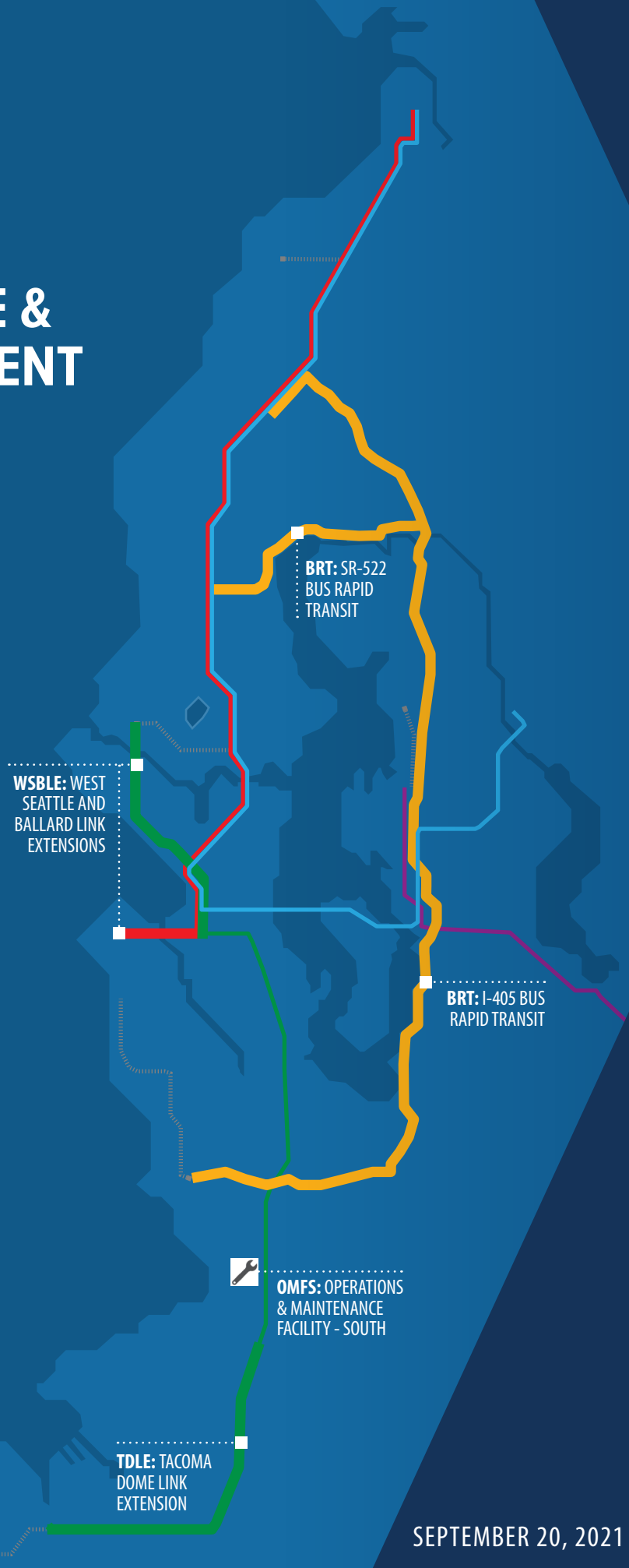
SOUNDTRANSIT

ST3 COST ESTIMATE & GENERAL ASSESSMENT SERVICES

TASK 3: Review and Recommendations for Management Methodology



PREPARED BY

Triunity, Inc.
Ott-Sakai & Associates, LLC
Commonstreet Consulting
Capo Projects Group
Arcadis

TRIUNITY

SEPTEMBER 20, 2021

Report Draft Issue Date: August 23, 2021

Report Final Issue Date: September 20, 2021

INTRODUCTION

In January of 2021 estimates were provided to Sound Transit (ST) Board of Directors (Board) indicating substantial increases in the cost to complete the ST3 expansion program. These increases, combined with reduced revenues because of COVID-19, required adjustment to the original timelines for completion of ST3, which were approved by the Board in August 2021. Through this realignment process and after gaining input from the public and partner organizations, the Board has established clear expectations about updated project delivery timelines.

To confirm affordability of the ST3 plan, the Board retained a team led by Triunity, Inc. with team members Ott-Sakai & Associates, Commonstreet Consulting, Capo Projects Group, and Arcadis (Assessment Team) to perform three tasks with a report to the Board as a deliverable for each of the tasks:

- **Task 1:** Review, analyze, and prepare an independent assessment of the cost estimate trends for specific ST3 capital projects.
- **Task 2:** Programmatic review and analysis of the agency's cost estimating methodology used to develop the ST3 construction and real estate estimates.
- **Task 3:** Review of and recommendations for the management methodology.

This report is the final deliverable for **Task 3.**

AGENCY

Sound Transit Board of Directors
401 S. Jackson Street
Seattle, WA 98101

TABLE OF CONTENTS

1.0 – EXECUTIVE SUMMARY

ST3 represents one of the most ambitious transit programs in the country. The Sound Transit Board and staff have shown their realization of this by implementing structural changes and adopting policies and procedures to address this challenge. This report provides another input to this effort to ensure the successful delivery of this important program.

This report is the deliverable for Task 3 in the Cost and General Assessment reports to the Sound Transit (ST) Board of Directors (Board). The first deliverable provided a review, analysis, and preparation of an independent assessment of the cost estimate trends for specific ST3 capital projects. The second deliverable focused on the programmatic review and analysis of the agency's cost estimating methodology used to develop the ST3 construction and real estate cost estimates. This Task 3 deliverable is focused on review and recommendations for the ST3 program management methodology for the ST3 Program with West Seattle and Ballard Link Extensions (WSBLE) serving as the case study.

As part of the ST3 Program, WSBLE is a large complex megaproject that is currently projected to cost more than $12 billion. WSBLE is currently in the planning phase at approximately 10% design with the Final Environmental Impact Statement (FEIS) anticipated to conclude in 2023. The Assessment Team has completed an evaluation of the project management oversight structure for WSBLE with a review of the project and agency organization including current and in-process organizational changes, relevant documentation, and interviews with ST staff. Our key observations and recommendations are summarized here with further commentary and explanation in the body of the report. It is intended that any recommendations resulting from our case study review of WSBLE can be applied program-wide on ST3 and to other ongoing or future ST projects where feasible.

After publishing the draft report, ST Board members and staff provided comments which were incorporated in this the final report.

All our recommendations are summarized in Appendix A. However, our key observation is that the agency has been actively working to improve the structure, enhance communication, streamline policies & procedures, and expedite reporting even before our first report. As can be seen in Appendix A, many of our recommendations were already in process by ST. Those in process should continue to be incorporated while the rest should be reviewed by the Board and considered for implementation by ST staff.

1.1 List of Acronyms

The following acronyms are used throughout the document:

- AHJ – Authority Having Jurisdiction
- BART – Bay Area Rapid Transit
- BRT – Bus Rapid Transit
- CCB – Capital Program Change Control Board
- CMGC – Construction Manager/General Contractor
- COVID-19 – Coronavirus Disease 2019
- DB – Design Build
- DBB – Design Bid Build
- DECM – Design, Engineering & Construction Management Department
- DEIS – Draft Environmental Impact Statement

- EIS – Environmental Impact Statement
- FEIS – Final Environmental Impact Statement
- FHWA – Federal Highway Administration
- FTA – Federal Transit Administration
- PCPP – Program Control Polices & Procedures
- PDB – Progressive Design Build
- PEPD – Planning, Environmental & Project Development Department
- PMP – Project Management Plan
- PSO – Portfolio Services Office
- P3 – Public Private Partnership
- ROD – Record of Decision
- ROW – Right of Way
- SEIP – Systems Expansion Implementation Plan
- ST – Sound Transit
- ST2 – Sound Transit 2 Systems Expansion
- ST3 – Sound Transit 3 Systems Expansion
- VE – Value Engineering
- VTA – Valley Transit Authority
- WSBLE – West Seattle and Ballard Link Extensions
- WSDOT – Washington State Department of Transportation

2.0 – BACKGROUND AND APPROACH

2.1 Purpose and Information Gathering

The purpose of this Task 3 assessment is to review the project management oversight structure for the WSBLE project as a case study and to make specific recommendations for improvement in oversight process and risk management, which may be applied to the entire ST3 Program and ongoing or future ST Projects. This was accomplished by conducting a review of relevant ST program documents, organizational charts, industry practices, and several interviews with ST staff and project teams. After publishing the draft report, ST Board members and staff were provided opportunities to review and comment. These comments were incorporated into the final report where applicable.

2.2 Current Policies & Procedures at Sound Transit

Several key policies and procedures were reviewed by the Assessment Team to gain a better understanding of management methodology. These are described in some detail in the following paragraphs.

1. ST has several Policies & Procedures and program-wide Plans and Policies. Some of these documents are developed and utilized at the departmental level while others are intended to function across the entire organization. The ST Program Control Policies & Procedures (PCPP), for example, were developed by the Project Controls unit and are primarily applicable to the work of the Planning, Environmental & Project Development (PEPD) department, the Design, Engineering & Construction Management (DECM) department, and the newly formed Portfolio Services Office (PSO). Other plans, such as the ST Five-Year Agency Strategic Plan, are developed within the Executive Branch by the Strategic Business Services Office and pertain to the entire agency. There are many such examples, but a complete review of all Policies & Procedures and Plans and Policies was not performed as part of this Task. However, the documents that were reviewed provided key insight into the management methodology.

2. WSBLE Project Management Plan (PMP) is the overarching project implementation plan that will ultimately span the entire project period (presently it just covers the project through planning). It describes approved policies, practices, and procedures related to the management, design, and construction of the project. All federally funded transit projects require a PMP as outlined in FTA Oversight Procedure 20 (OP20) – Project Management Plan Review. The PMP elements are tailored to set forth the specific action plan for implementing the project, and managing the cost, schedule, quality, and associated risks. FTA expects that Sponsor's PMP are based on a thorough understanding of risk-informed and sound project management strategies and plans. It should define the adequacy of the legal and administrative capabilities as well as its management capacity and capability to execute the project effectively and efficiently in all its aspects, including planning, design, construction, testing, and revenue operations.

3. An important part of that methodology is the Phase Gate Program. It is employed by the agency to progress projects through various phases of development and milestone "gates." The current program consists of six different gates that represent major milestones in the project development, such as initiation, design, construction, operations, and others. Once a project passes through a given gate, Board action is sometimes required; for example, the project team must seek approval from the Phase Gate decision-maker before going to the Board for the baselining action. The Phase Gate decision-makers are responsible for approving project team readiness and consist of agency-wide representation as determined for each individual project and Gate. The Phase Gate executive sponsor is the Executive Director of PSO.

The six levels of the phase gate program are represented in Figure 1 below. Currently WSBLE is in Phase Gate 1, entering Phase Gate 2 once the delivery method is chosen.

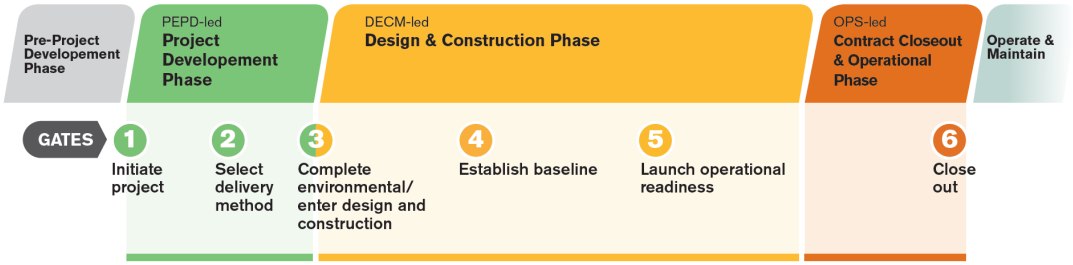


Figure 1: Phase Gate Program Overview

4. The capital program Change Control Board (CCB) is intended to evaluate and process changes to projects, contracts, agreements, procurements, and baseline documents for capital projects. This function was previously led within DECM by Project Controls but now resides within the PSO. The CCB convenes regularly and is composed of a group of voting members representing PSO, DECM, PEPD, finance, procurement, and operations who are responsible for evaluating, processing, and approving contract changes within the financial thresholds defined by the Board and executive leadership.

