figure 45.1: Estimates were made by comparing lengths of five different stages of the Charles Commons project. The existing schedule is attributed to the DBB method and the other methods were subsequently compared by stage duration.

Delivery	Risk	Experience	Schedule	Cost Control
DBB	Responsible for all risks associated with project	**None required**	Short bid selection Longer design & construction	Least value Low initial costs/high O&M costs Many CO's
DB	Political, O&M, financial risk, single liability	Team experience required	Longer bid selection Shorter design & construction	High value High initial costs/lower O&M costs Less CO's
DBOM	Political, financial risk	Owner & Team experience required	**Longer bid selection** **Shortest design & construction**	Highest value Highest initial costs/lowest O&M costs Less CO's
BOT	**Political**	Owner & Team experience required	Longest bid selection Shortest design & construction	**Highest value** **Low initial costs/low O&M** **Owner does not have ownership initially** **No CO's**

Figure 45.2: Comparisons between the delivery methods were made using four main issues: risk, experience, schedule, and cost control. BOT and DBOM were consistently better than the other delivery methods.

The table above compares the delivery methods by risk, experience, schedule, and cost control. The bolded areas are aspects of the project that are the most favorable. Since team and owner experience is not an issue on Charles Commons, only DBOM and BOT show exceptional performance characteristics. The only difference between DBOM and BOT is the financial risk, initial ownership, and initial bid selection.

DBOM/BOT Conclusion

Design-Bid-Build is inappropriate for Charles Commons compared to the design-build hybrids. Design-Bid-Build is responsible for the cost increases due to the added owner risk and longer design and construction. Charles Commons is nearing 650 PCO's due to the Design-Bid-Build delivery in addition to quality problems.

Design-Build is an improvement over DBB for Charles Commons. The risk pertaining to the steel and concrete prices, the unforeseen conditions, and design problems are eliminated from the contract, helping the developer maintain the budget of $54 million and giving the developer the upperhand in negotiations regarding these risks. Since JHU employs their own O&M staff from the campus and have consulted since 20% design on operations, Design-Build is an effective method for O&M. In addition, the estimated schedule benefits for Design-Build are a reduction of 8 weeks.

Design-Build-Operate-Maintain is the most appropriate delivery method for Charles Commons in respect to completing the project in time for Fall '06 opening. The savings of 10 weeks is critical to allow for the numerous delays and risks incurred on the project. DBOM may not be the most cost-effective initially, but the delivery allows the project to save the owner on lifecycle costs. The integration of an additional contractor to conduct O&M activities should not prove problematic for the experienced team. However, the JHU Board of Regents have rejected DBOM proposals in the past.

Build-Operate-Transfer also proves advantageous for the developers of Charles Commons. The schedule of BOT is the same as DBOM with the exception of the longer time to set up the financing of the project. BOT proves to be the least risky for JHU when the developers take on all of the risk of the project. In addition, change orders are eliminated. However, without JHU owning Charles Commons outright, some of their technologically-advanced equipment and high-quality may be sacrificed unless all of the specifications were performance instead of prescriptive. This time-consuming specification process may not be practical for the highly bureaucratic Johns Hopkins University. JHU must trust the design-builder to not sacrifice the quality of the overall project since JHU will not be in the position to own the project for some time.

Since there is a lack of owner quality control during the BOT design and construction term, BOT is not in the best interest of the JHU at this time. In addition, an outside O&M contractor may be more innovative and technologically-advanced in comparison with JHU Office of Facilities Management. Secondly, an outside O&M contractor will allow for more efficient MEP coordination such as digital modeling and can perform the MEP design and work to act as a seamless single entity for the design, construction, operations, and maintenance of the building. And finally, the extra two weeks of schedule savings proves that DBOM is a better choice for Charles Commons than Design-Build.

