CALIFORNIA STATE TRANSPORTATION AGENCY

Edmund G. Brown Jr.
Governor

Brian P. Kelly
Secretary

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Sacramento, CA 95814
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July 10, 2013

The Honorable Mark DeSaulnier, Chair
Senate Transportation and Housing Committee
State Capitol, Room 2209
Sacramento, CA 95814

The Honorable Bonnie Lowenthal, Chair
Assembly Transportation Committee
1020 N Street, Room 112
Sacramento, CA 95814

The Honorable Mark Leno, Chair
Senate Committee on Budget and Fiscal Review
State Capitol, Room 5019
Sacramento, CA 95814

The Honorable Nancy Skinner, Chair
Assembly Committee on the Budget
State Capitol, Room 6026
Sacramento, CA 95814

Dear Senator DeSaulnier, Senator Leno, Assembly Member Lowenthal, and Assembly Member Skinner:

This letter is to indicate that I have reviewed and approve the California High-Speed Rail Authority's (Authority) Risk Management Report as consistent with Provision 8 of Item 2665-306-6043 of the Budget Act of 2012 (SB 1029, Chapter 152, Statutes of 2012).

Sincerely,

Brian P. Kelly

BRIAN P. KELLY
Secretary

Attachment

cc list: See next page

cc: The Honorable Darrell Steinberg, President pro Tem, California Senate
The Honorable John Pérez, Speaker, California Assembly
The Honorable Ted Gaines, Vice Chair, Senate Transportation and Housing Committee
The Honorable Bill Emmerson, Vice Chair, Senate Budget and Fiscal Review Committee
The Honorable Eric Linder, Vice Chair, Assembly Transportation Committee
The Honorable Jeff Gorell, Vice Chair, Assembly Budget Committee
Ms. Carrie Cornwell, Chief Consultant, Senate Transportation and Housing Committee
Ms. Janet Dawson, Chief Consultant, Assembly Transportation Committee
Ms. Keely Bosler, Staff Director, Senate Budget and Fiscal Review Committee
Mr. Christian Griffith, Chief Consultant, Assembly Committee on the Budget
Ms. Diane Boyer-Vine, Legislative Counsel, State Capitol
Mr. Gregory Schmidt, Secretary of the Senate, State Capitol
Mr. E. Dotson Wilson, Chief Clerk of the Assembly, State Capitol

CALIFORNIA
High-Speed Rail Authority

July 31, 2013

The Honorable Mark DeSaulnier, Chair
Senate Transportation and Housing Committee
State Capitol, Room 2209
Sacramento, CA 95814

The Honorable Mark Leno, Chair
Senate Budget and Fiscal Review Committee
State Capitol, Room 5019
Sacramento, CA 95814

The Honorable Bonnie Lowenthal, Chair
Assembly Transportation Committee
1020 N Street, Room 112
Sacramento, CA 95814

The Honorable Nancy Skinner, Chair
Assembly Budget Committee
State Capitol, Room 6026
Sacramento, CA 95814

Dear Senator DeSaulnier, Senator Leno, Assembly Member Lowenthal, and Assembly Member Skinner:

The California High-Speed Rail Authority (Authority) is committed to transparency in the identification, assessment and management of project risks. To that end, the Authority has had in place a process for risk management since 2010. In September 2012, the Authority hired a risk manager and subsequently began to refine its strategy of identifying potential risks to the project and the steps necessary to mitigate those risks.

Provision 8 of Item 2665-306-6043 of the Budget Act of 2012 (SB 1029, Chapter 152, Statutes of 2012) requires the Authority to prepare and submit to the Legislature a report, approved by the Secretary of Business, Transportation and Housing, that details the elements of risk in the high-speed rail project.

Central to this reporting requirement is a comprehensive Risk Management Plan that "defines the roles and responsibilities for risk management and addresses the process by which the Authority will identify and quantify project risks, implement and track risk response activities, and monitor and control risks" throughout the duration of the high-speed rail project.

In addition to the development of a Risk Management Plan, SB 1029 requires the Authority to quantify the effect of identified risks in financial terms, maintain documents to track identified risks, establish mitigation steps, provide a plan for regularly reassessing its estimates of capital and support costs, provide a plan for reassessing risks and reserves, and provide a plan for integrating the estimates for capital, support costs and contingency reserves in required reports.

Attached is the Authority's Risk Management Plan, dated June 5, 2013, which contains all of the elements required by SB 1029.

If you have any questions or comments, please contact Matt Robinson, Deputy Director of Legislation, at (916) 324-1541 or matthew.robinson@hsr.ca.gov.

Sincerely,

Jeff Morales
Chief Executive Officer

Attachment

cc: The Honorable Darrell Steinberg, President pro Tem, California Senate
The Honorable John Pérez, Speaker, California Assembly
The Honorable Ted Gaines, Vice Chair, Senate Transportation and Housing Committee
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Mr. Gregory Schmidt, Secretary of the Senate, State Capitol
Mr. E. Dotson Wilson, Chief Clerk of the Assembly, State Capitol

CALIFORNIA
High-Speed Rail Authority

Project Risk Management Plan

June 5, 2013

www.hsr.ca.gov

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EXECUTIVE SUMMARY

The Risk Management Program provides the California High-Speed Rail Authority (Authority) with a formal, systematic approach to identifying, assessing, evaluating, documenting and managing risks that could jeopardize the success of the Project. These include specific engineering, environmental, planning, right-of-way, procurement, construction, organizational, stakeholder, budget and schedule risk, or any other potential inabilities to deliver the required results.

The Risk Management Program's objectives are to:

- Systematize the process by which the Authority responds to circumstances that could increase the cost or significantly delay or halt the Program
- Increase transparency regarding challenges to project plans and objectives
- Capture project opportunities
- Satisfy legal and regulatory requirements and meet the needs and expectations of other stakeholders
- Rationalize allocation of resources including cost and schedule contingencies

In furtherance of the above objectives and in accordance with SB 1029, the Risk Management Program will provide the following:

(a) A comprehensive risk management plan that defines roles and responsibilities for risk management and addresses the process by which the Authority will identify and quantify project risks, implement and track risk response activities, and monitor and control risks throughout the duration of each project

(b) A process by which identified risks will be quantified in financial terms

(c) Development of documents that will be used to track identified risks and related mitigation steps

(d) Plans for regularly updating its estimates of capital and support costs

(e) Plans for regularly reassessing its reserves for potential claims and unknown risks, incorporating information related to risks identified and quantified through its risk assessment processes

(f) Plans for regularly integrating estimates for capital, support costs, and contingency reserves in required reports

The risk management process is a 'living', iterative process that provides a structured, systematic procedure for managing risks. A complete risk management program comprises the following stages:

1. Prepare for Risk Management – Define the scope and objectives of the program risk management process and ensure that the risk process is fully integrated into wider program management.
2. Identification – Identify as many knowable risks as practicable.
3. Assessment – Evaluate key characteristics of individual risks, qualitatively and quantitatively, enabling them to be prioritized for further action.
4. Analysis – Employ Monte Carlo simulations and Sensitivity analysis to evaluate the combined

effect of risks on the overall program outcome and identifying key cost and schedule drivers, ranking risks with respect to one another based on their impact on project cost and schedule outcomes.

5. Management – Determine appropriate response strategies and actions for each individual risk as well as for overall program risk, and integrate both into a consolidated program management plan that includes monitoring and controlling risks by implementing agreed upon actions, regularly reviewing changes in program risk exposure, identifying additional risk management actions as required, and assessing the effectiveness of the Program.

For regions or sections of regions that have not designated a preferred alignment, quarterly workshops will be held to identify new or emergent risks and review previously identified ones. Assessments for these regions or sections will be qualitative. The focus of risk management efforts pre-designated preferred alignment will be on developing and implementing primary mitigations to avoid or mitigate threats or capture, enhance opportunities. These workshops will be conducted in conformance with the guidance provided in this Risk Management Plan under the supervision and at the direction of the Authority's Program Risk Manager.

Once a preferred alignment has been designated, workshops will be held as necessary to meet commercial milestones and legislative requirements or quarterly, whichever is more often. As above, new risks (threats/opportunities) will be identified and the current status of management efforts will be reviewed. However, risks will be assessed quantitatively for probability of occurrence and potential impacts. This information will be integrated with baseline cost and schedule estimates (stripped of contingency/float) and Monte Carlo simulations and Sensitivity Analysis will be performed to determine the range of possible project cost and schedule outcomes, the confidence level that can be attributed to these outcomes, and determine the relative importance of individual cost and schedule risks to overall project outcomes. Risks remaining following primary mitigation efforts or risks likely to arise during construction will be allocated and quantitative analysis will be redone for those risks that will be retained by the Authority. The results of this analysis will serve as a basis for making a risk-based contingency recommendation. Should significant threats remain after this process, (i.e., threats that have not been satisfactorily reduced by primary mitigation efforts, have not been contractually allocated to another party and have not or cannot be insured against by contingency (funds or float)), the Program will identify Secondary Mitigations.

This process is summarized in Table 1 and presented in more detail in the body of this Risk Management Plan.

Table 1 Risk Management Process

Adapted from Risk Analysis Methodologies and Procedures (2004), Federal Transit Administration, United States Department of Transportation, Washington, DC 20590

Risk Mgmt. Stage	Task
Prepare	Establish objectives for risk analysis and expected outcomes.
	Identify resources available and resources required
	Perform comprehensive review of base project scope, cost and schedule to validate reasonableness.
	Establish the project's base cost and schedule (base excludes contingencies that are not specific allowances for known but unquantified project elements). Risks costs and risk delays are added to the base.
	Project(s): *Scope, Cost, and Schedule Review (report on reasonableness and accuracy of scope, cost and schedule of project) Estimate of Base Project Costs and Durations (table of adjusted base costs and durations allocated to project components)*
Identify	Establish a comprehensive and non-overlapping list of possible risks to the project.
	Ensure all project components (major activities, contract units) are evaluated for risks and opportunities. Opportunities represent actions or measures that could reduce costs and delays as opposed to risks that increase costs and delays.
	Product: *Draft Risk Register*
Assess	Assess risks in terms of their likelihood of occurring and their potential costs and delay impacts when they do occur. Prior to designation of preferred alignment, risks will be assessed qualitatively. Following designation of preferred alignment, risks will be assessed quantitatively
	Estimate cost and schedule (i.e., duration) impacts of risks qualitatively or quantitatively, as appropriate.
	Identify correlated project components, that is, activities whose costs or durations move together in response to a risk event.
	Document estimated risk impacts on individual project components in the risk register.
	Product: *Completed Risk Register*
Analyze	Select the appropriate analysis method for estimating impacts of multiple risks on the project cost and/or schedule. This involves combining risks impacts depend upon the objective: (probable costs, probable durations) to obtain the risk cost or delay to a project. The method will depend upon the objective: •Evaluate risk cost impacts to the base project cost [Independent cost analysis] •Evaluate risk delay impacts to the base project schedule [Independent schedule analysis]
	Sensitivity Analysis: Rank risks by the magnitude of their effect on total project cost or duration, i.e., how much the project cost or duration changes when risk occurs. May be done in advance of, or in conjunction with, Monte Carlo analysis
	Use **Monte Carlo simulation** analysis methods for combining risk and base costs or schedule durations
	Review analysis results with expert panel/workshop participants and project owner management.
	Products: *Sensitivity analysis; Analysis Results in financial terms (risk plus base costs and/or durations; probabilistic estimates of total project cost and/or duration); Risk Analysis report Assessment Report (summary and findings of Prepare, Identify, Assess, Analyze)*
Manage	Prioritize risks for **mitigation**: unacceptable risks; high cost, high likelihood risks. Mitigation must be cost-effective;
	Allocate risks to parties best able to manage/mitigate them. Contract documents and alternative procurement methods offer means for distributing risks.
	Prepare a risk management plan describing risk mitigation strategies, responsible parties, likely costs and benefits, additional implementation requirements.
	Monitor performance of mitigation measures; reevaluate risk mitigation strategies as appropriate to improve outcomes.
	Products: *Priority Ranking of Risks for Mitigation; Risk Mitigation Register; Benefit-Cost Assessment of Risk Mitigation Costs; Risk Management Plan (attachment to Project Management Plan and Risk Assessment Report)*

1 INTRODUCTION

1.1 BACKGROUND

The Authority is committed to providing a high-speed rail system that meets, or exceeds, its objectives and that is ultimately judged to be a successful program. Risk is a measure of the potential inability to achieve program objectives within defined scope, cost and schedule constraints and assumptions. Essentially, risk management serves as a process for evaluating the program to determine whether the appropriate or optimal management processes have been selected, and assess whether any necessary waivers, deviations or non-conformances to these practices – either real or potential – have been identified. When combined, this information allows for a characterization of the resulting risks to the program.