2.3 Organization and Oversight Structure

The agency and program team organizations are robust and staffed with highly qualified professionals and subject matter experts. Earlier this year, ST underwent reorganization of staff to develop the new PSO department, which moved oversight of critical processes of project controls, engineering, and activation from other departments and increased responsibility of delivery to the project delivery teams, including embedment of some PSO functional staff within those delivery teams. Early planning documents (Fall 2020) defines the PSO as such:

- The overarching function is to provide core services including agency-wide tools, systems, and processes in support of the system expansion and service delivery lines of business. It also has a secondary but essential role to provide oversight of those functions.
- The PSO will maintain a core value of working collaboratively to seek win-win solutions. In fulfilling its mission, the PSO will establish, in an accessible form, standards, guidelines, and processes in support of the system expansion and service delivery lines of business. The goal is to embed efficiency and clarity into systems to the benefit of riders and taxpayers.
- Project-deployed staff will report directly to their project teams. The PSO will serve as a home base between projects, with the goal of retaining talented staff prior to them being redeployed to newly assigned project(s).

The existing departments that are most affected by this change are PEPD and DECM. Within PSO, the three prime units reporting to the PSO Executive Director are Project Controls, Engineering, and Portfolio Management & Integrity. PEPD, DECM, and PSO report directly to the Deputy CEO. The PSO functional organizational chart is attached as Appendix B.

The WSBLE organization that was implemented in the planning phase for WSBLE remains intact and was not specifically subjected to the reorganization earlier this year. This planning phase specifically includes development of the Draft Environmental Impact Statement (DEIS) and conceptual design work and is supported by the consultant

team led by HNTB Corporation. The project delivery organization for WSBLE is a cross-functional team composed of ST staff and consultants and is intended to be co-located subject to restrictions imposed by COVID-19. The PMP for WSBLE is in place for the planning phase, serving as the prime reference for managing the current phase of WSBLE. It is intended that the PMP will be amended periodically as needed while progressing through the various phases of development.

WSBLE initially employed a project leadership approach (hereinafter, "project director triangle") whereby the team leadership comprises three Project Directors representing the three functional units of Planning & Environmental Review, Final Design & Construction, and Operations; each director takes the lead when the project is in the phase of their functional unit. For example, WSBLE (presently in planning) is being led by the PEPD Lead. This is shown graphically below in Figure 2 taken from the ST's System Expansion Implementation Plan (SEIP) from December 2017. ST is currently contemplating a pilot project for the Bus Rapid Transit (BRT) program that will employ the project director triangle along with a Program Executive to lead the program through all phases, planning through construction and into operations, acting as a single point above the triangle. This is intended to create continuity and to establish a single source of accountability for the program through all phases and to provide consistency throughout project development. Other projects in ST3 may employ this concept of providing a Program Executive to stay with the project for its lifespan.

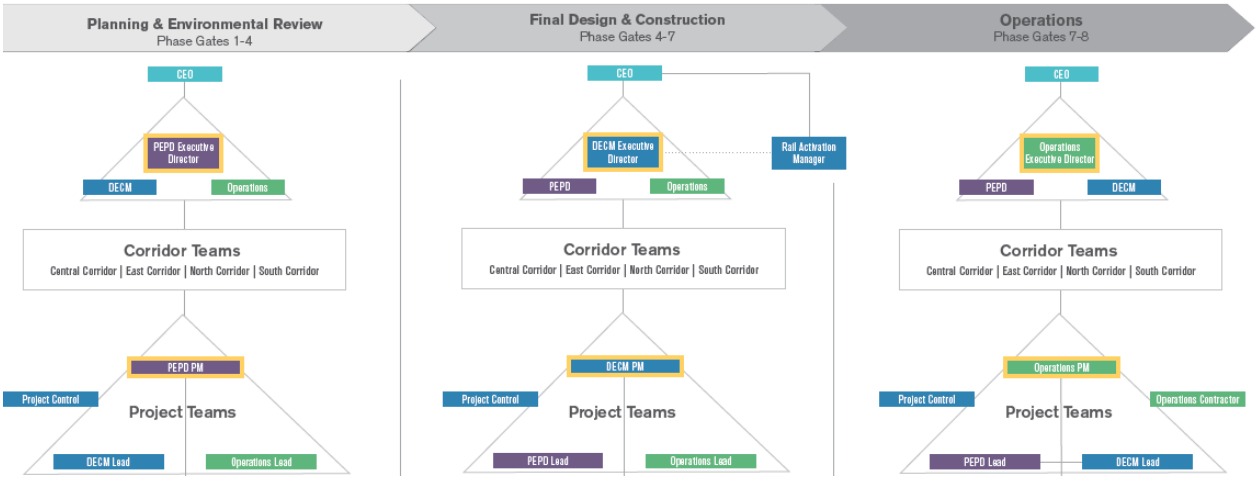


Figure 2: Program and Corridor Organizational Chart

2.4 Interviews with ST Staff and WSBLE Team

Of ST's approximately 1200 employees, approximately thirty were interviewed for the Task 3 report. Interviews were conducted across the agency with representatives from Executive Leadership, Procurement and Contracts, PEPD, DECM, PSO, and Operations. In addition, representatives from the WSBLE consultant team were interviewed.

Interviews were led by a panel from the Assessment Team with some follow-up questions in subsequent discussions. A series of typical questions were discussed along with specific questions related to the interviewee's area of expertise. Information gathered from these interviews was instrumental in forming the basis for our observations and recommendations related to this Task. In many cases, there were common themes detected from these interviews that further help reinforce our observations and recommendations.

3.0 – OBSERVATIONS

3.1 Policies and Procedures

1. ST employs many Project Control Policies and Procedures (PCPP) to guide project standards. The Assessment Team performed a review of the PCPP and found it to be robust and at or above industry standards. The PCPP consists of 22 separate procedural documents that are each updated separately, as needed, and cover a wide range of subjects relevant to Project Controls and Development including cost estimating, scheduling, change control, risk management, value engineering, and others. Some Policies & Procedures appear due for an overhaul while others may require fewer amendments to align with the new organizational structure resulting from standup of the PSO department and related changes to project delivery responsibilities. Also, clarifications may be required such as the procedure for probabilistic cost estimating related to current industry practice and the requirements of the Federal Transit Administration's (FTA) Risk and Contingency Review Oversight Procedure (FTA OP40).

   Updates to the PCPP are initiated within the Project Controls unit, processed formally within the ST CCB, and signed off by the Executive Directors from DECM, PEPD, and other relevant ST Director Level staff depending on the subject area.

2. Policies & Procedures pertaining specifically to Engineering Design and Construction Management have been previously developed and it is understood that they are subject to similar administrative procedures referred to above with respect to the PCPP. The Engineering Design criteria that were developed under DECM is now managed within the Engineering group in PSO. Specific procedures related to Construction Management remain within DECM. These Engineering Design and Construction Management Policies & Procedures were not reviewed as part of this Task; however, it is understood that these are currently being evaluated for necessary amendments with a specific focus on project delivery methodology and opportunities for cost savings.

Based on interviews with ST staff, some feel that there are an overwhelming number of Policies & Procedures across the agency and that there is a lack of understanding among some staff regarding how all these documents are intended to be applied or whether they are consistent with current business practices and preferred approaches for project delivery. This is not atypical for a large organization such as ST, and while the project director triangle described in Section 2.3 has helped open communication greatly across departments, there is still an opportunity for the PSO to introduce new consistency across the ST3 program with respect to these Policies & Procedures. Specifically, a team alignment process, elements of which have been initiated with the introduction of the new PSO structure, should be used to align people and processes, to help meet strategic goals and objectives, and to clarify and reinforce alignment of roles, responsibilities, communications, and working relationships.

3.2 WSBLE

3.2.1 WSBLE Program and Project Controls

WSBLE is currently in the planning phase and at approximately 10% design (Phase Gate 1 almost to Phase Gate 2 when the delivery method is chosen). There is an integrated schedule and an environmental & early design budget for WSBLE; however, consistent with current processes, a baseline budget will not be established until the projects progress through Phase Gate 4. Project Controls on WSBLE have been limited in the early planning phases as these

functions are more typically employed after Phase Gate 4 when the project budget has been established. ST typically sets the budget and schedule once 60 percent design is achieved or Phase Gate 4. It is anticipated that WSBLE may be broken into several separate projects and phased with different delivery dates per segment. This is contemplated with the ST3 program realignment, which was approved by the Board in August 2021. According to ST staff, WSBLE has been delayed for various reasons including COVID-19, delay with agency partner's reviews, and the realignment process. Part of realignment included establishing new schedules for delivery of the ST3 Program.

ST has a comprehensive procedure for determining the appropriate project delivery method(s) and contract packaging to pursue for each project. Draft recommendations for the WSBLE delivery method are presently in discussion by ST staff and partners. Project delivery methods and contracting strategies can have a major impact on many aspects of project implementation, such as organization, staffing, processes, schedule, and, potentially, cost. As in any major program, these decisions need to be thoroughly evaluated and should consider the full complement of alternatives ranging from design-bid-build (DBB), construction manager/general contractor (CMGC), design build (DB), progressive design build (PDB) to P3. Potential carve-outs (separate contracts) for things such as systems, parking garages, etc., are also important decisions.

3.2.2 Organization and Leadership on WSBLE

Employing an Executive Project Corridor Director for WSBLE with a project director triangle representing DECM, PEPD, and Operations has been useful in engaging key components of planning, design & construction, and operations in early decision making and project development. The WSBLE team, in general, appears well staffed, well managed, and highly competent. Additional collaboration from Operations and Real Property, and the planned inclusion of PSO functional staff directly in the project teams, as presently underway by ST will help improve this further. There is uncertainty among ST staff on if this leadership structure will change or be retained as WSBLE progresses through future phases of work, although this may be informed by a decision on delivery method. Based on past practice and the System Expansion Implementation Plan, overall leadership during the design and construction phases will transitions from PEPD to DECM.

There is good cohesion and morale across the project teams, including the WSBLE Phase 2 Consultant Team. The direct impacts on WSBLE from COVID-19 appear to be limited as the project team continues to collaborate well remotely. The Assessment Team did have one person indicate that morale outside of project teams could be low. This may be an isolated issue or may be specifically related to the difficult times due to realignment, the pandemic, remote work, and/or economic uncertainty. The Assessment Team did not specifically ask questions about morale.

3.2.3 Environmental Planning

WSBLE is currently a planning effort and the DEIS is expected to be published later this year. The ST Board has identified the preferred alternatives for the majority of the WSBLE alignment. The ST Board has the sole authority to identify preferred alternatives. This last critical step should be determined as soon as possible to eliminate the potential of additional delay.

