Company: Southern California Gas Company (U904G)
Proceeding: 2019 General Rate Case
Application: A.17-10-007/-008 (cons.)
Exhibit: SCG-215

SOCALGAS

REBUTTAL TESTIMONY OF RICK PHILLIPS AND SHARIM CHAUDHURY

(PIPELINE SAFETY ENHANCEMENT PLAN (PSEP))

JUNE 18, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

SoCalGas

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I. SUMMARY OF DIFFERENCES[1,2]

Table RDP-1
Summary of O&M Cost Differences
(Constant 2016 Direct Costs – Thousands)

	TOTAL O&M[3]	VARIANCE
SOCALGAS	**$249,468[4]**	**N/A**
ORA	**$162,704**	**($86,764)**
TURN/SCGC	**$200,210**	**($49,258)**
INDICATED SHIPPERS	**$202,054**	**($47,414)**

Table RDP-2
Summary of Capital Cost Differences
(Constant 2016 Direct Costs – Thousands)

	TOTAL CAPITAL[5]	VARIANCE
SOCALGAS	**$649,326**	**N/A**
ORA	**$645,502**	**($3,824)**
TURN/SCGC	**$522,567**	**($126,759)**
INDICATED SHIPPERS	**$444,300**	**($205,026)**

[1] The Coalition of California Utility Employees (CUE) filed testimony but did not propose any reductions to SoCalGas' forecast.

[2] The city of Long Beach filed testimony supporting the Post Test Year ratemaking proposal for PSEP as described in Exhibit SCG-44-2R (Malik) but at the level of spending forecasted by ORA.

[3] Amounts reflect the three-year (2019-2021) rate case cycle forecasts. Fourth-year (2022) O&M forecasts are discussed in Sections III.G and III.I.

[4] Does not include $2,484K recorded in Pipeline Safety Enhancement Plan – Phase 2 Memorandum Account (PSEP-2MA), amortization of which will be sought in a future proceeding.

[5] Amounts reflect the three-year (2019-2021) rate case cycle forecasts. Fourth-year (2022) Capital forecasts are discussed in Sections III.G through III.I.

II. INTRODUCTION

This joint rebuttal testimony addresses SoCalGas' request for the continuing execution of the Pipeline Safety Enhancement Plan (PSEP), which commenced in 2012. The forecast set forth in the Revised Direct Testimony of Rick Phillips (Exhibit SCG-15-R, Direct Testimony) is based on meeting the objectives described therein to: (1) enhance public safety; (2) comply with Commission directives; (3) minimize customer impacts; and (4) maximize the cost effectiveness of safety investments.[6]

Specifically, our rebuttal testimony addresses the following testimony from other parties:

- The Office of Ratepayer Advocates (ORA) as submitted by Nils Stannik and Pui-Wa Li (Exhibit ORA-03), dated April 13, 2018.
- The Utility Reform Network (TURN) and Southern California Generation (SCGC), jointly (Exhibit TURN/SCGC-01), as submitted by Catherine Yap, dated May 14, 2018.
- Indicated Shippers (Exhibit IS-1), as submitted by Michael Gorman, dated May 14, 2018.
- The Coalition of California Utility Employees (CUE) (Exhibit CUE-1), as submitted by David Marcus, dated May 14, 2018.

As a preliminary matter, the absence of a response in this rebuttal testimony to any particular issue does not imply or constitute agreement by SoCalGas with the proposals or contentions made by any party. The forecasts included in SoCalGas' direct testimony, provided at the project level, are based on sound estimates of its revenue requirements calculated as of the time of testimony preparation.

In our rebuttal testimony we address intervenors' testimony on the following key issues:

- SoCalGas' approach of developing detailed cost estimates for each project is a more accurate method for predicting the costs of individual projects than ORA's linear regression model, which ignores project-specific attributes.
- ORA's linear regression model is flawed, as evidenced by the facts that: 1) it is not used to assess *all* the PSEP projects in this Application, but just a select few;

[6] Ex. SCG-15-R (Phillips) at RDP-A-5.

2) its results are applied inconsistently; 3) it does not account for a large number of the cost components included in SoCalGas' pressure test project estimates on a project-specific basis; and 4) it is based almost entirely on PG&E's completed projects, and PG&E's reported costs do not include a significant cost component included in SoCalGas' cost forecasts

- TURN/SCGC and Indicated Shippers' proposed disallowance of the risk assessment, also referred to as "contingency," component of SoCalGas' detailed project cost estimates ignores industry knowledge and practice regarding the need and appropriate use of contingency in the project estimation process.
- ORA's, TURN/SCGC's, and Indicated Shippers' arguments for denying two-way balancing account treatment of PSEP costs are unfounded and outweighed by the benefits of granting two-way balancing account treatment.
- ORA's proposed modification of SoCalGas' project substitution proposal would add unnecessary time and complexity to the execution of PSEP projects.
- ORA and TURN/SCGC's interpretation of Title 49 of the Code of Federal Regulations, Part 192 Subpart J (Subpart J) is not supported.
- Indicated Shippers' proposal to extend the remaining timeframe to complete execution of the Valve Enhancement Plan is based on a misunderstanding of the status of the program described in Direct Testimony.
- TURN/SCGC's proposal to defer the majority of the costs associated with Line 44-1008 is speculative and ignores that, if need be, the project may be substituted through SoCalGas' project substitution proposal so that PSEP may continue to be executed "as soon as practicable"[7] in compliance with the Commission's directives.

For all the reasons stated in the Direct and this Rebuttal Testimony, SoCalGas' PSEP forecasts should be adopted by the Commission in their entirety to allow the continued successful execution of PSEP, which accomplishes California's pipeline safety enhancement and risk mitigation (i.e., RAMP) objectives.

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[7] Decision (D.) 11-06-007 at 19.

A. ORA

ORA's recommendations regarding PSEP are, in summary, as follows:[8]

- Utilizing its statistical model, which only reviews 19 of the 29 replacement projects included in this Application (and is applied to only 11 of those projects), ORA proposes a forecasted cost of $176.7MM, compared to SoCalGas' forecast of $276.9MM for the same 19 projects.[9],[10]
- SoCalGas' request for two-way balancing account treatment of PSEP costs should be denied.
- SoCalGas' forecasted Allowance for Pipeline Failures in the amount of approximately $4.1 million should be adopted, but only if two-way balancing account treatment is denied.
- SoCalGas' request for authority to substitute PSEP projects should be augmented to allow for more in-depth analysis of proposed project substitutions.
- SoCalGas' interpretation of the Commission's directive regarding compliance with the modern standards embodied in Subpart J is incorrect and should be clarified by the Commission.

B. TURN/SCGC

TURN/SCGC's joint recommendations regarding PSEP[11] are, in summary, as follows:

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[8] April 13, 2018 ORA Report on Risk Management Policy; Enterprise Risk Management Organization; RAMP/GRC Integration; Pipeline Integrity; SoCalGas PSEP (Nils Stannik, Pui-Wa Li) (Exhibit ORA-03).

[9] Ex. ORA-03 (Stannik and Li) at 26.

[10] Ex. ORA-03 (Stannik and Li) at 27. ORA includes SoCalGas' forecasted fourth-year projects in their analysis. ORA's proposed forecast for the 14 projects that fall within the three-year GRC cycle is $150.7MM.

[11] May 14, 2018, Prepared Direct Testimony of Catherine Yap addressing the Pipeline Safety Enhancement Program, Other Gas Transmission Costs, and Third Attrition Year, on behalf of The Utility Reform Network (TURN) and Southern California Generation Coalition (SCGC) (Exhibit TURN/SCGC-01).

- SoCalGas' test and replacement project forecasts should be reduced by approximately $63MM (O&M and capital) and $55.5 MM (capital), respectively, by eliminating the risk assessment component.[12]
- The $76.6 MM forecast for 50% of Line 44-1008, with the exception of $700K, should be excluded from this GRC cycle because the environmental review process will not be completed during the current GRC cycle.
- SoCalGas' request for two-way balancing account treatment of PSEP costs should be denied.
- SoCalGas' project substitution proposal should be granted.
- SoCalGas' interpretation of D.11-06-017 regarding testing or replacing pre-1970 pipelines that have records of a pressure test to assure compliance with the modern standards embodied in Subpart J is incorrect and should be clarified by the Commission.

C. INDICATED SHIPPERS

Indicated Shippers' recommendations regarding PSEP[13] are, in summary, as follows:

- SoCalGas' test, replacement, and Valve Enhancement Plan project forecasts should be reduced by approximately $58.6MM, $49.7MM, and $42.2MM,[14] respectively, by eliminating the risk assessment component.
- The pace of implementation of the Valve Enhancement Plan should be slowed to extend the timeline for completion from three years to six years,

[12] Ex. TURN/SCGC-01 (Yap) at 16. TURN/SCGC disallowance is based on a three-year GRC cycle. If the Commission were to adopt a four-year cycle, TURN/SCGC's proposed disallowance would increase to $77.6MM for pressure test projects and $77.5MM for replacement projects. *See id.* at 17.

[13] May 14, 2018 Prepared Direct Testimony of Michael Gorman on behalf of Indicated Shippers (Exhibit IS-1).

[14] Indicated Shippers base their proposed disallowances on a three-year GRC cycle. They do not address a possible four-year cycle.

with an accompanying reduction of the Valve Enhancement Plan forecast for the 2019 GRC Cycle of $101.9MM.

- SoCalGas' request for two-way balancing account treatment of PSEP costs should be denied.

D. CUE

CUE's recommendation regarding PSEP[15] is, in summary, as follows: SoCalGas' request for a two-way balancing account should be authorized.

III. REBUTTAL OF PARTIES' PSEP PROPOSALS

A. SOCALGAS' DETAILED COST ESTIMATES ARE THE MOST ACCURATE PREDICTOR OF PROJECT COSTS

As stated in the Direct Testimony, SoCalGas has developed cost estimates by assigning values to individual cost components based on detailed engineering and planning analysis. The engineering on the projects was advanced to an approximate 30% design level. The uniqueness of each PSEP project and the variability in cost components from project to project make such project-specific cost estimates the most accurate methodology to predict project costs.[16] This method is consistent with the Commission's directive in D.14-06-007 (approving SoCalGas and SDG&E's PSEP) that: "It is only fair that ratepayers should have the benefit of detailed plans for this Commission to consider before authorizing or preapproving the expenditure of many hundreds of millions of dollars."[17] This decision followed assertions by TURN and SCGC that the Class 5[18] or Class 4 estimates submitted by SoCalGas (and SDG&E) in that proceeding were

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[15] May 14, 2018 Prepared Direct Testimony of David Marcus on behalf of The Coalition of California Utility Employees (CUE) (Exhibit CUE-1).

[16] Ex. SCG-15-R (Phillips) at RDP-A-23.

[17] Decision (D.) 14-06-007 at 23.

[18] AACE International Recommended Practice No. 18R-97 "Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries," attached as Appendix A. AACE International (formerly known as the Association for the Advancement of Cost Engineering), an industry leading organization in the field of cost estimating defines Class 3, 4, and 5 estimates as follows:

too rudimentary for ratemaking.[19] In accordance with this directive and in light of the arguments by TURN and SCGC in that proceeding that Class 5 and Class 4 estimates are not appropriate for ratemaking purposes, SoCalGas provided Class 3 estimates in this Application. Class 3 estimates generally are prepared to form the basis for budget authorization, appropriation, and/or funding.[20]

The forecasts provided for each project in this Application are based on completion of about 30% of the engineering activities for each project. Subject matter experts in the areas of Project Execution, Engineering Design, Environmental, Construction, Land Services, Permitting, Compressed Natural Gas/Liquified Natural Gas, and Supply Management all contribute to this estimate development process. The project estimate, including a risk component appropriate for each project, is then developed by a dedicated estimating team.[21]

ORA, in contrast, does none of the above. It does not offer forecasts based on the "detailed plans" that the Commission and other intervenors argued for in A.11-11-002. ORA's proposal, in relying on a mere three project characteristics, is actually a rudimentary form of parametric estimating that, according to AACE guidelines, would be classified as a Class 5 estimate, the least accurate and rudimentary of all estimate classes.

<u>Class 3</u> – generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete.

<u>Class 4</u> – generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1 to 15% complete.

<u>Class 5</u> – generally prepared based on very limited information, and subsequently have wide accuracy ranges.

See Appendix A at 5-6.

[19] A.11-11-002, Opening Brief of The Utility Reform Network on Pipeline Safety Enhancement Plan Issues at pp. 76-79. TURN argued that the "Commission should defer adopting a forecast-based revenue requirement until it has the benefit of the more detailed engineering and design." *Id.* at p. 79. SCGC argued that "Applicants should be required to submit cost estimates in EAD proceedings that are no worse than Class 3 estimates and hopefully much better," and later that the cost estimates "should be at least Class 3 estimates." A.11-11-002, Southern California Generation Coalition Opening Brief at p. 30 and A.11-11-002, Southern California Generation Coalition Reply Brief at p. 5.

[20] Appendix A at 6.

[21] SoCalGas' detailed cost estimating process is described at Ex. SCG-15-R (Phillips) at RDP-A-22-27.

Even though SoCalGas' detailed project estimates are more accurate for approximating the costs of individual projects than ORA's approach, no matter how detailed a Class 3 estimate is, there is still inherent uncertainty in all estimates, and thus inclusion of a risk assessment component is appropriate, as described in greater detail in Section III.C.

B. ORA'S MODELS AND TURN/SCGC'S AND INDICATED SHIPPERS' PROPOSALS ARE FLAWED

1. Relevant Summary of Parties' Positions on Pressure Test Projects

Table RDP-3
Combined O&M and Capital Components
(Constant 2016 Direct Costs – Thousands)

Project Line	SoCalGas	ORA	TURN/SCGC	INDICATED SHIPPERS
235 West Section 1	$53,768	$53,768*	$40,803	$40,808
235 West Section 2	$36,860	$36,860*	$28,067	$28,065
235 West Section 3	$17,489	$17,489*	$14,746	$14,737
407	$5,150	$5,150	$4,239	$4,237
1011	$5,167	$4,286	$4,294	$4,293
2000 Chino Hills	$45,335	$8,349	$35,299	$35,297
2000 Section E	$15,520	$7,852	$11,947	$11,946
2000 Blythe to Cactus City	$51,845	$51,845*	$40,685	$40,686
2001 West Section C	$26,229	$9,680	$20,858	$22,424
2001 West Section D	$29,277	$11,023	$24,913	$26,811
2001 West Section E	$14,182	$7,755	$11,982	$12,925
TOTAL	**$300,822**	**$214,057**	**$237,832**	**$242,230**

*ORA has not opposed SoCalGas' forecast for these projects.[22]

[22] Ex. ORA-03 (Stannik and Li) at 28.

a. ORA

In forecasting costs for SoCalGas' projects, ORA utilized a statistical model similar[23] to one it used in A.17-03-021,[24] i.e., utilizing five years of purported actual cost data associated with pressure test and pipeline replacement projects completed by SoCalGas, San Diego Gas & Electric Company (SDG&E), Pacific Gas and Electric Company (PG&E), and Southwest Gas Company (Southwest).[25] As explained in detail below, ORA's statistical models should not be used to forecast PSEP project costs as they suffer from significant shortcomings:

i. ORA's models are missing important project factors/explanatory variables;

ii. ORA's models produce biased forecasts;

iii. ORA's models are based primarily on PG&E data, but do not recognize or account for differences among utilities; and

iv. ORA's pressure test database is composed almost entirely of PG&E projects and does not include the capital component of PG&E's pressure test projects.

