

# **WSDOT Guidelines for CRA-CEVP Workshops**

(INCLUDES COMMON ASSUMPTIONS)

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**Washington State  
Department of Transportation**

“We may not be able to get certainty, but we can get probability...” CS Lewis

## Contents

Foreword.....	5
Helpful Hints for Project Teams.....	6
CRA and CEVP® Workshops: Statement of Purpose.....	7
CRA and CEVP® Seven step process:.....	7
Base and Risk Defined.....	7
Recommended Participants.....	10
Workshop Teams and Participation.....	10
Pre-Workshop.....	11
A note on risk identification and assessment.....	14
Workshop Activities.....	16
Report Preparation.....	19
QA/QC: All have a role.....	22
Risk Response.....	24
RISK RESPONSE: ACTIONS.....	24
Remember.....	27
Appendix 1: Project Manager & Project Team - Duties.....	29
Appendix 2: Risk Lead(s) - Duties.....	34
Appendix 3: Cost Lead - Duties.....	36
Appendix 4: Subject Matter Experts (SME) - Duties.....	41
Appendix 5: CRA Coordinator - Duties (HQ/Region).....	43
Appendix 6: Notes for consideration for Risk Modelers.....	45
Appendix 7: Common Assumptions.....	48
I. SCOPE CHANGE VERSUS SCOPE VARIATIONS.....	49
II. DESIGN CRITERIA (GENERAL).....	49
III. BRIDGE SEISMIC DESIGN CRITERIA.....	50
IV. CONSTRUCTION MARKET CONDITION RISKS.....	51
<i>Number of Bidders</i> .....	51
<i>Other Market Condition Risks for Construction</i> .....	51
V. RIGHT-OF-WAY MARKET CONDITION RISKS.....	51
VI. PRELIMINARY ENGINEERING MARKET CONDITION RISKS.....	52
VII. DESIGN BUILD (DB) VERSUS DESIGN BID BUILD (DBB).....	52
VIII. FUEL PRICE INFLATION.....	52
IX. PROJECT SPECIFIC ASSUMPTIONS.....	52



## Foreword

This document establishes consistency in the practice of risk-based estimating at WSDOT and includes guidance for: Project Teams, Risk Leads, Cost Leads, Region CRA Coordinators and Subject Matter Experts. The Cost Risk Estimating Management team, as a part of the Strategic Analysis and Estimating Office of WSDOT, delivers risk-based estimating workshops for the state. Projects vary in terms of size, location and complexity; the process can be tailored to the needs of the project. The work done in the past would not have been accomplished without the committed and diligent work and contributions of our partners in the consulting community and WSDOT staff who have contributed to the development of these guidelines.

Three questions are fundamental to the search for a more accurate estimate on projects:

**(1) How much will it cost? (2) How long will it take? and (3) Why?**

One answer WSDOT found to these fundamental questions is the realization that an estimate is more accurately expressed, not as a single number, but as a range. To determine an accurate estimate range for both cost and schedule, key risks must be identified and considered. To present a comprehensive portrayal of a project in terms of cost and schedule, we must begin with a solid, well-prepared and well-documented base estimate. Base cost is defined as the planned cost of the project; the base cost does not include contingency. A list of risks is created of both opportunities and threats, called a Risk Register. The risk assessment replaces general and vaguely defined contingency with explicitly defined risk events that includes for each their associated probability of occurrence and impact on project cost and/or schedule. The risk component, for projects over \$10 million, is developed as part of a formal or informal cost risk workshop.

This process is consistent with the professional codes of ethics to which many of the workshop participants are bound. The agreements listed below represent fundamental aspects of estimating for public works projects, and are consistent with the American Society of Civil Engineers (ASCE) (<https://www.asce.org/inside/codeofethics.cfm>) and the Association for the Advancement of Cost Engineering (ACEI) (<http://www.aacei.org/membership/about/CanonEthics.shtml>) nationally recognized codes of ethics. Ten “Agreements” for workshop participants:

I agree to:

1. observe the highest standards of my profession;
2. communicate honestly and effectively;
3. be accountable and open in my estimating practice;
4. listen as others speak without regard to position or title;
5. foster broad participation in the process;
6. exercise authority appropriately and **not** pressure others to develop estimates to a pre-determined dollar figure;
7. be a good steward with public funds for projects for the public good;
8. strengthen my understanding and practice of the principles and values of estimating uncertainty and risk;
9. work to deepen my understanding of estimating project costs and schedules;
10. continue my education and the education of others.

## Helpful Hints for Project Teams

*(Quick reference, more detailed information can be found in the body and appendix of this document)*

1	Be prepared: know what is to be evaluated at the workshop; clearly describe the scope of the project; have a well organized, up-to-date, and easy to present project schedule and cost estimate appropriate to the level of project development.
2	Submit workshop request form <i>after</i> it is clear as to the project alternatives and/or scenarios to be evaluated. Allow at least 8 weeks advance notice from the time the workshop request form is submitted and when the first prep session will be held.
3	Use the Project Management Process as outlined in the WSDOT Project Management Online Guide.
4	Follow the guidance provided in this document and the Project Risk Management Guide.
5	Keep workshop attendance to a manageable size. An effective workshop has all of the necessary people present- not more than necessary. Too many people in a meeting can make it less effective, cumbersome and slow. Read the section on Pre-Workshop and Workshop Meetings in this document, particularly ‘Cautionary Notes Regarding Workshop Dynamics.’
6	Make sure the project manager and/or assistant project manager attend the workshop. It is crucial that someone able to speak from the owner’s perspective be present throughout the workshop.
7	Familiarize participants with the workshop process in advance of the workshop. The Strategic Analysis and Estimating Office can provide a representative from the CREM team to provide training and orientation in advance of the workshop.
8	When the workshop is over, it is over! The workshop is a “snapshot” examination of the project and issues of concern should be brought up during the workshop. Elicitation of risks and their characteristics are completed by the end of the workshop, then the modelers need to complete the modeling and analysis of the information generated at the workshop, without interference and disruption due to post-workshop wrangling and debate. Following the completion of the analysis risk response actions are to be developed and incorporated, by the project team, into the risk management plan. Benefits of the process resonate for weeks and months following the workshop as the project team uses information gained from the workshop in their day to day decision-making and project development activities.

A note about risk, uncertainty and estimating:  
“It is better to be approximately right rather than precisely wrong.”

## **CRA and CEVP® Workshops: Statement of Purpose**

Provide a useful, sound, and objective, analysis and report that the Project Team will own and act upon to improve and/or validate project cost schedule estimates. Workshops, conducted collaboratively with cost-risk experts and the project team will:

1. ***Define and review or validate cost and schedule base estimates*** using a Lead Cost and Schedule Reviewer, Subject Matter Experts, and WSDOT specialists.
2. ***Document assumptions and constraints*** used in developing the estimated project cost and schedule range.
3. ***Replace (or greatly reduce) the traditional project “contingency”*** with key identifiable risks that can be more clearly understood and managed.
4. Under the direction of a risk lead, ***identify and quantify key events*** in a project that can cause a significant deviation from the base cost and/or schedule. This identification and quantification should begin prior to the workshop through Advance Elicitation meetings.
5. ***Perform a Monte Carlo simulation analysis to model the collective impact of base and risk issues for the complete project as a system to produce an estimate of a reasonable range and distribution.***
6. ***Discuss and develop concepts for responses*** to risks to the schedule that could impact the cost of the project. Promote pro-active risk management by project teams. Provide the project team with actionable information on risk events that allow them to manage the risks (threats/opportunities) on an on-going basis, via mitigation strategies to better control project costs and schedules.
7. ***Perform “post-mitigation”*** analysis to ascertain the effectiveness of planned and/or implemented risk response actions.

## **CRA and CEVP® Seven step process:**

1. Select the project and method.
2. Structure the project team effort.
3. Define and evaluate the base cost estimate and schedule.
4. Assess uncertainty and risk.
5. Quantify uncertainty in the project cost and schedule.
6. Apply probabilistic analysis and document.
7. Implement and measure risk response actions, monitor, and control.

## **Base and Risk Defined**

The **Base Cost** represents the cost which can reasonably be expected if the project materializes as planned. The base cost estimate is unbiased and neutral.

A **Project Risk** is characterized quantitatively with the combination of the probability of an uncertain event and its consequences. A positive consequence presents an opportunity; a negative consequence poses a threat. In a project context, it is the chance of something happening that will have an impact upon project objectives.



We can think of risk management as the two pillars of risk management depicted above, “IDENTIFY and ANALYZE” and “RESPOND, MONITOR and CONTROL.”

Unless we incorporate the second pillar, we are not realizing the full value of risk management. When preparing our project management plan and work activities for our project, **we must include both pillars of risk management in our plan.**

The preparation activities before the workshop, the workshop itself, and the analysis of the input, comprise the first pillar. The second pillar requires that the project manager and project team develop response actions for the key risks, document the response actions, and incorporate this information into their risk management plan (as part of the project management plan update). The project manager and team then track the risks and the effectiveness of the response actions. A follow-up analysis can be performed to demonstrate the effectiveness of the response actions.

**Workshop Request by project team**

Project Team must include risk management activities in their project management plan

This flowchart is an "at-a-glance" reference, please review relevant portions of the WSDOT Guidelines for CRA-CEVP Workshops for more details.

**Pre-Workshop Activities**

- 1a) DETERMINE NEED**  
PROJECT TEAM - Confirm: Project Title, PIN, WIN, Mileposts are correct and WOA is setup. Complete the workshop request form and send to region CRA coordinator who forwards to the SAEO (CREM unit).
- 1b) LEARN THE PROCESS**  
SAEO OFFICE (CREM unit) - Provide: Orientation to Process Contact and negotiate with consultants (Risk Lead, Cost Lead, SMEs). Prepare task orders. Prepare and distribute Prep Session Agenda to participants. PROJECT TEAM: Review CRA website, workshop guidelines and other reference materials.
- 1c) ASSEMBLE PROJECT INFO**  
PROJECT TEAM – provide project information; include: current basis of estimate and project cost estimate, scope and schedule. Review reports from prior workshops/studies. Prepare list of issues of concern plan to host prep session.
- 2a) PREP SESSION**  
SAEO OFFICE (CREM) : PREP SESSION  
Risk Lead/Workshop coordinator develop draft project flowchart and make notes. Prepare action items. Provide Risk ID Sheets to Project Team.
- 2b) INVITE WORKSHOP PARTICIPANTS**  
SAEO OFFICE (CREM unit) and PROJECT MANAGER  
SAEO (CREM unit): Invite external independent SMEs and HQ specialty groups identified to participate in the workshop. Prepare workshop agenda and send Outlook invite to participants. PROJECT MANAGER: invite region participants and others who regularly work on the project from HQ.
- 3a) REVIEW PROJECT ESTIMATES**  
PROJECT TEAM - work with SAEO (CREM unit) to begin advance review of project cost and schedule estimates.
- 4a) ADVANCE ELICITATION**  
SAEO OFFICE (CREM unit)  
Work with Project Team to Arrange Advance Elicitation Interviews; conduct Advance Elicitation interviews with appropriate Project Team members and specialty groups. Elicitation continues and is finalized in the workshop.

**WORKSHOP**

- 5a) CONVENE THE WORKSHOP**  
Workshop Leader [SAEO (CREM unit)] and/or Region Coordinators direct the workshop. RISK LEAD takes the lead during risk elicitation, the COST LEAD takes the lead during cost review and validation. PROJECT TEAM hosts the workshop.
- PROJECT TEAM PROVIDES:
- Meeting Venue with internet connection.
- Visual aids such as:  
Aerial photos      Plan Sheets  
Project Exhibits    R/W Sheets  
Story Boards        Other items
- Project information, including:  
Basis of Estimate  
Project Cost Estimate  
Backup documentation  
Project Schedule  
Environmental Documentation  
R/W Parcels information  
R/W Cost Estimate  
Other Pertinent Information
- Typical Workshop Format  
-----  
CRA/CEVP workshop process overview  
Workshop Introduction  
-----  
Review/finalize project flowchart and scenarios with base durations  
-----  
Confirm validated base estimate  
-----  
Confirm Major Risk Items  
-----  
Confirm uncertainty in cost & schedule  
-----  
Identify and Evaluate Potential Risk Management Strategies  
-----  
Set date for mitigation review meeting  
-----  
SAEO (CREM unit) lead prepares action items.

**Post-Workshop Activities**

- 6a) PERFORM ANALYSIS**  
RISK LEADS prepare a presentation of **PRELIMINARY RESULTS**, and Prepare **REPORT** send to SAEO (CREM unit) to review and forward to Cost Lead and Project Manager .
- 6b) REVIEW REPORT**  
PROJECT TEAM Conducts a thorough and speedy review of draft report and promptly sends comments to SAEO (CREM unit) who works with the Cost-Risk-Team to finalize.
- 7a) RESPOND TO RISKS**  
PROJECT TEAM: Develop and implement risk response strategies. Maintain and update the project Risk Management Plan.
- 7b) POST-MITIGATION ANALYSIS**  
PROJECT TEAM/SAEO (CREM unit) to Assess and measure impact of response plan.
- 7c) MONITOR/CONTROL PROJECT TEAM**  
Continue to monitor risks and response actions for effectiveness.
- TASK ORDER CLOSEOUT**  
CONSULTANTS submit final invoices. SAEO (CREM unit) make final payments, close task orders and advise project manager and appropriate program manager that the task order is closed.