The ST System Expansion Implementation Plan from 2017, Strategic Initiative 2, states the following:

> *For major projects requiring environmental review and multiple alternatives, a reasonable range of alternatives must be studied in compliance with National Environmental Policy Act and State Environmental Policy Act, and Sound Transit staff and the Board must keep an open mind about all such alternatives until the completion of environmental review. However, staff will ask the Board to identify the preferred alternative at the end of the alternative development process and prior to starting preparation of draft environmental documents, having considered recommendation on this topic from the Leadership and Stakeholder Groups.*

Multiple alternatives were identified for study in the DEIS, based on the alternative development process. These alternatives were informed by evaluation of many factors including planning, environmental, and engineering considerations and stakeholder feedback including the recommendations of a Stakeholder Advisory Group and Elected Leadership Group. Pursuant to FTA direction, fiscal constraint of an alternative is no reason alone to pull the alternative from the environmental review. For that reason and others, ST staff should study all alternatives identified by the Board in the EIS so that whatever ST can afford to build will have been through the requisite environmental clearance. This approach may have the effect of creating an unaffordable project and sets up unrealistic expectations for the stakeholders and public. ST has previously noted that any costs for elements potentially beyond the scope identified in the ST3 Plan could be borne by third party funding commitments. This concept is outlined in the initial Partnering Agreement between ST and the City of Seattle. This Partnering Agreement also contemplates scope and risk reduction measures in the event of fiscal limitations. Furthermore, "agreement on scope changes and local contributions will be memorialized in the preferred alternative concurrence document or other agreements as mutually determined by the Parties."

All parties should recognize that the planning phase provides the greatest opportunities for significant cost savings. Once the environmental process is complete and memorialized in a Record of Decision (ROD), opportunities for change are limited and are more technical and incremental in nature. Selection of track alignments (at-grade, overhead, tunnel), grade separations, etc., are the most significant drivers of cost.

3.2.4 Stakeholders

WSBLE is currently fully contained within the boundaries of the City of Seattle and, therefore, the City is the prime authority having jurisdiction (AHJ). Other stakeholders are identified in the DEIS, but the prime permitting role for construction of WSBLE resides with the City of Seattle. The WSBLE team is currently working with City staff to develop a permitting plan that is intended to help streamline the process as the work moves further through engineering and construction. The initial Partnering Agreement between ST and the City for WSBLE was executed in January 2018 and provides a framework for how the parties intend to work together on project development.

The FTA is the prime Federal stakeholder and will be responsible for issuing the ROD at the end of the EIS process. This is necessary before the work may proceed to final design and construction. The FTA is currently engaged in reviewing the DEIS.

3.2.5 Right of Way (ROW)

The Assessment Team's observations with regards to ROW cost estimating and methodology have previously been summarized in the Task 1 and Task 2 reports, indicating that the Real Property group could have been more involved early on, potentially resulting in more accurate cost estimates. The lack of involvement at that stage was due to the agency's focus on acquisitions for ST2 projects that were then in the construction phase. Our understanding now is that real property staff is assigned on WSBLE to support all work related to ROW planning, estimating, and acquisition, and may assist in evaluating key project decisions made during the planning phase. Real property support is also provided through consultants serving the program.

The WSBLE team is considering a plan for early acquisition of critical real property that is needed to implement the work, and it is understood that parcels being considered for early acquisition would be required for any of the alignments currently being contemplated with the EIS. Early acquisition of ROW can mitigate risk related to schedule delay and cost escalation; however, there is also a risk that property takes could later be deemed unnecessary. This must be considered when making the case for early acquisitions. Consistent with the System Expansion

Implementation Plan, the WSBLE team has identified potential early acquisitions it intends to pursue once the Board has formally identified the preferred alternative and FTA approves property purchasing.

3.3 Portfolio Services Office (PSO)

The primary purpose of the PSO is to provide needed consistency in functional oversight of the ST3 program and its associated projects, including WSBLE, through Project Controls and refinement of program-wide policies, procedures, and internal governance. This oversight function could serve as independent oversight of the entire portfolio of ST3 projects and beyond, in addition to supporting the Engineering functions at the project level as needed with staff resources. The PSO will develop standards and guidelines for all project teams including new design criteria. Enabling Project Controls to function independently from PEPD and DECM is viewed positively across the organization.

The PSO is in the early stages of development and not all functions are fully implemented. The Assessment Team does not believe the PSO structure has been fully implemented on WSBLE thus far because PSO is new to this project that has been ongoing for over 2 years. Currently PSO is functioning primarily as a staff resource group. Key resources from within PSO need to be fully utilized by WSBLE and other project teams, although presently key positions within PSO remain unfilled.

Historically there has not been an annual evaluation of the complete portfolio of ST projects; however, this process is being addressed with the recent realignment resolution with the Board. This is expected to improve fiscal control and decision making across the ST3 program and assist the Board in budgeting and policy decisions. It is anticipated that PSO will be directly involved in the annual program review as approved in R2021-05 and Project Controls is specifically suited for this effort.

3.4 Risk Management

ST PCPP-13 Project Risk Management guides the project risk management planning and implementation at ST and WSBLE and includes consideration of qualitative and quantitative identification of risk and its related influence in probable cost outcomes. The latter is important in generating risk-based cost estimates, which are encouraged by FTA Oversight Procedure 40 (OP40) and are a standard practice for WSDOT, which requires a validated probabilistic risk-based cost estimate for all projects. As stated in PCPP-13:

> "*It is intended to provide a complete and consistent approach for project risk management planning as well as identify, categorizing, qualitatively assessing, prioritize, quantitatively analyzing, planning response for, allocating, monitoring, responding to, and controlling project risk through the design and construction of the project.*" Furthermore, PCPP-13 states: "*Risk management planning ensures that the level or scale, type, and visibility of risk management are commensurate with the nature and extent of a project's complexity, risk profile, and importance to the organization, the project's stakeholders, and its funding partners. Through planning, resource requirements for risk management are identified and the basis for evaluating and managing risk is defined. The risk management planning process is initiated early during project planning to ensure that risk management resources are available that the risk management standards can be effectively implemented.*"

According to the PCPP, at a minimum, a quantitative risk-based cost analysis is required at the time of Phase Gate 4 and may be required earlier at the direction of the Deputy Executive Director for Project Controls. Typical standards for risk management have been fulfilled in general for WSBLE. Some interviewees confirmed that they felt early risk management efforts on WSBLE could have been more robust, and it is unclear how risk-based costs were factored

into budget estimates consistent with the practice of other agencies and how anticipated risk mitigation costs were considered with respect to the early cost estimates.

The Project Controls unit has the expertise and resources available to provide sufficient project risk management and to help implement a risk-based cost estimating process. When necessary, the Project Controls team can rely upon outside consultants and subject matter experts who are highly specialized to support this work. In addition to implementing existing required procedures to assess and validate cost estimates at major project milestones, Project Controls could conduct additional interim assessments of key project cost and schedule drivers with the goal of providing earlier indications of potential cost and schedule risks to the project team, executive leadership, and the Board.

3.5 Change Control and Phase Gate

The capital program Change Control Board (CCB) has historically been managed from within DECM but now resides with PSO. The CCB is due for an overhaul and there may be opportunities to streamline activities between CCB and Phase Gate to improve efficiency and decision making.

The Phase Gate Program is currently managed within PSO, and issues with scalability of the program have been noted by ST staff. Currently, the CCB serves primarily as an administrative authority that processes change (change orders, policy, and procedure updates, etc.). The CCB does not significantly deliberate change issues. Decisions may have already been made on the change before it gets to CCB. The CCB does not function by looking forward to future potential changes in advance and then vetting and influencing changes by the committee.

3.6 Daylighting and Reporting

Historically there has been a challenge with reporting issues in a timely manner to executive leadership and the Board. This seems to be due to uncertainty of knowing when and where to report scope, schedule, or budget changes. This issue has recently been a major focus by the Agency as part of its continuous improvement program, which includes the creation of the PSO and monthly program briefings with executive leadership. Project Controls now has a variety of forums and reports to elevate issues of concern relating to cost or schedule. Additional interim assessments of key project cost and schedule drivers that will alert executive leadership and the Board of potential cost and schedule risks are being considered by the PSO.

4.0 – RECOMMENDATIONS

4.1 Policies and Procedures

ST Policies and Procedures are well developed and mature yet are due for a thorough programmatic review of agency requirements for optimization with the current environment, new organizational structure, and system requirements. Some areas require clarification, such as a process to use base cost validation and mandatory use of integrated cost and schedule quantitative modeling at early stages of project completion in PCPP-13.

It is recommended that the PSO group take the lead on an effort to streamline and update all relevant agency policies and procedures related to WSBLE and the ST3 program, including the Engineering Design Criteria and Construction Management procedures. The PSO has an opportunity to bring needed consistency program-wide and the PSO should be empowered to effectuate this needed change. This effort should consider all perspectives from project initiation, planning, procurement, engineering, construction, and operations with a serious focus on probable cost with value analysis, i.e., deliver the best product for the least cost that meets the intended purpose. Where feasible, customization should be minimized in favor of standardization. This effort should consider all potential project delivery methods that may be employed by ST and should be scalable for application to all kinds of projects, whether they are small or megaprojects.

It is recommended that Operations plays a prominent role in development of new standards related to WSBLE and the ST3 program. This should help to maximize operational efficiencies and passenger experience. Solicitation of input on new policies and procedures from outside sister agencies, consultants, and contractors is recommended as they can offer a unique perspective and understanding of how ST requirements may increase project costs. Policies & Procedures should be updated in time for any future procurement related to ST3 to ensure they form the basis of project development moving forward. Where possible, policies and procedures should be streamlined or eliminated if they do not align with current business practices or provide tangible benefit to the agency.

4.2 Program and Project Controls

The Project Controls unit within PSO should be utilized on all ST3 projects to define requirements and procedures for scope, schedule, and cost management and to serve a program support function, reporting up through the PSO and not the project. This should be consistent with the internal staff restructuring as defined in early PSO development documents (Fall 2020) and subsequent documents and department evolution. In collaboration with the project teams, Project Controls shall serve as a single source of truth on scope, schedule, and budget that can be relied upon by ST leadership and the Board for accurate information, whether it is perceived as good or bad news.

As recommended in the Task 2 Final Report, an annual program evaluation should be conducted on the ST3 projects. The Assessment Team understands that this is already underway per the Board's direction in the recent resolution (R2021-05). This should include development of standard reporting in a dashboard format with simplified graphics that can be used to communicate status with ST leadership, the Board, and program stakeholders. Reporting through the PSO to populate the dashboard data provides additional oversight to help ensure accuracy of all reporting along with standardization. Dashboard reporting should be continually maintained and updated by Project Controls with input from the project team with integration and oversight by PSO. This will ensure that real time information is available at any time to aid the Board and executive leadership in making sound, informed decisions.

Project team leadership and Project Controls should develop a short-term plan for implementing a thorough, focused cost validation as part of a risk-based probable cost estimate and Value Engineering approach that can be implemented before completion of the environmental process. Return on investment with Value Engineering has proven to be highest when utilized at the earliest phases of a project.

4.3 Organization and Leadership

A permanent Program Executive for all phases of project development makes sense for large programs to bring continuity and accountability. This individual would require strong planning, design, construction, startup, management, and political expertise to guide these long-term projects though-out its life cycle. Unless the individual with the resume suggested here is available, Sound Transit should continue to embrace the Project Director Triangle approach for ST3 projects and modify as appropriate on a project-by-project basis as determined by program leadership.