As demonstrated below, if ORA's models are even partially augmented to address a few, but not all, of the above flaws, ORA's recommended forecast reduction would be diminished drastically. This demonstrates that ORA's approach is far from reliable or credible for use in forecasting PSEP project costs.

i. ORA's PSEP Project Cost Forecasts Are Biased Because ORA's Statistical Models Do Not Include Important Cost Drivers

ORA developed statistical models using linear regression analysis to prepare alternative forecasts for SoCalGas' PSEP pressure test and pipeline replacement projects. As described by

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[23] In A.17-03-021, Application of Southern California Gas Company (U 904G) and San Diego Gas & Electric Company (U 902G) for Approval of the Forecasted Revenue Requirement Associated with Certain Pipeline Safety Enhancement Plan Projects & Associated Rate Recovery (filed March 30, 2017), ORA used its statistical model for replacement projects only.

[24] A.17-03-021 Scoping Memo and Ruling of Assigned Commissioner (dated August 8, 2017) at 8 contemplates a decision in this proceeding in September 2018.

[25] ORA excluded combined pressure test/replacement projects, projects with missing start and end dates, or projects that ORA classified as "abandonment" projects.

ORA, "[l]inear regression produces an equation that describes how cost relates to certain project factors, allowing one to predict how much a project should cost, on average, based on its characteristics."[26] ORA's regression models rely on a dataset ORA developed that is composed almost entirely of PG&E projects (for pressure test projects, approximately 95% of the data points are PG&E projects), and some SoCalGas/SDG&E and Southwest Gas projects, as described in Section III.B.1.a.iii and III.B.1.a.iv.

A prerequisite of a good regression model is that the model includes *all* critical project factors or explanatory variables that can explain the variations in costs across projects. Omitting essential explanatory variables results in bias and inaccuracy in the estimates of the effects of the explanatory variables (estimated coefficients) that are included in the model, the model's forecasts, and the prediction intervals of those forecasts. This renders such a model unreliable for forecasting purposes.[27] ORA notes that it enhanced its forecasting model in this proceeding relative to the one ORA used in A.17-03-021 by including an additional explanatory variable representing project duration. Additionally, ORA claims, "[t]he inclusion of project duration also helps account for project cost variances due to a variety of circumstances (since factors that raise costs, such as a hard-to-access location or delays due to specific environmental requirements, often lead to delays or longer construction times)."[28] While ORA's model may be improved by the inclusion of one additional consideration, ORA's models still are not sufficiently refined to forecast PSEP project costs because they omit other critical explanatory variables that drive project costs. For projects with similar durations, ORA's models are not able

[26] Ex. ORA-03 (Stannik and Li) at 22.

[27] Greene, W.H. (2008) *Econometric Analysis*, p. 133-134. Upper Saddle River, N.J.: Prentice Hall

[28] Ex. ORA-03 (Stannik and Li) at 25, 26.

to forecast project cost differences attributable to urban/rural locations, terrain, or differing environmental mitigation requirements. The absence of these essential cost drivers in the ORA model, and hence the inability to account specifically for the effects of these cost drivers, renders ORA's model inappropriate for forecasting PSEP project costs.

ii. The Results of ORA's Statistical Models Suggest that the Models Should Not Be Used to Forecast PSEP Project Costs

a. ORA's Models Produce Biased Project Cost Forecasts

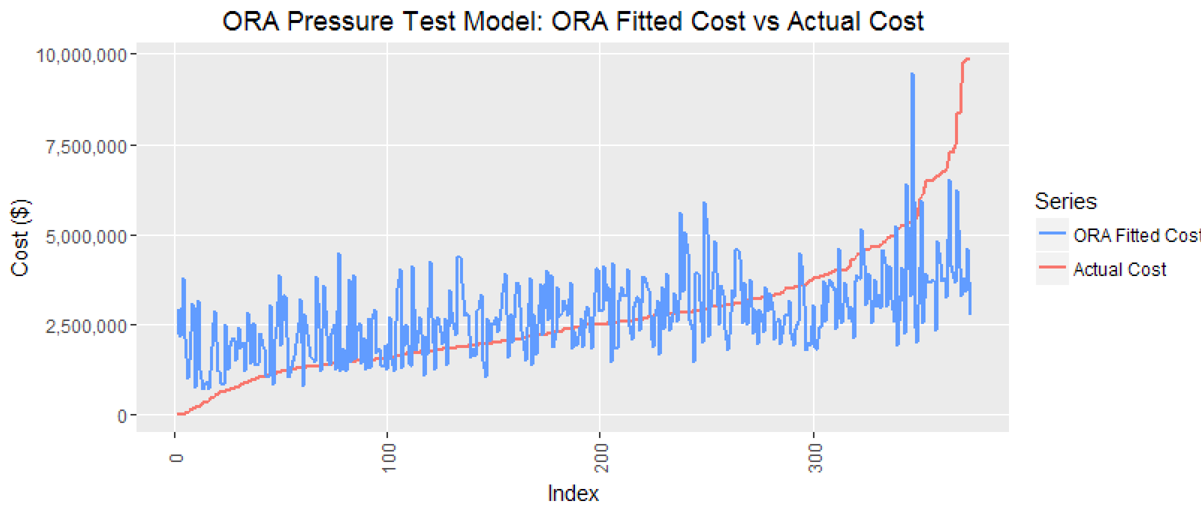
ORA bases its recommended reductions to SoCalGas' forecasts on 90% thresholds applied to its statistical models.[29] These thresholds are calculated as additional costs added on top of the forecasts produced by its pressure test and pipeline replacement models. When a model is inherently biased (i.e., when it systematically forecasts costs that are too high or too low), a 90% threshold also will be pushed too high or too low and also will be biased. The forecasts produced by ORA's models illustrate this flaw.

Using ORA's workpapers, data request responses, and PSEP project database, SoCalGas replicated ORA's pressure test and pipeline replacement cost forecasting models.[30] Comparing the purported actual project costs from ORA's database to the forecasts produced by ORA's models, it is clear that both of ORA's models are biased, over-forecasting lower cost projects and under-forecasting higher cost projects.

Figure RDP-1

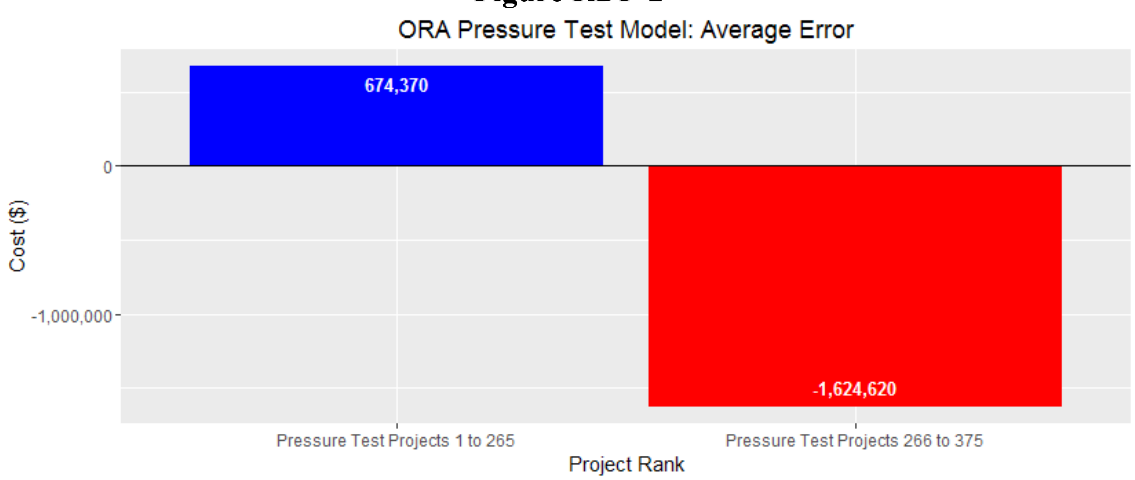
[29] ORA calculates 80% prediction intervals centered on its cost forecasts. If calculated correctly, there is an 80% probability that a project's cost will fall inside of the interval and a 10% probability that a project's cost will fall below the interval. Therefore, there will be a 90% chance that a project's cost falls at or below the upper limit of this threshold. We refer to this upper limit as the "90% threshold."

[30] SoCalGas was able to replicate ORA's pipeline replacement model exactly. While SoCalGas could not exactly replicate ORA's pressure test model, it was able to match ORA's model estimates very closely.



The above plot shows the actual costs of the pressure test projects in ORA's database in red, ranked from the lowest cost to the highest cost. The estimated costs for each project from ORA's pressure test model are overlaid in blue.[31] As shown in the plot above, ORA's model systematically over-forecasts the costs of less expensive projects and under-forecasts the costs of more expensive projects. Notably, the under-forecasting of costs in ORA's model is particularly egregious for the most-costly projects.

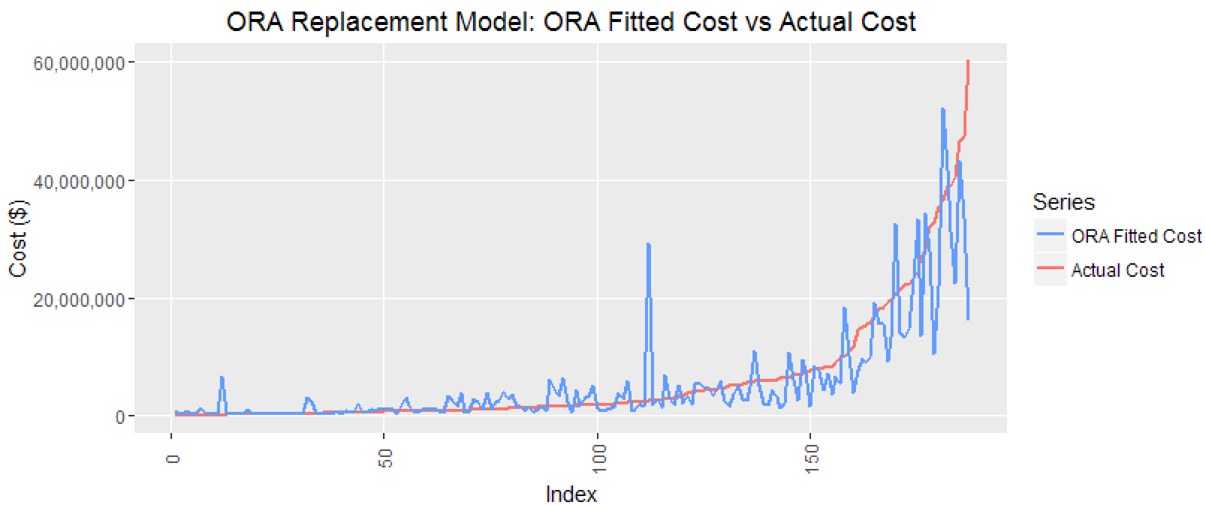
Figure RDP-2



[31] ORA's regression models produce an estimated project cost for each project in the ORA database (generally called "fitted values"). Because ORA's models are developed using the actual project costs in its database, the models are essentially tailored to reproduce these costs.

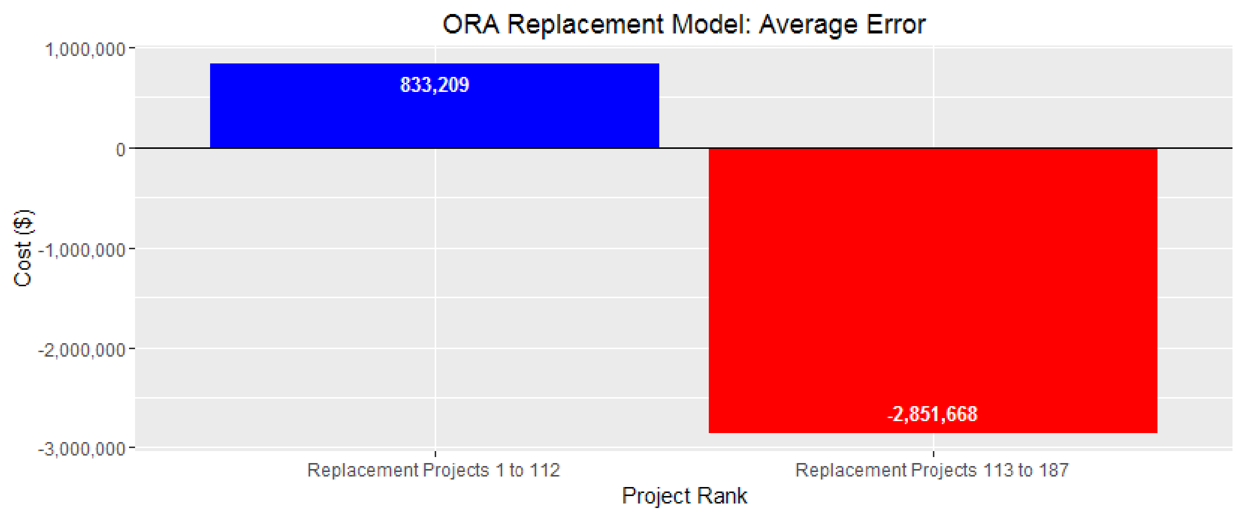
For the 265 lowest cost pressure test projects, ORA's pressure test model over-forecasts by an average of $674,370 per project. For the remaining 110 pressure test projects, the model under-forecasts by an average of $1,624,620 per project, more than double the average cost variance of the over-forecasts. Clearly, the model produces unreliable cost forecasts, especially for the higher cost projects.

Figure RDP-3



The above plot shows the actual costs of the pipeline replacement projects in ORA's database in red in increasing order from lowest cost to highest cost. The forecasted costs for each project according to ORA's model are overlaid in blue. As with the pressure test projects, ORA's replacement cost model systematically over-forecasts less costly projects and under-forecasts more costly projects. This is more pronounced for the highest cost projects on the right side of the plot.

Figure RDP-4



ORA's pipeline replacement model over-forecasts the 112 lowest cost pipeline replacement projects by an average of $833,209 per project. The remaining 75 pipeline replacement projects are under-forecasted by an average $2,851,668 per project. Like the pressure test model, the ORA pipeline replacement model is unreliable and highly biased with respect to higher cost projects.

ORA's 90% thresholds are centered on the forecasts from its models. Because of this, any bias in ORA's forecasts is transmitted directly to its 90% thresholds. The above plots show that ORA's forecasts are indeed biased and that this bias is especially egregious for the highest cost projects. As a consequence, its 90% thresholds are also markedly biased for the highest cost projects. This strong bias in forecasting high cost projects is particularly evident for the 2000 Chino Hills project discussed below.

b. Biased Project Cost Forecasts: The 2000 Chino Hills Pressure Test Project

ORA's 90% threshold implies that there is a 90% probability that a future project's cost will fall at or below the threshold established by ORA's models.[32] According to ORA, the purpose of the 90% threshold is "to account for factors that may additionally raise costs to set an upper bound for a reasonable cost forecast."[33] Admirable though the intent may be, because of

[32] Ex. ORA-03 (Stannik and Li) at 22, n. 56.

[33] *Id*. at 22.

the bias in the 90% threshold derived from the underlying forecasts from ORA's models, the threshold is unlikely to account for such factors sufficiently. To illustrate: the 2000 Chino Hills pressure test project is forecasted by SoCalGas to cost $45.3 million; but ORA's recommended forecast is $8.3 million – about 18% of SoCalGas' forecast. ORA's forecast of $8.3 million is based on a 90% threshold, meaning ORA expresses confidence that there is a 90% probability that this project will cost $8.3 million or less, while SoCalGas' forecast, based on the actual anticipated scope of work and construction activities is an order-of-magnitude higher. This clearly demonstrates that ORA's "conservative" forecast utilizing a 90% threshold is not and cannot be accurate for at least some PSEP projects.[34] ORA's assessment is limited and incomplete, and ORA does not explain why its statistical model produces such a significant variance from SoCalGas' detailed 2000 Chino Hills project forecast. Moreover, ORA does not identify which components or activities within SoCalGas' project estimate are inappropriate and/or can be eliminated to execute the project at only 18% of the cost SoCalGas estimates is needed to complete construction.

iii. ORA's Models Are Based Primarily on PG&E Data, But Do Not Recognize or Account for Differences Among Utilities

ORA's cost forecasting models assume that the costs of future PSEP projects can be forecasted based on historical PSEP project data. However, the overwhelming majority of the historical data used by ORA is derived from PG&E projects, as will be discussed in Section III.B.1.a.iv below.