Risk management is viewed as essential for successful project management and builds upon and extends other project management processes. A successful risk management program both requires and encourages individual commitment and responsibility, interdisciplinary collaboration and organizational commitment. Accordingly, the California High-Speed Rail Program (CHSRP) recognizes that effective management of risks is one way to significantly increase the chances of delivering a successful program and has developed a Risk Management Plan for this purpose.

1.2 PURPOSE AND OVERVIEW OF THE RISK MANAGEMENT PLAN

The Risk Management Program provides the Authority with a formal, systematic approach to identifying, assessing, evaluating, documenting and managing risks that could jeopardize the success of the Project. These include specific engineering, environmental, planning, right-of-way, procurement, construction, organizational, stakeholder, budget and schedule risk, or any other potential inabilities to deliver the required results.

The Risk Management Program's objectives are to:

- *Systematize the process by which the Authority responds to circumstances that could significantly delay, halt or increase cost on CHSRP* - minimize differences between project plans and objectives, determining risks and costs of proposed project changes and identify project alternatives that satisfy the Authority's objectives and priorities
- *Increase transparency regarding challenges to project plans and objectives* - prepare internal and external information that is reliable, timely and relevant, providing the means to achieve an acceptable level of cost and schedule certainty
- *Capture project opportunities* - aid the identification, and ability to take advantage of, positive events quickly and efficiently
- *Satisfy legal and regulatory requirements and meet the needs and expectations of other stakeholders* - support efforts to ensure compliance with legal and regulatory requirements, identify risks of non-compliance and identify and manage challenges of particular importance to local communities and other stakeholders

- *Rationalize allocation of resources* - allow the project to deploy resources more effectively by identifying key drivers of Development and Delivery and providing the means to manage cost estimate contingency and schedule float, thereby reducing overall capital requirements and improving capital allocations

In furtherance of the above objectives and in accordance with SB 1029, this document is intended to provide the following:

(a) A comprehensive risk management plan that defines roles and responsibilities for risk management and addresses the process by which the Authority will identify and quantify project risks, implement and track risk response activities, and monitor and control risks throughout the duration of each project [this document].

(b) Quantification of the effect of identified risks in financial terms [Sections 4.4 and 4.5, Appendices C, D and F].

(c) Development of documents that will be used to track identified risks and related mitigation steps [Section 4.6].

(d) Plans for regularly updating its estimates of capital and support costs [Section 4.1.1].

(e) Plans for regularly reassessing its reserves for potential claims and unknown risks, incorporating information related to risks identified and quantified through its risk assessment processes [Section 4.4 and 4.5.1-4.5.3].

(f) Plans for regularly integrating estimates for capital, support costs, and contingency reserves in required reports [Section 4.1, 4.5.2, Appendices A and C].

The Risk Management Program serves to balance the competing demands of scope, time, cost, quality, resources and risk. In pursuit of these objectives, the Program adopts the following standards for risk management deliverables:

1. Deliverables are presented within a substantively complete and appropriate engineering or project management context.
2. Deliverables are appropriately quantified, fully integrated, traceable and consistent, and compatible with findings or stated facts.
3. Where risk management deliverables are qualitative in nature, they are properly structured and clearly identified with respect to authorship.
4. Material analytic results of risk analysis are capable of independent analysis or reproduction using disclosed methods and assumptions generating similar analytic results within an acceptable degree of imprecision or error.
5. Funding agencies are able to assess whether it is appropriate to question the adequacy, accuracy, and completeness of the third party data, information, modeling or analysis.

This plan defines the Authority's risk management policy and the processes to be used to execute the Risk Management Program effectively. This approach to risk identification is used because it is believed to be effective in achieving the objectives set forth above.

The Risk Management Program will identify key risks and respective mitigation plans, and prioritize actions. These items are documented in the Program Risk Register, which will be periodically updated, reviewed with management at stipulated intervals, and used as the basis of reporting.

CHSRP's Senior Management is fully committed to the Risk Management Program and recognizes it to be an integral part of CHSRP's good management practices. Senior Management assures that this plan is understood, implemented and maintained throughout the CHSRP by all personnel.

The Risk Management Plan is based on the following:

- The Authority is responsible for final risk allocation options.
- The risk management process meets the Authority's risk objectives.
- The risk management process provides for a pragmatic and balanced assessment of the Authority's objectives and the construction industry's reasonable risk allocation issues and concerns.

In addition, CHSRP will be subject to the requirements of a number of funding and jurisdictional agencies that each have a certain amount of control over cash availability, permits, approach to the work, and construction processes. Risks associated with the foregoing will be addressed. To be successful, the Program must interact extensively with third parties, which figure predominately in this environment. Risks to effective third party interaction will be identified and managed.

2 DEFINITIONS

Consequence – The magnitude of the outcome of a Program decision, activity or other event.

Contingencies - Set-aside estimated amounts (either monetary set-asides for cost or time set-asides for schedule) included in the overall cost or schedule targets for the project. The amounts are designed to be used to overcome increases in cost or schedule that are due to potential risks, and for which no other mitigation measure is available. These contingency amounts may either be associated with a particular activity or category of cost, or set aside in a general fund. In most cases, the amount of risk a project experiences reduces as the project progresses toward completion. Similarly, it is expected that the amount of contingencies required for a project also decreases over time. However, at no time should it be planned that the contingency will be totally consumed until all project risk is removed—usually only at project completion or beyond.

Contingency Plan – A fallback plan developed for implementation if a risk response turns out to be not fully effective or an accepted risk occurs, along with identification of the conditions that trigger the execution of the plan.

Contingency Reserve – The amount of funds or time needed above the estimate to reduce the risk of overruns of program objectives to a level acceptable to the organization.

Likelihood – Assigned probability, expressed either qualitatively or quantitatively, that an identified risk will occur.

Monte Carlo analysis – A technique that performs a project simulation many times to calculate a distribution of likely results. See simulation. (PMI)

Opportunity – An uncertain condition or event that, if it occurs, has a positive effect on a project's objectives.

Probable Cost – The mean value of cost derived from combining distributions for cost and probability of occurrence.

Project Objectives – To deliver on an agreed-upon target such as cost, time, scope, or quality. For example, the project cost objective is to deliver the program within the agreed upon budget.

Qualitative risk analysis – Performing a qualitative analysis of risks and conditions to prioritize their effects on project objectives. It involves assessing the probability and impact of project risk(s) and using methods such as the probability and impact matrix to classify risks into categories of high, moderate, and low for prioritized risk response planning. (PMI)

Quantitative risk analysis – Measuring the probability and consequences of risks and estimating their implications for project objectives. Risks are characterized by probability distributions of possible outcomes. This process uses quantitative techniques such as simulation and decision tree analysis. (FHWA)

Residual Risk – A risk that remains after risk responses have been implemented.

Risk – An uncertain condition or event that, if it occurs, has a positive or negative effect on a project's objectives.

Risk Acceptance results from the recognition that further reduction of a particular risk would only come at the expense of CHSRP's fundamental goals, such as unacceptable service loss or cost increase, etc. Risk Acceptance often involves the potential consumption of CHSRP cost or schedule contingencies, project schedule float, or an increase in either project estimate or schedule delay.

Risk Assessment – Process of evaluating both the likelihood of an identified risk and the magnitude of its consequence.

Risk Avoidance – Available when a project element that is associated with certain potential risk events may be alternatively delivered through a less-risky process or design, or may be eliminated altogether.

Risk Evaluation – Process of comparing assessed risk ratings against pre-established criteria for the purpose of ranking the risks and identifying priorities.

Risk Management – Systematic process, guided by the CHSRP approved Risk Plan, which identifies, assesses, evaluates, mitigates, and manages risks for the purpose of significantly increasing the probability of delivering a successful Project.

Risk Management Cost – Risk Management Cost (RMC) is the total cost of all project risks, notices of potential claim, outstanding disputes and potential future (i.e., not identified as approved or pending) contract change orders on the project. The RMC is not a single number; it is a range of possible costs described by a probability distribution.

Risk Management Plan – The document that describes how project risk management will be structured and performed on the project. It is different from the risk register or the risk database that contains the data gathered and used in the risk management process.

Risk Management System – A repository that provides for collection, maintenance, analysis, and reporting of data gathered and used in the risk management processes.

Risk Mitigation – Process which identifies, evaluates, selects, and implements options to set risk at acceptable levels, given project constraints and objectives; it can include avoidance, transfer, reduction of the likelihood and/or the magnitude of the consequence, or the issuance of insurance when appropriate.

Risk Reduction – Planned action that will either reduce the consequence or the likelihood of a risk event.

Risk Register – A document containing the results of qualitative risk assessment and quantitative risk assessment and risk response planning. It is an output of the risk management processes and may be in the form of a risk database.

Risk Response – Actions taken to enhance opportunities and reduce threats to project objectives. Risk responses to threats are: *risk reduction, risk avoidance, risk acceptance, risk sharing and risk transference.*

Risk Response Planning – The process of developing options and actions to enhance opportunities and reduce the threats to project objectives.

Risk Score – Rating established by computing the product of the assigned likelihood and consequence values: *Maximum (cost impact, schedule impact) probability* where impacts and probability use a 1 – 5 scale

Risk Sharing – Occurs when the mitigation and the consequences resulting from a risk event become the responsibility of two (or more) parties involved in the project. An agreed-upon risk sharing agreement is developed to define sharing of risk between the involved parties.

Risk Transfer – Occurs when the mitigation and the consequences resulting from a risk event become the responsibility of a party other than the CHSRP; this may include a partial transfer (or risk sharing). This may also include the reallocation of scope in such a manner so as to transfer risks to scope elements or contract packages that are better suited to mitigate risk.

Secondary risk mitigation – Pre-planned, potential scope or process changes that may be triggered when risk events occur that require reduction of contingencies below minimum levels.

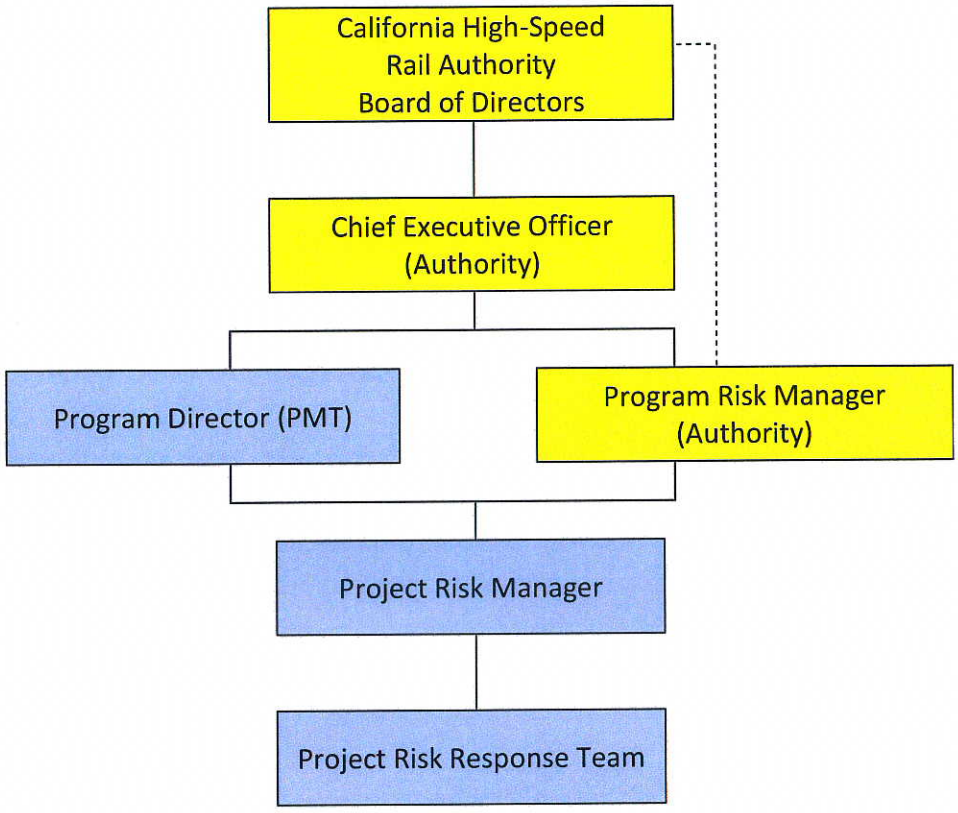
Simulation – Uses a project model that translates the uncertainties specified at a detailed level into their potential impact on objectives expressed at the level of the total project. Project simulations use computer models and estimates of risk at a detailed level and are typically performed using the Monte Carlo technique. (PMI)

3 RISK MANAGEMENT ORGANIZATION

3.1 RISK MANAGEMENT ORGANIZATION

The risk management organization for the CHST Project is shown in the Figure 1.