Market Outlook

Of the aforementioned markets, DBOM and BOT have different growth opportunities. DBOM and BOT futures can be forecast by analyzing the following:

1. Regions in which the owners are familiar with the trend and press articles have been released
2. Regions that have passed legislation and projects have been completed successfully
3. Regions or projects that have extraordinary demand for DBOM/BOT techniques (for example, power plants in the Southwest)
4. Current growth with reference to the origin projects of DBOM/BOT
5. Growing demand for DBOM/BOT

In the highway market, federal legislation such as SAFETEA-LU has promoted the use of DBOM/BOT delivery methods to streamline the government approval processes and deliver a project in which funding is not readily available.

The light rail train market favors the DBOM method because funding will become more problematic due to the infrastructure crisis. In addition, DBOM/BOT are excellent candidates for the high-speed rail initiative around urban centers along Interstate 95. Cities such as Charlotte, Raleigh, Jacksonville, Richmond, Fredricksburg, Washington, DC, Baltimore, Harrisburg, Philadelphia, New York, and Boston have been interested in building high-speed rail. However, fiscal issues have made this possibility a long shot. The study of BOT on the Taiwan High Speed Rail project may be the shot in the arm that high-speed rail needs.

The demand for new and updated utility infrastructure is far beyond its legislated funding. In addition, successful projects such as the Tolt River and Cedar Water Treatment project demonstrate the benefits of DBOM. BOT can be used for projects in the Southwest where funding is low but demand for electricity is at critical limits.

The demand in the building construction market is marginal for DBOM/BOT delivery methods. More states that pass DBOM/BOT legislation and more owner's executive boards that accept DBOM/BOT will significantly increase the viability of DBOM/BOT on building projects. Currently, only three states have DBOM/BOT legislation. The following table displays the current and forecasted market trends for the design-build hybrids:

Markets	Design-Build hybrid	Current (2006)		Future (2016)		Catalysts for Growth
		Market Share	Region	Market Share	Region	
Hi-way	DBOM	< 1%	Across USA	4%	Across USA	SAFETEA-LU, 2005 Federal legislation
	BOT	< 2%	Across USA	4%	Across USA	
Train	DBOM	45%	Across USA	60%	Across USA	High-speed rail for DC/NY corridor
	BOT	0%	Overseas	< 1%	Mid-Atlantic	
Utility	DBOM	< 1%	Seattle	5%	Northwest, Florida	States have passed DBOM legislation
	BOT	0%	Overseas	< 1%	Southwest USA	Not enough funding for power plants
Building	DBOM	< 1%	Northwest	2%	Northwest, Florida	States have passed DBOM legislation
	BOT	0%	Overseas	0%	Northwest	Redevelopment Corporation Laws

Figure 49: Market futures were predicted for DBOM/BOT in each of the four discussed markets drawing information from ENR and other sources. These predictions are highly arbitrary and conservative, but the overall trend of DBOM/BOT deliveries have been widely believed to increase over the next ten years.

It is important for state legislation for DBOM/BOT to be carried out as soon as possible to allow owners this choice for project deliveries. DBOM/BOT can greatly aid public and private owners with their financial, schedule, and lifecycle issues.

Owner's Guide to DBOM/BOT

In many studies, the selection of a project delivery method for a project is the largest decision the owner can make. The project delivery affects the relationships between the project team members and dictates the incentives on the project. In order to help owners weigh DBOM and BOT with the other delivery methods, an owner's guide to project delivery methods must be created.

Background

Tools for selecting project delivery methods have been on the market for years. Most are in the form of books, where after 300 pages of reading, an owner becomes more confused about the decision that when he had started. The specifics of project delivery selection are wholly dependent on the construction projects that were studied since many of the same projects can have completely different outcomes. Since time is an issue for the owner, the owner's guide must be only a few pages. In addition, the owner's guide must be written for a lay person. Any difficult language (whether vague or advanced) can confuse the owner into a bad decision.