**CRA and CEVP® Seven step process:**

1. Project and Method Selection
2. Structuring the Collaborative Team Effort
3. Define and Evaluate the Base Cost Estimate and Schedule
4. Identify and characterize Project Risk and uncertainty.
5. Confirm Quantified Risk and Uncertainty in the Project Cost and Schedule
6. Probabilistic Analysis and Documentation
7. Implement and measure risk response actions, monitor and control

**Figure 1 Pre-workshop, Workshop, and Reporting Activities**

**Table 1 Workshop Team (typical participants)**

<b>Project Team Members</b>	<b>Roles &amp; Responsibilities</b>
*Project Manager	Project resource and decision maker.
*Estimator	Prepare and document project estimate.
*Scheduler	Prepare and document project schedule.
*Lead Designer	Primary resource for design questions.
Key Technical Experts	Specialty groups as needed.
<b>Subject Matter Experts (SME)</b>	<b>Roles &amp; Responsibilities</b>
Project Team Experts Agency Experts (HQ et al) Other Stakeholders External Consultants	Internal SMEs work with external SMEs to review and validate project cost and schedule estimates. They provide objective review and comment regarding project issues, risks and uncertainty. At the end of the workshop the SMEs should provide a brief (i.e. one page) summary of their thoughts about the workshop.
<b>Cost-Risk Team Members</b>	<b>Roles &amp; Responsibilities</b>
*Risk Lead	Conducts risk elicitation and manages meeting during risk elicitation.
Risk Lead Assistant	Assists with risk elicitation and meeting management during risk elicitation.
*Cost Lead	Conducts Base Cost Review and validation; manages the meeting during cost review.
Cost Lead Assistant	If needed, assists the cost lead position, as appropriate.
CREM Workshop Coordinator	Coordinates the agenda and participants' discussions, works with the project manager to insure the success of the workshop.

\* These participants should also attend the prep session.

## Recommended Participants

Preparation for the workshop may take one or several meetings depending on the project size, complexity, and knowledge of the participants. The project manager/project team should work with the workshop coordinator and cost-risk team to identify the best combination of participants at each meeting. All participants do not need to attend all meetings. The goal is to make an effective use of time for all parties in a manner that insures a sound and objective analysis.

## Workshop Teams and Participation

### The Right Size and Participants

The criterion for project workshop team membership has to be “Who is absolutely critical to identify the problems we are dealing with?” The criterion of “criticalness” should include not only technical expertise and responsibility but also problem-solving and team skills. Workshop participants should:

1. Be involved, and
2. Be heard –in relation to their responsibility and/or expertise.

## Pre-Workshop

(determine need, learn the process, and assemble project information)

<b>Strategy Session</b>	<b>Orientation Session</b>	<b>Assemble Project Info</b>
<p>Does the project need a risk-based estimating workshop? If yes what type? (informal, CRA, CEVP, combined VE-CRA). See WSDOT directional documents (IL 4071.01). Determine timing and scheduling of workshop events. This can typically be accomplished via telecon between the CREM office and Project Manager.</p>	<p>Participants must understand the process and their role. Formal training provides a comprehensive presentation of the process. However, there are varying levels of experience and proficiency with the CRA/CEVP workshop process. Orientation sessions can be tailored to the project team and participants as appropriate.</p>	<p>The project manager and project team need to know what it is they are going to evaluate and clearly communicate that to the workshop participants. The process does provide an opportunity to examine more than one scenario but it is not practical to evaluate “the universe of every conceivable concept.”</p>
<p><b>Prep Session</b> Should be attended by the Risk lead, the Cost lead and the Project Team because they will be tasked to help develop the project flowchart, assemble initial project costs/durations and develop a list of risks eligible for significant impact on the project schedule or cost. At this meeting additional participants will be identified who should participate at the upcoming workshop. The identification of needed support from Subject Matter Experts (SME) is an especially important outcome of the prep session.</p>		
<p><b>Invite Participants</b> Determine who will be needed to attend the workshop and when they will be needed. Determine who will send the invites – typically the project team will schedule the rooms and invite region participants and specialists from Headquarters (HQ) with whom they have been working. The CREM office will invite the external cost-risk team members (consultants and other independent experts from HQ).</p>		
<p><b>Estimate and schedule review</b> After the prep session and before the workshop the cost lead and cost SME review the project team base cost and schedule estimate and provide recommendations for their consideration. (See the scope for the cost lead for a sample of review questions that should be asked at this stage). <i>Estimate review and base cost validation should begin in advance of the workshop. The Draft estimate and flowchart/schedule should be reviewed by affected project team disciplines prior to the workshop. The pre-workshop base cost estimate and flowchart/schedule must be submitted to the WSDOT region risk manager and all significant stakeholders outside of WSDOT prior to the workshop.</i></p>		
<p><b>Advance Elicitation Interviews</b> Prior to the workshop, the risk leads should meet with those specialty groups that elicit the most critical risks and are most crucial to project success. These particular risks will have significant effects on project objectives.</p>		

The best workshops, in terms of being effective and efficient, are those that have conducted ample advance work – particularly in the areas listed above.

## <sup>1</sup>**Conditioning Workshop Participants**

Prior to the actual workshop, participants need to know what to expect and what is expected of them. Participants are counseled to avoid bias and to be impartial during the discussions that ensue at the workshop. Individuals need to listen to all opinions and not stubbornly advocate a predetermined point of view. The following paragraphs describe procedures for conditioning the project team and subject matter experts to ready themselves for the workshop. The risk leads and cost leads are expected to be aware of potential biasing as they conduct their respective portions of the workshop.

### ***Conditioning Project Team – Overview for “bias reduction”***

The CRA/CEVP environment provides an opportunity for the project team to step back and share their cost and schedule estimates with others. The assurance of an accurate project cost estimate and schedule begins when a project teams initiates and aligns their team for the project. It is recognized that project teams work hard to maintain the quality of their estimates and schedules. Project teams, particularly early in project development, are often optimistic about their project. An optimistic estimate is generally a low estimate. A pessimistic or *conservative* estimate generally is an estimate that, in the judgment of the estimator is intentionally high in order to make sure there is enough money for the project. *Project teams should guard against all forms of bias at all stages of project development.* This bias has been observed, in some cases, to reverse itself as a project approaches completion of design. As the contract package begins to come together in advance of the advertisement date, project managers/engineers may become increasingly guarded about the financial needs of the project and give estimates for costs and schedule that are too high, thereby driving the project cost estimate higher.

The process, when properly followed, provides a sound base estimate and identifies risk events that can cause the project to turn out differently than planned. Attempting to revise estimates for the analysis outside this framework can make it difficult to disentangle effects and make the management of risks less effective. Identification and quantification of risk events will provide the project team with knowledge regarding identified risk events. The project manager must decide what action to take in response to the identified risks. The project manager may choose to avoid, transfer, mitigate, or accept the risk. Decisions regarding risk management may affect project budget and schedule.

### ***Conditioning Project Team—Procedures***

It is important to prepare the Project Team before and during the upcoming meetings and review with them the steps needed to complete the cost risk analysis.

1. Emphasize the “Statement of Purpose” to workshop participants.
2. Set up a Prep Meeting (ideally held a few weeks prior to workshop).

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<sup>1</sup> “The human element introduces an additional layer of complexity into the risk process, with a multitude of influences both explicit and covert. These act as sources of bias...which affect every aspect of risk management.” *‘Understanding and Managing Risk Attitude’* by Hillson and Murray-Webster. In our processes we attempt to “condition” participants to be aware of bias and make efforts to avoid and reduce bias in workshop inputs.

- a. Contact the Project Lead and arrange a visit to the project site for workshop participants who may not know the project. This can occur anytime before the workshop. Discuss the significant risks faced by the team.
  - b. Send the project manager an example of the project flowchart from a recent project. Contact the project manager to let them know that the draft project flowchart will need to be completed by the end of the prep meeting.
  - c. The flowchart is less detailed than a project schedule and needs to show the sequence and duration of major project activities; the flowchart depicts the assumed project delivery strategy.
3. The Cost Lead reviews the basis for the estimate of project cost and schedule durations, and discusses the with the project team member(s) who prepared and/or compiled the estimate.
  4. At the Prep Meeting, remind the Project Team to work up initial lists of “risks to the project”—both threats and opportunities—that have the potential to cause the project cost/schedule to be significantly and measurably different than planned.
  5. Inform participants that it is o.k. to have outcomes significantly different from what was planned (as long as they are plausible). When we are at a very early stage of design, the divergence from planned values is expected to be greater.

### ***Conditioning Subject-Matter Experts—Procedures***

Proper conditioning of subject matter experts and the risk elicitor is required to reduce the bias in expert response. Three biases tend to dominate in expert response and are described below. These are the “anchoring and adjustment bias,” “availability bias,” and the “representativeness bias,” all researched and documented in the 1970s by Kahnemann and Tversky (“Judgment Under Uncertainty: Heuristics and Biases” Tversky & Kahneman, 1974) and further refined by others. The biases tend to work in the direction of understating the range of uncertainty.

### ***Anchoring and Adjustment Bias***

This is the phenomenon of experts thinking they know more than they actually do. If you ask an expert for their best guess first, then they will tend to provide inadequate ranges.

1. Experts should be asked for the limits of the potential ranges first.
2. When providing extremes, experts should be able to describe the type of outcome that will generate the extreme case.
3. Ask the expert for a ‘plausible’ low and ‘plausible’ high. These can be treated in a variety of ways by the analyst who quantifies the risk. A standard needs to be established.
  - a. One method is to ask the expert for a plausible minimum and plausible maximum;
  - b. Another method is to ask the expert for a low and high percentile (i.e. 10% and 90%), and then use this information to generate the distribution;
  - c. A third method is to request another low and high percentile that the expert wishes to provide;
4. After obtaining the highs and lows, ask for the expert’s most likely value.

## A note on risk identification and assessment

Something to consider: those relatively new to risk analysis sometimes claim, in exasperation, “This is nothing more than guessing.” But this view does not represent the full actuality that assigning values for probability and impact relies on the expertise and professional judgment of experienced participants. The determination of a value for the probability of occurrence and its consequence to project objectives, if it occurs, is for many people a new activity and can seem strange at first. In any field, with experience, professionals develop intuition and an ability to understand projects to a greater degree than those not involved with project development and delivery in their industry. This experience and intuition is extremely valuable—in a risk workshop forum we surround ourselves with “wise counsel” to seriously and thoroughly discuss the project. It might be helpful to examine the word “guess” and compare it to other words such as ‘discernment’ and ‘judgment’ that more appropriately describe risk assessment. The following definitions come from the Merriam-Webster Online Dictionary/Thesaurus (with edits).

### **Discernment**

**1:** The quality of being able to grasp and comprehend what is obscure: skill in **discerning** (insight and understanding); the process of forming an opinion or evaluation by discerning and comparing; an opinion or estimate so formed; the capacity for judging; the exercise of this capacity.

### **Synonyms: Perception, Penetration, Insight, and Acumen**

These synonyms mean the power to see what is not evident to the average mind.

DISCERNMENT stresses accuracy; PERCEPTION implies quick discernment; PENETRATION implies a searching mind that goes beyond what is obvious or superficial; INSIGHT suggests depth of discernment coupled with understanding; ACUMEN implies characteristic penetration combined with keen practical judgment.

### **Judgment**

**a:** The process of forming an opinion or evaluation by discerning and comparing.

**b:** An opinion or estimate so formed; a formal utterance of an authoritative opinion; a position arrived at after consideration; an idea that is believed to be true or valid without positive knowledge; an opinion on the nature, character, or quality of something.

### **Guess**

To form an opinion from little or no evidence.

Synonyms: assume, conjecture, presume, speculate, and suppose, surmise, suspect, suspicion.

Related Words: gather, infer, hypothesize, theorize, believe, conceive, expect, imagine, reckon.

### **Decision**

The act or process of deciding: a determination arrived at after consideration : <make a decision>; report of a conclusion

A position arrived at after consideration <after much deliberation, we made a decision about what to use for an estimated unit price>.

**Synonyms:** conclusion, determination, diagnosis, judgment, resolution, verdict.

**Related Words:** mandate, finding, ruling, sentence, choice, option, selection.

### ***Availability Bias***

Experts are always receiving new information to add to their knowledge base. Frequently, when approached for their judgment, experts will have recent information that they have not had time to “blend-in” to their knowledge base.

One practical way to address this bias is to ask the expert a simple follow-up question regarding the issue being elicited: “Is there recent information you are using to provide your judgment?” If the answer is yes, then ask, “How does that new information weigh-in relative to all the other information you have accumulated over the years?” If the availability bias exists here, the expert, will often say something such as, “That’s a good question; let me think about it and get back to you.” Or, “I’ve thought about it and I have given the new information the proper weighting.”

### ***Representativeness or Stereotyping Bias***

This is the case where experts have base information, but don’t use it. Instead, they match an event with a stereotypical case. Biases, in expert response, can potentially lead to understating the range, so it is important that the risk elicitor properly condition participants and monitor and question participants if a bias is detected.