Figure 1: Risk Management Organization



3.2 ROLES AND RESPONSIBILITIES

The Authority has implemented an organizational structure to manage risk internally, on both a programmatic and project level. The roles and responsibilities in the risk management organization of the program are provided as follows.

Program Risk Manager (Authority)	• Ensures proactive response to all risks and opportunities that will impact the successful delivery of the Program • Approves and regularly reviews the Program Risk Management Plan in conjunction with Program Director to ensure compliance with applicable regulatory requirements and successful implementation • Approves risk management reports recommended by the Project Risk Manager • Promotes and directs risk management for the Program, maintaining its independence from Project and Program management • Participates in risk meetings as needed • Ensures implementation of risk response actions • Monitors the effectiveness of risk response actions • Consolidates project risk data into program level results • Reports to the Chief Executive Officer and Authority Board on risk management results, major issues and concerns • Accumulates the lessons learned in the area of risk management
Program Director (PMT)	• Ensures proactive response to all risks and opportunities that will impact the successful delivery of the CHSRP. • Recommends the Program Risk Management Plan to the Authority Chief Executive Officer • Reviews and recommends risk management reports to the Program Risk Manager and Authority Chief Executive Officer for approval
Project Risk Manager (PMT)	• Oversees and manages day-to-day risk management activities for the project. • Prepares for, schedules and conducts project risk meetings • Promotes risk management activities within the project team • Performs risk monitoring and control • Ensures quality of the risk data in the Risk Management System • Produces and keeps current the risk response plans • Tracks and monitors the effectiveness of risk response actions • Reports to the Program Risk Manager on all matters related to risk management • Accumulates the lessons learned in the area of risk management
Risk Response Team (see note below)	• Overall responsibility for maintaining currency of information in the risk register/Risk Management System (RMS) • Identify risks and their characteristics and assess in terms of probability of occurrence and impacts in conjunction with risk management personnel • Develop response strategy and actions • Document actions and report to the Project Risk Manager for inclusion in risk management updates • Monitor effectiveness of response actions • Communicate with the Project Risk Manager with regard to risk management actions, addition of new risks or retirement of old risks as appropriate
Risk Owners	• Implement agreed upon risk response actions • Report to the Project Risk Manager on effectiveness of the risk response actions. • Identify new risks that may emerge after response actions. • Communicate with Project Risk Manager regularly, including the need for other risk response actions.

Note on roles and responsibilities within Risk Response Team:

- Regional Managers are ultimately responsible for the currency and validity of risk information associated with their specific sections as well as the monitoring and control of response actions for those risks that are owned by personnel reporting to them, including Regional Consultants.
- Discipline leads are ultimately responsible for the currency and validity of risk information associated with their specific disciplines (e.g., Environmental, Engineering, Systems, Right-of-Way, and Procurement/Construction Management) as well as the monitoring and control of response actions for those risks that are owned by personnel reporting to them.
- Where there is overlap or conflict between the subject matter of the risk and regional organization (e.g., an environmental risk associated with a specific region), ultimate responsibility for vetting, monitoring and control of the risk rests with the Regional Manager or discipline lead who is in the reporting line of the risk owner. For example, the Regional Manager is responsible for monitoring and control of a particular engineering risk if ownership of that risk has been assigned to a Regional Engineer or member of the Regional Consultant's team. Conversely, the Engineering Manager would be responsible if the owner of the risk is a member of the Engineering Management Team.

4 RISK MANAGEMENT PROCESS

Risk management provides a systematic approach to identify and prioritize risks as well as action-oriented information to program and project managers to assist in the mitigation or avoidance of undesirable project outcomes and the 'capture' or enhancement of opportunities. Risk management is not an optional activity, nor is it a substitute for other project management processes. It is essential to successful management of program objectives. It adds the perspective of risks to the outputs of other processes (e.g., scheduling, budgeting and change management) and adds to their value by taking uncertainty into account to understand and manage challenges to the program's successful completion.

The risk management process is a 'living', iterative process that provides a structured, systematic procedure for managing risks. A complete risk management program comprises the following[1]:

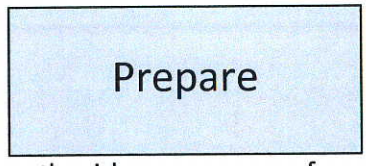
1. Prepare Risk Management – Define the scope and objectives of the program risk management process and ensures that the risk process is fully integrated into wider program management.
2. Identification – Identify as many knowable risks as practicable.
3. Assessment – Evaluate key characteristics of individual risks, qualitatively and quantitatively, enabling them to be prioritized for further action.
4. Analysis – Employ Monte Carlo simulations and Sensitivity Analysis to evaluate the combined effect of risks on the overall program outcome and identifying key cost and schedule drivers, ranking risks with respect to one another based on their impact on project cost and schedule outcomes.
5. Management – Determine appropriate response strategies and actions for each individual risk as well as for overall program risk, and integrate both into a consolidated program management plan, monitoring and controlling risks by implementing agreed upon actions and regularly reviewing changes in program risk exposure, identifying additional risk management actions as required, and assessing the effectiveness of the Program.

Note that while the above steps are listed sequentially, the process is iterative and, in practice, steps may be combined and are typically revisited as more information is developed about a particular risk or the wider project or program.

[1] See *Risk Analysis Methodologies and Procedures* (2004), Federal Transit Administration, United States Department of Transportation, Washington, DC

Risk Mgmt. Stage	Task
Prepare	Establish objectives for risk analysis and expected outcomes.
	Identify resources available and resources required
	Perform comprehensive review of base project scope, cost and schedule to validate reasonableness.
	Establish the project's base cost and schedule (base excludes contingencies that are not specific allowances for known but unquantified project elements). Risks costs and risk delays are added to the base.
	Project(s): *Scope, Cost, and Schedule Review (report on reasonableness and accuracy of scope, cost and schedule of project) Estimate of Base Project Costs and Durations (table of adjusted base costs and durations allocated to project components)*
Identify	Establish a comprehensive and non-overlapping list of possible risks to the project.
	Ensure all project components (major activities, contract units) are evaluated for risks and opportunities. Opportunities represent actions or measures that could reduce costs and delays as opposed to risks that increase costs and delays.
	Product: *Draft Risk Register*
Assess	Assess risks in terms of their likelihood of occurring and their potential costs and delay impacts when they do occur. Prior to designation of preferred alignment, risks will be assessed qualitatively. Following designation of preferred alignment, risks will be assessed quantitatively
	Estimate cost and schedule (i.e., duration) impacts of risks qualitatively or quantitatively, as appropriate.
	Identify correlated project components, that is, activities whose costs or durations move together in response to a risk event.
	Document estimated risk impacts on individual project components in the risk register.
	Product: *Completed Risk Register*
Analyze	Select the appropriate analysis method for estimating impacts of multiple risks on the project cost and/or schedule. This involves combining risks impacts depend upon the objective: (probable costs, probable durations) to obtain the risk cost or delay to a project. The method will depend upon the objective: •Evaluate risk cost impacts to the base project cost [Independent cost analysis] •Evaluate risk delay impacts to the base project schedule [Independent schedule analysis]
	Sensitivity Analysis: Rank risks by the magnitude of their effect on total project cost or duration, i.e., how much the project cost or duration changes when risk occurs. May be done in advance of, or in conjunction with, Monte Carlo analysis
	Use **Monte Carlo simulation** analysis methods for combining risk and base costs or schedule durations
	Review analysis results with expert panel/workshop participants and project owner management.
	Products: *Sensitivity analysis; Analysis Results in financial terms (risk plus base costs and/or durations; probabilistic estimates of total project cost and/or duration); Risk Analysis report Assessment Report (summary and findings of Prepare, Identify, Assess, Analyze)*
Manage	Prioritize risks for **mitigation**: unacceptable risks; high cost, high likelihood risks. Mitigation must be cost-effective;
	Allocate risks to parties best able to manage/mitigate them. Contract documents and alternative procurement methods offer means for distributing risks.
	Prepare a risk management plan describing risk mitigation strategies, responsible parties, likely costs and benefits, additional implementation requirements.
	Monitor performance of mitigation measures; reevaluate risk mitigation strategies as appropriate to improve outcomes.
	Products: *Priority Ranking of Risks for Mitigation; Risk Mitigation Register; Benefit-Cost Assessment of Risk Mitigation Costs; Risk Management Plan (attachment to Project Management Plan and Risk Assessment Report)*

4.1 PREPARATION



The goals and objectives of the risk management effort as well as personnel have been discussed in preceding sections. Preparation for risk management also requires establishing and performing a comprehensive review of project scope, cost and schedule and establishing the project's base cost and schedule. This is particularly true as the risk process moves from the more general and qualitative approach that is employed prior to designation of a preferred alignment to the more focused, quantitative approach that will be employed following selection of an alignment. This section discusses the process by which the project will establish the project's base cost and schedules, and lay the foundation for more focused risk management efforts.

Broadly, the purpose of this section is to describe how the Authority is systematizing the process for collecting, integrating and communicating cost, schedule and risk information. In terms of risk management, these activities lay the foundation for follow-on risk assessment, analysis, allocation and contingency recommendations.

The GAO identifies the following characteristics of a 'good' cost estimate in its *Cost Guide (2009)*, and these can broadly be taken to be the characteristics that the Risk Management Program will also use to define a 'good' schedule:

1. An **accurate** estimate is unbiased, not overly conservative or overly optimistic, and based on an assessment of most likely costs.
2. A **comprehensive** estimate ensures that all possible costs are included in sufficient detail to ensure that costs are neither omitted nor double counted.
3. A **well-documented** estimate is thoroughly documented, and includes source data and significance, clearly detailed calculations and results, and explanations for choosing a particular method or reference.
4. A **credible** estimate discusses any limitations of the analysis from uncertainty or biases surrounding data or assumptions.

Note that in order for an estimate to be credible (characteristic 4), the GAO expects both a sensitivity analysis and a risk and uncertainty analysis (discussed later in this document). While the cost estimate and schedule (developed with respect to a specific project scope) lay the foundation for risk management efforts, risk assessment and analysis enhance the plausibility and trustworthiness of the project's cost estimate and schedule.

The Program has developed a draft Basis of Estimate and Schedule template (Appendix C) to facilitate and document this effort. The process embodied in this document will provide for the following:

- Document the overall scope of contract package
- Establish a common basis among the project team - cost estimators, schedulers, engineering, environmental, procurement, right-of-way, etc – for discussion and decision making
- Communicate the estimator's knowledge of the contract package by demonstrating an understanding of scope and schedule as it relates to cost

- Alert the project team to potential cost risks and opportunities
- Facilitate the review and validation of the cost estimate and schedule
- Establish the initial baseline for scope, quantities and cost for use in cost trending throughout the project
- Provide a record of all documents used to prepare the estimate
- Provide a record of key communications made during estimate preparation.
- Act as a source of support during dispute resolutions
- Provide the historical relationships between estimates throughout the project lifecycle
- Reduce the number of addenda

The completed *Basis of Estimate* document will:

- Be factually complete, but concise
- Be able to support facts and findings
- Describe the tools, techniques, estimating methodology, and data used to develop the cost estimate
- Identify other projects that were referenced or benchmarked during estimate preparation
- Establish the context of the cost estimate and schedule and support estimate and schedule review and validation
- Identify estimating team members and their roles

These efforts will be led by Authority staff with support from Project Controls and Risk Management personnel.

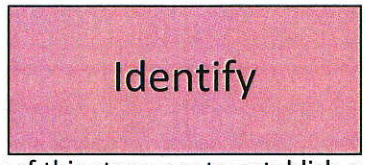
4.1.1 Updating Capital and Support Cost Estimates

The Program-wide estimate is an estimate of all capital costs associated with implementation the California High-Speed Rail Program. It is expected that as the CHSRP progresses, more detailed information will be developed requiring periodic updates of the estimate. Program-wide estimates will be re-estimated every two years as part of the updates to the Business Plan. The revised estimate will be established as the current baseline estimate for the program. Prior to adoption of the revised business plan estimate, the estimate will be reconciled to the previous business plan estimate.

Subsequent to the adoption of the baseline estimate all revisions to the baseline estimate as a result of configuration changes resulting from changes to alignment, development of more detailed plans, or actual bid costs will be tracked and approved through the Authority's change management procedure. The current baseline estimate together with all approved changes will be the basis by which the revised business plan estimate is reconciled.

In addition to the above requirement, as each segment of the overall alignment of the program evolves in development the segment or construction package will be estimated at the 15 percent design level and again following completion of the engineering for procurement design level. These detailed cost estimates will be the basis for integrating estimates for overall capital costs, support costs, and contingency reserves in reports.