We understand that changes are in process related to delivery responsibility, functional support, and overall reporting. It is also understood that the project teams are now responsible for delivery consistent with the approved scope, schedule, and budget. As noted in the ENO Center for Transportation recent report regarding transit, "Setting a clear structure for organizational decision-making responsibility, as well as coordination with other agencies and transportation modes, is critically important to the success of a transit project…In Denver, a delegated authority approach for the region's FasTracks system expansion led to faster turnarounds on key decisions and fewer project delays." The Assessment Team recommends a Program Management Team or function be enabled, either within PSO or elsewhere, which would be responsible for program management of the entire ST3 program and accountable to ST executive leadership. A Program Director similar to the Denver model, could be employed to lead this function to serve as a single source of accountability to the Board and executive leadership for the ST3 program.

ST should recognize and budget for programmatic needs that do not always fit nicely with projects (i.e., megaprojects in transit take a long time to design and build, plus, given their complexity, there will always be late changes that are necessary for technical compliance or to enhance the passenger experience). Also, ST should consider "completion contracts" that have enough capacity to install such enhancements. This could alleviate pressures on baseline projects. More often than not agencies do not have the fiscal resources to hold funding that may not be needed, but, in the event that a pool of funding can be found, governance can be defined that allows any leftover funds to go toward project betterments that otherwise remained unfunded.

4.4 Environmental Planning

The Board should prioritize finalizing the identification of a preferred alternative for all projects as early as conceivably possible. This will serve to establish early project budgets. To support this effort, the ST3 project teams should work closely with stakeholders to finalize the preferred alternative concurrence documents, including any agreements for third party funding or necessary scope deferral due to fiscal constraints.

To improve transparency and accountability, it is recommended that a complete evaluation of project risk-based validated cost estimates be developed for each remaining ST3 project alternative currently under consideration. In addition, a focused effort to assess opportunities for cost reductions (including geometric track alignments) while the projects still in planning should be conducted. Participants should include members of the project team, project controls (including the value engineering group), experienced personnel working on current construction projects, and peer review members from other agencies or organizations to provide an outside perspective. This will also assist the Board in making a well-informed decision in selecting the project to be built and project delivery approaches.

4.5 Stakeholders

The current pursuit of a new Project Partnering Agreement with the ST3 project cities, identifying how project permitting will occur, is a positive effort and should continue to be prioritized by ST leadership. This should help minimize schedule delays attributable to land use and permitting review. The ST System Expansion Implementation Plan states that, "in order to provide greater clarity and predictability for local governments, ST is developing

standardized agreement principles to address planning and permitting." It is recommended that this effort be done in full collaboration with the ongoing efforts on all ST3 projects.

The ST System Expansion Implementation Plan also states that, "Funding for a permitting manager may be included for complex projects if Sound Transit determines that so doing would be a benefit to securing permit management services from a partner agency or jurisdiction." This is recommended to be pursued on all ST3 projects, especially those with unique complexities like WSBLE.

Overall stakeholder interface requires a great deal of management attention. In addition to the essential definitions of critical factors such as the permitting process defined in agreements, a focused effort to bring the cities in as more than just a permitting agency would pay dividends. Project teams should be doing this with their many stakeholders, as they are on WSBLE. This includes best practices such as partnering meetings including participation by senior management from both organizations, co-location, and even consideration of assigning portions of the work to the cities. If feasible, this could include parts of the work that the cities do well, such as street paving, traffic signals, etc.

4.6 Right of Way (ROW)

During the planning stage of ST3, prior to the ballot measure, the ROW unit was resource limited and needed more staff or outside expertise to support the ST3 estimates while staff were focused on delivering ROW for ST2. This lesson learned must be transferred to ST3 as the program moves into property acquisition. The critical work related to identifying and acquiring the necessary real property that will be required to implement the program is underway and property acquisition is commonly on a project's critical path. The Assessment Team understands that ST has moved to ensure adequate ROW resources are in place to support timely acquisition of real property on the ST3 program.

Project Team Leadership and the ST Director of Real Property should work closely to develop an early acquisition plan and deploy resources to implement. While a preferred alignment has not yet been finalized, there are common real estate parcels that have been identified on some of the projects as necessary for any of the alignments that remain under consideration. These parcels should be pursued as soon as permissible within the confines of Board Policy, FTA guidelines, and any other requirements. The Eno Center for Transportation has found that "early and prompt land acquisition can result in significant time and cost savings for projects" and, thus, is encouraged to be prioritized on ST3.

4.7 Portfolio Services Office (PSO)

The development of the PSO is a necessary step and provides great potential to introduce needed process consistency across the organization and ST3 program. The PSO is intended to serve ST and engage in program-level process oversight and reporting, which is currently needed. Thus far, the PSO is serving primarily as a resource group. It is critical that the PSO group's role and mission be solidified and communicated across the agency, and this is needed from ST executive leadership.

This planned structure of the new PSO represents a significant change in how ST manages its projects. As such, it is important to recognize the challenges of implementing significant change, particularly those related to organizational change. The new PSO must balance its role of supporting the project teams with needed resources and expertise with its role of independently reporting project status to executive leadership and the Board. Therefore, it is important to clearly define the goals and processes of the PSO to the entire team. Extensive communication between the PSO and project teams is essential, beginning with executive leadership and the department leaders communicating their vision for the new PSO group and how it will facilitate program success. The team alignment process, which we believe was initiated with the introduction of the PSO related changes and which is used by other Washington state agencies and

US Metro programs, is recommended. Additional information on team alignment is available and an index of key elements is included in Appendix C.

While written policies are important to define the PSO mission, facilitated workshops with the key players to openly discuss goals, potential issues and concerns, measures of success, any overlaps in responsibilities, reporting protocols, project decision-making, etc., are also important. Ultimately, the project teams and the PSO must work together in a collaborative manner where the Project Directors are responsible for the project consistent with appropriate decision-making authority, while the PSO provides the necessary functional resources and a related process oversight role. Both the PSO and project team should be in concurrence on the reporting by the PSO and project team, even when the information being reported is negative. Achieving these results may not be easy, especially at the beginning when the structure is new, but it is certainly possible with the commitment of ST executive leadership and the key participants.

4.8 Risk Management

It is recommended to reinforce risk assessment/management efforts and related risk-based probable cost and schedule analysis for ST3 projects immediately. This requires providing quantitative cost and schedule modeling earlier in the project phase and consistently across projects. Specifically, ST should define and implement a risk-based probable cost and schedule function with dedicated ST staff consistent with the requirements of FTA OP40 and best practices of related agencies such as WSDOT and FHWA. This includes defining a budget level consistent with such practices, the experience of related US and Canadian transit agencies, and implementation of base cost validation.

A thorough evaluation of all current potential risks including real property, environmental, engineering, procurement, constructability, materials, and operations should be conducted, and the risk mitigation matrix should be updated for all ST3 projects. The risk mitigation matrix should specifically identify individual ST staff who will be responsible for managing the risk items through resolution along with quantifying potential cost and schedule implications. While multiple alignment alternatives remain, individual risk assessments for a representative range of alignments should be performed to inform decision making.

Each project should also develop a risk allocation matrix that summarizes risks being assumed by ST and those being assigned to other parties, particularly contractors. The well-known industry practice defined for ST staff in PCPP-13 is that each risk should be assigned to the party best able to manage and control that risk. Past contracts and lessons learned will provide a baseline for risk allocation. However, the construction industry is changing quickly and it would be most beneficial to engage with contractors to understand their perceptions of risk and how risk allocation affects project bidding costs.

Currently, there is much flux in the transit construction industry that should be considered when determining the project delivery method. Particularly concerning is that many reputable contractors are treating large, complex, lump-sum rail transit projects as inherently risky and are either adding high levels of contingency in their bids, deciding not to bid, or aggressively pursuing claims. In any case, this has been a strong factor in the rising costs of rail transit projects – not just at ST. It would be valuable to engage with contractors in effective dialogue to understand their concerns, listen to their input, and proceed accordingly. Delivery methods are not a panacea, but it is important to tailor the delivery method and contracting strategies to the specific project and risk profile. The full range of delivery methods should be considered including DBB, CMGC, DB, PDB, and P3. It may be valuable for ST to review its recommended approach with an outside peer review, which Valley Transit Authority (VTA) recently did with its latest BART extension project that is similar in size and cost to the WSBLE project. The Eno Center for Transportation recommends that “US Agencies should similarly break up construction projects into manageable sections and cap

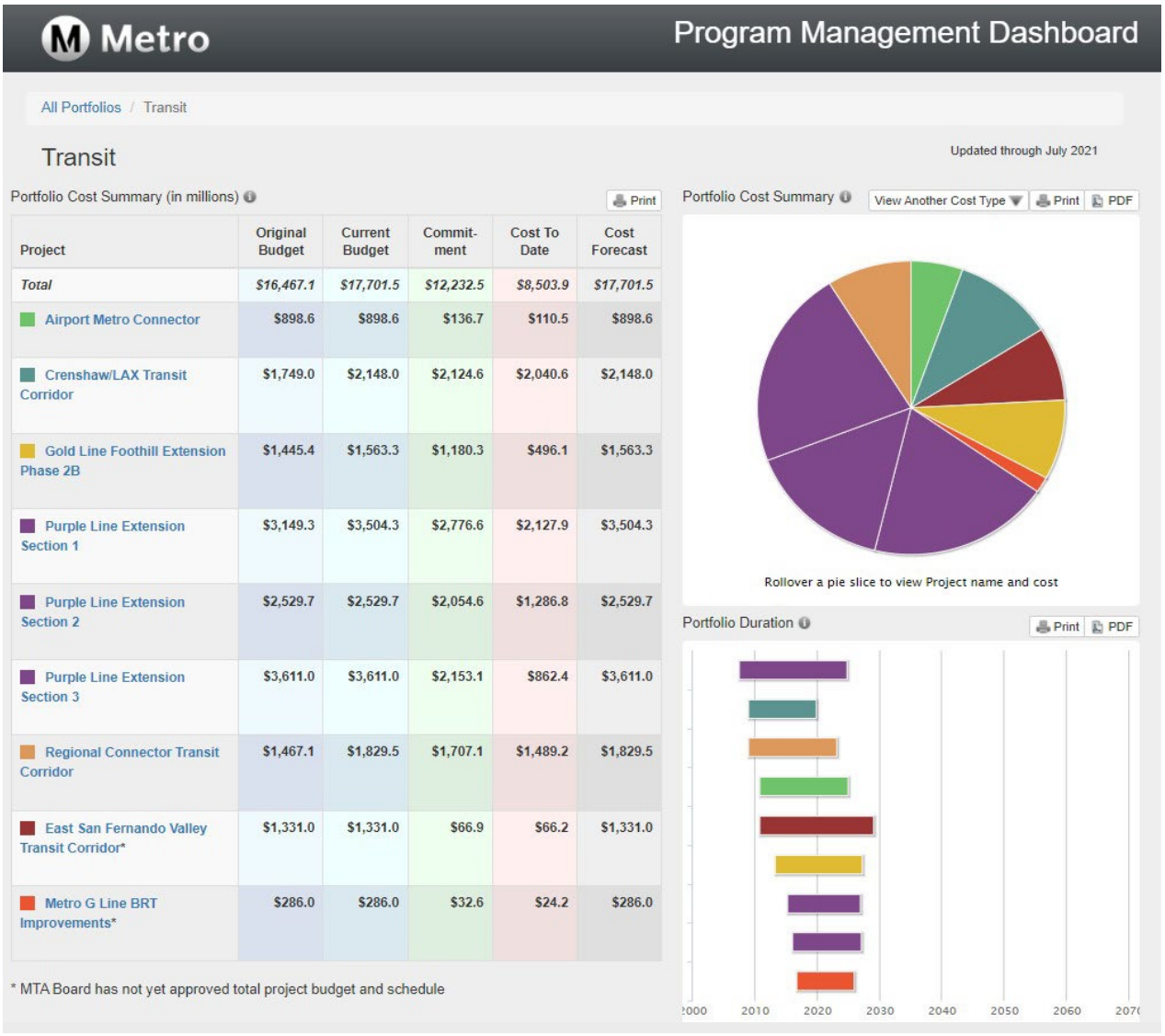
contracts at $300 to $500 million," in part to improve competition and reduce the potential for one contractor to impede progress.