### ***Conflict resolution***

Although uncommon, there may be situations where a significant difference of opinion has arisen between workshop participants, either during or following the workshop. There are many resources and references on the topic of conflict management and conflict resolution that can be obtained by “googling” the terms and/or visiting libraries and bookstores. However, a progressive process for resolving such disagreements at workshops is offered below:

1. One benefit of the CRA/CEVP workshop process is that it allows input in the form of ranges and percent probabilities. Usually the ability to capture input in ranges meets the needs of participants offering input. For example, if one participant states: “This risk event could cause \$1 million in additional cost...” and another says “This risk event could cause up to \$3 million in additional cost...” we can simply offer to capture the risk with a \$1 million to \$ 3 million impact range – typically, this will satisfy the parties with differing opinions about the impact.(Note: persons offering opinions should be able to state why they have the opinion and document information used to develop the opinion).
2. If we are not able to resolve the difference by capturing it as a range, in some cases it may be appropriate to evaluate additional scenarios that address the different opinions being offered. This is practical in some cases--to a point. Having too many scenarios can add cost and complexity to the workshop and may not be necessary or helpful to the overall evaluation of the project.

3. If a strong difference of opinion persists, and the first two options above will not resolve the matter, agree to gather data and meet to review and discuss the matter with the relevant parties and subject matter experts. Strive to use objective data, with guidance from the Risk Lead and Cost Lead, to reach an agreed-upon input. If, after a concerted effort to reach a consensus decision, disagreement still exists, it may be necessary to adopt a solution and document the dissenting opinion in the report.

When evaluating information, consider the following:

<b>Less reliable (less certain)</b>	<b>More reliable (more certain)</b>
One or very few observations	Many observations
Anecdote or case study	Scientific study
Unpublished	Published and peer-reviewed
Unrepeated	Results have been reproduced
Not similar project	Similar projects
No constraints or assumptions identified	Constraints and assumptions listed
No comparative explanation of information	Comparative analysis provided

*Thompson, Kimberly M. Risk In Perspective, with edits*

## **Workshop**

(Attended by Project Team members, the cost risk team, and necessary SMEs and/or project specialists)

The overall workshop objectives are:

1. Review and validate base cost estimates.
2. Identification of uncertainties and risks.
3. Characterization of uncertainties and risk (in terms of likelihood and impacts).

## **Workshop Activities**

### ***Elicitation (characterizing risk and uncertainty)***

Eliciting information from subject matter experts and project team participants is a vital part of the process. Risks are treated as events defined by both cause and outcome. A positive outcome presents an opportunity, while a negative outcome poses a threat to project objectives. Elicited information is recorded into a Risk Register for the project and becomes input for the Monte Carlo modeling. The Risk Register lists all identified risk events (both threats and opportunities), and appropriate detail describing the risk event. The Risk Register should be comprehensive and must be reviewed to insure that all risks and uncertainties have been quantified and that there is no double-counting of risk events.

#### **➤ Risk Event Properties**

- Likelihood (probability of occurrence)
- Consequences (impact to cost/schedule relative to the base estimate if the event occurs)
- Relationship with other events (independent versus correlated with other events)

#### **➤ Nature of Event Occurrence**

- Frequency of occurrence
- Number of occurrences during the project
- Number of potential outcomes (consequences)
- Event is independent or correlated with other events or among project activities

➤ **Consequences of Event Occurrence to Project Objectives**

- Defined in terms of cost impacts, schedule impacts, or both
- Uncertainty in event outcome

<sup>2</sup>Elicitation can be accomplished in a number of ways and may utilize any one or a combination of the following approaches:

- Elicitation in the workshop
- Elicitation through a questionnaire
- Elicitation interviews of individuals or small groups in advance of the workshop
- Teleconferencing
- Other methods

Preparation for elicitation provides:

- A base estimate and schedule (including the basis of estimate)
- Document of assumptions as a basis for risk assessment
- A list of base uncertainties

Elicitor guidance provides:

- Balance in participants' perspectives (watch for bias in responses)
- Formal elicitation
- Facilitated brainstorming
  - All credible ideas are listed and discussed
  - Consequences are assessed for likelihood and impact (frequency/magnitude)
- Guidance on:
  - Anchoring (see conditioning participants)
  - Worst and best case scenarios for consequences

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<sup>2</sup> Elicit - To draw forth...; to bring out... *from* the data in which they are implied. To extract, draw out (information) *from* a person...

### ***Elicitation of Sub-Groups***

Elicitation of subgroups, as opposed to having everyone attend every elicitation session, can in some cases provide a more efficient and effective approach to help ensure a properly focused elicitation with the correct SMEs present. This approach can help keep the number of individuals in the meeting to a manageable size. Group dynamics may begin to deteriorate after a group reaches a certain large size (e.g. many contributions but not necessarily from knowledgeable participants), and subdividing the elicitation provides a practical offset to the size problem. The subdivision of elicitation can happen on the same day, as well by allowing each of the Risk Leads to take a group into a separate room for elicitation. The following elicitation sub-groups have been used:

1. Right-of-way, Utilities and Railroad.
2. Environmental, Cultural Resources, Stormwater.
3. Structures and Geotech.
4. All Other: Design, Traffic, Work Zone Traffic Control, Constructability (staging/sequencing), scope issues/uncertainties, public pressures/opposition, local jurisdiction concerns, local market conditions/uncertainties, uncertainty in the base, management and other costs.

### ***Cautionary Notes Regarding Workshop Dynamics***

1. **The size of the group needs to be kept manageable.** Group dynamics deteriorates beyond a certain sized group. While a good mix of expert input is desired, care needs to be taken that the number of participants does not overwhelm the process or diminish the effectiveness of the workshops. For example, too many people in the room attempting to speak can “drown out” or dominate time that should be used to listen to the Subject Matter Experts.
2. Participants who are not familiar with the workshop process and/or risk based estimating need to be educated/acclimated to the process. Participants should know their roles and what will be expected from them during the workshop.
3. The workshop effort should be commensurate to project size and complexity. Choose the right size and approach for the project. The process is scalable.
4. The workshop environment itself should be large and comfortable. Workshop participants will be working together for several days; it is best not to have venues that are too small or confining.
5. Biases in expert response, and failures to characterize distributions and dependencies can result in understatement of the tails of the distribution. Elicitors need to be well-informed on the biases and have experience in reducing them.
6. Be careful of “discrete” thinking. The risks being quantified are schedule and cost. These are conceptually continuous random variables and can be modeled as such. However, *likelihoods* are properly modeled using a discrete distribution as discussed under “Distributions to Consider for Quantifying Risk,” in the appendices “Notes for Risk Modelers.”
7. For some specific events, discrete probabilities are appropriate.

## Report Preparation

The workshop report documents the results and process followed; the report is built in service of and in support for the project team’s risk management and project delivery efforts. Report preparation is a collaborative effort primarily between the project team and the cost risk team, with final control of editing and publishing the report resting in the hands of the project manager. Table 2 provides a general guide checklist for report writing.

**Table 2 Report Writing Responsibility**

<p><b>Project Manager/Project Team</b>  <i>The manager and team actively participate in the review and editing of the report.</i> They own the results and use them in their management system –including communication of results and publishing the results, including the “one-pager” on the project website.</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> An accurate and complete Workshop Request Form</li> <li><input type="checkbox"/> Project Photo for cover</li> <li><input type="checkbox"/> Cost and schedule estimates and a brief written summary describing their preparation</li> <li><input type="checkbox"/> Reconciliation of Differences from previous estimates</li> </ul>
<p><b>Subject Matter Experts</b>            Make notes during the workshop to provide for the report writing efforts.</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Key Risks</li> <li><input type="checkbox"/> Possible Response Strategies</li> </ul>
<p><b>Risk Lead</b>            Makes notes of key discussion topics during the workshop that may be helpful during report preparation, review and editing. Works closely with the project team and Cost Lead to insure the report is useful and understandable to the project team. Document the model logic and steps taken to insure a sound and objective analysis. Clearly identify “candidates for mitigation” and potential response strategies.</p> <p>Prepare a written draft of:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Executive Summary, (a “one-pager” will be included for each project analyzed)</li> <li><input type="checkbox"/> Chapter 1: Project Summary and Objective as provided by Project Team at workshop</li> <li><input type="checkbox"/> Chapter 2: Project alternatives, scenarios, and flowcharts used in modeling</li> <li><input type="checkbox"/> Chapter 3: Project Workshop Notes and Key Assumptions from workshop</li> <li><input type="checkbox"/> Chapter 4: Model Results</li> <li><input type="checkbox"/> Chapter 5: Discussion of Findings</li> <li><input type="checkbox"/> Appendix material</li> <li><input type="checkbox"/> Double-check report for clear and easy-to-understand language</li> <li><input type="checkbox"/> Check against QA/QC Checklist</li> <li><input type="checkbox"/> Bring report to final ready condition with edits in a timely manner.</li> </ul>
<p><b>Cost Lead</b>            Makes notes to aid in the writing of the estimate validation.</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Written overview of cost and schedule estimates</li> <li><input type="checkbox"/> Written review and validation of cost and schedule forecasts in simple language</li> </ul>
<p><b>Workshop Coordinator from CREM Office</b>            The workshop report is reviewed against the Cost and Risk Quality Control Checklist.</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> QA/QC Checklist Review</li> <li><input type="checkbox"/> Actively and regularly communicate and work with project team and cost-risk team through completion of report</li> <li><input type="checkbox"/> Obtain final copy from Project Manager for the file.</li> </ul>

NOTE: It is recommended that a designated “Report Editor/Coordinator” be identified prior to the workshop. The Project Manager can work with the CREM office to help determine who might serve in this role. The report editor/coordinator might be someone from the project team’s communication office, the cost-risk team, or other appropriate position.

**Draft Report**

This report is due two weeks after the workshop (or after final inputs has been provided to risk modeler). Every attempt should be made to provide inputs by the final day of the workshop. Allow one week for comments.

**Workshop Report (final)**

The final report is due two weeks after the Draft report was delivered (one week after comments are due). This report should be ready and complete with the one-pager and risk management plan spreadsheet.

**CEVP Results and Capital Budget Development Data Needs**

In order to load agency management systems and provide budget information, specific data needs to be provided to the region program management offices. This data is then loaded in to the Capital Program Management System (CPMS) and transferred to the Transportation Executive Information System (TEIS) for use in gaining budget approval.

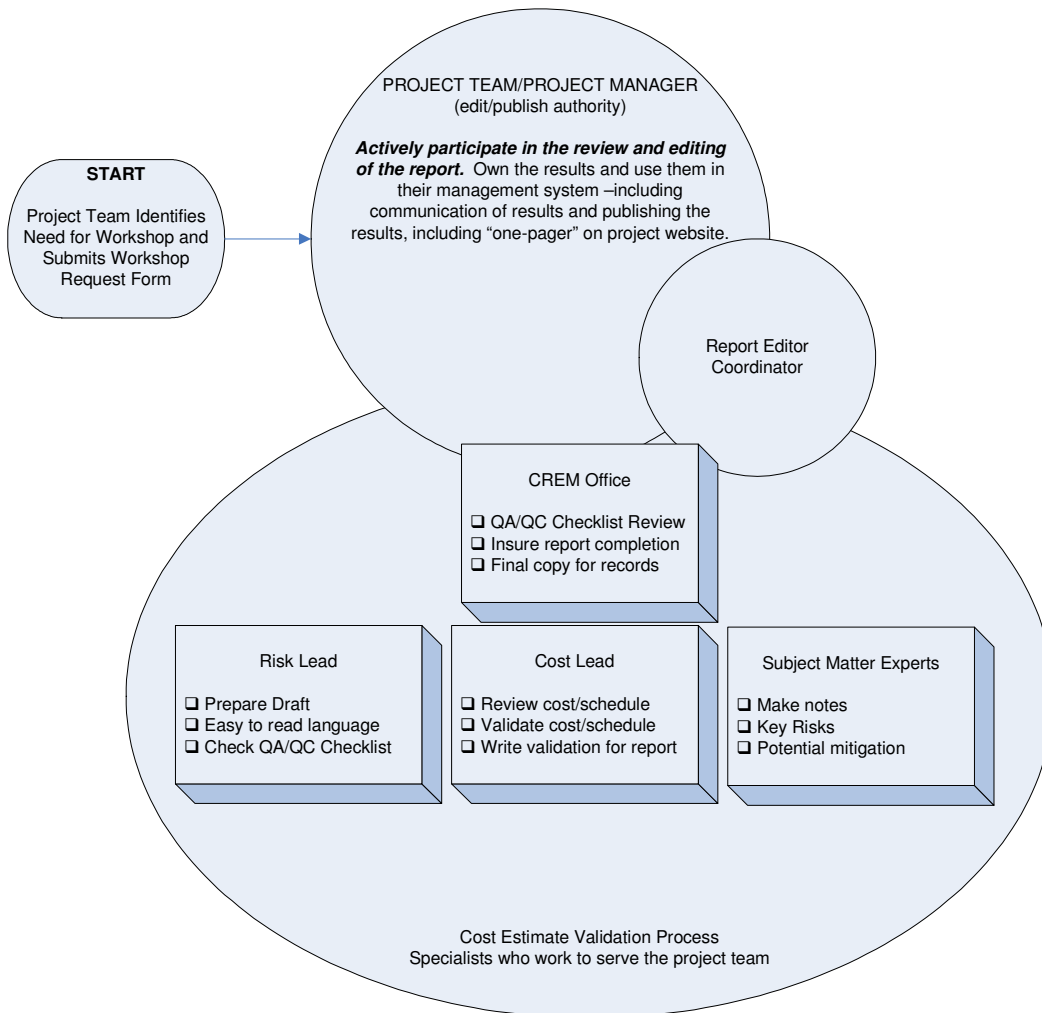
Required Data	Project schedule Data Milestone dates	Project Estimated Cost Data
	Begin Preliminary Engineering	Design Cost Estimate
	Begin Right-of-way Acquisition Phase	Right-of-way Cost Estimate
	Advertisement Date	Construction Cost Estimate
	Operationally Complete Date	