4.2 IDENTIFICATION AND OWNERSHIP



Risk identification includes examining the elements of project definition and management processes to identify the associated risks and their root causes that may prevent the project or program from being delivered within the constraints of minimum scope, schedule and cost, given the Program's management capacity and capability. The objectives of this stage are to establish a comprehensive and non-overlapping list of possible risks to the project and ensure that all project components (major activities, contract units) are evaluated for threats and opportunities. For major transit projects, such risks include:[2]

- Socio-political risks
- Financial risks
- Planning and design risks
- Environmental concerns
- Right-of-way acquisition
- Permitting requirements
- Third party agreements
- Technology applications, availability, and reliability
- Procurement requirements (vehicles, civil facilities, systems equipment, materials)
- Construction risks, including maintenance of traffic, changed conditions, utilities and subsurface conditions, etc.
- Other risks, such as acts of God (weather, etc.) and changes in regulatory conditions or market conditions

Risk identification, both threats and opportunities, will be iterative, comprehensive, objective and relevant to Program objectives. The identification stage forms the basis for the assessment, analysis and risk management activities that follow. There is no reasonable way to effectively accomplish any subsequent stages if the risk identification is not successful. In particular, the following factors shall define the risk identification stage[3]:

- **Early Identification** – All else being equal, the earlier a risk is identified, the more likely it can be effectively managed at lower cost (in cost or time); this applies to both threats and opportunities.
- **Iterative and Emergent Identification** – Not all risks can or will be identified at any given point in a project or program and risk identification will be done periodically for the life of Program. In addition, identification is not limited to the formal risk review sessions listed above. CHSRP team members can and should contact a risk manager when they identify a new risk or there is a significant change to an existing one.

[2] *Risk Analysis Methodologies and Procedures* (2004), Federal Transit Administration, United States Department of Transportation, Washington, DC

[3] *Practice Standard for Project Risk Management*, Project Management Institute, 2009

- **Comprehensive Identification considering Multiple Perspectives** – The Risk Management Program will consider a broad range of sources of risk with input from a range of stakeholders; limiting identification to a narrow range of sources or to a small number of team members is likely to lead to less than comprehensive view of the risks to the Program and increases the likelihood that the Program will be 'blind-sided' by a threat or miss a significant opportunity
- **Relevant to Program Objectives** – The identified risk should clearly relate to one or more of CHSRP's objectives (e.g., scope, cost and schedule) and this relationship shall be communicated in its description.
- **Complete Risk Statement and Level of Detail** – Risks will be clearly and unambiguously defined with a level of detail necessary to be clearly understood by those responsible for risk assessment and risk response planning (including determining who is in the best position to manage the risk). It is recognized that this objective is made more difficult by pursuit of early identification. The description of a risk will be developed and refined on subsequent iterations. It is highly unusual to have a complete, fully explicated risk statement after the first (or even second or third) pass at stating the risk, but this should be the goal for each iteration.

What **is** included in the risk register:
1. The risk is outside the scope of challenges that could reasonably be expected to be met (and overcome) by professional due dilligence
2. The risk or its management requires your or, especially, another group to significantly reprioritize effort or resources from what is being done currently. This includes instances when an important activity has been significantly underallocated for either in the current cost estimate or schedule.

When a risk is identified, ownership should be assigned to the person in the best position to manage this risk. This ownership assignment is done both by group (e.g., Authority, Engineering, Regional Consultant – Merced to Fresno) and by individual.[4] Risks identified far in advance of potential impact are likely to have a significant amount of uncertainty associated with them, including a lack of certainty about what the true underlying issues are and who is actually able to manage them. In such cases, a tentative assignment can be made with ownership assignment revisited and changed, if appropriate, once the risk is better understood. Such changes must be reviewed with the Project Risk Manager or Program Risk Manager and reflected in the risk register. Until such changes are reflected on the risk register, it will be assumed that the person listed owns the risk(s).

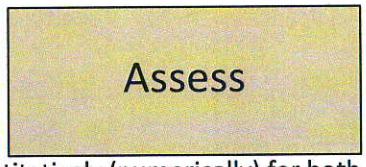
To facilitate risk identification and ensure a comprehensive and non-overlapping list of possible risks to the project, risk checklists will be employed in workshops. (An example is provided in Appendix B.)

Risk Identification will be led by Risk Management personnel at the regional or project level and overseen by the Authority Program Risk Manager. At the programmatic level, this effort will be led by

[4] 'Ownership' as it is discussed here is for the purposes of managing risks prior contract award through, for example, changes in design or planning. It is distinct from allocation, which is discussed in the Management section of this plan.

the Authority Program Risk Manager. For individual regional teams as well as at the Program level, risk workshops will be held at quarterly intervals.

4.3 ASSESSMENT



This section describes the process and criteria by which risks (both threats and opportunities) will be assessed, first qualitatively and then quantitatively. Prior to designation of a preferred alignment, risks will be assessed qualitatively for likelihood and cost, schedule, scope and quality impacts. Following designation, risk impacts will be assessed quantitatively (numerically) for both probability and cost and schedule impact. In conjunction with these numeric assessments, any applicable correlations between risks will be specified. Assessment information will be documented and collected in the Program Risk Register.

4.3.1 Qualitative Assessment

Qualitative assessment criteria are used to assess risks in broad terms, considering the risk's potential impact on the Program's objectives together with a consideration of the relative importance of these objectives and the proximity of the construction phase for the given segment. These assessments should be made with reference to the underlying scope of work. At the regional level, qualitative assessments will be used prior to designation of a preferred alignment.

Table 2 provides assessment criteria for qualitative assessment of threats. These assessments shall be made with respect to the underlying scope of work being examined. For example, at the regional level, any assessment of percentage increase or decrease in costs should be made with respect to the work for that region, not with respect to the overall Program cost. The qualitative assessment criteria for opportunities are given in Table 3. Table 4 provides criteria for the qualitative assessment of probability – the likelihood that a particular risk or opportunity will occur or be realized.

Table 2: Qualitative criteria for assessing threats to Program or Project objectives

Threat Level	Description
Very High	Time: Delivery plan milestone delay outside fiscal year Cost: > 20% cost increase Scope: Scope does not meet purpose and need Quality: Quality does not meet one or all of the following - Safety, C, O and M
High	Time: Delivery plan milestone delay of more than one quarter Cost: 10 to 20% cost increase Scope: Sponsor does not agree that Scope meets purpose and need Quality: Quality may be made acceptable through mitigations or agreement
Medium	Time: Delivery plan milestone delay of one quarter Cost: 5 to 10% cost increase Scope: Changes in project scope limits or features with 5 to 10% cost increase Quality: No safety issues, C, O, M deficiencies require Program Director or Authority approval
Low	Time: Delivery plan milestone delay within quarter Cost: < 5% cost increase Scope: changes in project scope limits or features with < 5% cost increase Quality: No safety issues, C, O, M deficiencies approved by project team
Very Low	Insignificant cost, time or scope impacts Quality degradation barely noticeable
C – Constructability, O – Operability, M – Maintainability	

Table 3 Qualitative criteria for assessing opportunities for the Program or Project objectives

Opportunity Level	Description
Very High	Time: Delivery plan milestone improves by more than 1 quarter Cost: > 5% cost decrease Scope: Improves chances to achieve project limits or features with cost increases of <2% Quality improvement is 'best in class'
High	Time: Delivery plan milestone improves by 1 quarter Cost: 3% to 5% cost decrease Scope: Improves chances to achieve project limits or features with cost increases of 2% to 5% Quality improvement can be claimed by project
Medium	Time: Delivery plan milestone improves but still within quarter Cost: 1% to 3% cost decrease Scope: Improves chances to achieve project limits or features with cost increases of 5% to 10% Quality: C, O, M improvement can be seen and measured
Low	Time: Delivery plan milestone does not improve but float is added Cost: < 1% cost decrease Scope: Improves chances to achieve project limits or features with cost increases of 10% or more Quality: C, O, M improvement noticeable by project team
Very Low	Insignificant schedule improvement or cost reduction Scope effect is not noticeable No quality improvement noticeable
C – Constructability, O – Operability, M – Maintainability	

Table 4 Qualitative criteria for assessing probability of threat or opportunity

Probability	Description
Very High	Highly likely to near certain to occur or be realized
High	More likely that risk or opportunity ***will*** occur or be realized than that it will not; e.g., 2-3 times more likely that it ***will*** than that it will not
Medium	Just as likely as not,'50/50' chance
Low	More likely that risk or opportunity will ***not*** occur or be realized than that it will; e.g., 2-3 times more likely that it will ***not*** than that it will
Very Low	Highly unlikely to near impossibility that risk or opportunity will occur or be realized

4.3.2 Quantitative Assessment

Once a preferred alignment has been identified, the Risk Management Group will implement a comprehensive reassessment of risks in quantitative terms. This effort will typically be preceded by

dedicated risk workshop led by the Authority Program Risk Manager to ensure that all major risks particular to the alignment and proposed design have been identified.

In the assessment process, risks are assessed for the following:

- Probability of occurrence
- The level of cost or schedule increase (decrease) for the identified threat (opportunity)

Table 5 provides the criteria for quantitative assessment of individual risks. These defined levels are intended to facilitate preliminary quantitative assessments and to serve as a consistent frame of reference for the project teams in assessing the identified risks although any quantitative analysis can and typically will incorporate more detailed assessments, particularly with regards to impact criteria, e.g., $10-$20 million with $12 million being Most Likely; as opposed to just $10 to $50 million (category 3 in Table 5).

Table 5 Quantitative Assessment Criteria

Threat Impact Level	Cost Increase	Schedule Increase
Very High (5)	> $ 100 M	6 Months and above
High (4)	$ 50 M to $ 100 M	4 to 6 Months
Medium (3)	$ 10 M to $ 50 M	2 to 4 Months
Low (2)	$ 1M to $10 M	1 to 2 Months
Very Low (1)	< $ 1M	1 Week to 1 Month
Probability Level	**Probability of Occurrence**	
Very High (5)	90 - 99%	
High (4)	65 - 89%	
Medium (3)	36 - 64 %	
Low (2)	11 - 35 %	
Very Low (1)	1 - 10%	
Opportunity Impact Level	**Cost Reduction**	**Schedule Reduction**
Very High (5)	> $ 100 M	6 Months and above
High (4)	$ 50 M to $ 100 M	4 to 6 Months
Medium (3)	$ 10 M to $ 50 M	2 to 4 Months
Low (2)	$ 1M to $10 M	1 to 2 Months
Very Low (1)	< $ 1M	1 Week to 1 Month

Note: These are simply a starting point, risks can and will be assessed with more detail, e.g., $5 million to $12 million with $7 million being Most Likely. More specific probability assessments are more difficult to support but may be made where underlying knowledge of the risk and its context makes it feasible.

Figure 2: Program Risk Matrix ('Heat Map') for Threats

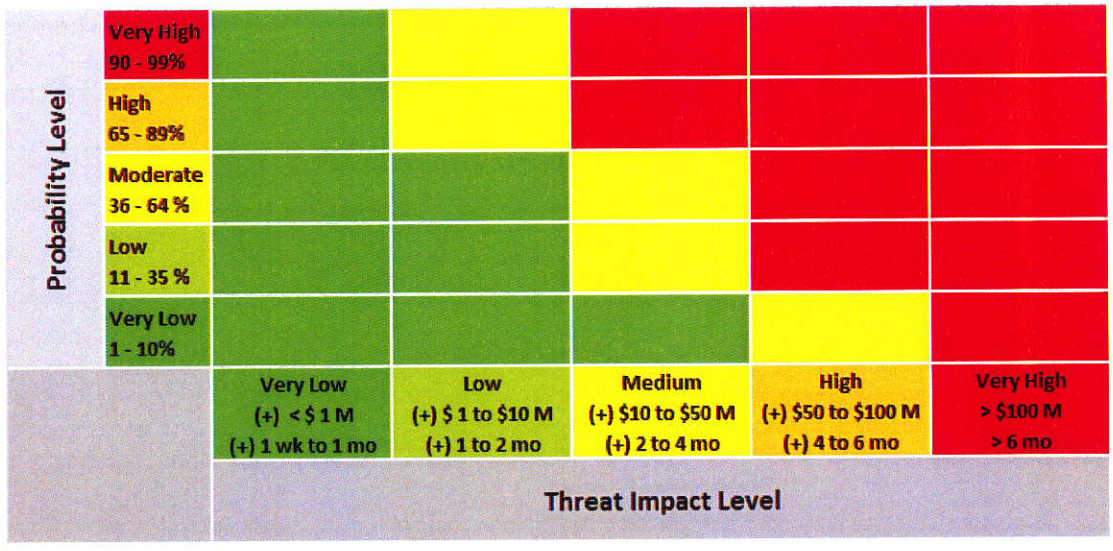
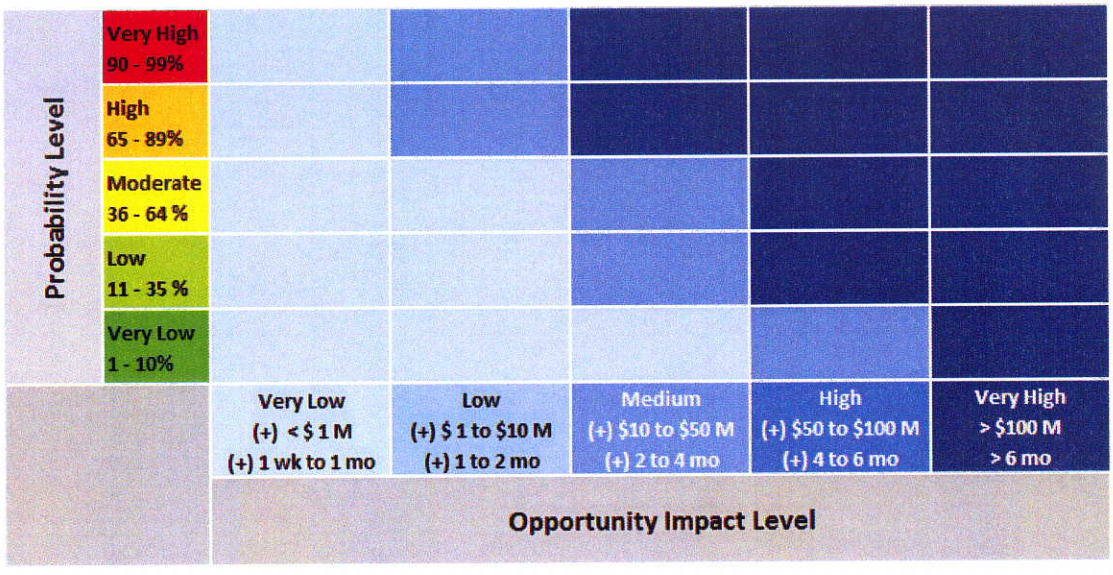