Neither ORA's pressure test cost model nor ORA's replacement cost model account for any differences between the utilities' PSEP projects. This section provides strong statistical evidence that these differences should not be ignored, and shows the results of improvements to ORA's models that account for differences in the utilities' PSEP projects contained in ORA's own database.

[34] These differences are particularly worrisome when they are so significant. There is a $37 million difference on just *one* project.

ORA's pressure test cost model is a linear regression model meant to capture the effect of the project length in miles, the pipeline diameter in inches, and the project duration in days. SoCalGas augmented ORA's model with an additional explanatory variable that captures additional project cost due to project length for SoCalGas and SDG&E projects only.[35] This additional variable is highly statistically significant,[36] indicating an extremely high degree of certainty (well over 99.99%) that it affects pressure test project costs for SoCalGas and SDG&E projects. Comparing predictive R^2, a measure of how well a model forecasts, the augmented ORA pressure test cost model explains PSEP project costs nearly 50% better than ORA's model.[37] The results of the augmented ORA model make it clear that there are aspects of these SoCalGas and SDG&E projects that are in some way different compared to PG&E projects and that any cost forecasting model needs to account for this fact, which ORA's model does not.

The pipeline replacement cost model used by ORA uses the same variables as its pressure test model except for the addition of a length-squared variable ($length^2$). SoCalGas has also augmented this ORA model with an additional variable that captures additional project cost due to project duration for SoCalGas and SDG&E projects only.[38] This additional variable is

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[35] The augmented model for pressure testing project cost is:

$$Pressure\ Test\ Cost_i = \alpha + \beta_1 * length_i + \beta_2 * diameter_i + \beta_3 * duration_i + \beta_4 * length_i * SCG/SDGE_i + e_i$$

$$where\ SCG/SDGE_i = \begin{cases} 1 & if\ SCG/SDGE\ project \\ 0 & otherwise \end{cases}$$

See Appendix B for regression results and software code for this model.

[36] Appendix B at 1. The p-value for the SoCalGas/SDG&E-length variable in the pressure test model is smaller than 2.2×10^{-16}.

[37] Based on 40 runs of 10-fold cross-validation, the average predictive R^2 for the augmented ORA model was 24.81% vs 16.96% for ORA's model.

[38] The augmented model for replacement project cost is:

$$Replacement\ Cost_i = \alpha + \beta_1 * length_i + \beta_2 * length_i^2 + \beta_3 * diameter_i + \beta_4 * duration_i + \beta_5 * duration_i * SCG/SDGE_i + e_i$$

$$where\ SCG/SDGE_i = \begin{cases} 1 & if\ SCG/SDGE\ project \\ 0 & otherwise \end{cases}$$

statistically significant,[39] indicating that it affects pipeline replacement project costs for SoCalGas and SDG&E projects. Comparing predictive R^2, the augmented ORA replacement model is an improvement on ORA's model.[40] The results of the augmented ORA pipeline replacement model show that there are aspects of these SoCalGas and SDG&E projects that are in some way different compared to PG&E and Southwest Gas projects. As in the case of the pressure test cost model, ORA's model does not account for any difference between the utilities' PSEP projects.

Following ORA's approach, SoCalGas calculated 90% thresholds for its proposed project costs. The 90% thresholds based on the augmented ORA models are higher compared to ORA's 90% thresholds (except for the Line 2005 project). For the pressure test projects, this is especially pronounced, reflecting the large improvement of the augmented ORA pressure test model relative to ORA's model.

Table RDP-4
90 % Thresholds and Disallowances: ORA Model vs. Augmented ORA Model
(Direct Costs)

Project Name	Project Type	SoCalGas Forecasted Cost	ORA 90% Threshold	ORA Proposed Disallowances	AUGMENTED ORA Model 90% Threshold	AUGMENTED ORA Model Disallowances Based On 90% Threshold Approach
407	Pressure Test	5,150,003	6,001,236	0	9,995,519	0
1011	Pressure Test	5,166,590	4,285,683	880,907	6,017,247	0
2000 Chino Hills	Pressure Test	45,335,233	8,349,113	36,986,120	19,116,847	26,218,386
2000 Section E	Pressure Test	15,519,987	7,852,455	7,667,532	17,355,365	0
2001 W Section C	Pressure Test	26,228,994	9,679,517	16,549,477	24,850,751	1,378,243
2001 W Section D	Pressure Test	29,276,933	11,022,926	18,254,007	30,789,057	0

[39] Appendix B at 6. The p-value for the SoCalGas/SDG&E-duration variable in the pipeline replacement model is 0.04847.

[40] Based on 40 runs of 10-fold cross-validation, the average predictive R^2 for the augmented ORA model was 68.85% versus 68.02% for ORA's model.

2001 W Section E	Pressure Test	14,181,668	7,755,309	6,426,359	17,252,479	0
225 North	Pressure Test	15,463,919	7,673,951	7,789,968	16,268,045	0
2001 West	Pressure Test	8,417,661	6,606,734	1,810,927	12,478,340	0
2005	Pressure Test	3,359,158	4,749,125	0	4,688,381	0
36-9-09 North Section 12	Replacement	9,812,585	8,407,696	1,404,889	8,856,189	956,396
36-9-09 North Section 14	Replacement	19,980,133	17,635,298	2,344,835	19,514,728	465,405
36-9-09 North Section 15	Replacement	14,193,433	14,119,335	74,098	15,665,624	0
36-9-09 North Section 16	Replacement	18,035,570	18,622,620	0	20,642,995	0
36-1032 Section 13	Replacement	17,811,294	28,707,529	0	31,912,560	0
36-1032 Section 14	Replacement	13,937,352	14,837,256	0	16,393,698	0
2000-E Cactus City Compressor Station	Replacement	6,697,990	10,337,425	0	10,435,439	0
2001 East Replacement	Replacement	3,798,756	9,584,995	0	9,825,288	0
5000	Replacement	4,486,491	8,967,782	0	9,000,028	0
TOTAL				**100,189,119**		**29,018,430**
TOTAL (Excluding 2000 Chino Hills Project)				**63,202,999**		**2,800,044**

The above table shows the 90% thresholds for PSEP project costs using the improved augmented ORA models. Relying on its models, ORA recommends disallowances of $100,189,119. Using the improved augmented ORA models results in a much smaller disallowance of $29,018,430. Excluding the 2000 Chino Hills project, for which ORA has dramatically under-forecasted the project cost, the disallowance based on the augmented ORA model is only $2,800,044 as compared to ORA's proposed disallowance of $63,202,999.

To be clear, neither ORA's models nor the augmented ORA models are adequate for forecasting SoCalGas' PSEP project costs. SoCalGas developed the augmented ORA models to demonstrate that the flaws in ORA's models are extensive enough that the models can be easily improved using data in ORA's own database that accounts for differences in PSEP project costs across utilities. Such differences must be accounted for in statistical modelling. However, even the augmented models remain fatally inferior to the Class 3 estimates prepared by SoCalGas, as the models are still missing cost drivers that are important for explaining PSEP project costs and thus continue to produce biased forecasts and biased 90% thresholds.

For the reasons discussed in this section, the Commission should reject ORA's statistical model-based proposed PSEP project cost forecasts in this proceeding.

ORA compounds the unreliability of its model by proposing to apply it inconsistently: when its model results in cost forecasts that are lower than SoCalGas' forecast, ORA proposes to apply its model; but when its model results in costs forecasts higher than SoCalGas' forecast, ORA proposes to ignore the results of its own model. It is difficult to ascertain the reason for ORA's proposal to apply its own model inconsistently. Possible explanations are that even ORA does not believe in the accuracy or applicability of its model, or simply that ORA's objective is to reduce the cost forecasts, whether or not there is valid justification for doing so. In either case, ORA's proposed inconsistent application of its model further underscores the unreliability of the model.

iv. ORA's Pressure Test Database Is Composed Almost Entirely of PG&E Projects and Does Not Include the Capital Component of PG&E's Pressure Test Projects

The database of completed pressure test projects that underlies ORA's model consists of 365 PG&E projects (approximately 95%) as compared to only 20 SoCalGas projects (approximately 5%).[41] The basic assumption underlying ORA's entire analysis is that another utility's project costs are representative of SoCalGas' project costs. The augmented ORA models discussed in Section III.B.1.a.iii above provide strong statistical evidence that this assumption is wrong. This section adds to that evidence by showing that this assumption ignores fundamental differences in project scope, geography, and cost components, and is one that the Commission has previously declined to make.

PG&E's PSEP calls for projects to be sequenced in an order that differs from SoCalGas' (and SDG&E's) PSEP. For example, while SoCalGas' initial pressure test projects, which are

[41] ORA Response to SEU-ORA-DR-02, Question 5.

among the 20 composing ORA's database, were executed primarily in more populated/dense areas, it is SoCalGas' understanding that PG&E's earliest completed PSEP projects were executed in less populated/dense areas, where it is generally less costly to complete projects. This can be validated by comparing the cost-per-mile (CPM) adopted by the Commission for PG&E in its 2015 Gas Transmission and Storage (GT&S) Rate Case ($840,000/mile)[42] with the amount proposed by PG&E in its 2019 GT&S Rate Case ($2,500,000/mile).[43]

Further compounding the lack of parity, the PG&E pressure test projects in ORA's database exclude the capital component of each project's costs, but ORA nevertheless proposes to use just the O&M portion of the project costs in its dataset to establish a cap for SoCalGas' pressure test projects, which include both O&M and capital costs. This is a significant error in ORA's attempt to use PG&E data to predict the costs of SoCalGas pressure test projects. Approximately 23% of SoCalGas' PSEP pressure test project cost estimates are capital.[44] Per PG&E's 2019 GT&S filing, the capital component of PG&E's pressure tests add approximately 24% to the cost of PG&E's pressure tests.[45]

C. TURN/SCGC'S AND INDICATED SHIPPERS' PROPOSAL TO ELIMINATE THE RISK ASSESSMENT COMPONENT OF PROJECT COST ESTIMATES IGNORES A NECESSARY COMPONENT OF PROJECT COSTS, AS RECOMMENDED BY INDUSTRY BEST PRACTICES

TURN/SCGC and Indicated Shippers both recommend the entire risk assessment[46] component of SoCalGas' detailed cost estimates be disallowed.[47] Rather than recognizing the

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[42] Decision (D.) 16-06-056 at Conclusion of Law (COL) 21.

[43] A.17-11-009, Direct Testimony of Bennie Barnes - Chapter 5 Workpapers; Table 5-12 at WP-5-48, attached as Appendix C.

[44] The capital cost components of a pressure test project are primarily as follows: the replacement of short sections of pipe to facilitate pressure testing in accordance with Company Accounting Guidelines, remediation/replacement of identified pipeline anomalies, and the replacement of taps.

[45] A.17-11-009, Direct Testimony of Bennie Barnes; Table 5-16 at 5-52 and Table 5-17 at 5-53, attached as Appendix D.

[46] TURN/SCGC and Indicated Shippers use the terms "risk assessment" and "contingency factors" interchangeably throughout their testimony. See, e.g., Ex. TURN/SCGC-01 (Yap) at 20; Ex. IS-1 (Gorman) at 37.

[47] TURN/SCGC propose the risk assessment component for pressure test and replacement projects be disallowed whereas Indicated Shippers propose the risk assessment component for pressure test and

risk assessment component as an integral part of a Class 3 estimate, TURN/SCGC argue it should be disallowed because it represents a significant and unreasonable cost to ratepayers.[48]

Indicated Shippers bases its proposal to disallow the risk assessment component on its opinion that SoCalGas can simply reduce the number of PSEP projects it conducts during the 2019 GRC cycle if costs exceed the allowed forecasts (i.e., net of the risk assessment component).[49] In other words, Indicated Shippers' position is that SoCalGas should slow down the pace of executing PSEP to keep costs within an authorized level of funding.

History has shown that project managers across all industries will, on average, underestimate the cost of a project. An industry association of professionals in this field, the AACE International (AACE), has published recommended practices to account for this tendency to underestimate project costs in order to correct for it and therefore produce a more accurate cost estimate.

AACE Recommended Practice 40R-08 (Contingency Estimating – General Principles) states:

> Contingency is a cost element of an estimate to cover the probability of unforeseeable events to occur and that if they occur, they will likely result in additional costs within the defined project scope.[50] [51]

AACE Recommended Practice 18R-97 (Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries), included as Appendix A, further confirms that the inclusion of a contingency is expected and integral to the development of accurate cost estimates:

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replacement projects, as well as the risk assessment component for the Valve Enhancement Plan be disallowed.

[48] Ex. TURN/SCGC-01 (Yap) at 20.

[49] Ex. IS-1 (Gorman) at 33.

[50] AACE International Transactions RISK.08 2009 Report "Defining Risk and Contingency for Pipeline Projects at RISK.08.7", attached as Appendix E.

[51] AACE International Recommended Practice No. 40R-08 "Contingency Estimating – General Principles," attached as Appendix F.

> The +/- value represents typical percentage variation of actual cost estimate *after application of contingency*" (emphasis added) and "Growth from Estimated Costs *Including Contingency* (emphasis added).[52]

Further, the final total contingency amount is the result of a series of risk assessments and is critical to the development of accurate cost estimates:

> Identifying risk and determining an appropriate amount of contingency is a challenge that must be addressed to ensure accurate information is available to base critical financial decisions upon.[53]

The above passages are also noteworthy because they *apply to all classes of estimates* – from the rudimentary Class 5, to the Class 3 of SoCalGas' estimates in this filing, to a Class 1 estimate for which much more detailed design and engineering has occurred. It is always recommended and expected for a cost estimate to contain a contingency element no matter the class of the estimate. It is established and recognized that a contingency amount is expected in all cost estimates.

Turning to the methodology for how to develop the contingency amount, per AACE:

> There is a range of useful contingency estimating methodologies.[54]

> Many methods and techniques have been proposed in the literature for estimating contingency. They are mainly risk analysis techniques.[55]

SoCalGas employed a methodology of having subject matter experts within the PSEP project execution team work with risk assessment experts within the PSEP cost estimating team to review risk variables (assumptions on productivity for contractors, environmental costs, permit conditions, material costs, etc.). These experts discussed the plausible variances for these cost components (*e.g.*, discussing the probability of the contractor's productivity being less than planned and if so, the magnitude of the potential reduction in productivity, with similar questions

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[52] Appendix A at 2, 4.

[53] Appendix E at RISK.08.1.

[54] Appendix G at 1.

[55] Appendix E at RISK.08.7.

for project-specific issues that drive environmental costs, land rights acquisitions, permit conditions, etc.). This team of cross-functional experts used their experience and knowledge of the specific conditions of each particular project to develop a consensus opinion of potential outcomes. TURN/SCGC describes the SoCalGas process well:

> Witness Phillips does not discuss contingency factors in his testimony but they are used pervasively throughout his workpapers. These contingency factors are generally denoted as "risk assessment" amounts that are added to the estimates *after* the analyst has done a detailed cost projection. For example, the analyst creates a very detailed projections of construction contractor costs in the "Construction Contractor" tab and the total amounts from that tab for each bid item are then brought into the "Estimate" sheet where construction contractor costs are added to the other elements, e.g. SoCalGas labor, engineering services, etc., that make up the entire projections. The contingency factors are then applied on the "Estimate" tab to each of the cost elements. These factors vary from project to project and from cost item to cost item, but they apply to all projects.[56]

This methodology used by SoCalGas to determine risks aligns with AACE's recommended practices. The AACE paper "AACE International Transactions Risk.08 – Defining Risk and Contingency for Pipeline Projects" states:

> Project specific risks are those that *are unique to a particular project's scope, strategies, attributes, and so on*. The nature of these risks and extent of their impact *are not consistent between projects in a given company* (emphasis added).[57]

The paper goes on to provide a recommendation of how to go about assessing risks that are unique to each individual project:

> Thus, to estimate project specific risks, the recommended practice is to use "expected value model."[58],[59]

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[56] Ex. TURN/SCGC-01 (Yap) at 21.