The best project delivery selection system (PDSS) was proposed by Anthony Vesay in his thesis for his Master of Science Degree in Civil Engineering. Mr. Vesay's PDSS Model uses a series of six questions to determine the best course of action. The six questions deal with:

1. Project Characteristics (well-defined vs. poorly-defined)
2. Time (critical vs. not-critical)
3. Owner Experience (experienced vs. inexperienced)
4. Team Experience (experienced vs. inexperienced)
5. Quality (industry-standard vs. above-standard)
6. Cost (critical vs. not-critical)

These questions led the owner to a decision amongst DB, CM@Risk, CM Agency, and DBB delivery methods. In order to add DBOM/BOT to this model, three of these questions must be adjusted to accommodate the different issues associated with the integrated methods versus the traditional methods.

Existing Guide Criteria

The six issues that affect the process of selecting project deliveries are a condensed form of an endless list of variables in a project. As described by Victor Sanvido and Mark Konchar in their book, Selecting a Project Delivery Method, the following are additional issues that the owner must consider:

Project's importance to the owner's future and concurrent projects;
Owner's experience in delivering jobs similar in size, type and location;

Degree of scope definition and potential for changes;
Owner's ability to staff and support the job;
Owner's ability to assume, manage and allocate risk for the project;
Limitations due to procurement practices and laws;
Owner's procurement and purchasing practices;
Expected level of owner involvement;
A pool of qualified team members;
An owner-designated staff to make timely decisions.

Since there are many issues, it would be most prudent to stay focused on the current six issues, since they seem to encompass the greatest cost or schedule consequences to the decision and are the most affected by the project delivery method.

Project Characteristics

Project characteristics is a vague issue in which the program scope definition is considered as either "well-defined" or "poorly-defined". First, the vagueness of "project characteristics" can mislead the owner as to its definition. The program scope definition is an important factor in the project delivery decision, but it can be affected by owner by his timeliness in making the project delivery system decision. If the owner takes to the time to make performance specifications and other program requirements, he/she would be most prepared to make this decision. In addition, the subjectivity of a "well-defined" vs. "poorly-defined" scope is an issue since it is the owner using this model. I would not be surprised if most owners choose the "well-defined" scope although they do not prescribe to the industry standard.

Time

Schedule can be critical in many ways. If a project begins design requiring completion before a designated move-in date, time can be a critical factor. Time may also be critical if the design completes on a project that cannot be constructed in the required timeframe due to lengthy design. Time is also critical as a way to finance the building itself where the project can be delayed due to the owner's lack of financial support. Again, this is subjective, but it should be assumed that a time-critical project requires fast-tracking and methods that could help streamline design and coordination processes.

Owner Experience

Of the criteria in the PDSS Model, owner experience is the most important. Experienced owners know how to "well-define" a scope, how to limit change orders, and most importantly, how to make quick, best-value decisions for their respective projects. But exactly what does the owner have to be experienced in to achieve the "experienced" path? Does the owner need to be experienced in the type of building, type of delivery method, or type of construction? I assume that this asks if the owner is able to make the best decisions during the project that he/she is yet to take on. Owner experience is an aggregate of the past experiences/decisions that the owner had to make in the similar type of building. Again, this is a subjective topic.

Team Experience

Team experience is important to the outcome of the project as well. The experience of the contractor, architect, and engineers with the type of building is important to finding the typical systems and processes without constantly "reinventing the wheel". However, there are situations in which the team is experienced with itself and not experienced with the type of building that can turn good relationships bad.

Quality

Quality is the most subjective issue on construction projects. A contractor and an owner have two different ideas of "quality" and they require architects and engineers to find common ground. Quality can be construed as "high-technology", monumental design, durability, and the lifespan of the structure. Durability and lifespan of the structure cannot be ascertained until years after the project's completion. High-tech laboratories and monuments can be low-quality facilities compared to other facilities of the same likeness. Exactly what is above-standard vs. industry-standard?

Cost

Cost is all-critical on every project. If cost was not critical on a project, a project manager would not be needed on the project because the engineer could specify anything. Value engineering and cost-cutting processes would not be needed if cost was not even somewhat critical. The only difference on the importance of cost is initial costing vs. lifecycle costing. The difference between cost-critical and cost-noncritical items shown on the PDSS Model is negligible; few of the project deliveries are distinguished by cost.