4.9 Change Control and Phase Gate

It is recommended that the PSO Executive Director and Portfolio Management & Integrity unit conduct a thorough evaluation of the current structure, purpose, and authorities of the CCB and Phase Gate Program. These functions should be streamlined to provide optimal efficiency for the agency in development of WSBLE and the ST3 program. Limitations on change authority delegated to Project Directors on megaprojects should be evaluated for opportunities to increase thresholds to improve project management. The Change Control Process should be applied earlier in the planning phase so that changes contemplated during planning are thoroughly vetted with consideration for long-term cost and schedule implications. Changes in alignment type (at-grade, overhead, tunnel) made during early planning or engineering should be subjected to formal approval from the CCB.

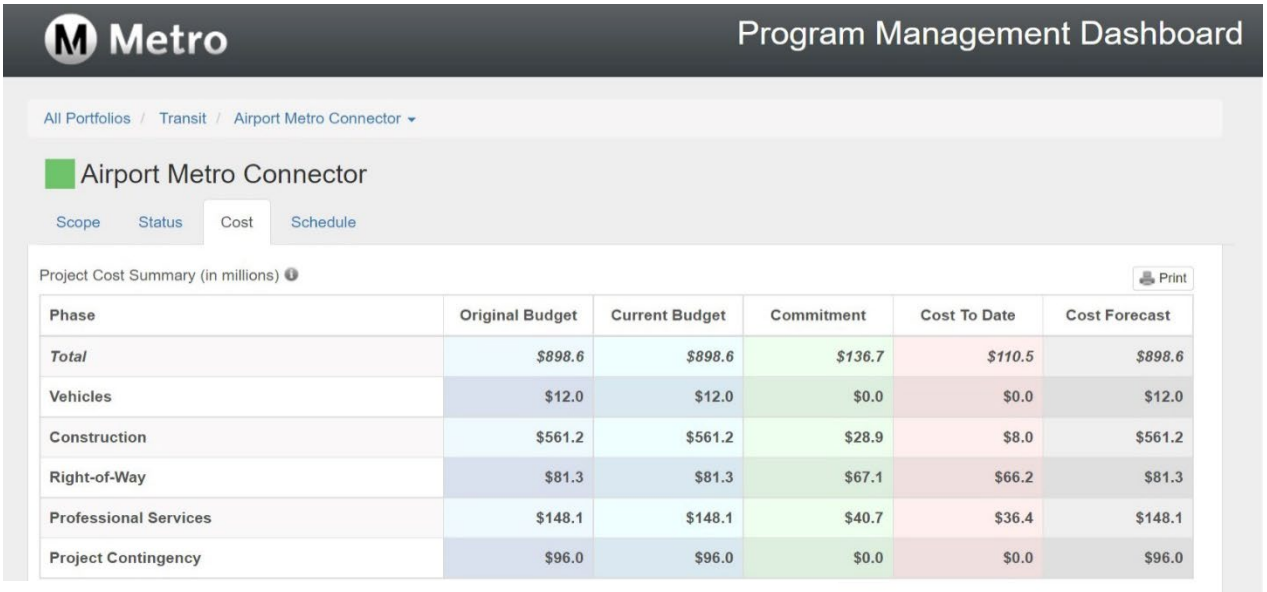
4.10 Daylighting and Reporting

The ST3 project teams should work collaboratively with ST leadership and the PSO on a plan to ensure that issues that have the potential to affect scope, schedule or increase cost estimates above a certain threshold are effectively communicated to ST leadership and the Board in a timely manner. Our recommendation is to build a dashboard similar to what LA Metro is using, shown in Figures 3 and 4 below. A regular forum or more frequent meetings should be held between project and agency leadership to improve this critical communication. At a minimum, these should occur monthly and should be program-wide to improve cross project coordination and consistency. These meetings would allow a critical review of performance, schedule, costs, and emerging issues for every active project. PSO Project Controls should develop metrics and materials focused on leading indicators for project performance to present focusing on leading indicators for project performance.



Project	Original Budget	Current Budget	Commit-ment	Cost To Date	Cost Forecast
Total	*$16,467.1*	*$17,701.5*	*$12,232.5*	*$8,503.9*	*$17,701.5*
Airport Metro Connector	$898.6	$898.6	$136.7	$110.5	$898.6
Crenshaw/LAX Transit Corridor	$1,749.0	$2,148.0	$2,124.6	$2,040.6	$2,148.0
Gold Line Foothill Extension Phase 2B	$1,445.4	$1,563.3	$1,180.3	$496.1	$1,563.3
Purple Line Extension Section 1	$3,149.3	$3,504.3	$2,776.6	$2,127.9	$3,504.3
Purple Line Extension Section 2	$2,529.7	$2,529.7	$2,054.6	$1,286.8	$2,529.7
Purple Line Extension Section 3	$3,611.0	$3,611.0	$2,153.1	$862.4	$3,611.0
Regional Connector Transit Corridor	$1,467.1	$1,829.5	$1,707.1	$1,489.2	$1,829.5
East San Fernando Valley Transit Corridor*	$1,331.0	$1,331.0	$66.9	$66.2	$1,331.0
Metro G Line BRT Improvements*	$286.0	$286.0	$32.6	$24.2	$286.0

Figure 3: LA Metro Dashboard for Transit Program



Phase	Original Budget	Current Budget	Commitment	Cost To Date	Cost Forecast
Total	*$898.6*	*$898.6*	*$136.7*	*$110.5*	*$898.6*
Vehicles	$12.0	$12.0	$0.0	$0.0	$12.0
Construction	$561.2	$561.2	$28.9	$8.0	$561.2
Right-of-Way	$81.3	$81.3	$67.1	$66.2	$81.3
Professional Services	$148.1	$148.1	$40.7	$36.4	$148.1
Project Contingency	$96.0	$96.0	$0.0	$0.0	$96.0

Figure 4: LA Metro Dashboard for Airport Metro Connector Costs

APPENDIX A – LIST of RECOMMENDATIONS

No.	Section	Recommendation	Priority	Action Underway	Responsible Party (TBD by ST)
1	4.1 Policies and Procedures	Update, streamline, or eliminate all Program Control Policies and Procedures (PCPP) for optimization and to reflect the new organizational structure.	High	Underway	
2	4.1 Policies and Procedures	Update or streamline the Design Criteria Manual and Standard Specifications where feasible to incorporate the latest operational requirements.	Medium	Underway	
3	4.1 Policies and Procedures	Seek input from outside sister agencies, consultants and contractors on new policies and procedures.	Medium		
4	4.2 Program and Project Controls	Develop dashboard reporting for all ST3 system expansion projects to communicate scope, schedule, budget, and risk with ST leadership and Board. Examples from LA Metro can be found at: https://mtadash.mlmprojectservices.com/.	High	Underway	
5	4.2 Program and Project Controls	For each ST3 system expansion project, perform independent review of latest cost estimates, risk identification and probabilistic modeling (described in Appendix C). Consistently apply to projects in early planning (less than 15% design).	High	Underway	
6	4.2 Program and Project Controls & 4.10 Daylighting and Reporting	All program reporting to ST leadership and the Board on scope, schedule, budget and risk should be reported through PSO Project Controls metrics and reporting materials (dashboard reporting) with leading indicators for project performance, to be reviewed regularly with agency executive leadership and the Board.	High	Underway via R2021-05	
7	4.3 Organization and Leadership	Utilize a single Project Director for the lifecycle of a project with a project director triangle supporting planning, design/construction, and operations. This individual should have planning, design & construction and operational experience to include practical, technical, managerial, and political expertise needed to guide these long-term projects.	High	Underway for BRT Program	
8	4.3 Organization and Leadership	Employ Program Director, Program Management Team of Function responsible for the entire ST3 Program to serve as single source of accountability to the Board and executive leadership for the program.	High		
9	4.4 Environmental Planning	Coordinate Board acceptance of a Preferred Alternative with any third-party funding agreements.	High	Underway	
10	4.4 Environmental Planning	Implement any accepted modifications from VE studies (structure types, station locations, construction sequencing, staging, etc.). Evaluate for consistency with environmental approvals.	High		

No.	Section	Recommendation	Priority	Action Underway	Responsible Party (TBD by ST)
11	4.4 Environmental Planning	Complete evaluation of project risk-based validated cost estimates for each remaining ST3 project alternative currently under consideration to aid in selection of preferred alternatives.	Medium		
12	4.5 Stakeholders	Memorialize project permitting plan with the local jurisdiction for the ST3 projects as early as possible	Medium	Underway	
13	4.5 Stakeholders	Allocate funding for a permitting manager (and assign) for the jurisdictions associated with the various ST3 projects.	Medium	Underway	
14	4.6 Right of Way	Complete an early acquisition plan for each ST3 project and deploy all available resources in pursuit of early acquisitions including seeking any necessary approvals from the Board and FTA.	High		
15	4.6 Right of Way	Ensure adequate Real Property staff resources are in place to support timely acquisition of real property (including early acquisitions) for the ST3 Program. This includes additional staff and support consultants with ROW expertise.	High	Underway	
16	4.7 Portfolio Services Office	ST executive leadership should solidify and communicate Agency wide PSO's role and mission.	High	Underway	
17	4.7 Portfolio Services Office	Consider implementation of the team alignment process for ST3 Program (focused on goals and clarity of roles, responsibilities, communications and working relationships) as described in Appendix C.	Medium		
18	4.8 Risk Management	Update and develop risk mitigation matrix for each ST3 project including assignment of ST staff for each risk mitigation item.	High		
19	4.8 Risk Management	Develop a risk allocation matrix for ST3 projects that summarizes risks being assumed by Sound Transit and those being assigned to other parties, particularly contractors. Identify responsible staff for management and mitigation of each individual risk item and regularly monitor and report on status.	Medium	Underway	
20	4.9 Change Control and Phase Gate	Streamline CCB to optimize efficiencies and remove redundancies with the Phase Gate process and clarify decision making.	Medium	Underway	
21	4.9 Change Control and Phase Gate	Maximize change authority financial thresholds delegated to Project Directors to improve ST3 program management.	Medium		

Portfolio Services Office
Functional org chart

Portfolio Services Office
EXECUTIVE DIRECTOR'S OFFICE

- Data management
- ST Evolving Practices (lessons learned)
- Department administration

PORTFOLIO MANAGEMENT & INTEGRITY

- Activation
- Enterprise Asset Management
- Portfolio Integrity
  - Governance
  - Quality
- Project Management and Resourcing
  - Resource Allocation
  - Non-system expansion projects
  - Program training
  - Project Management manual

ENGINEERING

- Infrastructure Engineering
  - Civil
  - Structural
  - Track
  - Operations In-house design
  - Design Technology
  - Capital Program Design (project-assigned staff)
- Systems Engineering & Integration
  - Train Control & Traction Power
  - Rail Vehicles
  - Systems Testing & Commissioning
  - Communications & SCADA
  - Civil-Systems Integration
  - Corridor Design Management - Systems
  - Construction Management - Systems
- Technical Standards & Requirements

PROJECT CONTROLS

- Project Control Delivery & Reporting
  - Corridor Project Controls
  - Program Reporting
- Program Control Services
- Schedule, Estimating, Risk & Value Engineering
  - Schedule Engineering
  - Cost Engineering
  - Risk Engineering
  - Value Engineering
- Configuration & Document Management
  - Document Control & Configuration

APPENDIX C - Megaproject Management & Delivery +WSDOT's CEVP Cost Estimate Validation Process

INTRODUCTION

The following paper outlines key elements and processes necessary for the delivery of complex megaprojects, based on John Reilly's work on delivery of such projects from 1970 – 2020 in the US, Canada, UK, Peru and Dubai plus related consulting in Germany and China (*Reilly 2016b*)[1]. These elements include strategic program management, team alignment, advanced management of cost, schedule and risk and alternative contracting/delivery methods. Specifics are described in books and conference proceedings authored by John. References are listed at the end of this paper.