[57] Appendix E at Risk.08.8.

[58] Appendix E at Risk.08.8.

[59] AACE International Recommended Practice No. 44R-08 "Risk Analysis and Contingency Determination using Expected Value," attached as Appendix G.

SoCalGas employs methods of AACE Recommended Practice 44R-08 (Risk Analysis and Contingency Determination Using Expected Value Analysis) and, as mentioned above, this Expected Value Analysis process is summarized by TURN/SCGC.

As an example, for the Line 2000 Section E project, SoCalGas developed its cost estimate by having its subject matter experts develop the most probable cost for approximately 30 different individual cost components. The subject matter experts then re-reviewed the individual cost components and developed estimates if things went worse than expected, and also if they went better than expected for individual cost components. Not all risks will actually come to fruition, but industry experience says some will occur. How to appropriately account for the probabilities of occurrence is built into the recommended practice methodology. SoCalGas used an industry accepted methodology that provides a most likely overall cost of the project. This projected overall project cost is higher than the sum of the individual initial cost component estimates. For the Line 2000 Section E project, the industry recommended methodology produces an estimated cost of $15.520 million. The sum of the individual components produces a cost estimate of $11.947 million. The difference between the two figures is project contingency. For the Line 2000 Section E project, the contingency amount is $3.573 million. This is the amount TURN/SCGC recommends the Commission disallow.

TURN/SCGC's recommendation indicates a lack of understanding of standard project cost estimating methods and about the industry's use of risk assessments that result in a contingency factor, and the improved accuracy of cost estimates by assessing the unique risks of individual projects. TURN/SCGC's misinformed statements include:

> No Matter How It is Dressed Up, the "Risk Assessment" Factor Proposed by the Applicants is Simply a Contingency Factor;[60]
>
> The Applicants Use of Contingency Factor Belies Its Assertions About the High-Quality Analysis Supporting Its Cost Estimates;[61] and

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[60] Ex. TURN/SCGC-01 (Yap) at 20.

[61] Ex. TURN/SCGC-01 (Yap) at 21.

> Witness Phillips does not discuss contingency factors in his testimony but they are used pervasively throughout his workpapers. These contingency factors are generally denoted as "risk assessment" amounts that are added to the estimates *after* the analyst has done a detailed cost projection.[62]

The above statements seem to imply some sort of nefarious motive when, in fact, the Class 3 estimates submitted by SoCalGas simply adhere to standard industry practices. TURN/SCGC further states:

> The application of such a "risk assessment" factor to these detailed cost estimates strongly suggests that the Applicants don't have much confidence in the quality of the estimates.[63]

Despite these assertions from TURN/SCGC, the application of a risk assessment component increases the quality of estimates and comports with industry recommended practices.

The TURN/SCGC witness describes her education and experience in the field of cost estimating for pipeline projects as follows:[64]

> [**QUESTION**:] Please state your education and/or experience in estimating.
> a. Please state your education and/or experience in estimating costs of pipeline installation and pipeline hydrotesting.
> b. Please state your education and/or experience in performing detailed estimating or parametric estimating.
>
> **RESPONSE**: I have received no formal education in cost estimation but have experience in evaluating costs estimated by utility personnel in gas, electric, and water GRCs as well as pipeline certification projects and PSEP proceedings. Regarding PSEP cost estimates, I have been the witness in I.11-02-019/A.11-11-002, A.14-12-015, A.16-09-005, A.17-03-021, as well as the current proceeding.

[62] Ex. TURN/SCGC-01 (Yap) at 20.

[63] Ex. TURN/SCGC -1 (Yap) at 21

[64] SEU-TURN-SCGC-02, Question 2, attached as Appendix H.

Contingency dollars in projects reflect expected real cost.[65,66] Contingency is defined in AACEi Recommended Practice 10S-90, *Cost Engineering Terminology* as:

> An amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs. Typically estimated using statistical analysis or judgment based on past asset or project experience. Contingency usually excludes: 1) Major scope changes such as changes in end product specification, capacities, building sizes, and location of the asset or projects; 2) Extraordinary events such as major strikes and natural disasters; 3) Management reserves; and 4) Escalation and currency effects. Some of the items, conditions, or events for which the state, occurrence, and/or effect is uncertain include, but are not limited to, planning and estimating errors and omissions, minor price fluctuations (other than general escalation), design developments and changes within the scope, and variations in market and environmental conditions. *Contingency is generally included in most estimates, and is expected to be expended.*[67]

Disallowing contingency dollars would be akin to disallowing another aspect in the overall cost estimate such as material cost, or contractor cost, or inspector cost. The latter items are specifically defined whereas contingency addresses anticipated costs that are not specifically defined; but nevertheless *contingency dollars are real expected costs that the industry dictates* should be included in a project's cost estimate to improve the accuracy of the cost estimate in order to approximate the final actual cost. The need for a contingency is based on real life experience across thousands and thousands of projects in different project areas across many industries.

1. TURN/SCGC's "Normalization" Approach Is Flawed and Should Not Be Relied Upon to Eliminate the Contingency Component

To support their argument that the contingency component costs should be disallowed, TURN/SCGC attempt to show that SoCalGas' cost estimates, even when stripped of the

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[65] AACE International Transactions EST.03 2004 Report on "Exploring Techniques for Contingency Setting," attached as Appendix I.

[66] Ex. IS-1 (Gorman) at 54; Schedule MPG-2.

[67] *Id.*; also available for free to the general public at https://web.aacei.org/docs/default-source/rps/10s-90.pdf?sfvrsn=18 (emphasis added).

contingency component, are "fairly generous."[68] To do so, TURN/SCGC attempt to compare actual costs from past SoCalGas projects (TURN/SCGC use the term "recorded" costs) to the forecasted costs of this filing by contriving four types of cost metrics for comparison.[69] However, these are not common metrics for cost comparisons; thus, in order to execute the forced comparison, TURN/SCGC first have to make a number of assumptions to derive costs for these metrics.

These derivations and comparisons are sufficiently flawed to render them inappropriate to support any conclusions for one primary reason: the "recorded" projects from which metrics are drawn and then used to compare to "forecasted" projects are almost all in urban areas, whereas the forecasted projects are almost exclusively in rural areas. The differences between the two types of projects are too great, even after attempting to "normalize" the data, to use the comparisons to support something as serious as reducing SoCalGas' well-founded cost forecasts.

Although TURN/SCGC like to generalize that projects in urban areas tend to cost more than projects in rural areas,[70] and thus its comparisons are noteworthy, there are very real differences between the recorded and forecasted projects (i.e., the urban projects compared to the rural projects). Projects in rural areas tend to have more environmental issues to mitigate; on average are about 20 times greater in length than the recorded projects; on average are larger in diameter; have different, frequently more onerous, permit conditions; are mostly in unpaved areas; and have hilly terrain compared to mostly flat terrain for the recorded projects.

Even with these notable differences, TURN/SCGC nevertheless conclude that two of the four cost areas reviewed by them "compare reasonably well" and "compare fairly well."[71]

For the category that "compares fairly well" – construction management costs -- four projects are listed that "significantly exceed the average,"[72] thus presumably dropping this category from comparing "reasonably well" to "fairly well." The reason for the increased costs is easily explainable. These four projects are planned to have multiple construction crews

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[68] Ex. TURN-SCGC-01 (Yap) at 28:5.

[69] Ex. TURN-SCGC-01 (Yap) at 28-29, 38-39.

[70] Ex. TURN-SCGC-01 (Yap) at 29, 32, 39.

[71] Ex. TURN-SCGC-01 (Yap) at 34.

[72] Ex. TURN-SCGC-01 (Yap) at 32:21-22.

operating concurrently, therefore necessitating greater construction management personnel, which in turn will cause costs to significantly exceed the average. Planning for multiple construction crews, while increasing daily construction management costs, results in a lower project cost because the project will be completed sooner.

Regarding another area reviewed by TURN/SCGC for comparison -- "time-related construction contractor costs" -- TURN/SCGC conclude that the forecasted costs were "twice as high"[73] as recorded costs. But this ignores that the two recorded pressure test projects that are most like the forecasted pressure test projects in terms of length and diameter, Line 2000-A and 2000 West sec (1, 2, 3), have recorded costs of $15.611 million and $13.148 million, which are actually in line with the forecasted average of $16.428 million.[74]

TURN/SCGC compare labor costs for SoCalGas employees for recorded projects to the forecasted projects and note that the hourly rates used for the forecasted projects are 22% higher than the recorded projects. This, too, is based on a reason. Permitting conditions for projects in urban areas frequently limit the work day in order to minimize traffic impacts. Rural projects have fewer such constraints and therefore typically work longer days. This reduces overall project costs because the projects are completed sooner, thereby reducing fixed costs charges. But it does lead to greater amounts of overtime hours with higher time-and-a-half or double-time rates; this is why the average hourly rate for the forecasted projects are higher than for the recorded projects.

TURN/SCGC seem to want to establish that SoCalGas has overpredicted the cost of the PSEP projects in this Application, and therefore the overall contingency factor of 26% for pressure test projects and 25% for replacement projects is too high and should be completely eliminated. However, TURN/SCGC has not so established. Moreover, the contingency component for each project, and for all projects in total, is accurately calculated and justified.

First, the contingency component for each project resulted from of a bottom-up approach from many different subject matter experts' review of the individual unique characteristics of the project. There was no orchestrated effort to push up contingency costs. Coincidentally, the

[73] Ex. TURN-SCGC-01 (Yap) at 34:12.

[74] Ex. TURN-SCGC-01 (Yap) at 32.

overall contingency amounts for the pressure test projects were almost exactly the same as the replacement projects, averaging 26% for pressure test projects and 25% for replacement projects.[75] Nevertheless, there was a wide variation of contingencies for individual projects. For the pressure testing projects, the contingency amount determined as a result of subject matter experts' review of the risks of the Line 235 West Section 3 project resulted in a contingency amount of 19%, while the same process with many of the same subject matter experts resulted in a 32% contingency for the Line 235 West Section 1 project. These lowest and highest contingency determinations are for different sections of the same pipeline. This further demonstrates that SoCalGas did not merely apply a random contingency.

The variation was even larger for replacement projects. The lowest contingency was 18% for the Line 2000-E Cactus City Compressor Station project, while the subject matter experts' review of risks for the Line 44-1008 project resulted in a 33% contingency amount. Interestingly, the high contingency factor for this project is validated by TURN/SCGC's concern that environmental permitting issues may prevent this project from starting during the GRC cycle.

Second, the average contingency amounts of 26% and 25% for pressure test and replacement projects, respectively, are in line with industry expectations for such projects. Information from an AACE article shows a range of 15% to 30% is anticipated for the stage that SoCalGas' projects were in when costs were developed.[76]

For these reasons, the Commission should reject TURN/SCGC's assertion that SoCalGas' project forecasts are too high and thus the contingency component should be denied.

D. MISCELLANEOUS PSEP COSTS

Table RDP-5
Miscellaneous PSEP Costs (Combined O&M and Capital Components)
(Constant 2016 Direct Costs – Thousands)

	SoCalGas	ORA	TURN/SCGC	INDICATED SHIPPERS
Allowance for Pipeline Failures	$6,170	$6,170	No Position	No Position

[75] Percentages represent 2019-2021 test and replacement projects.

[76] Percentages represent 2019-2021 test and replacement projects.

Implementation Continuity Costs	$5,599	No Position	No Position	No Position
Program Management Office (PMO)	$41,438	No Position	No Position	No Position
TOTAL	**$53,206**			

ORA supports SoCalGas' proposal for an Allowance for Pipeline Failures in the event of a pressure test failure, but only if the Commission rejects SoCalGas' proposal for two-way balancing account treatment of PSEP Costs.[77] As discussed further below, SoCalGas' request for two-way balancing account treatment is warranted. The Allowance for Pipeline Failures should be approved by the Commission regardless.

E. REPLACEMENT PROJECTS

Table RDP-6
Replacement Projects
(Constant 2016 Direct Costs – Thousands)

	SoCalGas	ORA	TURN/SCGC	INDICATED SHIPPERS
85 Elk Hills to Lake Station	$88,906	$88,906*	$72,230	$72,146
36-9-09 North Section 12	$9,813	$8,408	$9,312	$8,274
36-9-09 North Section 14	$19,980	$17,635	$16,801	$18,100
36-9-09 North Section 15	$14,193	$14,119	$11,919	$12,838
36-9-09 North Section 16	$18,036	$18,036	$14,775	$15,986
36-1032 Sec 11	$8,692	$8,692*	$7,334	$8,014
36-1032 Sec 12	$26,601	$26,601*	$22,697	$24,474
36-1032 Sec 13	$17,811	$17,811	$14,631	$15,645
36-1032 Sec 14	$13,937	$13,937	$11,842	$12,735

[77] Ex. ORA-03 (Stannik and Li) at 30.

44-1008 (50%)	$76,582	$76,582*	$700	$57,440
2000-E Cactus City Compressor Station	$6,698	$6,698	$5,621	$5,911
TOTAL	**$301,250**	**$297,425**	**$187,863**	**$251,563**

*ORA takes no position on SoCalGas's forecasts for these projects.[78]

ORA uses its model to evaluate 10 of the 14 PSEP pipeline replacement project forecasts included in this Application. ORA's model results in a lower forecast for three of the 10 projects, and ORA recommends a total disallowance of $3.8MM, or approximately 3.4% of SoCalGas' forecast for these 10 projects.

As described in Section III.A.1, the output of ORA's model for the nine pressure test projects modeled by ORA results in a much larger proposed disallowance of approximately 57% of SoCalGas' estimated pressure test costs, a disparity that brings into question the validity of ORA's model (discussed in detail in Section III.B.1.a above).

For these same reasons, ORA's model is too unreliable and fatally flawed to establish a cap for replacement project costs, particularly if SoCalGas is not authorized to continue to track PSEP costs in a two-balancing account, as proposed by ORA.

TURN/SCGC and Indicated Shippers propose that the risk assessment component for replacement projects be disallowed for the same reasons as for pressure test projects. The Commission should reject these proposals for the same reasons described in Section III.C.

TURN/SCGC further recommend that the majority of forecasted costs for the Line 44-1008 project be deferred to the 2022 and 2025 GRCs because the length of time estimated by SoCalGas to secure the necessary environmental approvals may preclude construction from starting during this GRC cycle. However, this ignores that even if the environmental permitting process precludes SoCalGas from initiating construction during the rate case cycle, SoCalGas would have the ability to request approval via the project substitution process, described in Section XII in Direct Testimony, to execute a substitute replacement project or projects from the queue so as to continue to execute PSEP "as soon as practicable" in compliance with the

[78] Ex. ORA-03 (Stannik and Li) at 28.

Commission's directives.[79] TURN/SCGC support SoCalGas' project substitution proposal,[80] and if the Line 44-1008 project had to be substituted, the rationale for the project substitution would also satisfy TURN/SCGC's proposal that projects should be substituted in order to avoid cost overruns.[81]

F. INDICATED SHIPPERS' PROPOSAL TO EXTEND THE VALVE ENHANCEMENT PLAN TO SIX YEARS IS BASED ON A MISUNDERSTANDING OF THE TIMING OF THE PROGRAM

Table RDP-7
Valve Enhancement Plan
(Constant 2016 Direct Costs – Thousands)

	SoCalGas	ORA	TURN/SCGC	INDICATED SHIPPERS
Valve Enhancement Plan	$246,000	No Position	No Position	$101,893
TOTAL	**$246,000**			**$101,893**

Indicated Shippers proposes two adjustments to the SoCalGas Valve Enhancement Plan forecast. First, consistent with its recommendation regarding the PSEP pressure test and replacement projects, Indicated Shippers proposes to remove the risk adjustment component from the Valve Enhancement Plan forecast.[82] Second, it recommends that SoCalGas implement the Valve Enhancement Plan forecast over six years (i.e., two GRC cycles) rather than the three years proposed.[83]

Indicated Shippers' proposal to remove the risk adjustment component from the Valve Enhancement Plan forecast should be rejected for the same reasons outlined in Section III.C of this testimony, which addresses this issue as it relates to pressure test and replacement projects.