**Management Endorsement**

Along with the data provided by the project team, agency management endorses which costs are to be used, and the schedule to be assumed. Guidance on use and reporting of CEVP®/CRA Results and CPMS Data Requirements is provided in Instructional Letter 4071 posted at: <http://wwwi.wsdot.wa.gov/docs/OperatingRulesProcedures/4071.pdf>

**Table 3 Workshop Report**

<b>Project Team Members</b>	The project team, just as they did before the workshop, owns the Project Management Plan, and all project development and delivery responsibilities. This includes all project cost and schedule estimates and the risk management plan. The project team owns the report for their use in aiding and assisting their risk management and project management activities.
<b>Subject Matter Experts</b>	During the workshop process, the SMEs are responsible for their opinions and objective advice offered during the workshop and report preparation.
<b>Risk Lead</b>	The Risk Lead is responsible for conditioning workshop participants and for conducting the risk elicitation. The Risk Lead is responsible for the modeling, analysis, and conclusions to be drawn from the analysis. The Risk Lead is also responsible for writing their portion of the report. Uses a Quality Control Checklist as a guide to insure an effective workshop experience that results in a sound and objective analysis of project costs, schedules, and risks. Clearly identifies "Candidates for Mitigation" and possible strategies for mitigating these key risks.
<b>Cost Lead</b>	The Cost Lead is responsible for reviewing and validating the project cost estimate and schedule. The Cost Lead is also responsible for preparing their portion of the report.
<b>CREM Workshop Coordinator</b>	The Workshop Coordinator is responsible for insuring the appropriate participants are in attendance at the appropriate times. In addition, the review of the report against the Quality Control Checklist will be performed by the Workshop Coordinator or others in the CREM office.



**Figure 2 Report Writing**

## **QA/QC: All have a role**

**PRIOR TO WORKSHOP:** The project team, project manager, appropriate specialty groups, and appropriate stakeholders must perform a reasonability check on materials developed prior to the workshop. The Cost and Risk Quality Control Checklist provided in Table 4 should be used by the Project Manager to insure that the project team is ready for the workshop. When the workshop is convened, most attendees should already be familiar with, and have had an opportunity, to comment on the scope, schedule and cost estimate that the project team has developed. The scope, schedule and cost estimate will be the subject of review and analysis at the CRA or CEVP workshop. At the discretion of the CREM office, Regional Risk Manager, or the Project Manager, the workshop may be postponed if the Cost and Risk Quality Control Checklist items are not all satisfactorily completed.

### **DURING AND AFTER THE WORKSHOP:**

1. The Project Manager, appropriate project team members, and specialty groups perform a reasonability check on the preliminary draft results, including charts.
2. The Project Team, Risk Lead and Cost Lead work together to deliver useful products that can improve project control through managing project cost and schedule risks. All members are equally important and must work cooperatively to achieve this objective.
3. Risk and Cost Elicitors coordinate and assist each other to make sure information is properly defined and coordinated during the workshop.
4. The modelers must carefully review the model to insure the information from the workshop is properly represented. The model logic must be described in the report, and the results presented to the Project Team and CREM.
5. Throughout the analysis, the risk elicitor works with the Project Team, WSDOT subject matter specialists, and external SMEs to make certain the risk information is correctly captured for use in the analysis.
6. Throughout the analysis, the Cost Lead works with the Project Team, WSDOT Subject Matter Experts, and external SMEs to make certain the cost information is correctly captured for use in the analysis.
7. The CREM office reviews the analysis/report for correctness and clarity; the Project Team Reviews the Analysis/Report to insure they understand the results and can confidently discuss them with others.

**Table 4 Cost and Risk QC Checklist**

<b>Cost and Risk Quality Control Checklist</b>	
<b>Cost Lead Review</b>	
1	<input type="checkbox"/> The "BASIS OF ESTIMATE" has been completed.
2	<input type="checkbox"/> All Project Team backup available has been reviewed and incorporated.
3	<input type="checkbox"/> The estimate scope has been validated with the CEVP workshop scope.
4	<input type="checkbox"/> All unit costs have been validated by professional judgment and/or historical cost information.
5	<input type="checkbox"/> All spreadsheet formulas have been reviewed and totals have been cross-checked.
6	<input type="checkbox"/> All costs and durations have been allocated to flowchart activities.
7	<input type="checkbox"/> Contingencies have been sufficiently removed from the base cost estimate and the inclusion in the risk estimate has been verified.
8	<input type="checkbox"/> All design allowances have been validated and allowances with large variation have been transferred to the risk estimate.
9	<input type="checkbox"/> All markup amounts have been verified and confirmed appropriate.
10	<input type="checkbox"/> All estimate assumptions and clarifications have been documented.
11	<input type="checkbox"/> Base uncertainty has been assessed and documented.
<b>Risk Lead Review</b>	
1	<input type="checkbox"/> The workshop process has been presented to the workshop team.
2	<input type="checkbox"/> Project Team Issues and Concerns have all been explored.
3	<input type="checkbox"/> Consensus on initial risk identification list has been achieved.
4	<input type="checkbox"/> Focus on key risks. Minor issues have been filtered out by consistent screening criteria.
5	<input type="checkbox"/> Remaining risks (threats and opportunities) are quantified in terms of likelihood and consequences.
6	<input type="checkbox"/> Potential risk mitigation measures have been captured.
7	<input type="checkbox"/> Contingencies and allowances have been coordinated with the Cost Team.
8	<input type="checkbox"/> Cost Lead has verified that risks are not included in the base cost estimate (no double counting).
9	<input type="checkbox"/> All issues, impacts, likelihoods and mitigation measures are documented consistently.
10	<input type="checkbox"/> All assumptions and clarifications have been documented.
11	<input type="checkbox"/> Team consensus has been reached on all risk items.
12	<input type="checkbox"/> All risk estimate backup has been documented (date, page number, and estimator's name).

## Risk Response

**Take action** in response to identified risks. Following identification and analysis of project risks project managers and project teams must take action in response to the identified project risks, focusing on risks of most significance.

In order to maximize the benefits of project risk management we must incorporate the project risk management activities into our project management plan and work activities. This means building risk management activities into our Work Breakdown Structure (WBS); WSDOT has a ready made WBS in the form of its Master Deliverables List (MDL) to help insure our project workplans are comprehensive, consistent and complete.

Risk Response requires effort to develop and implement response actions; we must plan for expending this effort following the results of our risk analysis. See the tool found at:

<http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/>

Descriptions of risk response actions follow:

<b>Actions in response to risks:</b>	<u>Threats</u>	<u>Opportunities</u>
	1. Avoid	1. Exploit
	2. Transfer	2. Share
	3. Mitigate	3. Enhance
	4. Accept	

### Risk Response: Actions

#### **AVOID (threats)**

Action taken to insure the probability or impact of a threat is eliminated.

Avoidance actions include: change project management plan to eliminate a threat, to isolate project objectives from the risk's impact, or to relax the project objective that is in jeopardy, such as extending schedule or reducing scope. Some risks that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise. *PMBOK*

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Two types of action 1) remove the cause of the risk (risk trigger); 2) execute project in different way while still aiming to achieve project objectives. Not all risks can be avoided or eliminated, and for others this approach may be too expensive or time-consuming, but this should be the first strategy considered for each risk.

*Effective Opportunity Management for Projects by David Hillson*

#### **EXPLOIT (opportunities)**

Action taken to insure the benefit of an opportunity is realized.

Opposite of avoid – this strategy is to insure a positive impact, an opportunity is realized. Taking action to make the opportunity definitely happen, such response actions include: assigning more talented resources to a project to reduce time to completion, and/or to provide better quality than originally planned. *PMBOK*

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Eliminate the uncertainty associated with a particular upside risk. An opportunity is defined as a risk event that if it occurs will have a positive effect on achievement of project objectives. Avoid and Exploit is the most aggressive of the response strategies and should be reserved for those “golden opportunities” with high probability and impacts.

*Effective Opportunity Management for Projects by David Hillson*

### **TRANSFER (threats)**

Action to allocate ownership for more effective management of a threat.

Transferring a threat does not eliminate it; the threat still exists however it is owned and managed by another party. Transferring risk can be an effective way to deal with financial risk exposure. Transferring project risk almost always involves payment of a risk premium to the party taking the risk, examples include: insurance, performance bonds, warranties, etc. Contracts may be used to transfer specified risks to another party. *PMBOK*

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Transferring risk involves finding another party who is willing to take responsibility for its management, and who will bear the liability of the risk should it occur. The aim is to ensure that the risk is owned and managed by the party best able to deal with it effectively. Risk transfer usually involves payment of a premium, and the cost-effectiveness of this must be considered when deciding whether to adopt a transfer strategy.

*Effective Opportunity Management for Projects by David Hillson*

### **SHARE (opportunities)**

Action to share with a third party; enhance/exploit opportunity.

Sharing a positive risk involves allocating ownership to a third party who is best able to capture the opportunity for the benefit of the project. Examples of sharing actions include forming risk-sharing partnerships, teams, or joint ventures, which can be established with the express purpose of managing opportunities. *PMBOK*

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Allocating risk ownership for an opportunity to another party who is best able to handle it, in terms of maximizing probability of occurrence and increasing potential benefits if it does occur. Transferring threats and sharing opportunities are similar in that a third party is used, those to whom threats are transferred take on the liability and those to whom opportunities are allocated should also be allowed to share in the potential benefits.

*Effective Opportunity Management for Projects by David Hillson*

### **MITIGATE – or reduce (threats)**

Action taken to reduce the probability and/or impact of a threat.

Risk mitigation implies a reduction in the probability and/or impact of an adverse risk event to an acceptable threshold. Taking early action is often more effective to repair than trying to repair the damage after the risk has occurred. Examples of mitigation strategies include: adopting less complex processes, conducting more tests and/or field investigations, developing a prototype; measures to address impact include: targeting linkages that determine the severity, such as designing redundancy into a subsystem may reduce the impact from a failure of the original component. *PMBOK*

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Mitigation or acceptance or the strategies most often used since the number of threats that can be addressed by avoidance or transfer are usually limited. Preventive responses are better than curative responses because they are more pro-active and if successful can lead to risk avoidance. Preventive responses tackle the causes of the risk; where it is not possible to reduce probability a mitigation response should address the adverse impact, targeting the drivers that determine the extent of the severity.

*Effective Opportunity Management for Projects by David Hillson*

### **ENHANCE (opportunities)**

Action taken to enhance opportunity.

This response modifies the “size” of an opportunity by increasing probability and/or impact. Seeking to facilitate or strengthen the cause of the opportunity, and proactively targeting and reinforcing its trigger conditions. Impact drivers can also be targeted, seeking to increase the project’s susceptibility to the opportunity. *PMBOK*

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This response aims to modify the “size” of the positive risk. We enhance the opportunity by increasing the probability and/or impact of an opportunity thereby maximizing benefits realized for the project. If the probability can be increased to 100% this is effectively an exploit response.

*Effective Opportunity Management for Projects by David Hillson*

## **ACCEPT**

Action taken to document the acceptance of the risk.

The term “accept” refers to risks that remain after response actions and/or for which response is not cost effective are accepted; risks that are uncontrollable (no response actions are practical) are also accepted. *Effective Opportunity Management for Projects by David Hillson*

Ultimately it is not possible to eliminate all threats or take advantage of all opportunities – we can document them and at least provide awareness that these exist and have been identified, some term this ‘passive acceptance’. In some cases, in some industries, a contingency reserve is established to deal with the aggregate residual risk that has been accepted, some term this ‘active acceptance’.

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As we continue through project development the project risk profile will change. Typically as we successfully respond to risks and our project knowledge increases our risk exposure will diminish. In effect we can retire risk reserve as risk events are successfully avoided or mitigated or we have passed the time during which the risk is active and it becomes retired.

## **Remember...**

CEVP is iterative in nature and represents a “snapshot in time” for that project for the known conditions at that point.

CEVP normally deals with identifiable and quantifiable project-type risks – i.e., those events that can occur in planning, design, bidding, construction, and changed conditions.

CEVP could also consider the larger, more difficult risks – “acts of God” that can have very high impact in cost and schedule on large programs – but at this point, these risks are not generally included. This is an area for review and development – in particular, how to characterize such events in a useful manner for better management of the projects. All exclusions and assumptions need to be clearly documented in the workshop report.