Figure 3: Program Risk Matrix for Opportunities



4.4 QUANTITATIVE ANALYSIS

After initial assessments have been made for all identified risks, the risk register data is locked in to become the baseline. The assessments for these risks are revised in future revisions and the progress of the risk response actions will be measured against the baseline.

Analyze

The objective of risk analysis is to utilize the risk assessments to develop a more detailed numerical analysis of the impacts to the program cost and schedule and understand what impact, collectively, these risks may have on Program cost and schedule objectives. The Program will primarily be employing Monte Carlo simulations to analyze cost and schedule risk exposure but other analysis tools (e.g., fault trees) may be employed to analyze particular situations or risks.

During risk analysis, the information developed for cost and schedule is integrated with the risk information generated in earlier steps in this process to develop risk and uncertainty impacted cost and schedule estimates.[5] Either prior to or in conjunction with Monte Carlo simulations, a Sensitivity Analysis will be performed to determine the impact on overall cost or schedule estimates of individual risks or uncertainties and provide a 'ranking' based on these determinations to support follow-on management activities.

To determine overall cost and schedule risk exposure, Monte Carlo simulations will employed. These will also facilitate Sensitivity Analysis within the context of the base cost and schedule. This is particularly important with regards to schedule analysis, where the risk's location within the schedule is as important, or more important, than the relative size (% X impact) of the risk itself.

Broadly, these processes are intended to provide a measure of overall cost and schedule risk exposure, identify prime drivers of cost overruns or schedule delays, establish levels of confidence for particular cost and schedule outcomes, and inform follow-on management efforts including prioritization, allocation and contingency recommendations. The objective is to prevent and assist other Program Management efforts to prevent the following:

- Cost overruns
- Schedule overruns
- Inadequate or misallocated contingency
- Contingency being expended faster than project can with support

Cost and Schedule risk analysis efforts will be led by risk management personnel under the supervision and direction of the Authority Program Risk Manager.

4.4.1 Sensitivity Analysis

The purpose of the sensitivity analysis is to describe the change, positive or negative, in the cost estimate that results from a change in a single construction element, quantity type or assumption. The

[5] As noted earlier, this is done on the base cost and schedule estimates, stripped of any explicit or implicit contingency or float to avoid double-counting.

resulting change in the overall cost highlights how sensitive the overall estimate is to the changes in a particular variable. Typical variables, or factors, often varied in a sensitivity analysis[6], include the following:

- A shorter or longer economic life
- The volume, mix, or pattern of workload
- Potential requirements changes
- Configuration changes in hardware, software, or facilities
- Alternative assumptions about program operations, fielding strategy, inflation rate, technology heritage savings, and development time
- Higher or lower learning curves
- Changes in performance characteristics
- Testing requirements
- Acquisition strategy, whether multiyear procurement, dual sourcing, or the like
- Labor rates
- Growth in software size or amount of software reuse
- Down-scoping the program

This analysis may be done as a precursor to a 'full' Monte Carlo risk analysis or in conjunction with it.[7] A cost sensitivity analysis will be performed for all construction packages following determination of a preferred alignment. The information developed during the cost sensitivity analysis will serve as a basis for cost risk analysis and inform contingency requirements.

4.4.2 Monte Carlo Cost and Schedule Risk Analysis

As discussed above, quantitative assessments (probability of occurrence and cost/schedule impact) of individual risks recorded in the risk register are used to support quantitative cost and schedule analysis. These assessments serve as a key, but not exclusive, input to determination of the program's financial risks. Information developed as part of the sensitivity analysis discussed above, and cost and schedule estimating process as well as reviews of the financial outcomes of past projects[8] and a consideration of the risk allocation embodied in different procurement strategies and contract terms also serve to inform quantification of the Program's financial risk exposure.

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[6] GAO, *Cost Estimating and Assessment Guide, 2009,* GAO-09-3SP, p. 147

[7] A sensitivity analysis, typically presented as a bar chart, is a common output of most software used for Monte Carlo analysis.

[8] See, e.g., "Risk Analysis and Contingency Determination Using Range Estimating," AACE, Humphreys, K., (2008), "Underestimating Costs in Public Works Projects," Journal of American Planning Association: Vol. 68, No. 3, Flyvbjerg, B., Holm, M. S. and Buhl, S. (2002), "TCRP Project G-07 Managing Capital Costs of Major Federally Funded Public Transportation Projects" U.S. Department of Transportation, Transportation Research Board (2005) and *Megaprojects and Risk: An Anatomy of Ambition* and included subsidiary studies, Flyvbjerg, B., Bruzelius, N. and Rothengatter, W. (2003)

The quantitative risk analysis has two principal components: the endogenous uncertainty/variability associated with individual schedule activities or line-item costs, and the exogenous (to the program schedule or cost estimate) risk events that may impact the schedule or cost estimate.

The uncertainty or variability in durations or cost elements is typically accounted for by the replacement of single point duration or cost estimates with ranges. Discrete cost and schedule risks with a probability of occurrence and, typically, a range of possible cost or schedule impacts (dollars or calendar/work days, respectively) are then applied to these estimates to account for exogenous risks that cannot be properly quantified or addressed by simply increasing the range around a particular cost element or activity. As noted above, these risks are typically captured in the risk register. The risk register is discussed further in Section 4.6.1.

Monte Carlo simulations are then performed on these risk and uncertainty impacted estimates to generate probability distribution curves. The result is that instead of one cost or schedule outcome, there will be multiple possible outcomes, each associated with a probability (confidence level) that it will be achieved.

As with sensitivity analysis above, quantitative analysis of cost and schedule will follow determination of a preferred alignment and be completed and reported to the Authority prior to contract award.

The application of Monte Carlo simulation for cost and schedule risk analysis is discussed in greater detail in Appendix D.

4.5 MANAGEMENT

Manage

Management involves a determination of appropriate response strategies and actions for each individual risk and for overall program risk to reduce the risk impact to the program. Risks will be prioritized for mitigation and cost-effective risk response strategies will be developed for individual risks, or a set of risks. The response strategies will include avoidance, transfer, reduction of the likelihood and/or the magnitude of the consequence, or the acceptance of risk when appropriate. All affected stakeholders will be involved in determining the appropriate risk response strategy. These strategies include one, or a combination, of the following:

- *Avoid* -- This strategy involves developing a response plan that eliminates the risk altogether or entirely insulate the project objectives from its impact.
- *Transfer* -- This strategy entails transference to a third-party that is better positioned to address a particular risk by contractual means – this approach is addressed under Allocation (Section 4.5.1).
- *Mitigate (Enhance in the case of Opportunities)* -- Involves taking actions that decrease either the impact, likelihood, or both, of a threat to an acceptable threshold; increase the likelihood or beneficial impact in the case of opportunities
- *Accept* -- This strategy is applied when a risk response plan is not feasible and accepting the risk remains the most effective solution. Depending on the severity of the potential impacts, this

strategy may necessitate development of a contingency plan to address the acceptance of risk and/or identification of contingency funds or schedule float to protect the project objectives

Collectively, these are termed Primary Risk Mitigations and take the form of a specific action or set of actions (or conscious determination not to take action in the case of Acceptance) taken in response to identified threats to project or program objectives. This is in contrast to Secondary Mitigation, discussed in a later section, which consists of pre-planned, potential scope or process changes that may be triggered when risk events occur that require reduction of contingencies below minimum levels. These actions form the basis for a larger response plan which comprises the following:

- *Assigning a named individual within a party who assumes an overall responsibility for the management of the risk* -- The risk owner takes the lead in identifying options to reduce the probability or impacts of the assigned risk.
- *Developing various options for potential reduction in the threat (or enhancement of the opportunity) and cost of implementing the option* -- The risk owner will involve subject matter experts and explore all options.
- *Selecting the best option for managing the risk* -- After developing various risk response options, the risk owner will, with help from subject matter experts, select the best possible option for the program. This selection process will take into account the cost of the responses, any impact on the project objectives, uncertainty of outcomes and the possible secondary and residual risks.
- *Assigning actions to execute the selected risk response plan* -- The risk owner will take lead in managing the selected risk response plan and may assign specific actions to other individuals who he or she believes are in the best position to implement them; regardless of any delegation, the risk owner maintains overall responsibility.

Development of risk response strategies will be led by risk management personnel in conjunction with the wider Program team and individual regional or technical teams as appropriate given the nature and importance to overall Program objectives of the given risk.

Appendix E presents some general risk avoidance and risk mitigation strategies.

4.5.1 Allocation

Where risks cannot be acceptably mitigated, or cannot be cost-effectively mitigated through planning or design, the Program will seek to eliminate or reduce the impact of threats to its objectives through allocation or by providing project reserves or contingencies (refer to Section 4.5.2). Risks identified early in the project development process can often be dealt with through better planning and design and this is the objective of identifying and implementing (primary) mitigations discussed earlier. As the project approaches contract award, under a Design-Build delivery approach, much of the mitigation of any remaining risks will necessarily need to be realized through carefully prepared contracts that equitably and cost- effectively allocate these risks between the Authority and the prospective contractor.

As the Federal Highway Administration (FHWA) states in its *Guide to Risk Assessment and Allocation in Highway Construction Management*, the objectives of risk allocation can vary depending on unique

project goals, but FHWA's four fundamental tenets of sound risk allocation will be followed on this Program:[9]

1. Allocate risks to the party best able manage them.
2. Allocate the risk in alignment with project objectives. Project objectives directly determine optimum risk allocation strategies, or when project risk allocation is justified in deviating from traditional industry standards.
3. Share risk when appropriate to accomplish project goals.
4. Ultimately seek to allocate risks to promote team alignment with customer-oriented performance goals.

In line with industry best practices, each Construction Package will be assessed individually to determine what risk allocation consistent with the Program's policies and objectives will be most likely to minimize the sum of initial cost (bids) and cost of retained risk exposure. [10] To document the risk allocation for specification of contract provisions and to serve as a communication tool for all team members throughout the design and construction management process, an allocation matrix will be prepared under the direction of the Authority.

An allocation matrix template is provided in Appendix F.

4.5.2 Contingency

The CHSRP is obligated to effectively manage risks. Following award of contracts for construction, the most obvious manifestation of this effective management of risks is for CHSRP to demonstrate that it has provided adequate cost and schedule contingency and that it is not consuming (drawing down) this contingency more rapidly than is supportable.

Actual contingency will be managed according to CHSRP's *Contingency Management Plan*, but it is predicated on the following points:

- Forecasted overruns will be resolved first through engineering, design, and administrative solutions, and use of Project Contingency or Program Unallocated Contingency will only be considered should all those fail to eliminate overrun situations.
- Contingency is to account for risk. Risk is created when some aspects of the project are unknown or when certain project elements are likely to cause concern. Steps will be taken to reduce such risks and thus avoid use of contingency.