John has been a project engineer, project director and specialized consultant for major Metro systems in Washington DC, Boston, Los Angeles, Atlanta, San Francisco, Toronto and London - plus major highway programs in Boston and Seattle. His profile can be accessed at www.JohnReilly.us

John Reilly Consulting
433 Grove Street, Framingham MA 01701
www.JohnReilly.us

[1] References are listed at the end of this paper cataloged as "author, year of publication"

MEGAPROJECTS MANAGEMENT – KEY FACTORS

Key characteristics of megaprojects include complexity - increasing exponentially with size - long time frames, high visibility, multiple organizations, political stakeholders and significant technical challenges. Out-turn cost performance has been, in a significant number of cases, problematic.

The media is a key factor shaping the public's view which, in some cases, has led to the perception that these large, complex programs are always delivered late, over budget, and with problems. This has been true for some projects, but certainly not for all, perhaps not even the majority. There have been, and continue to be, many large, complex projects that have been delivered successfully in terms of cost, schedule and performance using appropriated processes.

Owner's expectations

The Owner's expectations can be summarized:

1. The Project is completed within budget.
1. The Project is completed on time.
2. The Project will serve its intended purpose.
3. The Project satisfies all its constituents.

These expectations are fundamental. Meeting them is necessary for success and to secure funding for future projects.

Factors required for success

Key factors for megaproject success can be summarized:

1. Definition, communication and commitment to key goals and objectives (which normally flow from the overall strategic plan of the owner or agency).
2. Management and technical capability, use of appropriate tools and processes.
3. Well structured environment, obligations and regulations (control of external factors).
4. Adequate available and mobilized resources, appropriate to the project at hand.

These factors were first published by the US National Committee on Tunneling Technology (*USNCTT 1974*) and stemmed from a concern at that time about adequate management of projects in the uncertain, risky underground environment. These factors are still fundamental to successful delivery of projects.

Key Management Elements

Concerns about megaproject delivery issues in the 1990s led to discussions with International and North American owners, managers, designers and contractors regarding those key elements which are necessary for improved cost performance and management to budget. The question was asked "what differentiates a successful project from an unsuccessful one?" (*Reilly 2000c, 2000d*)

Core elements identified in responses included:

1. Management
   a. Effective leadership, capability and organization for project delivery – critical if the agency has not recently and successfully delivered a project of similar size and complexity.
   b. Improved cost estimation (validating base cost, identifying the "range of probable cost").
   c. Risk Management – identification, characterization, management and mitigation of risk
   d. Team Alignment – align people and processes to meet goals and objectives
2. Technical competence – in means, methods and applications.
3. Improved contracting and delivery methods – Design-Build, Progressive Design-Build, GC/CM, Alliancing (*WSDOT/Reilly & Smith 2008; Reilly 2000d, 2013c, 2020, 2021*).
4. Communications - continuous outreach to public, politicians, stakeholders and media.

Case Example WSDOT Urban Corridors Office

In 2001, the WSDOT Secretary, Doug MacDonald, who had previously managed the successful $3.8 billion Boston Harbor Project, was looking at the delivery of as several complex megaprojects. He was sensitive to the magnitude of the agency's task and the complexity of the potential problems it would face. In particular, building and maintaining public and political trust was a key success factor, necessary to secure public funding and understanding for these and future projects. The Nisqually earthquake of February 28, 2001, which damaged the elevated Alaskan Way Viaduct, accelerated the decision and implementation process.

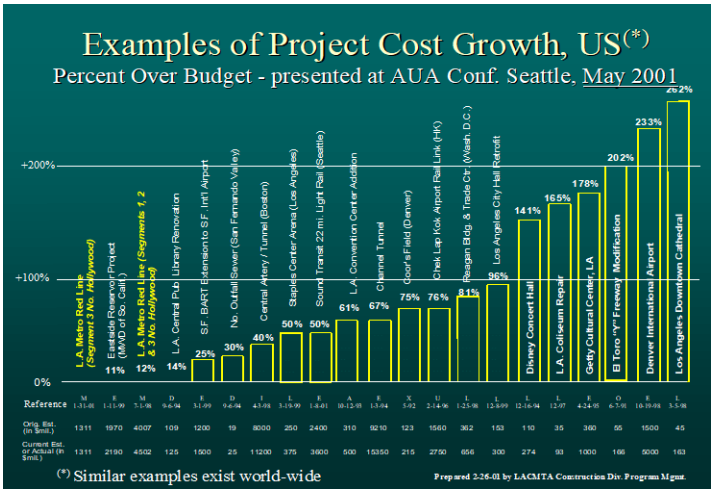
This led to the development and implementation, by WSDOT with the author and other consultants, of a special delivery unit (Urban Corridors Office) to deal with political interests, stakeholders, the Legislature and to implement a delivery-focused organizational structure. New management processes were developed and applied including methods to improve accountability and transparent reporting (*MacDonald 2001*), better cost estimating with cost validation and risk based probable outcomes - the CEVP process (*Reilly, McBride & Dye 2002; Reilly et. al. 2004c*) plus improved contracting and delivery methods (*WSDOT/Reilly & Smith, 2008*).

As part of these initiatives, a Team Alignment process – focused on goals and clarity of roles, responsibilities, communications and working relationships – was implemented for the Urban Corridors Office, the Alaskan Way project and the SR520 floating bridge project.

THE COST PROBLEM

Of all the issues that can arise on megaprojects, the initially published cost estimate, compared to the final out-turn cost, is an area to which owners, politicians, the public and stakeholders are most sensitive. Failure to manage the project and deliver it at, or under, the first published budget is perceived by the public as a failure of management with potentially severe impacts to the agency and its ability to secure future funding and support.

International considerations – early issues



In the 1990's cost overruns for complex transportation megaprojects were of concern to National and International Agencies and Associations. Reports showed overruns in the order of +50-200% of budget for a significant number of cases. In the US a 2001 Conference in Seattle presented cases of cost overruns up to +260% over budget (*graphic Stark 2001*).

Subsequently, a study of the out-turn costs of 258 infrastructure projects over 70 years (Flyvbjerg et. al. 2002) confirmed the above findings and asserted that the problem of grossly inaccurate cost forecasts was chronic and had been so for 70 years. It noted that there appeared to be "strategic misrepresentation".

There are many examples of poor cost performance for complex projects – prominent examples include those following. It should be noted that these are all good and useful projects with significant design and construction achievements, all well recognized e.g. "The extended Jubilee Line is attracting high levels of use and has received many prestigious awards." (*Arup, 2000*).

Examples of significant out-turn cost overruns include:

1. Great Belt Link, Denmark, +54% over budget.
2. Channel Tunnel, UK-France, +80% over budget.
3. London's Jubilee Line Extension +67% over budget.
4. Boston Central Artery at least 100% over what should have been the initial budget[2].
5. Denver Airport + 233% over budget.

Examples of good cost performance

Given that the media tends to highlight problems, it is helpful to recognize that many projects have been delivered at or under budget and close to schedule (*Galloway et. al. 2013, Foreword*). By now, almost everyone has heard about the significant cost overruns and delays in the delivery of Boston's Central Artery/Tunnel Project (CA/T) which published a ridiculously low cost estimate in the beginning, resulting in huge public skepticism and loss of credibility for the Agency (*Salvucci 2003; NAS 2003*).

[2] The initial $2.8 billion number should have been at least $7-9 billion. The final number was over $15 billion.

What has not been well reported are four other megaprojects in the author's hometown, Boston, with similar political circumstances and environmental requirements—that were successfully delivered under, at, or close to budget and schedule. These four projects are:

1. Boston Southwest Corridor Metro project: delivered at $743 million, $7 million (1% under the budget announced 9 years earlier) within six months of the date projected (the author was the GEC consultant Program Director on this program).
2. Logan Airport Modernization Program: completed within a "couple of percent" of the $4 billion estimate, announced several years earlier.
3. MBTA Red Line North Extension: delivered on schedule at $570 million, 12% less than the initial budget of $625 million.
4. Boston Harbor Project: delivered on schedule at $3.8 billion, 4% over the $3.65 billion budget.

Note that the first US subway was opened in Boston in 1897, on schedule, 20% under budget.

Basic acceptance requirements

The significant cost overruns, time extensions and other problems cited above reduced the credibility of agency management, design and construction personnel in the eyes of the public and political officials. As a result, many agency managers realized that, to successfully deliver these projects, the following key management requirements need to be addressed:

1. Ability to secure necessary funding.
2. Ability to set realistic budget, schedule and performance requirements.
3. Ability to meet budget, schedule and performance requirements.
4. A public communication outreach and stakeholder process.

Content of this and other papers

This paper outlines megaproject management considerations and WSDOT's CEVP process for determination of probable cost and schedule, which relates to items 2 and 3 above. (*Reilly et. al. 2002, MacDonald 2003, FHWA 2004*)

Two other megaproject management processes should be referenced in terms of their application to megaproject management. They are:

- Risk Management (program and delivery units, construction contracts)
- Team Alignment (program, delivery and functional units)

These processes can be addressed in future papers, basic content is noted at the end of this paper

For publications related to processes essential for the successful delivery of complex megaprojects the reader is referred to publications such as "Managing Gigaprojects" (*Galloway et. al. 2013*); "Megaprojects – Challenges and Recommended Practices" (*Hatem & Corkum 2010*) and "Recommended Contract Practices for Underground Construction" (*UCA 2008 & 2019*). The author of this paper contributed to chapters on Cost, Schedule and Risk Management in these publications.

WSDOT'S COST ESTIMATE VALIDATION PROCESS - CEVP®

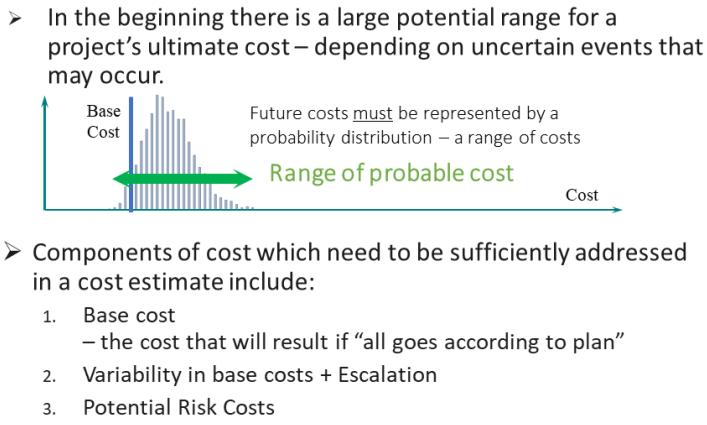
INTRODUCTION

WSDOT's Cost Estimate Validation Process CEVP® was developed in 2002 to better estimate the probable cost of complex transportation projects and to form a basis to communicate those probable costs to the public and key stakeholders. A summary can be seen at https://www.johnreilly.us/cevp-riaat-cost-risk-management/ including an example of an application for the Alaskan Way project in Seattle, which used CEVP plus Value Engineering to revise the scope of this complex megaproject to meet the Legislature's budget.