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[79] D.11-06-017 at 19.

[80] Ex. TURN/SCGC-01(Yap) at 48.

[81] Ex. TURN/SCGC-01 (Yap) at 48.

[82] Ex. IS-1 (Gorman) at 41.

[83] Ex. IS-1 (Gorman) at 41.

Indicated Shippers' proposal to extend the remainder of the Valve Enhancement Plan from three to six years should also be rejected, as it is based on a misinterpretation of the status of the Valve Enhancement Plan. Indicated Shippers incorrectly assumes that the Valve Enhancement Plan is a new program being implemented in this GRC.[84] For example, Indicated Shippers states:

> Accomplishing valve enhancement over a six-year period, with SoCalGas identifying high priority valve replacements to do first, will allow for SoCalGas to meet the Commission's objective of accomplishing this valve enhancement program over a reasonable amount of time.[85]

The Direct Testimony indicates to the contrary, i.e., that the Valve Enhancement Plan is an ongoing program, in more than one section. For example, on page RDP-iii, SoCalGas requests the Commission:

> Authorize SoCalGas to continue construction of the 284 valve project bundles presented in this Application in furtherance of the *continuing* (emphasis added) implementation and execution of the PSEP Valve Enhancement Plan mandated by the Commission in D.14-06-007.[86]

The reference to SoCalGas "continuing" implementation of the Valve Enhancement Plan can also be found on pages RDP-A14, A-19, and A-48.

Further, in response to IS-DR-03 Question 3-5j, SoCalGas explained:

> [E]xecution of the PSEP Valve Enhancement Plan began in 2012 and is anticipated to be completed in 2021, concurrent with the 2019 GRC cycle.[87]

These dates are also included in responses to IS-DR-03, Question 3-5.o[88] and IS-DR-07 Question 7-1.b.[89]

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[84] Ex. IS-1 (Gorman) at 41, Mr. Gorman continually refers to the "implementation" of the Valve Enhancement Program and makes other statements that lead to this conclusion."

[85] Ex. IS-1 (Gorman) at 41.

[86] Ex. SCG-15-R (Phillips) at RDP-iii.

[87] Ex. IS-1 (Gorman) at 55, Schedule MPG-2.

[88] Ex. IS-1 (Gorman) at 56; Schedule MPG-2.

[89] IS-SCG-007, Question 7-1.b, attached as Appendix J.

Further, as indicated in response to Indicated Shippers' Data Request IS-007, Question 7-1.b, completing the remainder of the Valve Enhancement Plan in 2021 is consistent with the requirement set forth in D.11-06-017 that PSEP should be completed "as soon as practicable,"[90] the requirement in Public Utilities Code section 957 that "[t]he commission shall additionally establish action timelines, adopt standards for how to prioritize installation of automatic shutoff or remote controlled sectionalized block valves pursuant to paragraph (1), ensure that remote and automatic shutoff valves are installed as quickly as is reasonably possible,"[91] and the directive in the Natural Gas Pipeline Safety Act of 2011 that the plan "shall include a timeline for completion that is as soon as practicable."[92]

For these reasons, Indicated Shippers' proposal should be rejected and SoCalGas' request for funding to complete the Valve Enhancement Plan during this GRC cycle should be approved.

G. FOURTH YEAR PRESSURE TEST PROJECTS

Table RDP-8
Fourth Year Pressure Test Projects (Combined O&M and Capital Components)
(Constant 2016 Direct Costs – Thousands)

	SoCalGas	ORA	TURN/SCGC	INDICATED SHIPPERS[93]
225 North	$15,464	$7,674	$11,808	No Position
1030	$25,355	$25,355*	$20,484	No Position
2001 West	$8,418	$6,607*	$6,795	No Position
2001 East	$21,450	$21,450*	$17,735	No Position
2005	$3,359	$3,359	$2,655	No Position
TOTAL	**$74,046**	**$64,445**	**$59,477**	No Position

*ORA takes no position on SoCalGas' forecast for these projects.[94]

[90] D.11-06-017 at 19.

[91] Pub. Util. Code § 957.

[92] Pub. Util. Code § 958.

[93] Indicated Shippers did not address Fourth Year projects; however, it does recommend the Commission reject the proposed change to a four-year GRC cycle.

[94] Ex. ORA-03 (Stannik and Li) at 28.

In the event the Commission adopts a four-year GRC cycle, the forecasts for SoCalGas' fourth year pressure test projects should be adopted for the reasons set forth in Sections III.B and III.C.

H. FOURTH YEAR REPLACEMENT PROJECTS

Table RDP-9
Fourth Year Replacement Projects (Capital Components)
(Constant 2016 Direct Costs – Thousands)

	SoCalGas	ORA	TURN/SCGC	INDICATED SHIPPERS[95]
2001 East Replacement	$3,799	$3,799	$2,992	No Position
5000	$4,486	$4,486	$3,462	No Position
44-1008 (50%)	$76,582 (50%)	$76,582*	$700	No Position
TOTAL	**$84,867**	**$84,867**	**$7,154**	

*ORA takes no position on SoCalGas' forecast for these projects.[96]

In the event the Commission adopts a four-year GRC cycle, the forecasts for SoCalGas' fourth year replacement projects should be adopted for the reasons set forth Sections III.B and III.C.

I. FOURTH YEAR PROGRAM MANAGEMENT OFFICE COSTS

Table RDP-10
Fourth Year PMO Costs (Combined O&M and Capital Components)
(Constant 2016 Direct Costs – Thousands)

	SoCalGas	ORA	TURN/SCGC	INDICATED SHIPPERS
Fourth Year PMO Costs	$12,989	No Position	No Position	No Position
TOTAL	**$12,989**			

In the event the Commission adopts a four-year GRC cycle, the forecasts for SoCalGas' fourth year project management costs should be adopted.

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95 Indicated Shippers did not address Fourth Year projects; however, it does recommend the Commission reject the proposed change to a four-year GRC cycle.

96 Ex. ORA-03 (Stannik and Li) at 28.

IV. OTHER ISSUES

A. ORA'S, TURN/SCGC'S, AND INDICATED SHIPPERS' REASONS FOR DENYING TWO-WAY BALANCING ACCOUNT TREATMENT OF PSEP COSTS ARE UNFOUNDED

ORA opposes SoCalGas' request for two-way balancing account treatment on the basis that the time lapse between the development of the cost estimates and construction does not alone warrant balancing account treatment and that SoCalGas has not demonstrated the project costs are inherently unpredictable. ORA further asserts that the project cost estimates are "fairly well-developed" and that the majority of the estimates contain contingencies of up to 20% in certain categories to account for some level of cost uncertainty.[97] Finally, ORA states that PG&E completed its entire PSEP program without balancing account treatment under a single, forecasted cost and contends that SoCalGas has provided no evidence showing that it is incapable of managing its projects to a fixed budget or that SoCalGas' project costs are inherently more unpredictable than PG&E's.[98]

TURN/SCGC assert similar arguments to oppose SoCalGas' request for two-way balancing account treatment. Further, using the same argument as in their opposition to the contingency component of SoCalGas' forecasts, TURN/SCGC assert PSEP projects are not fundamentally different than other natural gas utility activities that do not receive balancing account treatment.[99] TURN/SCGC also claim that because, in their witness's opinion, PSEP projects are well defined and Phase 1B and 2A projects have fewer uncertainties than Phase 1A projects since they are in more rural locations, balancing account treatment is unnecessary.[100]

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[97] Ex. ORA-03 (Stannik and Li) at 29.

[98] Ex. ORA-03 (Stannik and Li) at 29. These arguments ignore that PG&E, from the very earliest stages of PSEP, was treated differently than the other utilities. For example, in D.11-06-017, the Commission ordered regarding the utilities' ratemaking proposals, "For PG&E *only*, proposed cost allocation between shareholders and ratepayers." D.11-06-017 at 23 (emphasis added). The other utilities were ordered merely to forecast costs and rate impacts associated with PSEP. *See id.*

[99] Ex. TURN/SCGC-01 (Yap) at 47.

[100] Ex. TURN/SCGC-01 (Yap) at 47.

Indicated Shippers opposes two-way balancing account treatment on the basis that such an account would remove any economic incentive on the part of SoCalGas to manage PSEP costs.

CUE supports SoCalGas' request for two-way balancing account treatment in recognition of the fact that the costs in question are subject to upward as well as downward uncertainty.[101] CUE further asserts that one-way balancing account treatment would only be appropriate if the Commission also adopts SoCalGas' PSEP forecasts in their entirety.[102]

As discussed in Direct Testimony, PSEP implements specific Commission and Legislative directives to pressure test or replace in-service transmission pipelines. In this Application, SoCalGas details specific scopes of work for specific pipeline projects and proposes to complete these scopes of work within this GRC cycle. As such, this is not business as usual, as asserted by intervenors. SoCalGas will not have discretion to manage broad categories of activities within an overall authorized budget. Where there are detailed and discrete scopes of work for specific projects that must be executed, and where the only certainty is that actual costs will deviate from even the most robust estimates, a two-way balancing account is the only mechanism for protecting both customers' and SoCalGas' interests by authorizing recovery of only the actual costs of implementing PSEP. As further explained in the Direct Testimony, during the (at minimum) three-year time lapse between the preparation of the cost estimates included in this Application and the start of construction, external forces are likely to come into play that may impact what today is a reasonable cost estimate. Construction, contractor, and material costs may change and new environmental regulations may be enacted.[103],[104] An illustrative example is that, as PSEP transitions into the GRC process, there will be a time lag between the completion of Phase 1A pipeline projects and the commencement of construction on the Phase 1B and 2A projects in this Application. Specialized contractor resources, such as welding and coating inspectors, that have completed the SoCalGas Operator Qualification

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[101] Ex. CUE-1 (Marcus) at 20.

[102] Ex. CUE-1 (Marcus) at 20.

[103] Ex. SCG-15-R (Phillips) at RDP-A-22.

[104] For example, in recent months, steel tariffs have been announced, implemented, and put on hold multiple times, in varying order, for various countries.

process and training on SoCalGas safety requirements can, and will, leave SoCalGas jobs to find steadier work during this dip in pipeline construction activity, often venturing outside California. A reduction in the labor pool in all likelihood would drive up costs and impact SoCalGas' rates for services. The alternative -- adding new specialized contractor personnel that are not well-versed in SoCalGas standards -- would not be as productive or efficient as new personnel would need to become familiar with company-specific work methods.

Further supporting the need for a two-way balancing account, CUE notes that for some projects ORA's models have predicted costs greater than SoCalGas' forecasts, and thus SoCalGas may have under-forecasted some of their projects.[105]

ORA's, TURN/SCGC's, and Indicated Shippers' opposition to a two-way balancing account ultimately amounts to a penalty imposed on SoCalGas, which is clearly contrary to the Commission's directive in D.14-06-007 that:

> This decision *does not propose or adopt any penalty for SDG&E or SoCalGas*. We do however identify certain costs that should be absorbed by shareholders instead of ratepayers. Consistent with long-standing ratemaking principles, ratepayers will generally bear the reasonable costs for a safe and reliable natural gas transmission system.[106]

SoCalGas' proposal, supported by CUE, for a two-way balancing account is fair to both ratepayers and shareholders. If costs come in lower than projected, ratepayers will benefit from the lower costs. If costs come in higher than estimated, shareholders are not penalized. Either way, ratepayers do no pay more than the actual costs of executing the projects.

B. ORA'S MODIFICATION OF THE REQUEST FOR PROJECT SUBSTITUTION ADDS UNNECESSARY TIME AND COMPLEXITY TO IMPLEMENTING PSEP AS SOON AS PRACTICABLE

ORA proposes that SoCalGas' request for authority to substitute PSEP projects be modified to allow for more in-depth analysis of the proposed project substitutions. Specifically, ORA recommends that project substitutions be addressed through an expedited pre-approval process similar to what the Commission uses in evaluating "some interstate gas capacity

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[105] Ex. CUE-1 (Marcus) at 21.

[106] D.14-06-007 at 31. This is in contrast to the Commission's ruling in D.11-06-017. *See* Footnote 98.

contracts."[107] Further, ORA proposes a working group consisting of SoCalGas/SDG&E, the Commission's Energy Division, ORA, TURN, Office of Safety Advocates, and the Commission's Safety and Enforcement Division be formed for purposes of this review.[108] ORA also offers an alternative where project substitution could be allowed in a narrow, well-defined set of circumstances, or if the projects are of similar cost and scope (e.g., same type, length, cost, etc.).[109] Finally, ORA recommends that if the Commission does not adopt any of its proposals, SoCalGas' request to substitute projects when circumstances so require should be denied.[110]

Although SoCalGas appreciates ORA's acknowledgement that project substitution is reasonable and might be necessary under certain circumstances,[111] the alternatives proposed by ORA add unnecessary time and complexity to SoCalGas' implementation of Commission-mandated safety work "as soon as practicable."[112] Even with an "expedited" approval process, the length of time required for the parties to convene and review the reasonableness of project cost estimates will take a significant amount of time and would adversely impact SoCalGas' ability to substitute a project in a timely manner.

It should be noted that ORA's proposal is not new. SCGC made a similar proposal in A.11-11-02 for an Expedited Application Docket procedure to review SoCalGas and SDG&E PSEP projects. The Commission rejected this proposal in D.14-06-007.[113]

TURN/SCGC state SoCalGas' project substitution request is reasonable so long as the Commission is clear that unanticipated conditions do not include mere exceedance of forecasts.[114] To be clear, SoCalGas does not propose to use the project substitution process for

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[107] Ex. ORA-03 (Stannik and Li) at 31.

[108] Ex. ORA-03 (Stannik and Li) at 30, 31.

[109] Ex. ORA-03 (Stannik and Li) at 31, 32.

[110] Ex. ORA-03 (Stannik and Li) at 32.

[111] Ex. SCG-15-R (Phillips) at RDP-A-56 reflects a slight modification to SoCalGas' project substitution proposal and requests authority to substitute projects in the event of a project delay *or when it is prudent to accelerate the execution of a PSEP project.*

[112] D.11-06-017 at 19.

[113] D.14-06-007 at 23.

[114] Ex. TURN/SCGC-01 (Yap) at 48.

this purpose and, as described in the Direct Testimony, if project substitution is necessitated, SoCalGas would identify the circumstances requiring the change in a Tier One advice letter.[115]

C. ORA AND TURN/SCGC'S INTERPRETATION OF PSEP DECISIONS REGARDING SUBPART J IS NOT SUPPORTED

ORA contends that SoCalGas' interpretation of Subpart J is incorrect.[116] This position is based on the interpretation of Commission decisions and federal regulations that, in ORA's opinion, acknowledge the appropriateness and validity of pre-1970 pressure testing. In support of its position, ORA cites Commission language from D.15-12-010, which found that SoCalGas (and SDG&E, as applicable) shareholders are responsible for the cost of testing pipelines installed between 1956 and 1961 for which SoCalGas and SDG&E do not have a record of pressure test. The decision does not address pressure testing pre-1970 pipelines for which there *is* a record of a pressure test for purposes of compliance with "modern standards."