Guide Criteria Amendments

The most subjective of the six criteria listed in the PDSS Model are project characteristics, quality, and cost. The other criteria can be adjusted to become more

specific, but their distinguishing characteristics will remain. The proposed amendments are financial emphasis, specifications, and type of funding.

Type of Funding

The type of funding (public vs. private) can directly affect the owner's ability to make timely decisions, to fund the project, and to mitigate the political risks associated with public projects. The private owner's ability to bypass the bureaucracy of the government's decision-making process is the sole reason to the widespread growth of Public-Private Partnerships (PPP's). These partnerships allow the private entity to make small critical decisions without submitting the decision to a commission or committee of government/university officials.

The owner's ability to fund the project is greatly increased on public projects compared to private projects. Capital projects must be completed for growth and economic strategies of the government and will be completed even if the local government finds itself in financial turmoil. However, the payment process of the government may also be delayed since it is unlikely the contractor can sue the owner for damages.

The political risks associated with public projects can determine many projects' outcomes. For example, the political risks on the Seattle Monorail Project (SMP) were great and the public voted for the project to end. Administrations change hands and one administration could platform a referendum to halt a capital project of another's. The type of funding will replace the project characteristics to allow the two-page model to be divided public vs. private.

Specifications

The type of specifications can greatly differentiate the traditional methods from the design-builds. Performance specifications, typically used on design-build projects, provide the design professionals criteria in which design risks can be assigned to the design-builder. This risk greatly affects change orders on the project and the importance of cost-control to the owner.

Prescriptive specifications, typical with most building projects, cause the owner to maintain the risk of the designers that he/she employs. A "bad" set of documents can really be problematic for a project in the areas of scope definition and change orders. The type of specifications will replace the quality in order to decrease the subjectivity of the model.

Financial Emphasis

The financial emphasis (initial-cost vs. lifecycle cost) bring together the owner's financial situation and program goals in an accurate assessment of the importance of cost control. The owner's financial situation will stipulate whether the owner is trying to develop a property to sell, which affects the quality of the building, or if the owner is trying to build a monument (a building that lasts forever). If the owner is under a tight O&M cost schedule with his/her buildings, the owner may make decisions to insure the best long-term investment. The O&M area hints to the owner's program goals, for which the project team must be counterpart to. The financial requirements area will replace the inconsequential cost section of the PDSS Model.

The Integrated Project Delivery System Selection Model (IPDSS)

This project delivery system selection model integrates all of the traditional and design-build methods of construction. The three amended criteria make the IPDSS effective in differentiating the design-builds from the traditional methods of construction. As shown in the following table, it is difficult to compare the design-builds with each other, but the application of the table to the IPDSS model shows the comparison. The comparison of the traditional methods as analyzed by Vesay have remained the same in most aspects since time, owner experience, and team experience were the largest differentiating factors in Vesay's PDSS model.

The application of DBOM/BOT to public projects assumes that its use is legal according to the IPDSS model. In many states, the DBOM/BOT initiative has not been fully recognized by the government, although it is forecasted that these delivery methods will become universally-accepted. Also, performance specifications usually require pre-qualification of bidders and a longer pre-bidding program design by the owner. The owner should consider the advantages/disadvantages of performance specifications while consulting this IPDSS model.

Criteria Comparison for IPDSS Model

Criteria	Criteria Range	Delivery Method
Type of Funding	Public	BOT
		DBOM
		DB
	Private	DBB
		CM@Risk
		CM Agent
Schedule	Fast-track	DBOM
		BOT
		DB
	Normal	CM@Risk
		CM Agent
		DBB
Owner Experience	Experienced	CM@Risk

		CM Agent
		DBB
	Inexperienced	DB
		DBOM
		BOT
Team Experience	Experienced	BOT
		DBOM
		DB
	Inexperienced	CM@Risk
		CM Agent
		DBB
Specification	Performance	BOT
		DBOM
		DB
	Prescriptive	CM@Risk
		DBB
		CM Agent
Financial Emphasis	Initial Cost	DBB
		CM@Risk
		CM Agent
	Lifecycle Cost	DB
		BOT
		DBOM

Figure 55: The six criteria are compared in this chart to show the comparable nature of the three amended criteria. In each criteria, the design-builds are consistently different than that of the traditional methods.