It is good to remember that risk based estimating, as in CRA/CEVP workshops, does not provide an “answer book” with all uncertainty removed from the project. Risk based estimating and consideration of project uncertainty and project risk does not add costs to a project –it reveals them.

Risk Based estimating is an analysis of data provided by the project team and workshop attendees. The analysis provides useful information for the risk management element of the overall project management plan. A report is provided that can be used by decision makers and the project team to develop an action plan. The resulting workshop report is information for decision makers to act upon. It is not a decision document... it is an *information document* for decision makers.

“We have to do the best we know how at the moment...; If it doesn't turn out right, we can modify it as we go along”. FDR



**Appendix 1: Project Manager & Project Team - Duties  
(Cost Risk Estimating Management)**

Project teams typically look to the CRA/CEVP® workshop process as a tool to help improve the accuracy, consistency, and confidence in their project cost and schedule estimates. This process also helps project managers and teams with their project risk management efforts, a required component of all project management plans. During this collaborative process, uncertainty within a project is identified and quantified. Project schedules and cost estimates are owned by the project teams. Development of risk based estimates through the CRA/CEVP® workshop process is a collaborative effort between the project team, experts in cost and risk analysis, and external Subject Matter Experts.

Workshops are usually held early in project development, from late-planning to early stages of developing the contracts plans, specifications and estimate (PS&E). Risk Management is an ongoing project management activity and the project manager and project team should continue to pro-actively manage risk up until advertising the contract. Continuing risk management and risk assessment should look at the knowledge gained through the workshop process, and pay particular attention to evaluating the sequence of construction activities and scheduling through completion of the PS&E.

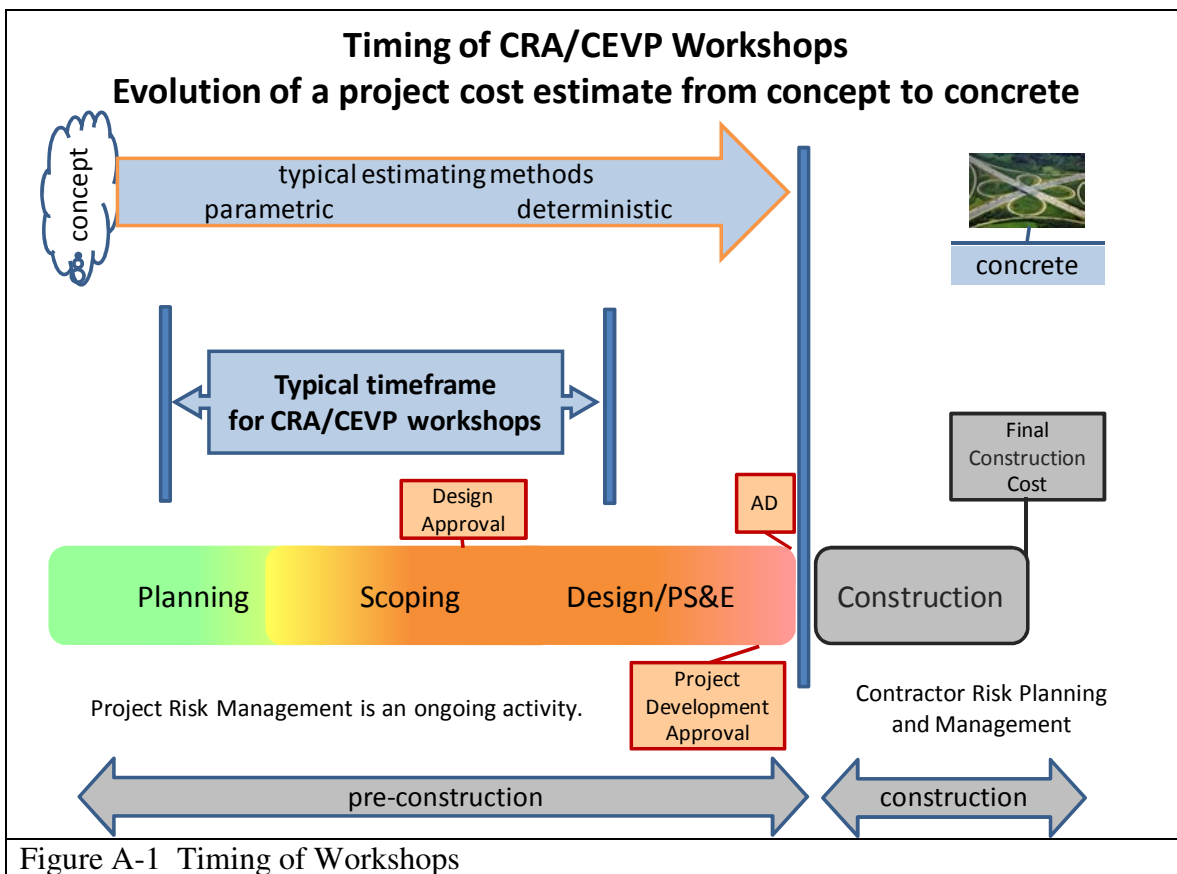


Figure A-1 Timing of Workshops

Project schedules and cost estimates are owned by the project teams, and must be updated regularly. This may involve conducting workshops periodically (typically a workshop is held every one to two years). The workshop effort begins with a request from the project team. The process focuses on the project team for input of primary information, and of course the project team utilizes the workshop results as they deem appropriate, to more effectively manage their projects. The two main elements of an estimate are: *Base Cost* – which represents the cost if the project materializes as planned; and *Risk Events* – a combination of the probability of an uncertain event and its consequences. A positive consequence presents an *opportunity*; a negative consequence poses a *threat*. Note that risk events are separate from variability that is inherent in the base.

## **CEVP®**

Generally, CEVP® follows the seven steps process outlined below:

1. Project and Method Selection
2. Structuring the Project Team Effort
3. Define and Evaluate the Base Cost Estimate and Schedule
4. Assess Uncertainty and Risk
5. Quantify Uncertainty in the Project Cost and Schedule
6. Probabilistic Analysis and Documentation
7. Implement and measure risk response actions, monitor and control

After the probabilistic analysis is complete, the results are then interpreted, documented and reported to the project team. Standard results include total project cost and schedule distributions both in terms of current dollars and year of expenditure dollars. The resulting distributions, or ranges, have specific probability characteristics and are reported as percentage values.

## **Statement of Purpose for CEVP®/CRA Workshops**

To provide the Project Manager and Project Team with actionable information that can be used to shift the odds in favor of project success. To provide a useful, sound, and objective analysis and report that the Project Team will own and act upon to improve, as well as to validate and confirm their project cost and schedule.

The project risk management performance can be measured by comparing “pre-mitigated” to “post-mitigated” results, then identifying risk responses to ascertain the amount of risk relief to be accomplished through risk management efforts.

The process provides a tool for the project team to evaluate the quality and completeness of the current Project Estimate. It is intended to increase confidence in the project cost and schedule forecasts and to identify areas of uncertainty.

The workshop process is not intended to “recreate the wheel,” or second-guess the Project Team. It is not a substitute for other necessary Project Management functions such as project control and value engineering.

<b>Typical applications of results:</b>	
<ul style="list-style-type: none"> <li>• Presentation of cost estimate range</li> <li>• Project assessment and management</li> <li>• Risk Management</li> <li>• Value Engineering</li> </ul>	<ul style="list-style-type: none"> <li>• Integrated Project/Program Mgmt.</li> <li>• Design/Build and Other Applications</li> <li>• Communications</li> <li>• Financial Management</li> </ul>

Risk based estimating, such as CRA/CEVP®, does not provide an “answer book” with all uncertainty removed from the project. Probability, not certainty, is the outcome from the workshop process.

The CRA/CEVP® workshop effort is an analysis of data provided by the team in collaboration with subject matter experts and cost and risk experts. It provides useful information for risk management and is an integral part of the overall project management plan. The project team owns the workshop report and results to help them develop a plan of action to respond to the identified risks. The report written from the CEVP analysis is not a decision document... it is an information document for decision-makers.

### **Project Status Prior to CRA/CEVP Workshop**

1. The Project Team must provide plans and documents that describe the scope, schedule, and cost estimate of the project. The project manager needs to approve of the project management plan, including scope, schedule, and cost estimate prior to the workshop. In addition, all key contributors need to confirm and accept the estimate that is being presented for analysis in the workshop. The information presented by the project team should not be a surprise to the specialty groups and stakeholders involved in the project.
2. Describe the level of project maturity (i.e. percentage of design completion).
3. Describe the character and timeframe of the project and issues of concern.

*The Project Manager and Project Team should remain mindful of the overall workshop objectives, which are to:*

1. *Review and/or validate base cost estimates.*
2. *Identify project uncertainties and elicitation of project risks*
3. *Characterize uncertainties and risk; which are documented in a Risk Register.*

To insure the quality of our workshops and effectively use the subject matter experts at the workshops, the project manager and project team do the following:

- Submit CRA/CEVP Workshop Request Forms at least 8 weeks prior to the workshop; for some projects, such as SR 520 and AWV, project managers have asked these be submitted at least 12 weeks in advance.
- The following documents should be submitted 2 weeks prior to the workshop:
  - Updated Project Management Plan (including Risk Management Plan)
  - Current project schedule to be used in the workshop
  - Current estimate file with assumptions and basis of estimate
  - Current Project Summary (and detailed project scope)

The items above need to be completed and turned in early so that workshop participants can learn the basic elements of the project, and begin review of key items of the cost estimate. Project estimate review and risk assessment are the main workshop topics.

## **Project Team Responsibilities and Requirements**

The project team needs to make available, for the majority of the workshop, key people who can represent the Project in areas essential to the Project Objectives. This includes:

- ❑ Project Management (to provide project context and relationship with stakeholders);
- ❑ Engineering (design and construction)
- ❑ Cost Estimating
- ❑ Scheduling
- ❑ Environmental permits, processes and mitigation

The Project Manager is to insure the availability of project team members who can speak to the issues raised in the workshop and are familiar with the documentation.

The Project Team must be prepared to identify applicable risk elements (global and project specific), the interrelationships of the risks, and the characterization of the risks in terms of likelihood and impacts. If the Project Team is interested in pricing the project for different delivery methods, e.g., Design-Bid-Build vs Design-Build, they need to be prepared to discuss this.

The Project Team, working collaboratively with the workshop team, should be prepared to discuss and determine:

- ❑ Exclusions
  - ❑ Funding
  - ❑ Programmatic Issues
  - ❑ Others
- ❑ Adequate Subject Matter Expert participation
- ❑ Authority to “de-bias” the input
- ❑ The optimal process balance between effort and accuracy; level of analytical detail and- how to handle dependence, correlations, and distributions.
- ❑ The probabilistic risk-based integrated cost and schedule modeling needs.
- ❑ Global versus project specific risks and other uncertainties
- ❑ Treatment of base uncertainties.

## **Items Required from the Project Team Prior to the Workshop**

The project team must produce the following items ahead of time and have them available at the workshop:

- ❑ Project Team Organizational Chart.
- ❑ Project Team Contact Information.
- ❑ Project Vicinity Map, informational documents, aerial photos, et al.
- ❑ Project Definition Documents and Design Criteria used.
- ❑ Summary or overview of Project Plan(s) that indicate the project elements at the type, size, and location level. This may include concept plans, cross-sections, illustrations, public information documents, memorandums of understanding, geotech info, etc.
- ❑ If there are multiple alternatives there needs to be a description of status and relationships sufficient to understand the options and to plan the workshop priorities.
- ❑ The Basis of Cost Estimate.
- ❑ Current Estimates (unit prices, parametric estimates, combination...), including an overall “project/program rollup estimate”. Please note the base year of the estimate.
- ❑ A preliminary listing of risks and the Project Team’s issues of concern.
- ❑ A preliminary project flowchart showing key tasks and relationships from current status through completion of construction and open to traffic.
- ❑ Current Design and Construction schedule, including description of how durations were determined and an explanation of the construction sequencing strategy.
- ❑ **Estimated durations and costs associated with completion of Preliminary Engineering:**
  - ❑ Mapping and Surveys
  - ❑ Engineering and Design
  - ❑ Geotechnical Investigation
  - ❑ Environmental Process and Permitting
  - ❑ Environmental Mitigation Design (including Administrative costs)
  - ❑ Hazmat Remediation Design
  - ❑ Structures
  - ❑ Hydraulics
  - ❑ All other relevant areas for the subject project
- ❑ **Estimated durations and costs associated with completion of Right-of-way:**
  - ❑ Real Estate Services
  - ❑ Right-of-way Acquisition Services (includes administrative costs)
  - ❑ Access Management
  - ❑ Right-of-way property costs
  - ❑ All other relevant areas for the subject project
- ❑ **Estimated durations and costs associated with completion of Construction:**
  - ❑ Construction Engineering
  - ❑ Construction cost of project
  - ❑ Lump sum items (i.e. weigh station, maintenance facility/equipment, Park & Ride lot, etc.)
  - ❑ Utility relocations
  - ❑ Hazmat Remediation
  - ❑ Environmental mitigation (cost to construct)
  - ❑ Allowances for miscellaneous add-ons (lighting, signing, striping, SC&DI, etc.) with explanation as to what items are covered and percentage to be used, and why.
  - ❑ All other relevant areas for the subject project.