SoCalGas and SDG&E prepared the PSEP in response to the Commission's directive in D.11-06-017 that all California pipeline operators "must file and serve a proposed Natural Gas Transmission Pipeline Comprehensive Pressure Testing Implementation Plan (Implementation Plan) to comply with the requirement that all in-service natural gas transmission pipeline in California has been pressure tested in accord with 49 CFR 192.619, excluding subsection 49 CFR 192.619 (c)."[117] The Commission issued this order after concluding that "all natural gas transmission pipelines in service in California must be brought into compliance with modern standards for safety. Historic exemptions must come to an end with an orderly and cost-conscience implementation plan."[118]

In issuing this mandate, the Commission expressly found that pipeline operators should be required to replace or pressure test all pipelines not tested in accordance with federal regulations adopted in 1970:

> Natural gas transmission pipelines placed in service prior to 1970 were not required to be pressure tested, and were exempted from then-new federal regulations requiring such tests. These regulations allowed operators to operate a segment at

[115] Ex. SCG-15-R (Phillips) at RDP-A-56.

[116] Ex. ORA-03 (Stannik and Li) at 32.

[117] D.11-06-017 at 29 (Conclusion of Law No. 4) and at 31 (Ordering Paragraph No. 4).

[118] *Id*. at 18.

> the highest actual operating pressure of the segment during the five-year period between July 1, 1965 and June 30, 1970.[119]

> Natural gas transmission pipeline operators should be required to replace or pressure test all transmission pipeline *that has not been so tested*.[120]

TURN/SCGC argue that SoCalGas and SDG&E are not required to comply with these Commission directives and, on that basis, recommend the Commission make clear that Phase 2B of SoCalGas and SDG&E's PSEP need not be executed.[121] In making this recommendation, TURN/SCGC ignore the language in Commission decisions expressly mandating California pipeline operators to prepare and execute comprehensive plans to test or replace all pipeline segments that have not been tested in accordance with post-1970 federal pressure testing regulations. Instead, TURN/SCGC selectively quote from language in those same Commission decisions regarding when the costs of testing or replacing post-1955 pipe cannot be recovered in utility rates. Specifically, the witness for TURN/SCGC states, "the Applicants' interpretation of D.11-06-017 is clearly contradicted by Ordering Paragraph 3 of the same decision, which states: 'A pressure test record must include all elements required by the *regulations in effect when the test was conducted*. For pressure tests conducted prior to the effective date of General Order 112, one hour is the minimum acceptable duration for a pressure test.'"[122] TURN and SCGC's witness further states:

> In subsequent decisions, the Commission made it abundantly clear that the PSEP does not include pipeline segments for which the Applicants have a record of a pressure test that was required at the time the pipeline was constructed. In D.16-06-007, the Commission ordered that the costs of pressure tests "must be absorbed by the shareholders of SDG&E and SoCalGas in situations where the company has

[119] *Id*. at 28 (Finding of Fact No. 6).

[120] *Id*. at 28 (Finding of Fact No. 7) (emphasis added).

[121] Unexpectedly (because (a) TURN/SCGC and ORA agreed that this issue should be raised in Applicants' GRC [or a forecast application for PSEP], and accordingly SoCalGas raised this issue in this proceeding, and (b) this issue specifically is included in the Scoping Memorandum and Ruling as an item within the scope of this proceeding), on April 11, 2018 TURN and SCGC jointly filed a petition for modification of D.11-06-017 on just this issue. *See* Assigned Commissioner's Scoping Memorandum and Ruling at 4-5.

[122] Ex. TURN/SCGC-01 (Yap) at 49 (emphasis in original).

failed to maintain records of strength testing required at the time of installation of the pipeline."[123]

TURN/SCGC's witness again quotes language regarding disallowances as further support for her recommendation: "about eighteen months later, in D.15-12-020, the Commission said there should be a disallowance 'where pressure test records are not available that provide the minimum information to demonstrate compliance with the industry or regulatory strength testing and record keeping requirements then applicable....'"[124]

None of the language quoted by TURN/SCGC addresses the Commission's express mandate that all transmission pipelines in the State must be brought into compliance with 1970 pipeline regulations. It is that language that defines the scope of SoCalGas and SDG&E's PSEP, including Phase 2B. SoCalGas, and all California pipeline operators, must bring the State's transmission pipelines into compliance with modern standards and are required to pressure test or replace all transmission pipelines that have not been tested to post-1970 pressure test standards (i.e., "modern standards," or Subpart J).

If the Commission nevertheless determines that SoCalGas need not address Phase 2B of PSEP, SoCalGas requests that the Commission's ruling be applied prospectively,[125] and that certain Phase 2B work be permitted on a case-by-case basis depending on pipeline condition and project needs. For example, TURN/SCGC has determined that the approximately 2.8 miles[126] of Phase 2B work included in this Application are reasonable and were added to projects to reduce overall costs and enhance constructability.[127]

Moreover, SoCalGas requests that if the Commission determines that Phase 2B of PSEP should not be executed, the Commission should provide clearly that not all the documentation requirements set forth in Subpart J subsection 49 CFR 192.517 are required for pipelines constructed prior to the adoption of the federal regulation (although *a* record of a pressure test

[123] Ex. TURN/SCGC-01 (Yap) at 49.

[124] Ex. TURN/SCGC-01 (Yap) at 49.

[125] There are two proceedings (A.16-09-005 and A.17-03-021) pending in which Phase 2B miles are implicated. Decisions in those proceedings are expected this year (2018).

[126] Represents three-year (2019-2021) GRC total.

[127] Ex. TURN/SCGC-01 (Yap) at 50.

meeting then-applicable standards would still be required). SoCalGas interprets D.11-06-017 as requiring full compliance with Subpart J; therefore, it would be out of compliance if it does not have all of the documentation required by Subpart J but not by the earlier standards/guidelines. The following table summarizes SoCalGas' understanding of documentation requirements that were not required prior to adoption of 49 CFR 192:

Table RDP-11

Documentation Requirements - >20% Specified Minimum Yield Strength (SMYS)

	Pre-1955	**1955-1961**	**1961-1970 (GO 112)**	**Post 1970 (49 CFR 192 Subpart J)**
Test Duration	No	No	No	Yes
Record of Pressure Readings	No	No	No	Yes
Significant Elevation Changes	No	No	No	Yes
Disposition of Leaks and Failures	No	No	No	Yes

The Commission finding should state specifically that the documentation requirements of 49 CFR 192.169, excluding subsection 49 CFR 192.619 (c), are not required for tests conducted prior to the effective date of Subpart J in November 1970. As a result, pipelines with a record of a pre-1970 pressure test would not need to be re-tested to meet the documentation requirements of Subpart J.

V. CONCLUSION

To summarize, SoCalGas developed detailed cost estimates in support of the PSEP forecast in this Application. These forecasts necessarily include a risk assessment component that is appropriate and industry-accepted for the class of estimates developed. The Commission should approve the forecasts described in the Direct Testimony so SoCalGas can continue this important safety work, which began in 2012, to meet the Commission's directive to execute PSEP as soon as practicable while meeting SoCalGas' PSEP objectives to (1) enhance public safety; (2) comply with Commission directives; (3) minimize customer impacts; and (4) maximize the cost effectiveness of safety investments. Further, the Commission should approve

SoCalGas' request for two-way balancing account treatment as it provides assurance to customers that they will not pay more than the actual costs of completing these safety-related projects. SoCalGas' requests for project substitution and a pipeline failure allowance should be granted in their entirety. Finally, the Commission should clarify whether Phase 2B work is required to be executed as part of PSEP.

This concludes our prepared rebuttal testimony.

APPENDIX A

AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

Rev. November 29, 2011

Note: As AACE International Recommended Practices evolve over time, please refer to www.aacei.org for the latest revisions.

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COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

November 29, 2011

PURPOSE

As a recommended practice of AACE International, the *Cost Estimate Classification System* provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The *Cost Estimate Classification System* maps the phases and stages of project cost estimating together with a generic project scope definition maturity and quality matrix, which can be applied across a wide variety of process industries.

This addendum to the generic recommended practice (17R-97) provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the process industries. This addendum supplements the generic recommended practice by providing:

- a section that further defines classification concepts as they apply to the process industries; and
- a chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic recommended practice, an intent of this addendum is to improve communications among all of the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the process industries.

The overall purpose of this recommended practice is to provide the process industry definition deliverable maturity matrix which is not provided in 17R-97. It also provides an approximate representation of the relationship of specific design input data and design deliverable maturity to the estimate accuracy and methodology used to produce the cost estimate. The estimate accuracy range is driven by many other variables and risks, so the maturity and quality of the scope definition available at the time of the estimate is not the sole determinate of accuracy; risk analysis is required for that purpose.

This document is intended to provide a guideline, not a standard. It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for process industries that can be used as a basis to compare against. This addendum should allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

INTRODUCTION

For the purposes of this addendum, the term process industries is assumed to include firms involved with the manufacturing and production of chemicals, petrochemicals, and hydrocarbon processing. The common thread among these industries (for the purpose of estimate classification) is their reliance on process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs) as primary scope defining documents. These documents are key deliverables in determining the degree of project definition, and thus the extent and maturity of estimate input information.

Estimates for process facilities center on mechanical and chemical process equipment, and they have significant amounts of piping, instrumentation, and process controls involved. As such, this addendum may apply to portions of other industries, such as pharmaceutical, utility, metallurgical, converting, and similar industries. Specific addendums addressing these industries may be developed over time.

This addendum specifically does not address cost estimate classification in non-process industries such as commercial building construction, environmental remediation, transportation infrastructure, hydropower, "dry" processes such as assembly and manufacturing, "soft asset" production such as software development, and similar industries. It also does not specifically address estimates for the exploration, production, or transportation of mining or hydrocarbon materials, although it may apply to some of the intermediate processing steps in these systems.

The cost estimates covered by this addendum are for engineering, procurement, and construction (EPC) work only. It does not cover estimates for the products manufactured by the process facilities, or for research and development work in support of the process industries. This guideline does not cover the significant building construction that may be a part of process plants.

This guideline reflects generally-accepted cost engineering practices. This addendum was based upon the practices of a wide range of companies in the process industries from around the world, as well as published references and standards. Company and public standards were solicited and reviewed, and the practices were found to have significant commonalities. These classifications are also supported by empirical process industry research of systemic risks and their correlation with cost growth and schedule slip[8].

COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Notes: [a] The state of process technology, availability of applicable reference cost data, and many other risks affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

Table 1 – Cost Estimate Classification Matrix for Process Industries

Table 1 provides a summary of the characteristics of the five estimate classes. The maturity level of definition is the sole determining (i.e., primary) characteristic of Class. In Table 1, the maturity is roughly indicated by a % of complete definition; however, it is the maturity of the defining deliverables that is the determinant, not the percent. The specific deliverables, and their maturity, or status, are provided in Table 3. The other characteristics are secondary and are generally correlated with the maturity level of project definition deliverables, as discussed in the generic RP[1]. The characteristics are typical for the process industries but may vary from application to application.

This matrix and guideline outline an estimate classification system that is specific to the process industries. Refer to the generic estimate classification RP[1] for a general matrix that is non-industry specific, or to other addendums for guidelines that will provide more detailed information for application in other specific industries. These will provide additional information, particularly the project definition deliverable maturity matrix which determines the class in those particular industries.

Table 1 illustrates typical ranges of accuracy ranges that are associated with the process industries. Depending on the technical and project deliverables (and other variables) and risks associated with each estimate, the accuracy range for any particular estimate is expected to fall into the ranges identified (although extreme risks can lead to wider ranges).

In addition to the degree of project definition, estimate accuracy is also driven by other systemic risks such as:

- Level of non-familiar technology in the project.
- Complexity of the project.
- Quality of reference cost estimating data.
- Quality of assumptions used in preparing the estimate.
- Experience and skill level of the estimator.
- Estimating techniques employed.
- Time and level of effort budgeted to prepare the estimate.

Systemic risks such as these are often the primary driver of accuracy; however, project-specific risks (e.g. risk events) also drive the accuracy range[3].

Another way to look at the variability associated with estimate accuracy ranges is shown in Figure 1. Depending upon the technical complexity of the project, the availability of appropriate cost reference information, the degree of project definition, and the inclusion of appropriate contingency determination, a typical Class 5 estimate for a process industry project may have an accuracy range as broad as -50% to +100%, or as narrow as -20% to +30%.

Figure 1 also illustrates that the estimating accuracy ranges overlap the estimate classes. There are cases where a Class 5 estimate for a particular project may be as accurate as a Class 3 estimate for a different project. For example, similar accuracy ranges may occur for the Class 5 estimate of one project that is based on a repeat project with good cost history and data and the Class 3 estimate for another project involving new technology. It is for this reason that Table 1 provides ranges of accuracy range values. The accuracy range is determined through risk analysis of the specific project.

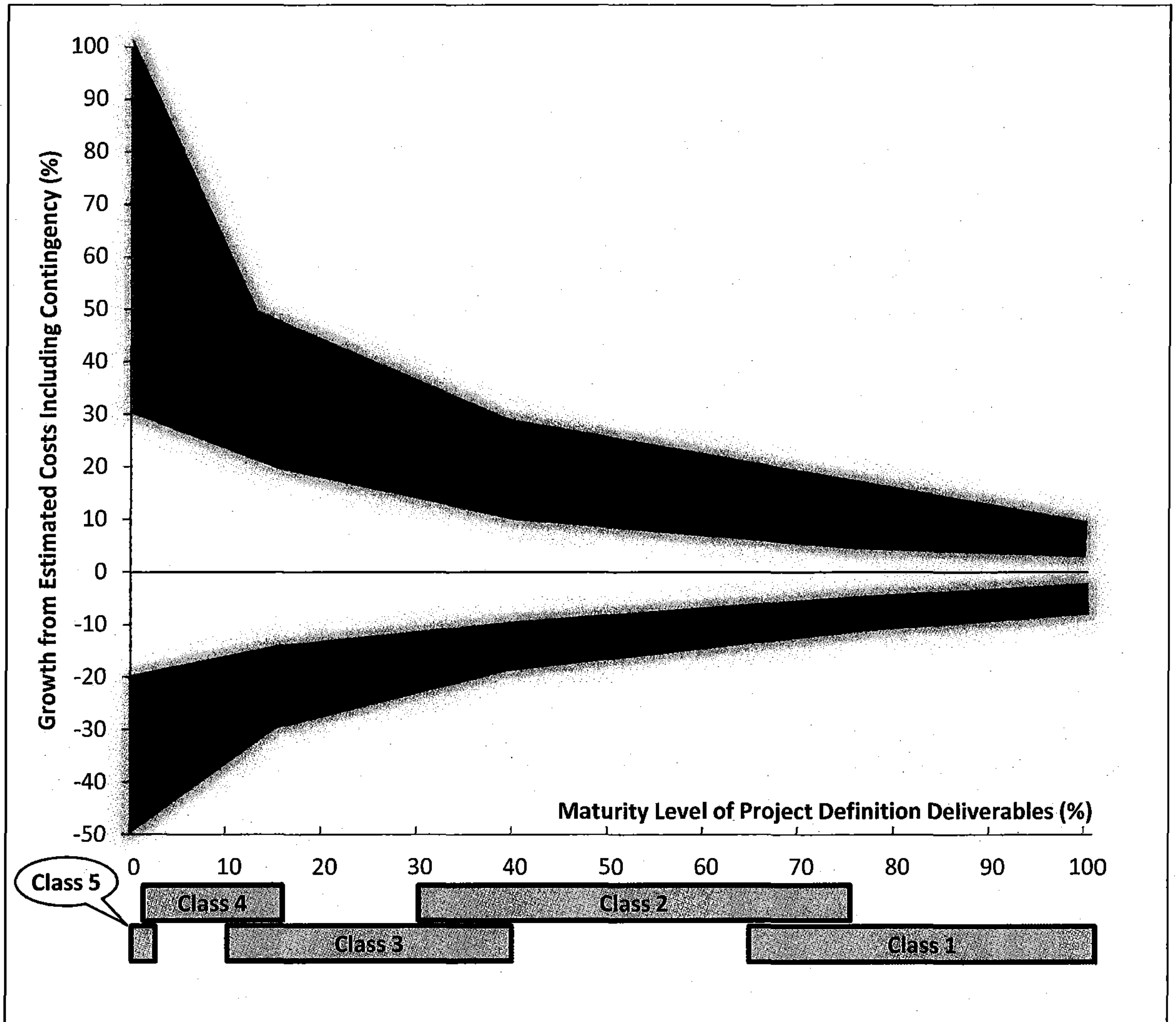

Figure 1 – Example of the Variability in Accuracy Ranges for a Process Industry Estimate

DETERMINATION OF THE COST ESTIMATE CLASS

The cost estimator makes the determination of the estimate class based upon the maturity level of project definition based on the status of specific key planning and design deliverables. The percent design completion may be correlated with the status, but the percentage should not be used as the Class determinate. While the determination of the status (and hence class) is somewhat subjective, having standards for the design input data, *completeness and quality of the design deliverables will serve to make the determination more objective.*

CHARACTERISTICS OF THE ESTIMATE CLASSES

The following tables (2a through 2e) provide detailed descriptions of the five estimate classifications as applied in the process industries. They are presented in the order of least-defined estimates to the most-defined estimates. These descriptions include brief discussions of each of the estimate characteristics that define an estimate class.