IPDSS 1.1: Integrated Project Delivery System Selection Model (Public Projects)

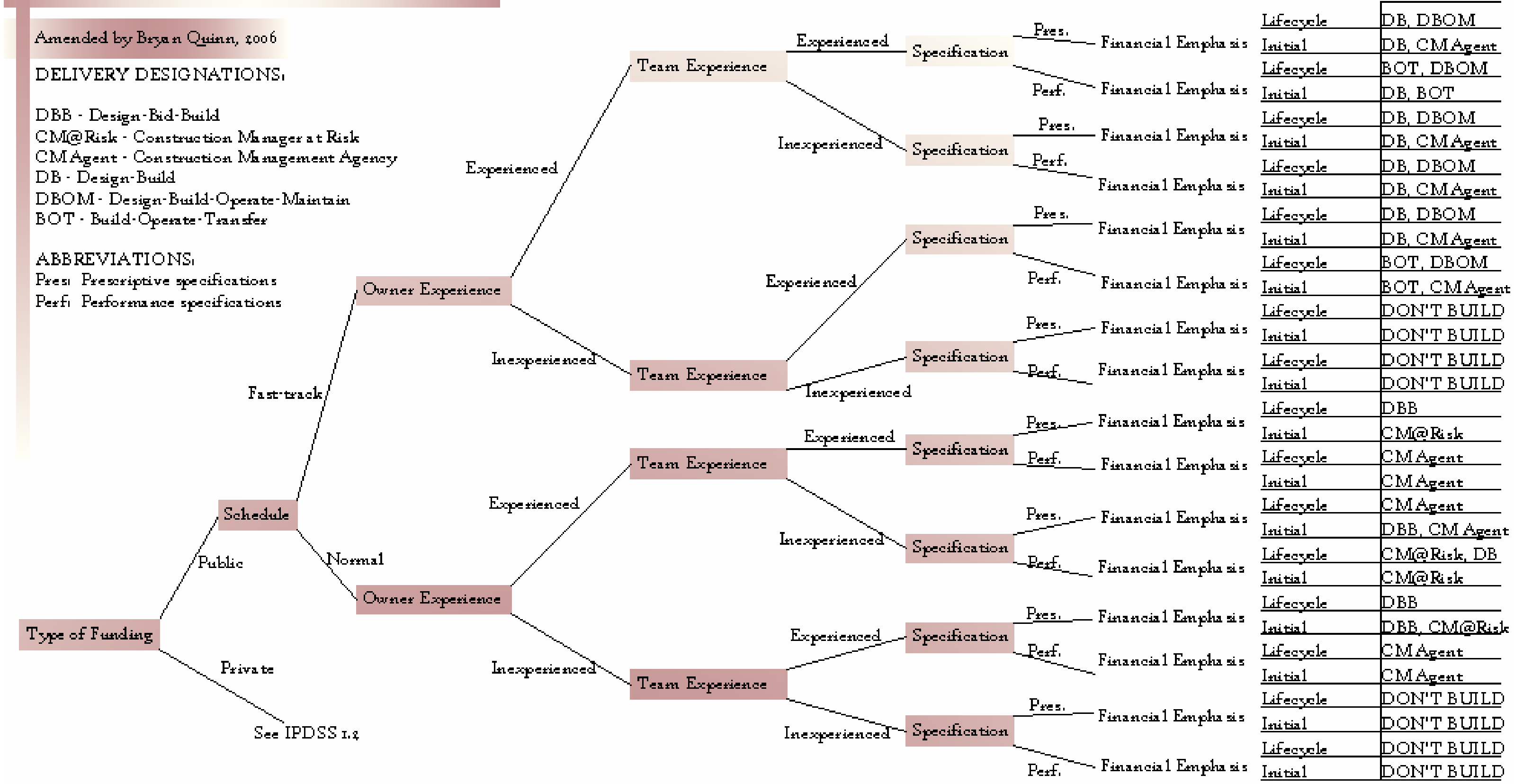
Based on the PDSS Model by Anthony Vesay, 1994