## **Appendix 2: Risk Lead(s) - Duties** **(Cost Risk Estimating Management)**

### **Notes for Risk Lead(s)** **Description of Work:**

The risk lead(s) participate in a peer-level review or due diligence analysis on the scope, schedule and cost estimate for various projects to evaluate quality and completeness, including anticipated risk and uncertainty in the projected cost and schedule.

The Risk Lead:

- Leads the risk portion of the process including risk elicitation and <sup>3</sup>**project flowchart development** for modeling.
- Keep flowchart practical; it should be a simple but complete representation of the project schedule. It is the ‘backbone’ of the analysis and can be thought of as an abstract of the project schedule.
- Participates in cost validation or review and risk uncertainty workshops for selected projects.
- Conducts prep sessions, followup meetings, or rerun sessions as necessary.
- Provides reports and presentations documenting workshops.
- Provides reports using report guide or table of contents.
- Develops or implements workshops on topics such as project definition, and risk identification and management.

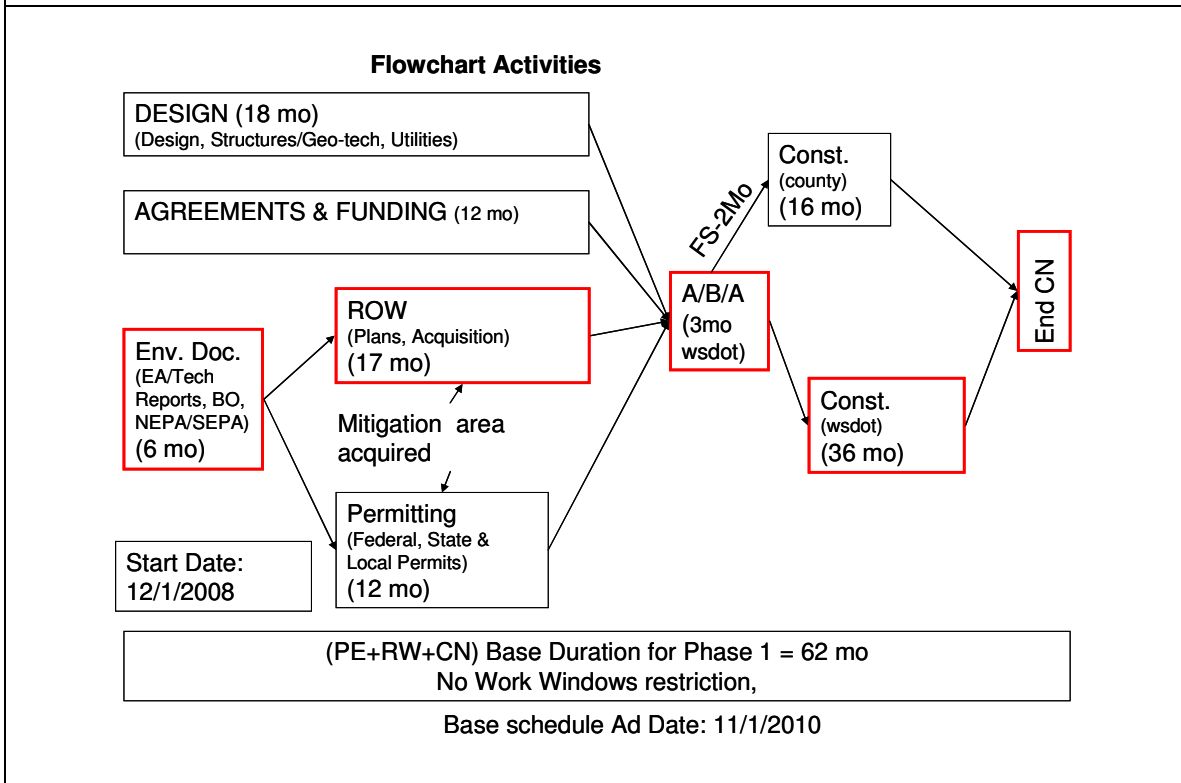
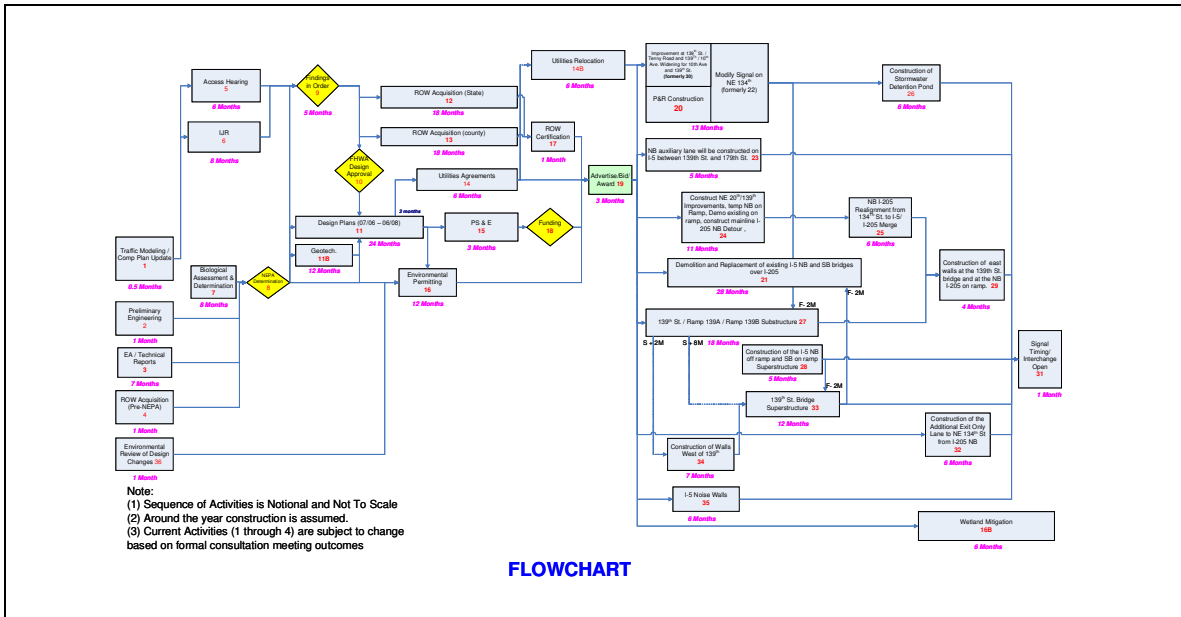
These functions are critical to WSDOT's success in delivering projects on-time and on-budget. It is anticipated that Cost Risk Assessment and CEVP reviews for each project can be accomplished in a reasonable timeframe, including a 1-5 day concentrated workshop. WSDOT personnel, with aid of multiple specialty groups, will coordinate CRA/CEVP. Work may include the documentation of the viability of assumptions made regarding a project's configuration, scope, schedule, character, and, through risk analysis, the potential impact of risk events that may occur. The project may include creating reports documenting information determined or discovered.

Risk workshops vary based on project needs, but include risk identification, probabilistic risk assessment, development of management strategies, a probabilistic look at the effectiveness of management strategies, and other variants. Consistent methodology for probabilistic risk assessments must be used by the Risk Lead.

The Risk Lead plays a vital role to insure the analysis is a sound and objective analysis. It is also imperative that the analysis process and results are clear and usable by the project team. The process, as documented, must include the underlying assumptions and constraints of the analysis in a manner that is easily comprehended by the project team who will have to communicate the result of the workshop to others. The report should “tell the story” of the project scope, schedule, and cost estimate.

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<sup>3</sup> Flowcharts should as simple as possible but still represent the project activities in a realistic manner with proper sequence and durations (see Figure A2-1 on the following page).



**Figure A2-1 Flowchart Examples**

Notice the two flowcharts in Figure A2-1 above. They are for the same project; however one is simple and easy to follow while the other one is more complex. They both meet the needs for risk modeling but one is much easier to work with. Remember more activities do not always mean more clarity.

## **Appendix 3: Cost Lead - Duties** ***(Cost Risk Estimating Management)***

### **Special Notes for the Cost Lead**

#### ***Description of work***

The Cost Lead will participate and lead portions of a Cost Estimate Validation Process (CEVP) or Cost Risk Assessment (CRA) workshop for the project. Work includes workshop participation, leadership and facilitation, preparation, pre-workshop meetings, documentation, follow up, reconciliation of workshop results, management consulting, technical report writing, process evaluation and communication, and meeting requests to rerun models or assess new scenarios for the project. Also includes traveling to and from the workshop and project locations. Provides support for the workshop for the project.

#### **The Cost Lead:**

Assists with the workshop process by taking primary responsibility for:

- Leads the Review and validating the project team's estimate;
- Supports the project team in the development of the base cost estimate;
- Supports the project team in making any adjustments to the base estimate as a result of the review.
- Supports the development of the risk register by proposing cost and schedule risk items to deal with risks and opportunities that are identified as part of the cost and schedule review.
- Reviews the project team's work to distribute the base costs against the activities identified in the flow chart.
- Works collaboratively with the project team to review and validate the final cost estimate to be used in the model. Confirms concurrence of the validated estimate with the project team and subject matter experts.
- Leads the Review and critiques the project team's schedule.

#### **Deliverables:**

The Cost Lead will:

1. Provide comments and validation of the project base estimate.
2. Work with the project team's estimator to develop base cost breakdowns for flowchart activities of the project for use in the risk modeling as soon as possible during or immediately following the workshop.
3. Provide a written report on the Base Cost review, and validation, and schedule review for inclusion in the risk analysis workshop report to the project office and CREM Team. The report is due within one week following the end of workshop or earlier if required and agreed to at the workshop.

Typical cost questions to be asked by the Cost Lead and the Subject Matter Experts (SMEs):

- Have you completed the Project Estimate Basis form? What is the basis of the estimate?
- How current is it? When was it updated?
- Do unit prices correlate to similar scope projects in the area? Are they truly comparable?
- Does the current scope of the work match the scope that the estimate is based on?
- Does the estimate include engineering, engineering services during construction, construction management services?
- What is the stage of the design?
- What is the accuracy of the survey data?
- What field investigations have been done, existing conditions analysis?
- What geotechnical work has been done to date? Is there data from past projects in the area?
- Cuts and Fills: What has been assumed for reuse, import, export and disposal, temporary stockpiling, haul distances, location of imported materials?
- Assumptions on compaction? Seasonal variability?
- Assumptions on stability of cuts, sheeting, retaining walls, slope protection during construction?
- If dewatering is required, are there perched water tables and other maintenance of excavations during construction, treatment of dewatering to meet permits?
- ROW: How current are surveys and estimates of costs? Partial or full parcels?
- Temporary Utilities, staging areas, parking storage and lay down?
- Knowledge of utilities in project area, relocation requirements, ability to isolate and shutdown? Are replacements needed prior to isolation? Can replacements be installed at proper elevation?
- Erosion protection?
- Special conditions: extraordinary staffing requirements, night work, stop times due to fish or wildlife issues, noise limits, and dust control?
- What has been assumed for overhead, insurance, bonding, project management, safety, QC community liaison, trailers, utilities, parking home office overhead, and profit?
- Assumptions for material availability? Backfill, sheeting, piles, concrete, rebar access for delivery, double handling requirements?
- Production rates assumed? Is this work similar to other work done in the area?
- Assumptions for Maintenance of traffic, staging of construction, needed temporary barriers, ramps bridges, supports, technology?
- Estimated mitigation, noise walls, Stormwater detention ponds wetlands?
- What contingencies are built into the estimate?
- Has a change order allowance been built into the estimate?

### Typical schedule questions:

- How long have similar projects taken?
- How many \$/month at average and at peak would have to be spent to meet the schedule?
- What season is it expected that the Notice To Proceed (NTP) will be issued? Will certain months be lost due to the start date?
- Has mobilization and demobilization time been included in the schedule? How many workers are assumed to be working on the project at the peak of construction?
- Does the construction phasing and traffic management plan match the schedule assumptions?
- How many concurrent work areas are assumed? Are there crews available to staff all of those areas?
- What are the assumed production rates for each of the major elements, earthwork, foundations, piers, beams deck, sub-base, base, paving etc.?
- If the NTP is issued as planned, can the landscaping be completed in the required season for the specified plantings?

### **Tips**

1. The project team owns the estimate; let the project team establish what they want out of the process.
2. Don't get bogged down into details, keep the discussion relevant to the overall size of the project For example, don't waste a lot of time discussing a \$100,000 item on a \$50,000,000 project.