For each table, the following information is provided:

- **Description:** a short description of the class of estimate, including a brief listing of the expected estimate inputs based on the maturity level of project definition deliverables. The "minimum" inputs reflect the range of industry experience, but would not generally be recommended.
- **Maturity Level of Project Definition Deliverables (Primary Characteristic):** Describes a particularly key deliverable and a typical target status in stage-gate decision processes, plus an indication of approximate percent of full definition of project and technical deliverables. For the process industries, this correlates with the percent of engineering and design complete.
- **End Usage (Secondary Characteristic):** a short discussion of the possible end usage of this class of estimate.
- **Estimating Methodology (Secondary Characteristic):** a listing of the possible estimating methods that may be employed to develop an estimate of this class.
- **Expected Accuracy Range (Secondary Characteristic):** typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this represents about 80% confidence that the actual cost will fall within the bounds of the low and high ranges. The estimate confidence interval or accuracy range is driven by the reliability of the scope information available at the time of the estimate in addition to the other variables and risk identified above.
- **Alternate Estimate Names, Terms, Expressions, Synonyms:** this section provides other commonly used names that an estimate of this class might be known by. These alternate names are not endorsed by this Recommended Practice. The user is cautioned that an alternative name may not always be correlated with the class of estimate as identified in Tables 2a-2e.

CLASS 5 ESTIMATE	
Description: Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systematic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Block flow diagram agreed by key stakeholders. 0% to 2% of full project definition. **End Usage:** Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.	**Estimating Methodology:** Class 5 estimates generally use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb.

Table 2a – Class 5 Estimate

CLASS 4 ESTIMATE	
Description: Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Process flow diagrams (PFDs) issued for design. 1% to 15% of full project definition. **End Usage:** Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.	**Estimating Methodology:** Class 4 estimates generally use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Screening, top-down, feasibility (pre-feasibility for metals processes), authorization, factored, pre-design, pre-study.

Table 2b – Class 4 Estimate

CLASS 3 ESTIMATE	
Description: Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Piping and instrumentation diagrams (P&IDs) issued for design. 10% to 40% of full project definition. **End Usage:** Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase control estimates against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate is often the last estimate required and could very well form the only basis for cost/schedule control.	**Estimating Methodology:** Class 3 estimates generally involve more deterministic estimating methods than stochastic methods. They usually involve predominant use of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project. **Expected Accuracy Range:** Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, feasibility (for metals processes) development, basic engineering phase estimate, target estimate.

Table 2c – Class 3 Estimate

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CLASS 2 ESTIMATE	
Description: Class 2 estimates are generally prepared to form a detailed contractor control baseline (and update the owner control baseline) against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the bid estimate to establish contract value. Typically, engineering is from 30% to 75% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, piping and instrument diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: All specifications and datasheets complete including for instrumentation. 30% to 75% of full project definition. **End Usage:** Class 2 estimates are typically prepared as the detailed contractor control baseline (and update the owner control baseline) against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change management program.	**Estimating Methodology:** Class 2 estimates generally involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detail takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods. **Expected Accuracy Range:** Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.

Table 2d – Class 2 Estimate

CLASS 1 ESTIMATE	
Description: Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, overall engineering is from 65% to 100% complete (some parts or packages may be complete and others not), and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: All deliverables in the maturity matrix complete. 65% to 100% of full project definition. **End Usage:** Generally, owners and EPC contractors use Class 1 estimates to support their change management process. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution. Construction contractors may prepare Class 1 estimates to support their bidding and to act as their final control baseline against which all actual costs and resources will now be monitored for variations to their bid. During construction, Class 1 estimates may be prepared to support change management.	**Estimating Methodology:** Class 1 estimates generally involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities. **Expected Accuracy Range:** Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.

Table 2e – Class 1 Estimate

ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Table 3 maps the extent and maturity of estimate input information (deliverables) against the five estimate classification levels. This is a checklist of basic deliverables found in common practice in the process industries. The maturity level is an approximation of the completion status of the deliverable. The completion is indicated by the following letters.

- **None (blank):** development of the deliverable has not begun.
- **Started (S):** work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.
- **Preliminary (P):** work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.
- **Complete (C):** the deliverable has been reviewed and approved as appropriate.

	ESTIMATE CLASSIFICATION				
	CLASS 5	**CLASS 4**	**CLASS 3**	**CLASS 2**	**CLASS 1**
MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	**0% to 2%**	**1% to 15%**	**10% to 40%**	**30% to 75%**	**65% to 100%**
General Project Data:					
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S/P	C	C	C
Process Flow Diagrams (PFDs)		P	C	C	C
Utility Flow Diagrams (UFDs)		S/P	C	C	C
Piping & Instrument Diagrams (P&IDs)		S/P	C	C	C
Heat & Material Balances		S/P	C	C	C
Process Equipment List		S/P	C	C	C
Utility Equipment List		S/P	C	C	C
Electrical One-Line Drawings		S/P	C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	C	C	C
Spare Parts Listings			P	P	C
Mechanical Discipline Drawings			S/P	P/C	C
Electrical Discipline Drawings			S/P	P/C	C
Instrumentation/Control System Discipline Drawings			S/P	P/C	C
Civil/Structural/Site Discipline Drawings			S/P	P/C	C

Table 3 – Estimate Input Checklist and Maturity Matrix (Primary Classification Determinate)

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APPENDIX B

ORA PSEP Pressure Test Model Regression Results

```
lm(formula = cost_escalated ~ distance + diameter + duration,
    data = reg.data)

Residuals:
     Min       1Q   Median       3Q      Max
-4125280  -950439  -229953   635661 19018214

Coefficients:
             Estimate Std. Error t value  Pr(>|t|)
(Intercept) 529681.66  237023.72  2.2347   0.02603 *
distance    336551.27   35668.01  9.4357 < 2.2e-16 ***
diameter     54819.69    9176.73  5.9738 5.436e-09 ***
duration      3085.15     521.58  5.9150 7.543e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1825100 on 371 degrees of freedom
Multiple R-squared:  0.2812,  Adjusted R-squared:  0.27538
F-statistic: 48.378 on 3 and 371 DF,  p-value: < 2.22e-16
```

Augmented ORA PSEP Pressure Test Model Regression Results

```
lm(formula = cost_escalated ~ distance + diameter + duration +
    sempra.distance, data = reg.data)

Residuals:
     Min       1Q   Median       3Q      Max
-5571101  -888788  -215692   637770  7017458

Coefficients:
                  Estimate Std. Error t value  Pr(>|t|)
(Intercept)      809587.81  198824.73  4.0719 5.707e-05 ***
distance         239790.73   30684.55  7.8147 5.770e-14 ***
diameter          46158.72    7680.95  6.0095 4.459e-09 ***
duration           3131.12     434.88  7.2000 3.388e-12 ***
sempra.distance 1182289.68   92402.66 12.7950 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1521700 on 370 degrees of freedom
Multiple R-squared:  0.50168, Adjusted R-squared:  0.4963
F-statistic: 93.125 on 4 and 370 DF,  p-value: < 2.22e-16
```

PSEP Pressure Test Models Analysis Code
Program: R

```
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ OPTIONS, LOADING LIBRARIES @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# set working directory
getwd()

setwd("C:/Users/GDTeplow/Unsynced Files")

loadpath = getwd()


# set output options
options(width = 90, digits=8)
options(tibble.print_max = 1000, tibble.print_min = 200, tibble.width = Inf)
par(mfrow=c(1,1), mar=c(5.1, 4.1, 4.1, 2.1), mgp=c(3, 1, 0), las=0) # reset graphing options

# Setting up ggplot2 colors for use in plots
gg_color_hue <- function(n.col) {
  hues = seq(15, 375, length = n.col + 1)
  hcl(h = hues, l = 65, c = 100)[1:n.col]
}

n.cols=3 # Number of main colors that will be plotted
gg.cols = gg_color_hue(n.cols)

# Setting seed
set.seed(123)

# load required packages
library(tidyverse)
library(dplyr)
library(lubridate)
library(lmtest)
library(sandwich)
library(boot)
library(timeDate)
library(forecast)
library(leaps)
library(Metrics)
library(scales)
```

```
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ LOADING DATA @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# Importing the data
data.csv <- read.csv(paste(loadpath,"/GRC ORA PSEP Hydrotest Data.csv",sep=""),
                     quote="\"", header = TRUE, stringsAsFactors = FALSE, fileEncoding="UTF-8-BOM")
data <- as.data.frame(data.csv)
data$duration <- as.numeric(data$duration)


# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ PREPARING THE DATA @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# Creating utility dummies and factors
data$utility2 <- ifelse(data$utility == "SEMPRA", "sempra", "pge_swg")
data$sempra.dummy <- ifelse(data$utility2=="sempra",1,0)



# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ Hydrotest Cost Modeling @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# Creating the regression data frame
reg.data <- data %>%
  filter(status == "completed") %>%
  select(utility2, cost_escalated, cost_escalated, distance, diameter, duration, duration_adj,
sempra.dummy) %>%
  mutate(distance.2 = distance^2,
         sempra.distance = sempra.dummy * distance)


# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
# Replicating ORA's Model
reg1 <- lm(cost_escalated ~ distance + diameter + duration, data=reg.data)
summary(reg1)
glm.fit1 <- glm(cost_escalated ~ distance + diameter + duration, data=reg.data, family=gaussian)

# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
# ORA's Model With SCG/SDGE-Distance Interaction
reg2 <- lm(cost_escalated ~ distance + diameter + duration + sempra.distance, data=reg.data)
```

```
summary(reg2)
glm.fit2 <- glm(cost_escalated ~ distance + diameter + duration + sempra.distance,
                data=reg.data, family=gaussian)


#@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
# Cross-validation to calculate predictive R-squared

cost <- function(cost_escalated, fitted.values)
  1 - ( sum((cost_escalated-fitted.values)^2)/
  sum((cost_escalated-mean(cost_escalated))^2) )


cv.glm1.df <- as.data.frame(matrix(0,40,2))
for (i in 1:40){
  z <- cv.glm(reg.data, glm.fit1, cost, K=10)$delta
  cv.glm1.df[i,] <- z
  print(z)
  }

mean(cv.glm1.df[,2]) # Bias-corrected cross-validation


cv.glm2.df <- as.data.frame(matrix(0,40,2))
for (i in 1:40){
  z <- cv.glm(reg.data, glm.fit2, cost, K=10)$delta
  cv.glm2.df[i,] <- z
  print(z)
}

mean(cv.glm2.df[,2]) # Bias-corrected cross-validation



# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ Calculating the 80% Prediction Intervals @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

predict.data <- data %>%
  filter(status == "future") %>%
  select(proj_name, utility2, cost_escalated, distance, diameter, duration, duration_adj, sempra.dummy) %>%
  mutate(distance.2 = distance^2,
         sempra.distance = sempra.dummy * distance)
pred.int1 <- predict.lm(reg1, predict.data, level=0.80, interval="prediction")
pred.int2 <- predict.lm(reg2, predict.data, level=0.80, interval="prediction")
```

```
print(cbind(predict.data$proj_name, pred.int1))
print(cbind(predict.data$proj_name, pred.int2))




# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ Plotting Model Results @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# Plotting results of ORA Hydrotest cost model (regression #1)
#@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

# Creating plot data for ORA Model
plot.data1 <- reg.data
plot.data1$resids <- reg1$residuals
plot.data1$fits <- reg1$fitted.values
plot.data1 <- arrange(plot.data1, cost_escalated)

# Plotting the fits vs the actual project costs
ggplot(data=plot.data1, aes(x=seq(1,dim(plot.data1)[1],1), y=cost_escalated, color=gg.cols[1])) +
  geom_line(size=1) +
  geom_line(data=plot.data1, size=1, aes(x=seq(1,dim(plot.data1)[1],1), y=fits, color=gg.cols[3])) +
  scale_x_continuous(name="Index") +
  scale_y_continuous(label=comma, name="Cost ($)") +
  scale_color_manual(name="Series", labels=c("ORA Fitted Cost","Actual Cost"),
                     values=c(gg.cols[3], gg.cols[1])) +
  theme(axis.text.x = element_text(angle=90, vjust=0.5), panel.grid.minor = element_blank()) +
  labs(title="ORA Pressure Test Model: ORA Fitted Cost vs Actual Cost")


df <- data.frame(project.rank=c("Pressure Test Projects 1 to 265", "Pressure Test Projects 266 to 375"),
                 fcast.error=c(-round(mean(reg1$residuals[1:265]),0),
                               -round(mean(reg1$residuals[266:375]),0)))

ggplot(data=df, aes(x=project.rank, y=fcast.error, fill=project.rank)) +
  geom_bar(stat="identity") +
  geom_hline(yintercept=0) +
  scale_fill_manual(values=c("blue", "red")) +
  scale_x_discrete(name="Project Rank") +
  scale_y_continuous(label=comma, name="Cost ($)") +
  labs(title="ORA Pressure Test Model: Average Error") +
  geom_text(aes(label=comma(fcast.error)), vjust=c(1.6, -0.8), color="white", size=3.5, fontface="bold") +
  theme(legend.position="none")
```

ORA PSEP Pipeline Replacement Model Regression Results

```
lm(formula = cost_trans ~ distance + diameter + duration + distance.2,
    data = reg.data)

Residuals:
     Min       1Q   Median       3Q      Max
-876.134  -74.019   -1.443   83.940  791.720

Coefficients:
              Estimate Std. Error t value  Pr(>|t|)
(Intercept) 138.784986  26.094237  5.3186 3.043e-07 ***
distance    337.916153  23.276219 14.5177 < 2.2e-16 ***
diameter     14.608506   1.772078  8.2437 3.225e-14 ***
duration      0.288236   0.069637  4.1391 5.325e-05 ***
distance.2  -24.933759   2.931699 -8.5049 6.508e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 181.31 on 182 degrees of freedom
Multiple R-squared:  0.77963, Adjusted R-squared:  0.77479
F-statistic: 160.97 on 4 and 182 DF,  p-value: < 2.22e-16
```

Augmented ORA PSEP Pipeline Replacement Model Regression Results

```
lm(formula = cost_trans ~ distance + diameter + duration + distance.2 +
    sempra.duration, data = reg.data)

Residuals:
     Min       1Q   Median       3Q      Max
-882.906  -85.437   -0.420   93.249  796.621

Coefficients:
                 Estimate Std. Error t value  Pr(>|t|)
(Intercept)     134.76294   25.96456  5.1903 5.602e-07 ***
distance        343.07920   23.23582 14.7651 < 2.2e-16 ***
diameter         14.19637    1.77010  8.0201 1.275e-13 ***
duration          0.27859    0.06925  4.0230 8.432e-05 ***
distance.2      -25.35381    2.91592 -8.6949 2.062e-15 ***
sempra.duration   0.49607    0.24970  1.9867   0.04847 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 179.86 on 181 degrees of freedom
Multiple R-squared:  0.78433, Adjusted R-squared:  0.77838
F-statistic: 131.65 on 5 and 181 DF,  p-value: < 2.22e-16
```