[9] David B. Ashley, James E. Diekmann, Keith R. Molenaar, *Guide to Risk Assessment and Allocation in Highway Construction Management,* p. 31, U.S. Department of Transportation, Federal Highway Administration (2006)

[10] 'Because of the advantages and disadvantages associated with efficient and equitable allocation of risk, each project should be assessed individually and to determine for each risk what allocation consideration will reduce the overall cost to the project's total cost of risk.' *Allocation of Insurance-Related Risks and Costs on Construction Projects* (1993). Construction Industry Institute, Austin, TX.

- Management will treat the use of contingency as the next to last resort used in order to complete a project, only followed by de-scoping the project.
- Alternatives shall always be explored before applying de-scoping functionality. De-scoping of the project should always be avoided and project stakeholder concurrence should be obtained before scope is removed.
- Contingency shall not be used to increase the scope of work unless such new scope is deemed absolutely necessary for the functionality of the project and it was omitted from the original scope of work.

Categories of risks considered in the determination of the contingency allocated to a specific project include, but is not limited to, design development, differing site conditions, schedule adjustment, third party requirements, and contract administrative issues. Examples of trends that might adversely affect the contingency drawdown include:

- Schedule delays that persist in any given area such as design, procurement process, a specific contract, utility work, etc.
- An inordinate number of contract change orders coming from a specific contract
- Market conditions that are known to increase contract costs such as limited number of bidders, increasing fuel and material prices, etc.
- Interface issues between two or more contracts that have the potential to worsen with no attention

To help determine adequate contingency, prior to award of any construction contract the Authority will reassess CHSRP's cost and schedule risk exposure. This reassessment will be focused on those risks or uncertainties that the Authority will retain following primary mitigation efforts and any contractual allocation to other parties. Broadly, this process will involve repeating the quantitative analysis described earlier (Sensitivity Analysis and Monte Carlo simulations) considering only those risks that have not been eliminated by primary mitigation and for which CHSRP will be contractually responsible (those remaining after allocation). The systematic re-evaluation is intended to provide both a better understanding of the appropriate contingency and what it may be used for.

The contingency itself is an acknowledgement of, and insurance against, the potential adverse affects of unmitigated risks. The advantage of this risk based approach and its employment of Monte Carlo simulations is that it provides information about the level of confidence (probability of sufficiency of contingency) that such assigned contingency provides. This probabilistic assessment of project risk provides a means for establishing project budgets with varying levels of confidence against cost overruns.

4.5.3 Secondary Mitigation Planning

Secondary risk mitigation consists of pre-planned, potential scope or process changes that may be triggered when risk events occur that require reduction of contingencies below minimum levels.

The CHSRP will actively conduct primary risk mitigation, as described previously in this Risk Management Plan, to reduce the overall level of risk. This will improve the CHSRP's chances of having sufficient contingency available for unanticipated costs or schedule delays. There will, however, be risks that cannot or have not been anticipated or cannot practically, be avoided, mitigated or allocated in a cost-effective manner. For situations or specific risks where available contingency will not be enough to protect CHSRP against significant adverse impacts to its cost or schedule objectives, the Program will develop secondary mitigation plans to provide the means to replace contingency expended beyond planned amounts for any period of time.

4.6 Monitoring and Control

The risk management process is intended to be continuous and ongoing for the life of the project. Project/Program Managers and Risk Manager(s) are expected to regularly monitor and review their risk management efforts to ensure compliance and maintain current records of their risk management efforts. In particular:

- Individual risks are regularly reviewed to ensure that they accurately describe a current threat to, or opportunity for, project objectives; that their assessments reflect the best estimate of potential impacts and probability; and that management strategy and mitigations are well-founded.
- Individual team members with management responsibility for one or more risks monitor and report on the above for their particular risks to the Project or Program Risk Manager as appropriate.
- The Project Managers and Risk Manager(s) identify and report on the key risks facing the project at the current time.
- The status of individual response actions is regularly updated to reflect the current status of these efforts and team member responsibilities.

The Project Risk Manager or Risk Response Team leader is responsible for motivating and scheduling these small-scale reviews and update sessions with the individual or functional groups. It is the responsibility of individual team members or group leads to alert the Project Risk Manager or Risk Response Team leader of any changes in previously identified risks, or new risks that have been identified in the course of their work, in a timely manner. This information is collected in the Program's risk register.

4.6.1 Risk Register and Risk Management System

Risk information is collected in the Program's risk register. The information collected for each risk includes the following:

- Identification – Description of the risk (threat or opportunity) as well as the general risk category (e.g., Environmental or Engineering/Design) and the appropriate section designation such as Program-wide or Bakersfield-Palmdale, as appropriate.

- Ownership – Program personnel with overall responsibility for managing and reporting on current status of the risk.
- Assessment – The potential cost or schedule impacts to the Program as well as the probability of occurrence; the assessment criteria may be either qualitative (e.g., 'Low') or quantitative (e.g., <$1M).
- Management – The strategy for managing the risk as well as specific response actions developed to counter the threat or capture the opportunity (where management strategy is not 'accept').
- Additional information will be collected for risks as it is developed and appropriate such as associated contract package, standard cost category or WBS element.

The Program risk register provides a description of the event which is determined to result in a risk to the Program's cost, schedule, quality or other desired objective, a description of the outcome if that risk event were to occur together with, at a minimum, a qualitative assessment of the risk. In accordance with general risk management principles, overall management responsibility for the individual risk – risk ownership – will be assigned to the group in the organization in the best position to manage the risk. Within the assigned group a particular, named individual will assume responsibility for carrying out, or directing others to carry out, designated response actions (mitigations). The risk register is a living management tool which is regularly updated through the risk review process, with risks being added and removed from the risk register, re-rated and adjusted as appropriate through the regular reviews and as a result of the individual risk mitigation plan implementation. As discussed previously, for elements of the Program that are more advanced, a quantitative assessment of the risk, the likelihood (%), cost and/or schedule impact should the risk event occur are also assessed.

In order to better collect, monitor, and report on risk information, a Risk Management System (RMS) will be developed and deployed in fiscal year 2012-13. It will provide the following features and functionality:

- Enter new risks to a project risk register
- Edit existing risks and assign a probability to indicate each risk's probability of occurrence along with a severity to indicate the likely cost and schedule impacts of each risk for quantitatively assessed risks
- View a risk "heat map" – a risk matrix indicating the distribution of risks against probability and severity ratings
- Synopsis of initial impacts compared to current impacts
- Document and manage risk mitigation action items on a periodic basis
- Generate standard and customized risk reports in PDF, Excel and on screen
- Risk Register (standard and custom reports including filtering the records)
- Risk Matrix Generation of individual, top and summary risks
- Generation of risks by owners and action items
- Basic tools to add/append, delete and edit records

- Query of specific record(s)
- Historical record of identified risks
- Administration page for security and permission(s)

Continuous monitoring and control of the program risk register ensures that CHSRP personnel have an understanding of the challenges currently facing the CHSRP and their role in combating them as well as making them aware of possible opportunities to improve the Project, reduce costs or save schedule. As the FTA states, '...projects are more prone to cost overruns and schedule delays when recipients treat the risk register and corresponding risk mitigation measures to be static once developed. Continual review and updating of the risk register is a necessary component of a robust risk management program.' [11]

[11] *FTA Project and Construction Management Guidelines*, p. G-14, Federal Transit Administration, U.S. Department of Transportation, Washington, DC, July 2011 Update

5 REPORTING

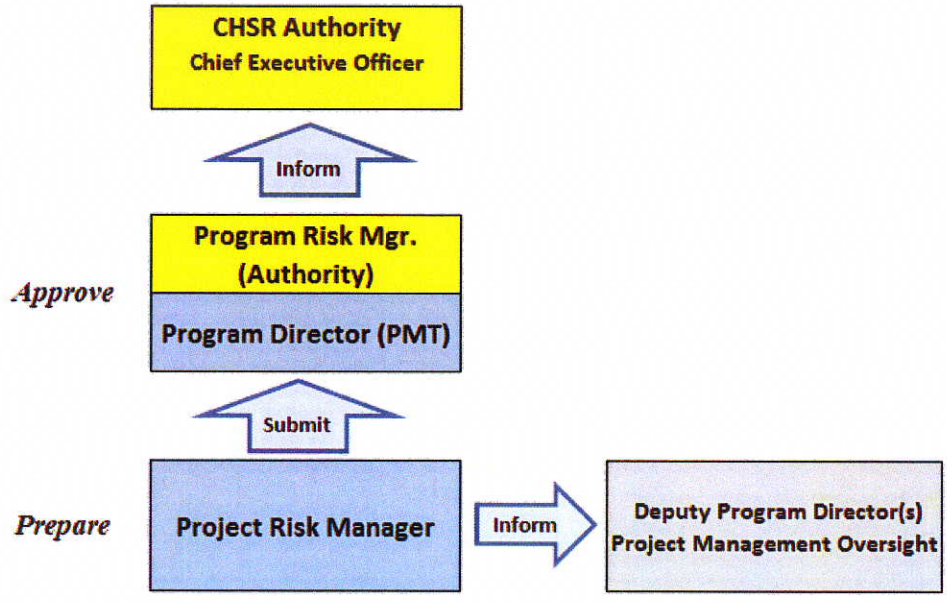
Effective risk reporting allows management to quickly grasp the key concerns and recent changes, identify who has prime responsibilities for actions as well as the status of priority actions. The information provided will address the following questions:

- What are our key risks/showstoppers and what is being done to manage them?
- Which key risks have ineffective responses or outstanding improvement actions?
- What has changed since the last period?
- What could prevent us from delivering on the strategic program objectives and what is being done to mitigate these issues?
- What is the reason for current performance gaps and do the risks and opportunities identified previously explain this? If not, what must be done to improve our risk and opportunity management and our forecasting?

5.1 REPORTING SEQUENCE

The Project Risk Manager reports to the Program Director and Authority Program Risk Manager (Figure 4). All deliverables are submitted to the Program Director and/or Authority Program Risk Manager, depending on the nature of the deliverable, for approval.

Figure 4: Reporting Sequence for Risk Management Deliverables



APPENDIX A – SCHEDULE OF RISK MANAGEMENT ACTIVITIES AND ASSOCIATED DELIVERABLES

Risk Management Activities Schedule				
Frequency	**Purpose**	**Timing**	**Personnel in addition to risk management**	**Associated Deliverable**
Monthly	Review progress, direction and emergent risks with Authority	Bi-weekly	As determined by Program Risk Manager, fixed meeting attendees are Program Risk Manager (Authority) and Risk Manager (PMT)	As directed by Program Risk Manager
	Review and update of risk registers	Monthly meetings as part of regularly scheduled Regional Team meetings; dedicated risk workshops held quarterly	Regional teams, Regional Director(s), others as appropriate	Program Risk Register
	Schedule and Cost Review	Weekly updates, reviews quarterly	Project Controls Group	Schedule and Cost Estimate updates as necessary for Monthly Progress report(s) and/or quantitative analysis
	Emergent risks and risk response tracking	Continuous	Risk Owners and identifiers	Monthly Progress Report
Quarterly	Engineering/Technical and Railroad Operations Risk Assessment and Update	During month prior to end of quarter	Engineering Program Mgr.; Railroad Operations Mgr.; Infrastructure, Systems, Rolling Stock, Systems Integration, Regulatory Approvals leads; Project Controls scheduler and/or cost estimator as necessary	Quarterly Program Risk Report
	Environmental Risk Assessment and Update	During month prior to end of quarter	Environmental Program Mgr.; Environmental Planning, Regulatory and Monitoring, Environmental Permits and Biology leads; Environmental scheduler; Environmental Specialists as needed	Quarterly Program Risk Report
	ROW Risk Assessment and Update	During month prior to end of quarter	ROW and Real Estate Support; Project Controls Scheduler	Quarterly Program Risk Report
	Third Party Agreements	During month prior to end of quarter	Commercial Mgr. and/or Deputy Commercial Mgr.; Third-party Contracts Mgr.; Railroad Agreements lead;	Quarterly Program Risk Report
	Construction group	During month prior to end of quarter	Construction Mgr.; Construction Management group leads; Procurement/Commercial Mgr.	Quarterly Program Risk Report
	Schedule and Cost Review	During month prior to end of quarter	Operations Manager; Project Controls Manager;	Quarterly Program Risk Report
	Program Risk Workshop	During month prior to end of quarter	Program Director; All group Leads	Quarterly Program Risk Report
As needed	Interim reports including targeted risk assessments /analysis	as directed	varies based on subject matter	Interim reports
	Quantitative cost and schedule analysis	as directed	Project Controls Group	Schedule or Cost Risk Analysis Reports
	A report detailing elements of risk in the high-speed rail project as per *Section 9.8. Item 2665-306-6043 added to Section 2.0 of the Budget Act of 2012.*	Prior to awarding contracts	All senior personnel including group leads	Risk Analysis Report for Contract Award (SB 1029)