## **Base Cost Assessment**

Estimating is a maturation process that follows the project development. Therefore there is always a story behind the estimate; it is rarely a straight forward linear process. It is *imperative* that you understand how the estimate was generated. Take the time to have the project team explain the history of the estimating process. Also, while the project team talks through how the estimate was generated they are mentally checking that the process is correct. The following is a step-by-step guide through the assessment process:

- 1) **Confirm Cost Matches Scope**  
Gain a comprehensive understanding of the project scope, limits, major items of work such as structures, construction staging, phases, etc. during the project team presentation. Validate that the scope description, drawings, and estimate match in terms of work items. Use the expertise of the team to validate the design elements. For example if there is a curved bridge, has the team assumed steel girders and factored that into the unit price?
- 2) **Confirm Unit Prices are Valid**  
Experience, bid tab data, and recent projects in the area can be used to validate unit prices. Estimate the per square foot unit price of bridge deck is sometimes contentious, topics of discussion frequently center on foundation type; superstructure type and geometry. Unit price estimates also include confirming the tax rate which varies by county; the per acre cost for right of way; mobilization markup; and engineering markup. Bid histories are useful but not the final answer, especially if bid histories are more than 3 months old. In such cases care and judgment must be used to ascertain the appropriate and valid current unit prices.
- 3) **Identify Contingency (internal & external)**  
Strip out the contingency in the base cost estimate. That this needs to be done is obvious when contingency appears as an explicit line item in the estimate. There can also be contingency hidden within the line items, such as inflated unit prices, rounding up of quantities, etc. What needs to be taken out is a judgment call based on discussions with the estimator.
- 4) **Split Estimate to Match Flowchart**  
The estimate needs to be cut apart to match the flowchart boxes. This is typically, environmental cost, preliminary engineering, PSE, ROW and construction. This work needs to be closely coordinated with the risk group and confirmed by the workshop participants (project team, cost-risk team, and subject matter experts).
- 5) **Determine Risk Costs in Collaboration with the Risk Team**  
Generate risk items and determine costs (this occurs in the workshop). This should be a high level estimating effort. If this step becomes voluminous, consider ways to divide and conquer. It is imperative that the cost and risk

scope items match- and that there is no overlap of costs and risks, nor are there any omissions.

#### **Appendix 4: Subject Matter Experts (SME) - Duties (Cost Risk Estimating Management)**

Cost Risk Estimating Management is a program created and developed to better estimate transportation projects. The program provides the framework for two comparable processes “Cost Estimating Validation Process” (CEVP) and “Cost Risk Assessment” (CRA.) These processes involve intensive collaborative workshops where transportation projects are examined by teams of top engineers, risk managers, Internal and External Subject Matter Experts from local and national private firms and public agencies and from WSDOT specialty groups with the Project Team.

External and/or Internal Subject Matter Experts participate in **peer-level** systematic project review, or due-diligence analysis, and risk assessment to identify and describe cost and schedule risks based on the information at hand. The review process examines how risks can be lowered and how the project cost and schedule vulnerability can be reduced.

The Subject Matter Expert should have extensive expertise in his/her specialty area. In addition to the technical expertise the SME is expected to provide guidance and assistance on defining the cost and schedule of the projects activities related to his/her expertise. While the SMEs should focus on their area of expertise it is expected that the SMEs provide input on one or more of the following risk categories: Management; Environmental; Third Party; Design; Construction Cost estimating and cost control, Construction planning and phasing, Construction implementation; Construction claims and disputes; Real Estate and Right-of-Way, Operation & Maintenance and Safety.

The SME should understand that Risk Management could require a negative frame of mind but once identified, risks should be managed positively, so that the risks are addressed in the best possible way to minimize their influence on a project.

The SME should understand that Risk Assessment does not need to be exact to be useful, particularly during the early stage of a project. Risks and opportunities go hand in hand and their analysis should have equal consideration. Much of the power of CEVP and CRA workshops lies in the rigorous disciplined approach and the ability of team members to focus collectively, both inwardly and outwardly on a broad range of topics. The SME should...

- Provide objective input in his or her field and cooperate with all team members by crossing conventional boundaries.
- Have an open attitude to change by encouraging team and individuals’ creative thinking.
- Stay aligned to the workshop process and focus on fulfilling the ultimate workshop mission: projects delivered on time and on budget.
- Be familiar with the WSDOT process for CRA and CEVP® workshops, including the policy statement, common assumptions, and other guidance.

- Have a clear understanding of the specific terminology used during workshops such as: allowances, contingency, base cost, cost uncertainty, schedule uncertainty, risk, opportunity, etc.

In addition to active participation in the workshops the SME may be asked to provide documentation of the viability of assumptions made regarding the project's configuration, scope, schedule, cost estimate, and the potential impact of risk events that may occur.

The SME may be asked to participate in a follow-up or rerun session as requested; and provide reports or presentations documenting their work.

The SMEs and the Project Team members should strive to produce a clear and concise product (CEVP or CRA report) that would help the decision maker with sound and objective analysis in order to make informed decisions.

Note: It is preferred to have at least one SME with estimating experience from a "contractor's" perspective; that SME would participate with the Cost Lead in the review and critique of the project team estimates and schedule. This discussion should take place, if possible, in advance of the workshop.

## **Appendix 5: CRA Coordinator - Duties (HQ/Region)**

### ***Cost Risk Estimating Management***

CRA Coordinators help accomplish the CRA/CEVP® program in accordance with Department policy and guidelines. It is expected that region coordinators will promote and help advance the effective use of CRA/CEVP® workshops in their region and that project managers and teams use the workshop results to actively manage risk. Project teams know the details of their project; the cost-risk team knows the workshop process, modeling, and the goals of the effort, and its limitations. The Region CRA Coordinator should be familiar with both and can serve as a bridge between the project team and cost-risk team.

Specific duties include:

1. Identify the need for CRA-CEVP® workshops for region projects (work with project offices) to estimate workshops for the upcoming 12 months.
2. Establish approximate timeframes for CRA-CEVP® workshops (with as much advance notice as is practical, discuss with project offices).
3. Review workshop request forms for completeness:
  - Make sure all information is provided.
  - Make sure project office is setting up WOA with appropriate Group Numbers, prior to the workshop.
4. Work with the project office to make sure there is an appropriate location for the workshop (adequate size and space), and other helpful meeting items are available.
5. Be familiar with the CRA/CEVP® workshop process.
6. Be familiar with the CREM website. It is frequently updated and occasionally additional material is posted:  
<http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/default.htm>
7. Help identify training needs and take advantage of training opportunities as they arise (cost estimating class, risk based estimating class).
8. Prepare to serve as workshop leader/coordinator for some workshops in your region.
9. Advocate, within your region, participation in CRA/CEVP® workshops as opportunities arise. For example, in order to have independent specialty group representation, it may be possible, on occasion, to request a person from a neighboring region to provide subject matter expertise.
10. Advocate pro-active risk response actions that are documented in the project risk management plan.
11. Make sure that feedback from workshops is provided using the post-workshop evaluation form.
12. Maintain records of CRA/CEVP® accomplishments within the Region. Include involvement of workshop participants; key risks identified and mitigation strategies implemented. Monitor the effectiveness of the risk assessment and mitigation efforts.
13. Report on the risk management and estimating support needs of the region.
14. Attend training to improve skill levels and maintain and improve proficiency in the areas of project risk management and estimating.

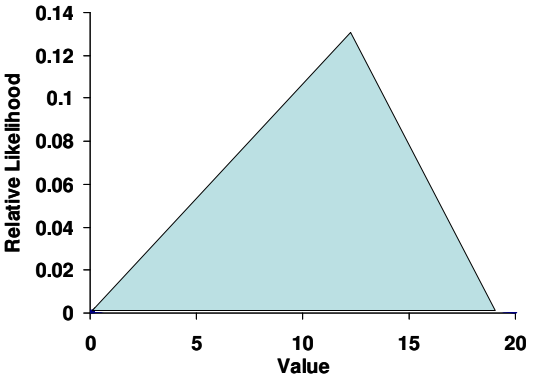
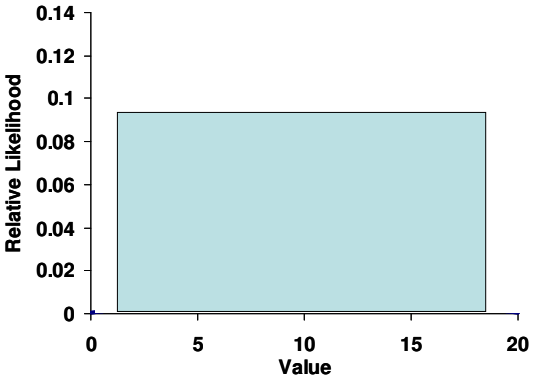
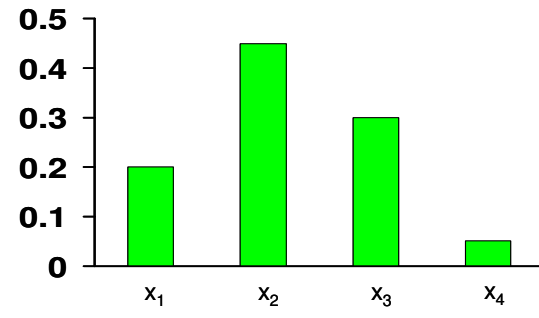
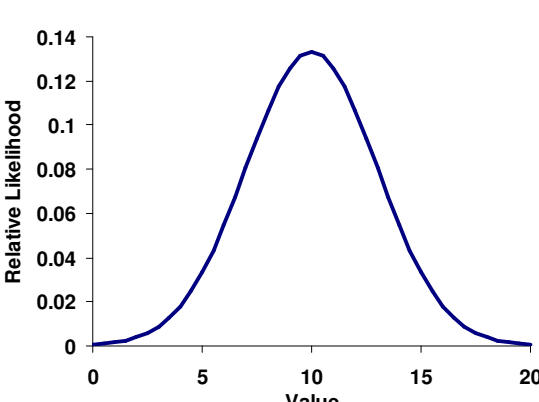
## CRA Coordinator – “How-to” (Example walk-through of a typical project):

- ◆ Meet with the project team.
  - Determine upcoming projects that will require a risk-based estimating workshop. Work with the team early to help them identify, well in advance (8 weeks lead time or more), appropriate timing for a workshop. These target dates can be entered into the project work schedule.
  - Advise the project team to include risk management (activities) in their project schedule. This includes: Risk Planning, Risk Identification, Qualitative Risk Analysis, Quantitative Risk Analysis, Risk Response Planning, Monitoring and Control.
  
- ◆ Once a timeframe for a workshop is established take the following steps:
  1. Go to the CREM website and download a workshop request form (<http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/>) ;
  2. Work with the project team to make sure the form is completed in its entirety. During this time check Outlook Calendar “WSDOT re VERA” to determine dates that may be available for workshops and include this information in the workshop request form.
  3. Meet with the Area Engineer or Project Development Engineer and Design Team to give an overview of the workshop process.
  4. Work with the Cost Risk Estimating Management (CREM) team to determine appropriate cost and risk leads, and subject matter experts, and help complete the participation matrix.
  5. Determine who will send invitations to workshop participants – often the region will invite region and project team, and CREM Workshop Coordinator will invite others (Cost Lead, Risk Leads, SMEs, HQ representatives, etc.)
  6. Continue to communicate/coordinate to make sure workshop materials are being made ready and available by the project team to the Cost-Risk team and Subject Matter Experts. Follow-up with certain workshop participants to ensure their participation in the process is well timed and appropriate.
  7. Attend prep sessions and workshops.
  8. Post-workshop: follow-up with the CREM workshop coordinator and other as appropriate to make sure action items are being communicated and follow-up on them to make sure they are progressing. Help tie up any remaining loose-ends from the workshop. Make sure the risk register properly documents the risks discussed at the workshop (particularly the larger risks).

### Specific things the Region Coordinator can do to enhance the process:

- Advise the project team that the project scope, schedule and estimate need to be current for the workshop. Estimates should be well-organized and easy to follow and should align with the flowchart that is drafted at the prep session. The Estimator should have backup notebook, calculations, and assumptions available for rapid retrieval of information, if needed.
- Assist with coordinating advance elicitation between the project team and risk leads.
- Work with the CREM workshop coordinator to help develop an effective agenda (participants in the workshop will know what to expect and when to attend).
- Advocate for early geotechnical explorations, and other specialty work as appropriate, for the subject project.