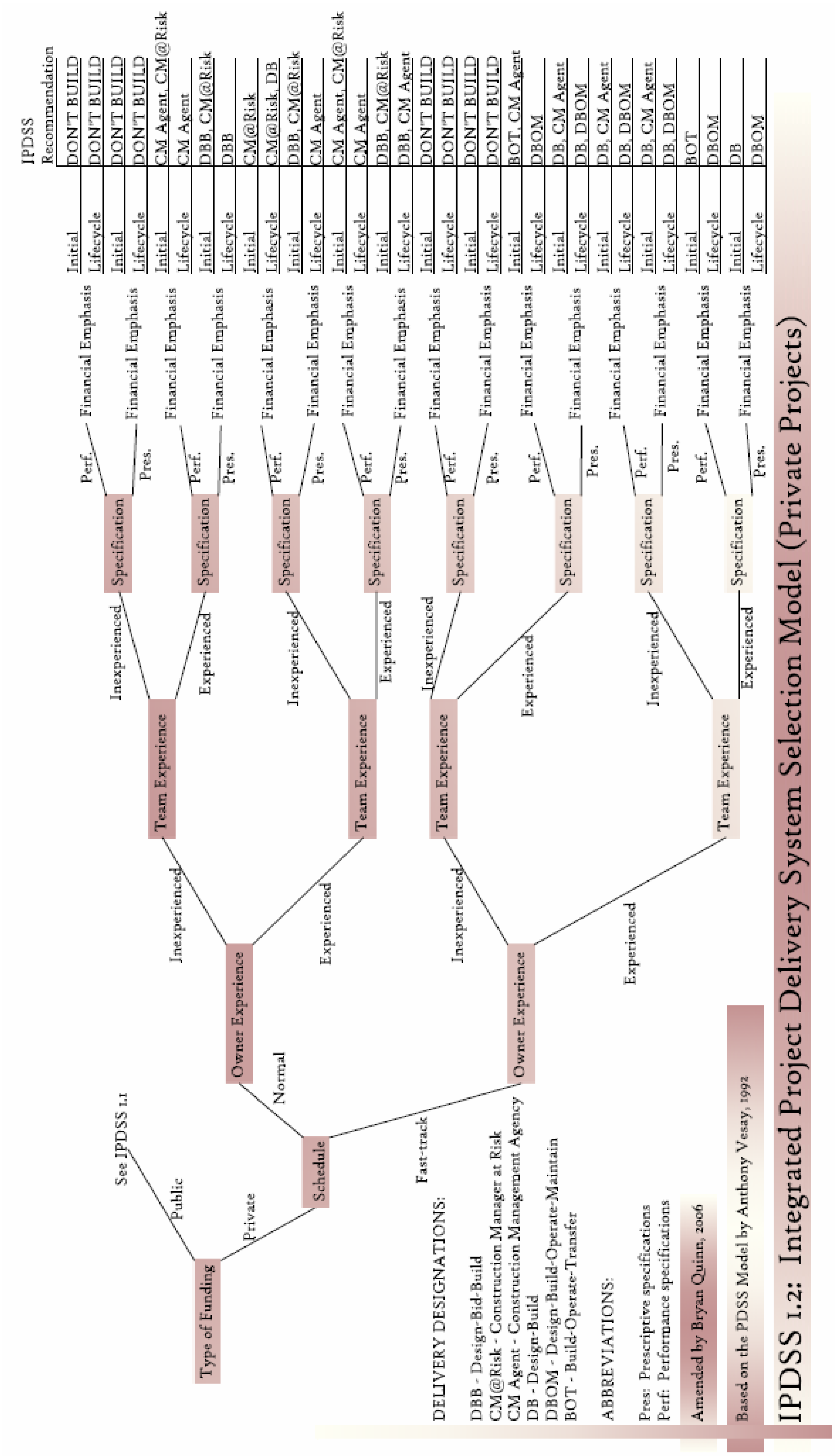
Amended by Bryan Quinn, 2006

DELIVERY DESIGNATIONS:

DBB - Design-Bid-Build
CM@Risk - Construction Manager at Risk
CMAgent - Construction Management Agency
DB - Design-Build
DBOM - Design-Build-Operate-Maintain
BOT - Build-Operate-Transfer

ABBREVIATIONS:
Pres: Prescriptive specifications
Perf: Performance specifications




IPDSS 1.2: Integrated Project Delivery System Selection Model (Private Projects)
Type of Funding
Public
See IPDSS 1.1
Private
Schedule
Normal
Fast-track
Owner Experience
Inexperienced
Experienced
Team Experience
Specification
Perf.
Pres.
Financial Emphasis
Initial
Lifecycle
IPDSS Recommendation
DON'T BUILD
CM Agent, CM@Risk
CM Agent
DBB, CM@Risk
DBB
CM@Risk
CM@Risk, DB
DBB, CM Agent
BOT, CM Agent
DBOM
DB, CM Agent
DB, DBOM
BOT
DB
DELIVERY DESIGNATIONS:
DBB - Design-Bid-Build
CM@Risk - Construction Manager at Risk
CM Agent - Construction Management Agency
DB - Design-Build
DBOM - Design-Build-Operate-Maintain
BOT - Build-Operate-Transfer
ABBREVIATIONS:
Pres: Prescriptive specifications
Perf: Performance specifications
Amended by Bryan Quinn, 2006
Based on the PDSS Model by Anthony Vesay, 1992

IPDSS Conclusion

In order to create an owner's guide to DBOM/BOT, Vesay's 1992 PDSS model was amended in three categories to effectively compare the design-builds and the traditional methods. The three amended criteria, the type of funding, specification, and financial emphasis, helped shape my Integrated Project Delivery Selection System (IPDSS) into a valuable tool for owners who are hesitant to use DBOM/BOT. The culmination of the case studies, JHUCC analysis, and owner's guide show how DBOM/BOT has been tested, has been effective, and can be used on many applicable building projects.

The PDSS is an ever-changing document because as more methods of delivering construction projects surface, the decision-making process for the owner will change. The IPDSS is an attempt to continue making easy-to-understand documents for owners so that they can make the most-informed decisions. These informed decisions will result in better construction projects and relationships.

References

Smith, Nancy C. and Castellana, Philip. January 2004. "DBOM Update, Independent Evaluation of Alternative Approaches Relating to Operations and Maintenance Component of DBOM Contract for the SMP Green Line." Paper presented to SMP Board.

Cracchiolo, Anthony and Simuoli, Victor. 2004. ASCE: Moving Through the Millennium: Automated People Movers VIII. JFK AirTrain: Project Management Issues on a Large DBOM Project.

Paulson, B.C. (1976). "Designing to Reduce Construction Costs." Journal of the Construction Division, 102(CO4): 588.

ENR, Feb 27,2006. Volume 256, Number 8

Construction Research Congress 2005 – Paper 7547, Risk Management on Build-Operate-Transfer Projects. John E. Schaufelberger. Copyright ASCE 2005.

Dahl, Peter and Horman, Dr. Michael et al. Evaluating Design-Build-Operate-Maintain Delivery as a Tool For Sustainability.

Masucci, Maury and Freidheim, Kitty. Airport Owners' Guide to Alternate Project Delivery Systems.

Anonymous Author. White Paper: Project Delivery Methods - Buckman Diversion Project.

Miller, John B. and Garvin, Michael J. et al. Toward a New Paradigm: Simultaneous Use of Multiple Project Delivery Methods. Journal of Management in Engineering, Vol. 16, No. 3, May/June, 2000. Copyright ASCE.

Dahl, Peter. "Finding a Leaner Approach to the Airport Project Delivery Process" The Pennsylvania State University AE Senior Thesis.

Ritchie, Walter D. Alternative Project Delivery. Copyright ASCE 2004.