APPENDIX B – SAMPLE RISK IDENTIFICATION CHECKLIST

Group	Associated Risks
Political, Government and External Risks (POL)	• Political support incl. Legislative actions/changes to Legislation • Public outreach and Stakeholder coordination • Public interference due to construction activities • Public response to accidents or incidents during construction • Legal challenges • Changing Regulatory Environment/Requirements • Relations with city and state agencies • Relations with public and private utilities • Force Majeure • Other political, governmental, external risks
Financial Risks (FIN)	• Financial Capacity - Program funding and cash flow requirements • Commercial Viability incl. Revenue and Ridership/demand forecasts • Market Volatility/Escalation • Inflation • Exchange rate • Insurance and Bonding • Financial planning documentation
Program Management and Controls Risks (PGM)	• Program Identification and (HSR System) Planning (scope including changes) • Program Interfaces and communication • Partnering/Subcontracting • Resource planning and allocation (including personnel) • Program Scheduling (methodologies, assumptions, and estimates) • Program Cost (methodologies, assumptions, and estimates) • Program controls (including Program mgmt. and procurement documentation, change control and QA/QC policies and procedures)
Environmental Risks (ENV)	• Environmental Task Management (incl. Alternative Analysis and EIR/EIS process) • Environmental Agreements, MOU/MOAs, Permits (AMMP) and coordination (ACOE, USEPA, SHPO, USFWS, CADFG) • Transportation (Traffic and Circulation) • Air quality, noise and vibration • Biological resources and ecosystem (including wetlands) • Hydrology and water resources • Aesthetics and visual quality • Socioeconomics, communities, and environmental justice • Agriculture, including prime and unique farmland • Parks, recreation and open space • Cultural/historic resources • Cumulative and secondary impacts

Group	Associated Risks
Engineering Technical Risks (ENG)	• Engineering Management (including resources, scheduling, deliverables and QA/QC) • Engineering Design Criteria and Guidance • Efficacy and Constructability of Design • Data reliability and Design completeness • Accountability for Design • Civil/Infrastructure • Architectural • Station area planning • Geotechnical/Tunneling, including Geology, soils and seismicity • Unforeseen site conditions • Systems (including technical requirements of public utilities, EMI/EMF issues) • Rolling stock • Systems integration • Systems Testing and commissioning
Right of Way Risks (ROW)	• General strategy, guidelines and implementation • Identification • Appraisals • Right of way engineering and acquisition • Relocations and property management
Contracting / Procurement Risks (PROC)	• Procurement strategy and planning (incl. policies and procedures, contract packaging, timing of major bid activities and inter-relationship with program scheduling and cost estimates) • Contract documents (incl. soundness/completeness of contract agreements, General Conditions and Special Provisions) • Advance utility relocations • Procurement of long lead time items • Identification of waste site/borrow site • Construction labor costs and availability • Material and equipment costs and availability • Potential contractor bankruptcies • Lack of competition / number of bidders on contracts • Workload of local contractors • Availability of specialty contractors
Third Party Agreements and Permits (PER)	• Master Agreements, MOU/MOAs, Permits • Regulatory approvals/waivers • General third party issues/coordination • Advance construction agreements with utilities and agencies

Group	Associated Risks
Construction and Site Risks (CONS)	• Logistics • Health and Safety • Design errors or omissions • Faulty workmanship • Contractor competence • Subcontractor problems • Interface issues with other contractors for adjacent projects • Local community restrictions and accommodations • Unforeseen ground conditions • Temporary construction/facility requirements and mobilizations • Weather • Utilities relocations • Unidentified utilities • Hazardous materials/contaminated soil • Previously unidentified Archaeological/Historical/Cultural site
Operations & Maintenance Risks (O&M)	• Railroad Systems Operations and Maintenance Task Management • Operations Planning • System Safety and Security • Infrastructure and Rolling Stock Maintenance • Operational start-up

APPENDIX C – BASIS OF COST AND SCHEDULE TEMPLATE

This template was developed with reference to the following documents:

- AACE International Recommended Practice No. 38R-06: *Documenting the Schedule Basis*, Edward E. Douglas, III CCC PSP (Author), 2009
- AACE International Recommended Practice No. 34R-05: *Basis of Estimate*, Todd Pickett, CCC (Author), 2010
- *Preparing a Basis of Estimate*, AACE International Transactions EST.10, Mr. Todd Pickett, CCC, 2005

BASIS OF ESTIMATE AND SCHEDULE for

Contract Package ##

Most recent addendum (*if applicable*)

Physical Limits of Contract Package

Based on Cost Estimate prepared mm/dd/yyyy

Schedule prepared mm/dd/yyyy

Black headings *indicate section should be prepared jointly by cost, scheduling and in some cases other project team members to ensure all are working from the same information and with the same understanding of that information.* **Green headings** *indicate cost team is primary,* **dark red** *indicates scheduling team.*

1. PROJECT DESCRIPTION

2. SCOPE

3. METHODOLGY

3.1 Cost

3.2 Schedule

4. EXECUTION STRATEGY

4.1 Principal Cost Components

Cost Category	Description	Approximate % of total contract estimate	Comments

4.2 Key Project Dates

4.2.1 Critical Path

4.2.2 Path of Execution

4.2.3 Punchlist, Turnover and System Startup

5. PLANNING BASIS

5.1 Design Basis

5.2 Cost Basis

5.3 Scheduling Basis

#	Question	Include?			Comments
1	Has NEPA/CEQA process begun?	Yes	No	N/A	
2	Has a preferred alternative been selected?	Yes	No	N/A	
3	Have environmental mitigation measures been defined and included in the estimate?	Yes	No	N/A	
4	Have necessary (major) environmental permits/requirements been identified and incorporated into the schedule?				
5	Has an alignment been established?	Yes	No	N/A	
6	Have right of way requirements been researched and priced?	Yes	No	N/A	
7	Have a typical section(s) been established?	Yes	No	N/A	
8	Have the geotechnical site conditions been researched?	Yes	No	N/A	
9	Have potential geotechnical cost issues been factored into the estimate?	Yes	No	N/A	
10	Has a drainage report and concept plan been prepared?	Yes	No	N/A	
11	Has a noise analysis been performed?	Yes	No	N/A	
12	Are sound walls included in the estimate?	Yes	No	N/A	
13	Have retaining wall types been defined?	Yes	No	N/A	
14	Has a traffic analysis (modeling, HCM, LOS, etc,) been performed?	Yes	No	N/A	
15	Has a life cycle cost analysis been performed?	Yes	No	N/A	
16	Has a preliminary construction phasing strategy been developed to help estimate traffic control, detours, temporary structures, temporary construction easements, right-of-way acquisition etc.?	Yes	No	N/A	
17	Have any investigations been done in regards to potential major utility impacts?	Yes	No	N/A	
18	Has a conceptual landscaping and aesthetics plan been developed?	Yes	No	N/A	
19	Are there any design deviations that are or expected to be of concern?	Yes	No	N/A	
20	Were other projects used as metrics of comparison for the estimate? If so, please list projects.	Yes	No	N/A	
21	Has funding been identified for: Design/PS&E?	Yes	No	N/A	
22	Has funding been identified for: Right-of-Way?	Yes	No	N/A	
23	Has funding been identified for: Construction?	Yes	No	N/A	
24	*Other?*				

16. ESTIMATING TEAM

Lead Cost Estimator:	Name and Contact Info
Quantity Survey:	Name and Contact Info
Unit Cost Development:	CHSRP bid items
Summarization and Presentation:	Name and Contact Info
Estimate Review and QA/QC:	Name and Contact Info
Lead Scheduler:	Name and Contact Info
Summarization and Presentation:	Name and Contact Info
Estimate Review and QA/QC:	Name and Contact Info

Attachment A: Estimate Deliverables Checklist

Attachment B: Reference Drawings

Attachment C: Schedule Documents

Attachment D: Additional Attachments (*as necessary*)

APPENDIX D – QUANTITATIVE RISK ANALYSIS

Schedule Risk Analysis

A schedule risk analysis has two principal components: 1) the duration uncertainty associated with individual tasks or activities, and 2) the risk events that may impact the schedule. It is premised on the underlying schedule's activities and logic. Typically, the underlying schedule has already been developed with planned durations and relationships between activities – this is the 'deterministic' schedule. This deterministic schedule is imported to Oracle Primavera Risk Analysis and the deterministic (single point duration) estimates are replaced with duration ranges (Minimum and Maximum) or three-point estimates (Minimum, Most Likely, Maximum):

- Minimum (Min): the shortest duration that could reasonably be achieved given work and assumptions; this is the 'blue sky' duration estimate – how long a given activity would take if everything goes 'right'.
- Most Likely (ML) (optional): the amount of time assessors expect the activity to take; these are the durations that the Monte Carlo simulations use to develop the 'deterministic' finish date shown in figures.
- Maximum (Max): the longest the activity is expected to take under the given assumptions; note that these are based only on the inherent nature of the activity in question, it does not take into account such discrete risks as tunnel collapse or failure to acquire necessary right-of-way.

This operation essentially replaces the assumptions necessarily made in order to arrive at a single point estimate of duration in the deterministic schedule with an explicit consideration of the duration uncertainty. Identifiable, discrete schedule risks can then be applied to this uncertainty impacted schedule *where there potential impact has not already been accounted for by the applied uncertainty.* Each of these quantified schedule risks will have a probability of occurrence and, typically, a range of possible impacts. For example, a risk that a particular parcel may unexpectedly[12] go to condemnation may be specified or assessed 10%/6-12 months, i.e., there is a 10% chance this parcel will go to condemnation and if this occurs it will take an additional 6 to 12 months. These risk events are then associated with the appropriate activity within the schedule, essentially adding an activity to the schedule, though one which does not always occur. Which activity or task the risk is applied to is of critical importance in schedule risk analysis: a schedule threat of 2 month delay may not delay the overall schedule at all (if, for example, it is applied to an activity with > 2 months of float) or delay it a full 2 months (if applied to an activity that is always on the critical path) or anywhere in between.[13]

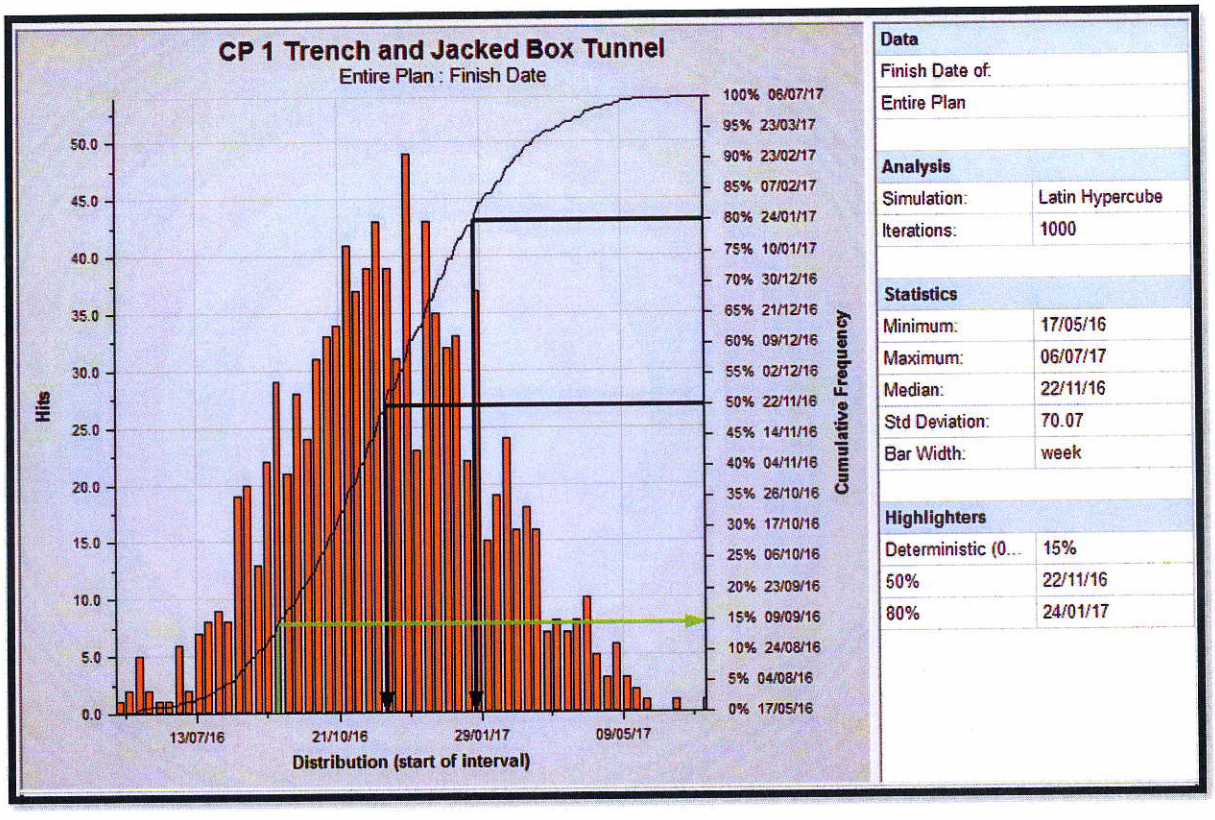
Monte Carlo simulations are then performed on this risk and uncertainty impacted schedule to generate probability distribution curves. For planned activities with duration uncertainty, on each iteration the program randomly selects a value (duration) within the distribution defined by Min/ML/Max values associated with the activity. Values closer to 'most likely' are selected more often, while values closer to the extreme ends, either very optimistic or very pessimistic, are selected less often. Latin Hypercube sampling is employed to ensure that the full range of each distribution is sampled. Activities or risk events for which a most likely duration cannot be determined have only optimistic and pessimistic durations specified, forming a uniform distribution, with any value from optimistic to pessimistic equally likely to be selected on any given cycle. Since planned activities are part of the original schedule, they 'happen' on every cycle and the variability is entirely due to the uncertainty of their duration, not their existence. This contrasts with risk events, which may or may not happen on any particular iteration, depending on the assessed probability of the schedule risk.