## Appendix 6: Notes for consideration for Risk Modelers

Triangular Distribution	Uniform Distribution
 <p>A graph showing a triangular distribution. The x-axis is labeled 'Value' and ranges from 0 to 20 with increments of 5. The y-axis is labeled 'Relative Likelihood' and ranges from 0 to 0.14 with increments of 0.02. The distribution is a triangle with its base on the x-axis from 0 to 20 and its peak at a value of 12.5 with a relative likelihood of approximately 0.13.</p>	 <p>A graph showing a uniform distribution. The x-axis is labeled 'Value' and ranges from 0 to 20 with increments of 5. The y-axis is labeled 'Relative Likelihood' and ranges from 0 to 0.14 with increments of 0.02. The distribution is a rectangle with a constant relative likelihood of 0.09 between values 1 and 18.</p>
<p>A Triangular distribution is a continuous distribution representing a three-point estimate. This is one of the most common and widely used distributions in risk modeling. It is common to assume that there is a chance that the min and max values will be exceeded (5/95, 10/90, etc.). These percentiles may change to represent different levels of uncertainty in the estimate.</p>	<p>A uniform distribution is a continuous distribution where only the maximum and minimum values can be estimated. This distribution is used when there is considerable uncertainty over the duration of an activity or cost impact of a risk event and hence a “most likely” value cannot be estimated.</p>
Multi-Point Discrete Distribution	Continuous Curve Distribution
 <p>A bar chart showing a multi-point discrete distribution. The x-axis has four points labeled <math>x_1</math>, <math>x_2</math>, <math>x_3</math>, and <math>x_4</math>. The y-axis is labeled 'Relative Likelihood' and ranges from 0 to 0.5 with increments of 0.1. The bars have heights of 0.2, 0.45, 0.3, and 0.05 respectively.</p>	 <p>A graph showing a continuous curve distribution. The x-axis is labeled 'Value' and ranges from 0 to 20 with increments of 5. The y-axis is labeled 'Relative Likelihood' and ranges from 0 to 0.14 with increments of 0.02. The curve is bell-shaped, peaking at a value of 10 with a relative likelihood of approximately 0.13.</p>
<p><math>X_1 = 20\%</math></p> <p><math>X_2 = 45\%</math></p> <p><math>X_3 = 30\%</math></p> <p><math>X_4 = 5\%</math></p>	<p>Three points are defined (high (max, low (min) and best guess); then a continuous distribution (such as Pert or other) is used to characterize the potential risk impact. Although these methods can provide a realistic representation of uncertainty these curves are hard to define and so should only be used when there is sound, documented information on the variability of a particular risk element. It is common to assume that there is a chance that the min and max values will be exceeded (5/95, 10/90, etc.). These percentiles may change to represent different levels of uncertainty in the estimate.</p>
<p><b>Multi-point discrete distribution:</b> In some cases a risk element can only take particular values (i.e. is not continuous) or be used to approximate a continuous distribution.</p>	
<p>Figure A6-1 Some common distributions for risk events</p>	

### ***Distributions to Consider for Quantifying Risk***

When characterizing risks during workshops many elicitors and workshop participants may be more comfortable using simple distributions or multi-point discrete distributions to characterize uncertainties. The Risk Lead (elicitor) should determine the risk characterization that meets the need of the risk elicited and fits the group dynamics of a particular workshop membership. The distributions are representations of the “range and shape” of uncertainty. Elicitors may elicit ranges of information (min/max; low/high) and shape of information (symmetric, skewed). Consider this: Simulations are useful to the extent they reflect reality. Cost and duration (schedule) are conceptually continuous random variables and should be modeled in a way that simulates this nature. This can be accomplished through continuous distributions or approximated with a discrete representation as depicted above.

There are two parts to the risk, which define the risk register:

1. Probability of Occurrence - What is the estimated likelihood of this event occurring?
2. Impact – If the event occurs what is the impact in terms of cost and/or schedule? This part typically requires only 3 inputs from the expert, minimum, maximum and most likely or best-guess. As depicted in Figure 6A-1 previously, the uniform distribution is used when only the minimum and maximum values can be estimated.

### ***Interdependencies or Correlations Between Random Variables***

Interdependencies between two (or more) base uncertainties cost and durations, risk events, or their impacts in an analysis can occur due to a variety of conditions. The uncertainties may be:

1. mutually exclusive;
2. conditionally dependent in terms of likelihood, but independent in terms of impact;
3. correlated (a common case here is cost and duration for a given risk event).

Items 1 and 2 can easily be modeled with analysis logic. Correlation can be modeled statistically or the relationship among correlated events can be described in terms of conditional probability networks. The conditional probability “event tree” has been used successfully in WSDOT and other transportation-oriented risk evaluations.

### ***Typical Model Settings***

Consider the following settings:

1. 5,000 iterations (typical).
2. Latin-hypercube sampling.

### ***Directives for Implementing the Response Actions to Major Risks***

(Items for the Project Team to Review and take action)

A critical and useful output of the risk analysis for the Project Team is the ranked risks indicating the risks, in a prioritized order, that most significantly affect project objectives.

This information provides a roadmap to the risks that have the most promise for benefiting the project through pro-active efforts to respond to the risks.

The more significant risks, sometimes termed “candidates for mitigation”, are often times known by the project manager and project team in advance of the formal analysis. The Monte Carlo simulation more formally quantifies and ranks these significant risks. It identifies those risks that are most responsible for variation in the bottom-line (cost or schedule) as determined from the modeling.

An effective way to present the risks that have the largest potential impact to the cost or the schedule is by a “regression sensitivity” chart (i.e. “Tornado diagram”), depicting the “candidates for mitigation” in order of importance.

### ***Integrating Cost and Schedule Risks***

(A history and practice at WSDOT)

Since 2002, when WSDOT first introduced the Cost Estimate Validation Process (CEVP®), the cost and schedule risks have been integrated into the risk model as part of the Monte Carlo Simulation. It is our expectation that the risk-based estimating models used for evaluation WSDOT project integrate both cost and schedule risks.

## **Appendix 7: Common Assumptions**

### ***CRA, CEVP® and informal workshops***

Common assumptions provide a consistent approach to common and recurring issues encountered at CRA/CEVP® and informal risk workshops. Common assumptions are *not* intended to replace the sound judgment and wise counsel provided by the workshop participants who have gathered to review the cost and schedule estimates, and identify risks and assess uncertainty in the project schedule and cost estimates. If additional project specific assumptions are identified, they shall be documented in the workshop report for the project.

The common assumptions in this appendix allow completion of CRA and CEVP® workshops within the time allowed and resources available. They have been chosen to produce the best results possible under these constraints. Consequently, workshop results are, in general, limited by these assumptions. It is also noted that project specific assumptions are often also required to allow a defined project to be put forward for evaluation.

Evaluated risks reflect a “snapshot” of the project at the specific time of the risk assessment. The snapshot is based on the project scope presented by the project team from current plans and available information. This means that the risk model is based on current best estimates for costs, schedules, risks, and construction phasing and activity sequencing. Risk identification depends on the expertise of the project and cost-risk team. After evaluating the project cost and schedule estimate along with an assessment of risks results, a report is written to identify a range for the cost and schedule, and a register of the risks. Significant risks are ranked in order of importance based on impact to project objectives, in an effort to control project costs and schedule and to manage project risks.

A risk event may hold the possibility of a positive or negative effect on a project. A positive potential presents an opportunity to the project and a negative potential poses a threat to the project.

Project managers, and the project teams, are expected to use the results of the risk assessment by developing and implementing responses to significant risks. The response actions should be documented and incorporated into the project management plan updates and monitored and controlled.

## I. Scope Change versus Scope Variations

Scope – the sum of the *products, services, and results* to be provided as a *project* (i.e. the Work Breakdown Structure, WBS).

Scope Change – any change to the *project scope*. A *scope change* almost always requires an adjustment to the project *cost* or *schedule*.

Scope Creep – adding features and functionality (*project scope*) without addressing the effects on time, *costs*, and *resources*, or without *customer approval*.

Scope Definition [process] – The *process* of developing a detailed *project scope statement* as the basis for future project decisions.

*Source: Project Management Institute, PMI PMBOK® GUIDE 2004 3<sup>rd</sup> Edition*

WSDOT may elect, on its own initiative, to revise the scope of the project by adding, removing, or revising particular elements of the project. Such items are not risk events. Instead these can be treated as alternative project scenarios or “deltas” to the base assumed project.

SCOPE VARIATIONS (some may commonly refer to this as scope creep) - Uncertain items or events, not entirely within WSDOT’s control, that may cause variations to the scope and hence changes to the schedule or budget are considered risks and will be captured as risk events and included in the risk-based estimate analysis.

## II. Design Criteria (general)

It is left to the project teams to insure they are using current and appropriate design criteria for their projects, and that any design deviations or variances are properly documented and shared. It is also expected that project schedules and estimates provided by the project team reflect this.

### III. Bridge Seismic Design Criteria

(note: check with WSDOT HQ Bridge to confirm)

*The AASHTO Subcommittee on Bridges and Structures in their July 2007 meeting adopted the 1000 year seismic map for both the Load Resistance Factor Design (LRFD) Bridge Design Specifications (force-based design), and the LRFD Guide Specifications for Seismic Design (displacement-based design). The cost increases mentioned above for bridges and walls are estimated to be the same in both cases.*

#### Bridge Seismic

**Soil Liquefaction Design Criteria:** Existing criteria is provided in the WSDOT Geotechnical Manual. Bridge projects built in the lowland areas of Western Washington and in Seismic Design Category D may be affected by soil liquefaction during seismic events. **Designs for new bridges and the widening of existing bridges must identify the liquefaction risk and estimate the costs of mitigating or resisting soil liquefaction to maintain a stable structure during a seismic event.** The policy defined in WSDOT Geotechnical Manual section 6.1.2.2.1 shall be incorporated where an existing bridge is to be widened and liquefiable soil is present. The Lifeline and Earthquake hazard map created by the United States Geological Survey (USGS) in 2000 can be used to help identify general areas with the potential of soil liquefaction. A link to the web page is listed below:

<http://wrgis.wr.usgs.gov/docs/wgmt/pacnw/lifeline/map266kb.html>

The cost of bridge projects with liquefiable soils may include soil modification, foundation retrofit, or complete bridge replacement. The assessment of these project specific risks and the importance of the structure must be addressed by Geotechnical and Structural Engineers.

**The new LRFD Guide Specifications for Seismic Bridge Design Manual** shall be used for all bridge designs beginning January 2008. Maps of the horizontal spectral response acceleration are presented in LRFD Guide Specifications for Seismic Bridge Design figures 3.4.1-2 through 3.4.1-4.

Cost increases for each seismic design categories are assumed to be:  
Bridges located in Seismic Design Category A will have no increase in the structures costs. Bridges located in Seismic Design Category B shall be evaluated for cost increases on a case-by-case basis by the Bridge and Structures Office. Cost increases associated with the implementation of the new LRFD Guide specifications for Seismic Bridge Design are estimated to be 5% for bridges in Design Categories C and D.

#### Wall Seismic

**New LRFD Guide Specifications for Seismic Bridge Design** shall be used for all wall designs beginning January 2008.

Cost increases associated with the implementation of the new LRFD Guide Specifications for walls are estimated to be 5% for walls in Design Categories A and B, and 15% for walls in Design Categories C and D.

**IV. Inflation Rate Information & Market Conditions**

NOTE: Project teams need to insure their base estimates are current and reflect current prices at the time the estimate is prepared for the workshop.

See: <http://wwwi.wsdot.wa.gov/ppsc/pgmmgt/cpms/tables.asp>

**IV. Construction Market Condition Risks**

**Number of Bidders**

Data provided from the WSDOT Construction Office indicates that as the number of bidders is reduced, bid amounts tend to increase. Typically, with four or more bidders the effect on the bid amount is negligible. To capture this effect, workshops need to consider to what extent the reduction below the normal number of bidders will influence the bid amount. A reasonable range of impact is: a 0% to 8% increase over Engineer’s Estimate for construction. The probability of the occurrence of this risk will be determined during the workshop. The project team must explain why they feel their project will be subject to a “non-competitive” bidding environment. In addition, as part of the workshop process, strategies for enhancing the bidding environment in order to attract more bidders must be discussed and identified as a mitigation strategy for this risk. Common mitigation strategies include: timing of the advertisement and work packaging

Phase	PE	R/W	Construction Cost Estimate Risk	
Reduced Number of Bidders	n/a	n/a	Impact +0% to +8%	Probability Determined at workshop

**Other Market Condition Risks for Construction**

<sup>4</sup>Other market conditions are typically reflected in risks captured through the risk elicitation process. Project teams wishing to capture additional market condition risks beyond that described above must justify why they think their project is subject to additional market condition risks. They must provide a well documented explanation describing what makes their project susceptible to additional market condition risks, and clearly state the sources for characterization of the risk (probability and consequences).

**V. Right-of-way Market Condition Risks**

GUIDANCE: Real estate markets are best characterized by those professionals familiar with the geographic area. In consideration of this fact, subject matter experts such as: region real estate services and region right-of-way staff, or others considered knowledgeable about real estate markets in and around the project area should be elicited. These subject matter experts can provide input regarding the cost of right-of-way and uncertainty associated with the real estate

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<sup>4</sup> Caution needs to be exercised regarding Market Condition Risks. While the Risk Lead must be thorough in making sure to capture and recognize risk uncertainty, he must also guard against the potential of double-counting. The analysis must clearly document what is being used and why.

market in the geographic area of the project. Issues to consider include: ZONING and SPECULATION.

## **VI. Preliminary Engineering Market Condition Risks**

GUIDANCE: In general, risks related to Preliminary Engineering (PE) adequately reflect market conditions. Occasionally there may be concern regarding availability of skilled labor, a topic which can be discussed in the workshop, if necessary. If it can be shown that project specific market condition risks for PE need to be captured, they must be clearly identified and documented. Sources for characterization of the risk (probability and consequences) must be clearly stated, along with why this project has this risk when other projects do not.

## **VII. Design Build (DB) versus Design Bid Build (DBB)**

To date, the DB versus the DBB decision is being made project by project. Project directors are expected to discuss the overall contracting approach with their regional administrator, and final approval must come from Headquarters.

Workshop general guidance is as follows: With regard to added or reduced cost expectations resulting from going to a Design-Build, look at categorizing the risks that you are asking the design-builder to assume, then estimate the cost.

## **VIII. Fuel Price Inflation**

It is assumed the Construction Cost Index (CCI) table accounts for fuel price inflation. It is assumed that no additional risk factor is needed to address fuel prices. (Also see Regional Transportation Improvement District, RTID assumptions).

## **IX. Project Specific Assumptions**

Project specific assumptions, that are in addition to or different from these common assumptions should be documented in the project workshop report.