Development of WSDOT's CEVP®[3]

In 2002 concerns regarding management of several upcoming megaprojects, plus large cost growth of the planned SR167 project, caused the Washington State Secretary of Transportation, Doug MacDonald, to ask for better, more reliable cost-estimating and management practices. Two key consultants, with WSDOT staff, developed a concept of combining independent validation of the "base cost" with quantitative risk identification and then probabilistically modeling the base cost plus risks to produce a "range of probable cost" (*Reilly 2001; Reilly, McBride & Dye 2002*).

Base cost is defined as the estimated cost of the project if everything goes as planned and assumed. The base cost does not include contingency but does include the normal variability of prices, quantities and like units. Once the base cost is established, and validated, related risks are identified and characterized (quantifying probability and consequence including opportunities and threats) and used as input to a probabilistic model.



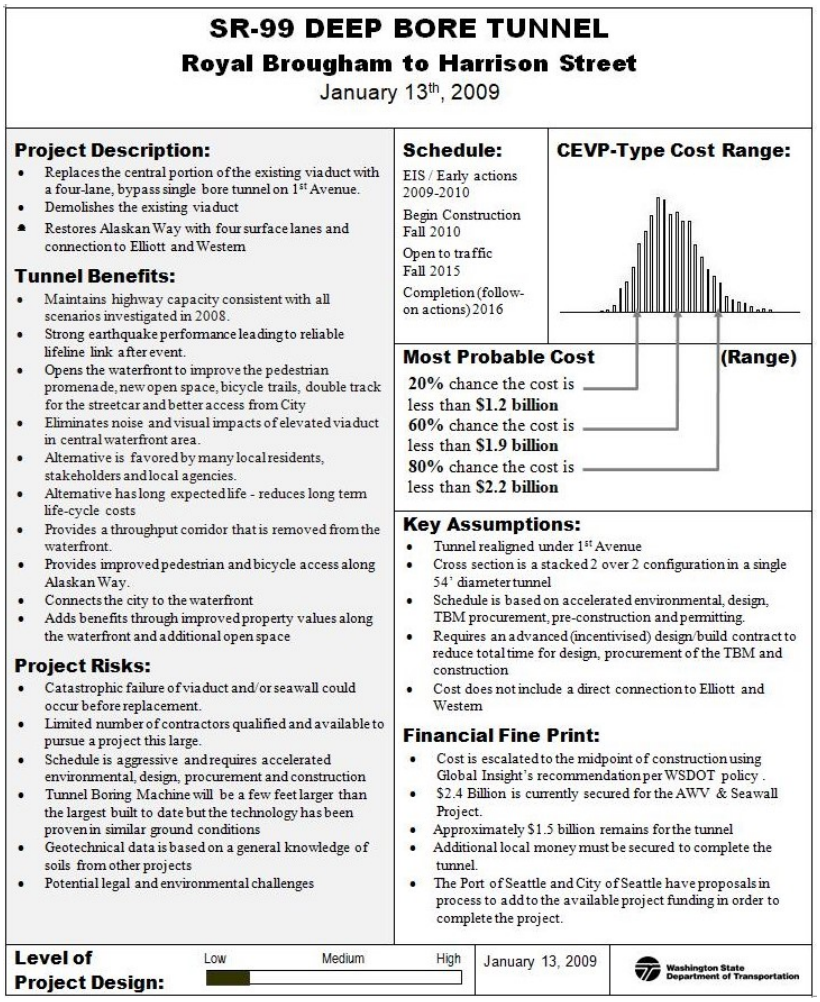
CEVP replaces general and often vaguely defined "contingency" with explicitly defined risk events, with an associated probability of occurrence and the potential impact on cost and schedule for each risk event. Because the risks are explicitly identified and quantified, they can then be effectively managed by a normal risk management and response process.

[3] CEVP is registered to WSDOT to recognize its role in the development of the process and to ensure that CEVP principles are used in applications that reference CEVP.

Application of CEVP to a complex megaproject

For the SR99 Deep Bore Tunnel project of the Alaskan Way Viaduct and Seawall Replacement program, the CEVP process of validated base cost, base variability and the probable consequence of risk events, combined in a Monte-Carlo simulation model, was used to produce a probable range of cost and schedule, including the probability of achieving the desired cost and schedule.

For the public, we produced a "1-pager" which included the project description, benefits, schedule, range of probable cost, key risks and assumptions (Figure 1).



SR-99 DEEP BORE TUNNEL

Royal Brougham to Harrison Street

January 13th, 2009

Project Description:

- Replaces the central portion of the existing viaduct with a four-lane, bypass single bore tunnel on 1st Avenue.
- Demolishes the existing viaduct
- Restores Alaskan Way with four surface lanes and connection to Elliott and Western

Tunnel Benefits:

- Maintains highway capacity consistent with all scenarios investigated in 2008.
- Strong earthquake performance leading to reliable lifeline link after event.
- Opens the waterfront to improve the pedestrian promenade, new open space, bicycle trails, double track for the streetcar and better access from City
- Eliminates noise and visual impacts of elevated viaduct in central waterfront area.
- Alternative is favored by many local residents, stakeholders and local agencies.
- Alternative has long expected life - reduces long term life-cycle costs
- Provides a throughput corridor that is removed from the waterfront.
- Provides improved pedestrian and bicycle access along Alaskan Way.
- Connects the city to the waterfront
- Adds benefits through improved property values along the waterfront and additional open space

Project Risks:

- Catastrophic failure of viaduct and/or seawall could occur before replacement.
- Limited number of contractors qualified and available to pursue a project this large.
- Schedule is aggressive and requires accelerated environmental, design, procurement and construction
- Tunnel Boring Machine will be a few feet larger than the largest built to date but the technology has been proven in similar ground conditions
- Geotechnical data is based on a general knowledge of soils from other projects
- Potential legal and environmental challenges

Schedule:

EIS / Early actions 2009-2010

Begin Construction Fall 2010

Open to traffic Fall 2015

Completion (follow-on actions) 2016

CEVP-Type Cost Range:

Most Probable Cost (Range)

20% chance the cost is less than **$1.2 billion**

60% chance the cost is less than **$1.9 billion**

80% chance the cost is less than **$2.2 billion**

Key Assumptions:

- Tunnel realigned under 1st Avenue
- Cross section is a stacked 2 over 2 configuration in a single 54' diameter tunnel
- Schedule is based on accelerated environmental, design, TBM procurement, pre-construction and permitting.
- Requires an advanced (incentivised) design/build contract to reduce total time for design, procurement of the TBM and construction
- Cost does not include a direct connection to Elliott and Western

Financial Fine Print:

- Cost is escalated to the midpoint of construction using Global Insight's recommendation per WSDOT policy .
- $2.4 Billion is currently secured for the AWV & Seawall Project.
- Approximately $1.5 billion remains for the tunnel
- Additional local money must be secured to complete the tunnel.
- The Port of Seattle and City of Seattle have proposals in process to add to the available project funding in order to complete the project.

Level of Project Design: Low Medium High

January 13, 2009

Washington State Department of Transportation

Figure 1- CEVP summary, initial 2009 analysis, SR99 Deep Bore Tunnel

Process to manage to Budget

Because of normal "wants and desires" scope tends to grow to exceed that which is capable of being delivered for the authorized budget. For the SR99 Deep Bore Tunnel, design development after decision to proceed resulted in the probable cost exceeding the authorized budget of $1.96

billion. Work to bring the project into compliance with a 60% probability[4,5] of delivery at $1.96 billion was initiated and included an augmented CEVP process with Value Engineering and a "Tiger Team" to critically evaluate scope and alignment options. Two cycles of cost reduction using this augmented CEVP process were needed to comply with the budget probability.

Figure 2 diagrams this CEVP/VE/Scope review analysis. The result was a defined project scope, which would satisfy purpose and need, and which resulted in a 60% probability of delivering the project at the $1.96 billion authorized amount.

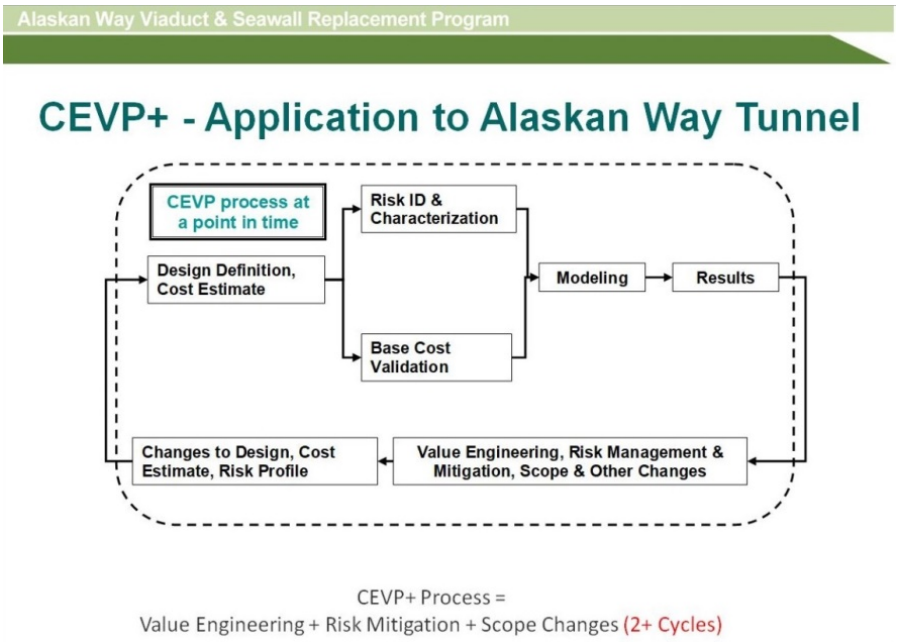


Figure 2 – CEVP+, Value Engineering and Scope management to meet authorized budget

[4] The WSDOT budget policy in 2009 was to use the 60% probability CEVP result. In actual fact, the consultant who developed the CEVP analysis recommended that 80% be used – a recommendation which was close to the final out-turn cost after the project risks eventuated and the legal cases were resolved.

[5] In the early CEVP applications, an 80% probability was used for budgeting, consistent with levels of uncertainty at that time and the historical record of cost overruns on complex megaprojects.