[12] If it is expected, the Program's baseline schedule will be updated

[13] A 'two-month' risk can delay the overall schedule by more than two months if it pushes an activity into a 'blackout' period, out of a work-window, that it would not otherwise have been affected by.

The result is that instead of one finish date, the resulting schedule now has multiple possible finish dates, each associated with a probability that it will be achieved. These results are often collected into a histogram, with the height of each bar representing the frequency of the particular outcome during the Monte Carlo simulation. In Figure 5, the hit count on the left-hand axis gives the number of cycles for which that particular finish date (horizontal axis) was the outcome of the simulation. From this we can develop a cumulative distribution function (the stretched S-curve in the figure, associated with the right-hand axis). The right-hand axis gives particular probabilities with corresponding finish dates. For example, a finish date of February 23, 2017 is paired with 90%, indicating that in 90% of the simulations, the given work was completed on or before February 23, 2017.

Figure 5: Schedule Risk Probability Distribution



Cost Risk Analysis

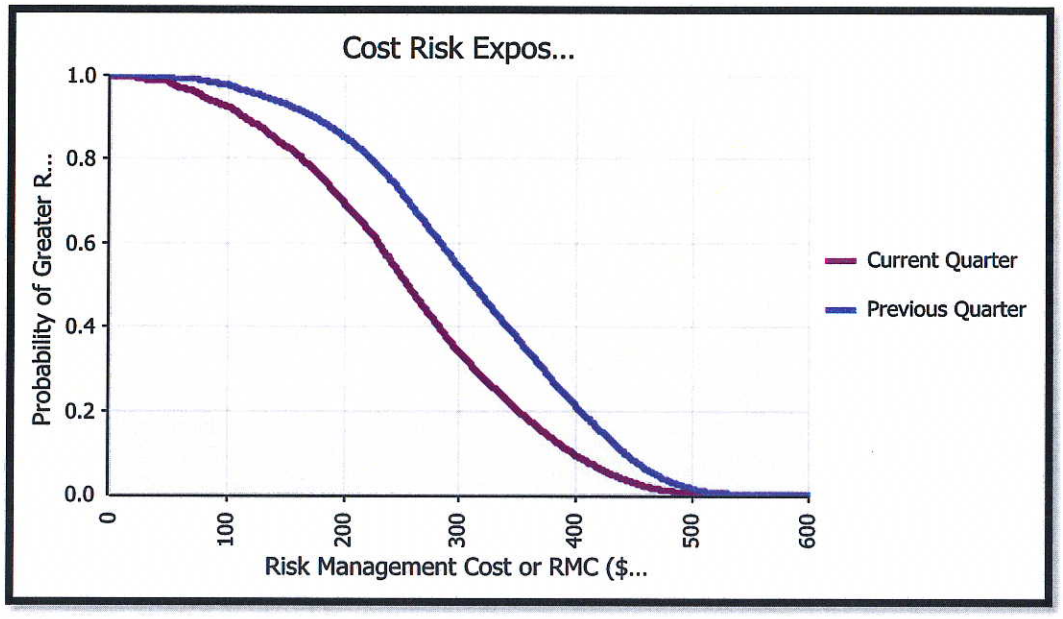
Cost risk analysis is performed in the same manner as schedule risk analysis, replacing single-point cost estimates with ranges representing the underlying uncertainty and applying cost risks to the estimate. Unlike schedule risk analysis, which cost element the particular risk is applied to does not affect the overall cost risk exposure, though it does have implications for the contingency associated with the particular cost element or category.

Monte Carlo simulations are performed using Palisade's @Risk software to generate a probability distribution of the total cost of risks, herein defined as risk management cost (RMC), in the risk register. This analysis utilizes the

three-point estimate for cost impact and probability and run thousands of iterations[14] to generate the probability distribution graph.

Figure 6 shows an example of a RMC probability distribution chart. For a selected probability level, this chart compares the RMC for current quarter with the previous quarter. For example, the current quarter RMC at 70% (0.70) is approximately $200 M as compared to previous quarter RMC of $250 M. That is, in the current quarter, there is a 70% chance that the identified risks will result in an increase in costs of at least $200M to the program if not successfully mitigated, transferred or avoided.

Figure 6: Risk Management Cost Probability Distribution



[14] Actual number of iterations will vary depending on character and number of inputs but in all cases will be set such that number of iterations is greater than number necessary for (solution) convergence

APPENDIX E – RISK AVOIDANCE AND MITIGATION STRATEGIES

General Tactics and Strategies for Avoiding or Mitigating Scope, Schedule and Resource Risk

Scope risk avoidance tactics

- Identify the minimum acceptable deliverable, avoid overdesign
- Negotiate and clearly document all interface deliverables
- Avoid untried, unfamiliar or 'bleeding edge' technology whenever practical
- Plan to design using standard, modular or well-understood methods
- Buy instead of make

Scope risk mitigation strategies

- Explicitly specify project scope and all intermediate deliverables in measurable, unambiguous terms, including what is not in the deliverable; eliminate 'wants' as early as possible – make them part of the scope or drop them
- Gain acceptance for and clear and consistent specification change management process
- Build models, prototypes and simulations
- Deal with scope risks promptly
- Minimize external dependency risks
- Consider the impact of external and environmental problems
- Keep all plans and documents current

Schedule risk avoidance tactics

- Reduce the number of critical paths
- Modify the work to have fewer activity dependencies
- Schedule the highest uncertainty activities as early as possible
- Avoid having all the same staff members working on two successive or concurrent critical (or near-critical) activities
- Decompose lengthy activities further
- Reschedule work to provide greater flexibility

Schedule risk mitigation strategies

- Use 'expected' estimates when worst cases are significant – estimate a realistic expected duration and use it to reflect potential schedule exposure and in determining proposed schedule
- Schedule highest priority work early
- Schedule proactive notifications
- Use parallel, redundant development
- Be conservative in estimates for training and new hardware
- Partition long projects into a sequence of shorter ones
- Schedule project reviews
- Rigorously track progress and report status frequently

Resource risk avoidance tactics

- Obtain names for all required project roles
- Get explicit availability commitments from all project staff (and their managers)
- Work to limit commitments by project staff to other projects, maintenance and support work and other time conflicts; explicitly document those that remain
- Modify plans to reduce the load on fully loaded or over-committed resources
- Use the best people available for the most critical activities
- Use mentoring to build teamwork and establish redundancy for critical skills
- Locate and gain access to experts to cover all skill areas not available on the project team
- Minimize dependence on a single individual or other resource for project work
- When outside services are required, use suppliers that have been successful in the past or that are otherwise trusted
- Establish contract terms with all suppliers that are consistent with project objectives

Resource risk mitigation strategies

- Avoid planned overtime
- Use 'expected' cost estimates where worst-case activity costs are high – estimate a realistic expected cost and use it to reflect the potential financial exposure and in determining expected budget
- Obtain firm commitment for funding and staff
- Anticipate staffing gaps
- Encourage team members to plan for their own risks
- Rigorously manage outsourcing
- Detect and address flaws in the project objective promptly
- Rigorously track project resource use

APPENDIX F – DRAFT RISK ALLOCATION TEMPLATE

This template is based on Washington State Department of Transportation's (WSDOT's) risk allocation matrix for Design Build Projects. The actual allocation including the particular risks will be based on the specifics of the construction package under examination. The allocation effort will be led by the Authority Program Risk Manager in consultation with the PMT Commercial team and with reference to the applicable contracts.

RISK	Design-Build		
	Owner	Shared	Design Builder
Design Issues			
Definition of Scope			
Project Definition			
Establishing Performance Requirement			
Preliminary survey/base map			
Geotech Investigation - Initial Borings based on prel des.			
Geotech Investigation - Initial Borings based on proposal			
Establish/Define initial subsurface conditions			
Initial project Geotechnical Analysis/Report			
Proposal specific Geotechnical Analysis/Report			
Plan conformance with regulations/guidelines/RFP			
Plan accuracy			
Design Criteria			
Conformance to Design Criteria			
Design Review Process			
Design QC			
Design QA			
Owner Review Time			
Changes in Scope			
Constructability of Design			
Contaminated Materials			
Right of Way Issues - CHSR Authority acquisition of parcel			
Establishing R/W Limits			
Access Hearings/Findings and order			
R/W Plan Approval			
Appraisal/Review			
Establish Just Compensation			
Acquire Right of Way			
Construction Easements			
Permanent Easements			
Condemnation			
Complete Relocation			
Take Possession			
Certification			

RISK	Design-Build		
	Owner	Shared	Design Builder
Environmental			
Define Initial Project env impacts			
Define parameters for impacts			
Environmental Investigation			
Environmental Permits			
Environmental Mitigation			
Environmental Compliance			
Known Hazardous Waste - mitigation			
Unknown/nondefined hazardous waste - mitigation			
Obtain Environmental Approvals - Const. related			
Local Agency, Utility, Railroad Issues			
Identification of initial local agency impacts			
Obtaining Initial local agency permits			
Establishing initial local agency requirements			
Establishing final/actual local agency impacts			
Modifications to existing local agency permits			
Identification of initial utility impacts from preliminary des			
Establish initial Utility Locations / Conditions			
Defining required utility relocations from preliminary des			
Relocation of utilities prior to contract			
Relocation of utilities under agreement during contract			
Modified agreement with private utility based on final des			
Modified agreement with public utility based on final des			
Damage to Utilities under Construction			
Verification of Utility Locations/Conditions			
Coordination with Utility Relocation Efforts during contract			
Utility Owner/Third Party caused/related delays			
Identification of RR impacts based on preliminary design			
Obtaining initial RR agreement based on preliminary des			
Coordinating with RR under agreement			
Other work/Coordination			
Third Party Agreements (Fed, Local, Private, etc.)			
Coordinating with Third Parties under agreement			
Coordination/collection for third party betterments			
Coordination with Other Projects			
Coordination with Adjacent Property Owners			

RISK	Design-Build		
	Owner	Shared	Design Builder
Construction			
DBE compliance			
Safety			
Construction Quality/Workmanship			
Schedule			
Materials Quality			
Materials documentation			
Material availability			
Initial performance requirements of QC/QA Plan			
Final Construction/Materials QC/QA Plan			
Construction/Materials QA			
Construction QC			
Construction QA Oversight			
Construction IA testing/inspection			
Construction Staking			
Erosion Control			
Spill Prevention			
Accidents within work zone			
Damage within work zone			
Third Party Damages			
Operations and Maintenance During Construction			
Maintenance under Construction - new features			
Maintenance under Construction - exist. features			
Maintenance of Traffic			
WSP Callbacks - on site traffic control assistance			
Damage to Utilities under Construction			
Falsework			
Shop Drawings			
Equipment failure/breakdown			
Work Methods			
Early Construction / At Risk Construction			
Community Relations			
Performance of defined mitigation measures			
Warranty			
Force Majeure / Acts of God			
Strikes/Labor Disputes			
Tornado/Earthquake			
Epidemic, terrorism, rebellion, war, riot, sabotage			
Archaeological, paleontological discovery			
Suspension of any environmental approval			
Changes in Law			
Lawsuit against project			
Storm/Flooding			
Fire or other physical damage			
Differing Site Conditions/Changed Conditions			
Changed Conditions			
Differing Site Conditions			
Completion and Warranty			
Establishment/definition of any risk pool			
Long term ownership / Final Responsibility			
Insurance			