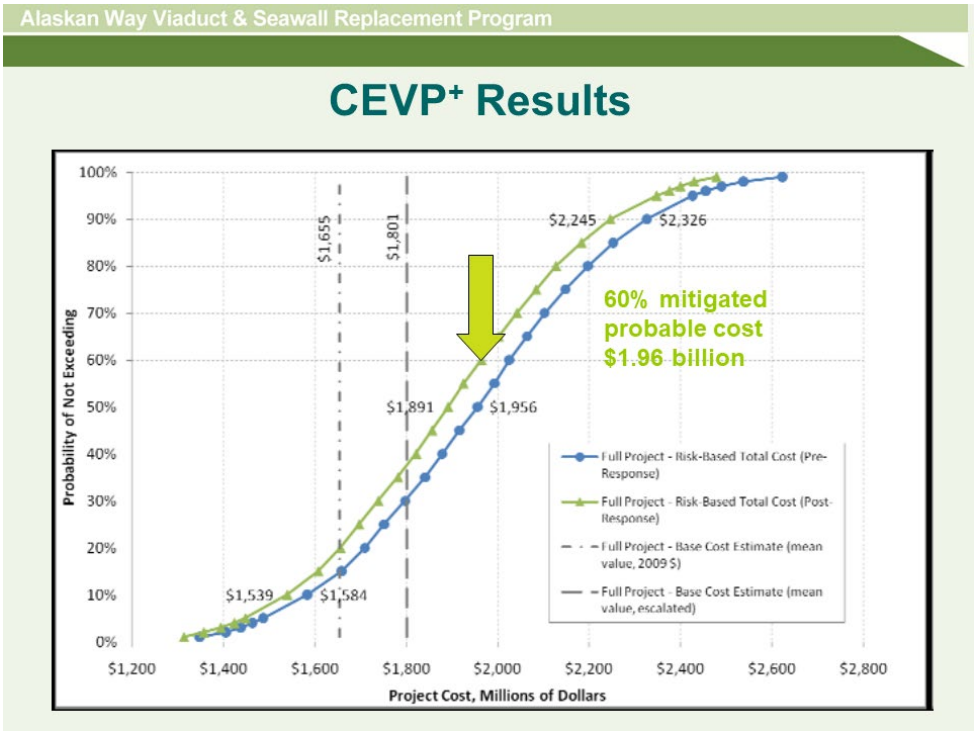


Figure 3 – Probabilistic CEVP+ result for the Alaskan Way Deep Bore Tunnel

Final design proceeded on the basis of the scope and alignment defined by the CEVP+ and VE work. Subsequently a design-build contract, with the largest tunnel boring machine (TBM) in the world at that time, was bid and awarded. Early in construction the project suffered a major issue with the tunnel boring machine which broke down in the initial drive. The risk events associated with this breakdown had been anticipated by WSDOT, and listed on their risk register, but while the consequence was large, the estimated probability of occurrence was very low - an example of the difficulty of dealing with high-impact/low probability events. Fortunately for WSDOT the design-build contract provisions and WSDOT's management of the project resulted in a favorable legal outcome.

Benefits of CEVP

Benefits identified with the CEVP/CRA process and associated risk management, taken from surveys within WSDOT and a recent study reported by WSDOT and ODOT (*Gabel et. al. 2022*) have shown that CEVP or CRA (a simpler process for smaller projects) has the following benefits:

1. Is inclusive and aligns the team on a pathway of successful project delivery.
2. Reduces tension and anxiety related to project uncertainty.
3. Builds confidence and credibility in decision making.
4. Improves risk appetite and allows for strategic risk-taking behavior.
5. Has a positive influence on creative thinking and innovation.
6. Improves quality and confidence in the base cost estimate and schedule.

Evaluation - cost and schedule outcomes

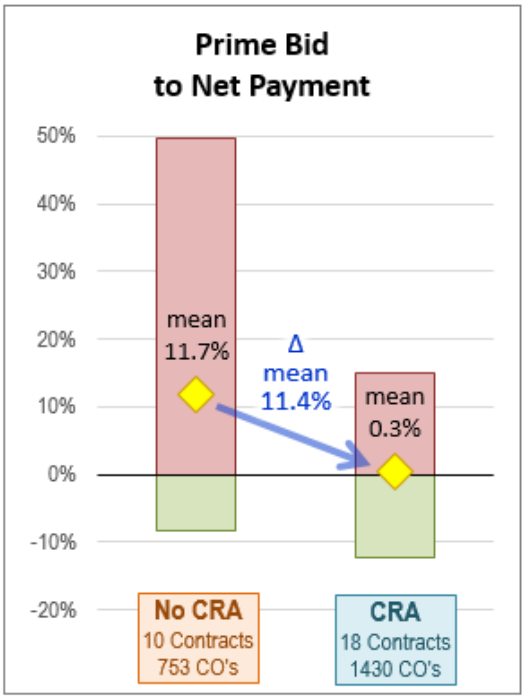
WSDOT evaluated the cost and schedule outcomes for 28 highway projects completed by them to quantify the benefit of risk-based estimating and formal risk management. It found that those projects that had completed a CRA were more likely to be completed with a total contract cost at or below the engineer's estimate, experience a lower post-award cost and schedule growth, and experience more predictable outcomes than those projects that did not undergo a CRA. The CRA activities included facilitated workshops, risk analysis, and formal risk management which appeared to provide significant, if intangible, results for the owner agencies.

Key findings from these comparisons included:

1. Post-award contract change order percentages reduced, on average, from +10.3% to +3.9% for cost and from +18.2% to +8.2% for time when a CRA was performed.
2. Additionally, the standard deviation in post-award changes reduced by 13.1% for cost and by 9.3% for time when a CRA is conducted, indicating a tendency toward more consistent post-award project delivery outcomes.

The results indicate a quantifiable benefit to project cost and schedule outcomes in terms of:

3. More reliable estimates and consistent engineer's estimates as evidenced by the reduced overrun percentages and reduced cost variance, and
4. More effective and consistent post-award project delivery outcomes as evidenced by reduced change order percentages (mean and standard deviation) for both cost and time.



	No CRA	CRA
Standard Deviation	0.199	0.070
% at or below Prime Bid	30%	50%

Figure 4 – Comparison of CEVP/CRA projects vs. non CEVP/CRA projects

APPLICATION OF CEVP

CEVP was presented to FTA and FHWA at the TTB conference Washington DC in January of 2003 by Secretary MacDonald and John Reilly (*MacDonald 2003*). The process was evaluated by those agencies and the process, or a similar probabilistic risk-based cost estimate process (PRBE), was adopted and has been applied by those agencies since that time. FHWA and the National Highway Institute have recently developed an eBook training model for the application of PRBE (the author of this article wrote the basic input text).

To our knowledge CEVP and/or PRBE has been used extensively in the US, Canada, Germany and Austria plus Peru and potentially Australia. WSDOT has a Cost-Risk Estimating Management (CREM) office in Olympia and regularly hosts presentations on the process – membership of the CREM working group includes some 80 professionals from the US and Canada with attendees of the CREM bi-monthly presentations also including Ireland, Germany, Austria and Peru.

For further information, see:

https://wsdot.wa.gov/construction-planning/project-management/risk-assessment/home

Thank you for your interest in this topic – please send questions to John at John@JohnReilly.us

RISK[6] MANAGEMENT

As noted in the previous section, because the risks identified in the CEVP analysis are explicitly characterized and quantified, they can be effectively managed with a normal risk management and response process. Treatment of risk and risk management is addressed in a separate white paper, the contents of which include:

Risk Management– Identification, Characterization, Response

[6] The ISO (International Organization for Standardization) definition of risk is the "effect of uncertainty on objectives"

TEAM ALIGNMENT FOR MEGAPROJECTS

"Team Alignment" and "Teambuilding" processes use strategic-level planning to fully engage all participants and stakeholders in a project, to enhance management's effectiveness and leadership, to sharpen the delivery team's focus on the key goals, objectives and deliverables, to increase efficiency and capability, to mitigate conflict, to reduce risk and to accelerate problem resolution.

Team Alignment is addressed in a separate white paper, the contents of which include:

REFERENCES – MEGAPROJECT MANAGEMENT & CEVP

1. Arup, 2000. The Jubilee Line Extension, End-of-Commission Report by the Secretary of States Agent UK Department of the Environment, Transport and Regions, July.
2. FHWA 2004, Megaprojects, Building Public Trust, Public Roads July/August, p17.
3. Flyvbjerg, B, Holm, M S and Buhl, S 2002. Underestimating Costs in Public Works Projects: Error or Lie?, Journal of the American Planning Association, Summer, 2002 Vol 68, Issue 3.
4. Gabel M, Sujka M, Davis Z and Keizur A 2022 "Risk Based Estimating for Capital projects, Does It Work? Pre-publication draft, to be submitted to the January 2022 TRB Conference, Washington DC.
5. Galloway, P D, Nielsen, K R & Dignum, J L 2013. "Managing Gigaprojects", ASCE press.
6. Hatem, D J & Corkum, D H, 2010. Megaprojects and Recommended Practices, ACEC Press.
7. MacDonald, D B, 2001. Grey Notebook, WSDOT Quarterly Performance Report.
8. MacDonald, D B, 2003. Meeting the Perils of Early Cost-Estimating for Complex Construction Projects, TRB Conference, January 15, 2003.
9. NAS 2003, Completing the "Big Dig": Managing the Final Stages of Boston's Central Artery/Tunnel Project, National Academy of Sciences, http://www.nap.edu/catalog/10629.html
10. Reilly, J J, 2000c. Tying it together – Policy, Management, Contracting and Risk, an Overview, Proc North American Tunneling Conference 2000, Boston, June, pp 159-168.
11. Reilly, J J, 2000d. The Management Process for Complex Underground and Tunneling Projects, Jn. Tunnelling and Underground Space Technology, Vol 15, No 1, pp 31-44.
12. Reilly, J J, McBride, M, Dye, D, 2002. Guideline Procedure, Cost Estimate Validation Process (CEVP) Washington State Department of Transportation, January.
13. Reilly, J J, McBride, M, Sangrey, D, MacDonald, D & Brown, J, 2004c. The development OF CEVP, WSDOT's Cost-Risk Estimating Process, Proceedings, Boston Society of Civil Engineers, Fall/Winter.
14. Reilly, J J, 2013b. Foreword in Managing Gigaprojects, Ed Galloway, P D , Nielsen, K R & Dignum, J L, ASCE press
15. Reilly, J.J. 2016b "Megaprojects – 50 years, What Have We Learned?" ITA WTC2016 Proc. April.
16. Reilly, J.J. & Hatem, D., 2017 "Boston's Central Artery / Tunnel Project – Lessons Learned" Proc. RETC June.
17. Reilly, J.J. 2020 "TBM Procurement, Risk and Technology Advancement" TunnelTalk November 5.
18. Reilly, J.J. 2021 "TBM Procurement, Risk and Technology Advancement – Part 2" TunnelTalk April.
19. Salvucci, F.P. 2003 "The 'Big Dig' of Boston, Massachusetts: Lessons to Learn", Proc. International Tunnelling Association Conference, Amsterdam, April.
20. Stark, C, 2001, Chart of 21 Projects, Cost and Cost Overruns Compared to Budget, presented at the US Underground Construction Association Conference, March 19.
21. USNCTT 1974. Better contracting for underground construction, Standing committee No 4 (Contracting Practices), US National Committee on Tunnelling Technology, National Academy of Sciences, Washington DC.
22. WSDOT / Reilly & Smith 2008 "Alternative Contracting and Innovative Project Management", WSDOT Report to the WA State Legislature, ed. Dyer, transmitted by Secretary Hammond.

Team Alignment for Megaprojects

INTRODUCTION

On any mega-program or megaproject it is essential to focus the leadership and project teams on key program goals, objectives and deliverables, to create an efficient structure to meet those key goals and objectives and to resolve misalignment, disagreements and potential conflicts quickly, positively and effectively. Collaborative working relationships are needed to foster innovation and add value. In all cases, for complex mega- programs, collaboration is essential to deliver the program successfully.

"Team Alignment", "Partnering" and "Teambuilding" processes[(1)], as well as effective strategic-level planning, should be used to fully engage all participants and stakeholders in a project, to enhance management's effectiveness and leadership, to sharpen the delivery team's focus on the key goals, objectives and deliverables, to increase efficiency and capability, to mitigate conflict, to reduce risk and to accelerate problem resolution.

[1] We will generally use the term "Alignment" in the text. In this context, Partnering, Teambuilding, Chartering and Project "Alignment" processes all have similar goals and use similar processes. The specific names used depend on the application and context. Partnering is generally applied to construction contracts, team alignment to agency units and delivery organizations.