PSEP Pipeline Replacement Models Analysis Code
Program: R

```
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ OPTIONS, LOADING LIBRARIES @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# set working directory
getwd()

setwd("C:/Users/GDTeplow/Unsynced Files")

loadpath = getwd()


# set output options
options(width = 90, digits=8)
options(tibble.print_max = 1000, tibble.print_min = 200, tibble.width = Inf)
par(mfrow=c(1,1), mar=c(5.1, 4.1, 4.1, 2.1), mgp=c(3, 1, 0), las=0) # reset graphing options

# Setting up ggplot2 colors for use in my plots
gg_color_hue <- function(n.col) {
  hues = seq(15, 375, length = n.col + 1)
  hcl(h = hues, l = 65, c = 100)[1:n.col]
}

n.cols=3 # Number of main colors that will be plotted
gg.cols = gg_color_hue(n.cols)

# Setting seed
set.seed(123)

# load required packages
library(tidyverse)
library(dplyr)
library(lubridate)
library(lmtest)
library(sandwich)
library(boot)
library(timeDate)
library(forecast)
library(leaps)
library(Metrics)
library(scales)

# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ LOADING DATA @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# Importing the data
```

```
data.csv <- read.csv(paste(loadpath,"/GRC ORA PSEP Replacement Data.csv",sep=""),
                     quote="\"", header = TRUE, stringsAsFactors = FALSE, fileEncoding="UTF-8-BOM")
sapply(data.csv, class)
data <- as.data.frame(data.csv)
data$duration <- as.numeric(data$duration)
sapply(data, class)


# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ PREPARING THE DATA @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# Creating ORA's transformed cost variable
data$cost_trans <- data$cost_escalated^(0.42)
data$utility2 <- ifelse(data$utility == "SEMPRA", "sempra", "pge_swg")
data$sempra.dummy <- ifelse(data$utility2=="sempra",1,0)


# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ Replacement Cost Modeling @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# Creating the regression data frame
reg.data <- data %>%
  filter(status == "completed") %>%
  select(utility2, cost_escalated, cost_trans, distance, diameter, duration, duration_adj, sempra.dummy) %>%
  mutate(distance.2 = distance^2,
         sempra.duration = sempra.dummy * duration)



# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
# Replicating ORA's Model
reg1 <- lm(cost_trans ~ distance + diameter + duration + distance.2, data=reg.data)
summary(reg1)

glm.fit1 <- glm(cost_trans ~ distance + diameter + duration + distance.2, data=reg.data, family=gaussian)



# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
# ORA's Model With Sempra-Duration Interaction
reg4 <- lm(cost_trans ~ distance + diameter + duration + distance.2 + sempra.duration, data=reg.data)
summary(reg4)

glm.fit4 <- glm(cost_trans ~ distance + diameter + duration + distance.2 + sempra.duration,
                data=reg.data, family=gaussian)


#@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
# Cross-validation to calculate predictive R-squared
```

```
cv.glm1.df <- as.data.frame(matrix(0,40,2))
for (i in 1:40){
  z <- cv.glm(reg.data, glm.fit1, cost, K=10)$delta
  cv.glm1.df[i,] <- z
  print(z)
}
mean(cv.glm1.df[,2])


cv.glm4.df <- as.data.frame(matrix(0,40,2))
for (i in 1:40){
  z <- cv.glm(reg.data, glm.fit4, cost, K=10)$delta
  cv.glm4.df[i,] <- z
  print(z)
}
mean(cv.glm4.df[,2])


# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ Calculating the 80% Prediction Intervals @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

predict.data <- data %>%
  filter(status == "future") %>%
  select(proj_name, utility2, cost_trans, distance, diameter, duration, sempra.dummy) %>%
  mutate(distance.2 = distance^2,
         sempra.duration = sempra.dummy * duration)

pred.int1 <- (predict.lm(reg1, predict.data, level=0.80, interval="prediction"))^(1/0.42)
pred.int4 <- (predict.lm(reg4, predict.data, level=0.80, interval="prediction"))^(1/0.42)

cbind(predict.data$proj_name, pred.int1)
cbind(predict.data$proj_name, pred.int4)


# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #
# @@@@@@@@@@ Plotting Model Results @@@@@@@@@@ #
# @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ #

# Plotting results of ORA replacement cost model (regression #1)
#@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

# Creating plot data for ORA Model
plot.data1 <- reg.data
plot.data1$resids <- reg1$residuals
plot.data1$fits_trans <- reg1$fitted.values
plot.data1$fits <- (reg1$fitted.values)^(1/0.42)
plot.data1 <- arrange(plot.data1, cost_trans)
```

```
ggplot(data=plot.data1, aes(x=seq(1,187,1), y=cost_escalated, color=gg.cols[1])) +
  geom_line(size=1) +
  #geom_point(size=2) +
  #geom_hline(yintercept=xint, linetype="dashed", color="red") +
  geom_line(data=plot.data1, size=1, aes(x=seq(1,187,1), y=fits, color=gg.cols[3])) +
  #geom_point(size=3, aes(x=seq(1,187,1), y=fits, color=gg.cols[3])) +
  scale_x_continuous(name="Index") +
  scale_y_continuous(label=comma, name="Cost ($)") +
  scale_color_manual(name="Series", labels=c("ORA Fitted Cost","Actual Cost"),
                     values=c(gg.cols[3], gg.cols[1])) +
  theme(axis.text.x = element_text(angle=90, vjust=0.5), panel.grid.minor = element_blank()) +
  #theme(legend.position="none") +
  labs(title="ORA Replacement Model: ORA Fitted Cost vs Actual Cost")


df <-
  data.frame(project.rank=c("Replacement Projects 1 to 112", "Replacement Projects 113 to 187"),
             # fcast.error=c(format(-mean(reg1$residuals[1:265]),digits=6, nsmall=0, big.mark=","),
             # format(-mean(reg1$residuals[266:365]),digits=6, nsmall=0, big.mark=",")))
             fcast.error=c(-round(mean( plot.data1$cost_escalated[1:112] - plot.data1$fits[1:112] ),0),
                           -round(mean( plot.data1$cost_escalated[113:187] - plot.data1$fits[113:187] ),0)))
ggplot(data=df, aes(x=project.rank, y=fcast.error, fill=project.rank)) +
  geom_bar(stat="identity") +
  geom_hline(yintercept=0) +
  scale_fill_manual(values=c("blue", "red")) +
  scale_x_discrete(name="Project Rank") +
  scale_y_continuous(label=comma, name="Cost ($)") +
  labs(title="ORA Replacement Model: Average Error") +
  geom_text(aes(label=comma(fcast.error)), vjust=c(1.6, -0.8), color="white", size=3.5, fontface="bold") +
  theme(legend.position="none")
```

APPENDIX C

Workpaper Table 5-12
Pacific Gas and Electric Company
2019 Gas Transmission and Storage Rate Case
Workpapers Supporting Chapter 5, Asset Family - Transmission Pipe
Hydrostatic Testing for D.11-06-017 Forecast Calculation, MATs JTC and 34A

Line No.				
1	MAT JTC and 34A - Hydrotesting under D.11-06-017			
2	YEAR	Forecast 2016 Base $, NCM	Escalation Factor	Forecast ($, NCM)
3	2019	$70,318,959	1.069	$75,199,095

Line No.				
4	MAT JTC - Hydrotesting under D.11-06-017			
5	YEAR	Forecast 2016 Base $, NCM	Escalation Factor	JTC Forecast ($, NCM)
6	2019	$69,088,015	1.069	$73,882,723

Line No.				
7	MAT 34A (StanPac) - Hydrotesting under D.11-06-017			
8	YEAR	6/7th Forecast 2016 Base $, NCM	Escalation Factor	34A Forecast ($, NCM)
9	2019	$1,230,945	1.069	$1,316,372

Line No.				
10	Calculation of Annual Forecast Including Application of Disallowance			
11		JTC Forecast (2016 Base $, NCM)	34A (StanPac) Forecast (2016 Base $, NCM)	34A - 6/7th Forecast (2016 Base $, NCM)
12	2019-2021 Program Forecast	$ 271,057,568	$ 5,634,354	N/A
13	2019-2021 Annual Average	$ 90,352,523	$ 1,878,118	N/A
14	2019-2021 Disallowance %	24%	24%	N/A
15	2019-2021 Annual Disallowance	$ 21,264,508	$ 442,016	N/A
16	**2019-2021 Allowance**	**$ 69,088,015**	**$ 1,436,102**	**$ 1,230,945**

Line No.							
17	NTSB pipe in 4 years, and extend total program by one more year, completion in ~2026						
18	Summary of Miles and Forecast, Unescalated $ to Complete Hydrostatic Testing of Pipe under D.11-06-017						
19		2019-2021		Post Rate Case		Total Program	
20	Category	Miles [(a)]	2016 $, NCM	Miles [(a)]	2016 $, NCM	Miles [(a)]	2016 $, NCM
21	NTSB Targeted Tests	97.95	$ 248,230,182	20.28	$ 87,681,383	118.22	$ 335,911,565
22	Non-NTSB with ILI Overlap	11.75	$ 26,114,482	15.56	$ 13,935,438	27.31	$ 40,049,920
23	Non-NTSB Pipe	0.66	$ 2,347,257	176.41	$ 299,668,991	177.07	$ 302,016,248
24	**Totals:**	**110.35**	**$ 276,691,922**	**212.25**	**$ 401,285,811**	**322.60**	**$ 677,977,733**

Line No.				
25	Post 1955 Disallowance Analysis			
26	2019-2026 - Remaining Miles Under D.11-06-017 (Hydrotesting and Replacements)			
27	Install Year	Miles [(a)]	%	Allowance
28	**Post 1/1/1956**	76.21	24%	Disallowed
29	**Pre 1/1/1956**	247.60	76%	Allowed
30	Total:	323.81	100%	N/A

31 (a) Source of Miles: D.11-06-017 Remaining Scope of Work (Hydrotests/Replacements in lieu of hydrotests) Workpaper.

APPENDIX D

TABLE 5-15
POST-1955 EXPENDITURES ALREADY REMOVED FROM FORECAST IN 2019
(MILLIONS OF DOLLARS)

Line No.	D.11-06-017 Sub-Program	Removed From Forecast
1	Hydrostatic Testing	$23.2
2	Expense Replacement in Lieu of Hydrostatic Testing	$4.1
3	Capital Replacement in Lieu of Hydrostatic Testing	$8.1

2) TIMP Pressure Tests

PG&E's forecast for TIMP Pressure Tests is based on application of the hydrostatic testing cost calculator to a list of forecast projects for the rate case period.

a) LNG/CNG to Support Hydrostatic Testing

PG&E's LNG/CNG expense forecast was computed using an average historical annual program cost, based on costs between 2014 and 2016.

PG&E's LNG/CNG capital forecast was computed from estimated costs for replacing capital LNG/CNG equipment, additions of equipment, and for required emission reduction equipment needed during the rate case period.

d. Expenditure Tables

Table 5-16 provides a summary of expenses and Table 5-17 provides a summary of capital expenditures associated with the Hydrostatic Testing Program from 2016 through 2021.

TABLE 5-16
SUMMARY OF EXPENSES
(THOUSANDS OF NOMINAL DOLLARS)

Line No.	Description	MAT	2016 Recorded	2017 Forecast	2018 Forecast	2019 Forecast
1	Hydrostatic Testing (D.11-06-017)	JTC,34A	$54,100	$127,175	$154,166	$75,199
2	Replace in Lieu of Hydrotest	JT6	137	100	600	13,446
3	TIMP Pressure Tests	HPF, 34A	79,463	16,896	21,038	64,282
4	LNG/CNG	GMD	2,315	2,300	2,058	2,775
5	Total Expenses		$136,016	$146,471	$177,861	$155,702

TABLE 5-17
SUMMARY OF CAPITAL EXPENDITURES
(THOUSANDS OF NOMINAL DOLLARS)

Line No.	Description	MAT	2016 Recorded	2017 Forecast	2018 Forecast	2019 Forecast	2020 Forecast	2021 Forecast
1	Hydrostatic Testing Capital	75N, 44A	$40, 068	$25,781	$27,377	$19,853	$20,477	$21,079
2	Replace in Lieu of Hydrotest	75R, 75Q	41,118	23,547	6,762	26,393	27,223	28,023
3	LNG/CNG	73D	3,100	3,966	4,705	3,651	3,766	3,877
4	Total Capital Expenditures		$84,285	$53,294	$38,843	$49,897	$51,465	$52,978

4. Pipe Replacements

This program addresses pipe replacements specific to: (1) Vintage Pipe Replacement Program; and (2) pipe replacement for other pipeline safety and reliability purposes.

Vintage Pipe Replacement

Approximately 47 percent of PG&E's gas transmission pipelines were designed, manufactured, constructed, and installed before the advent of California pipeline safety laws in 1961. While age alone does not pose a threat to pipeline integrity, age does play a role because of the type of vintage manufacturing and construction practices that were acceptable at that time.[37] PG&E considers "vintage pipe" to include pipe manufactured or constructed and fabricated using certain historic practices that are no longer being used today. Historic manufacturing methods include pipe made with: flash welds; low frequency ERW seam; single submerged arc welded seams; or furnace lap welded seams. Historic fabrication and construction methods include pipe that was installed using: wrinkle bends; mechanical/compression couplings; miter bends and other non-standard fittings like orange peel reducers; chill ring welds; bell and spigot; pipe that was constructed with the acetylene girth welding process; and branch connections made with unsupported saddle connections.

37 This is supported by the report, "The Role of Age in Pipeline Safety," prepared for the INGAA Foundation, Inc., by John F. Kiefner and Michael J. Rosenfeld, November 8, 2012, Report No 2012.04, which concluded that 85 percent of incidents occurred irrespective of a pipeline's age, with 15 percent related in some way to the age of the pipeline.

APPENDIX E

RISK.08

Defining Risk and Contingency for Pipeline Projects

F. Cristina Figueiredo, P.Eng. and Brent Kitson, P.Eng.

ABSTRACT— Pipeline projects are linear projects that often stretch over several communities, states, provinces or even countries. Local economic conditions will impact the cost of the project and can vary by location. Pipeline projects will be impacted by economic volatility. Alberta is an example of an economy that has experienced an unprecedented rate of escalation in the labor market in recent years. Large pipeline projects are impacted by global economic conditions. Components such as steel for pipe and pipe fabrication are impacted by the global market. The scoping and execution of pipeline projects require the input and coordination of numerous internal stakeholders, customers, regulatory bodies, resources and public bodies. Identifying risk and determining an appropriate amount of contingency is a challenge that must be addressed to ensure accurate information is available to base critical financial decisions upon. This paper will address processes to define risk and contingency for pipeline projects. Some of the typical risks associated with pipeline projects will be discussed.

Keywords: Contingency, cost, financial, labor, pipeline projects, risk and scope

The planning and execution phases of a pipeline project require the involvement and coordination of numerous internal stakeholders, and external stakeholders including customers, public and private regulatory bodies, and resources. The identification of the risks involved in such projects is essential to ensure accurate information is available to base critical financial decisions as well as to minimize exposure to potential adverse impacts. During the pipeline project lifecycle, risk shall be managed in a continuous, consistent, structured and standardized approach.

Risk is the exposure to the potential impacts of a possible event. The potential impact may be positive or negative. A possible event causing negative effects is a "threat", while a possible event causing positive effects is an "opportunity."

The possibility of occurrence of an event depends on how likely it is to happen. Risk level is described by the mathematical product of the probability for an event to occur, multiplied by the expected magnitude of impacts caused by the event. The conceptual formula to assess risk level is: RL = P x I, where, RL = Risk Level, P = Probability and I = Impact. When impact is evaluated in financial terms, impact is equal the estimated monetary value of the damages (threat), or the estimated monetary value of the benefits (opportunity). Risk can be mitigated by reducing or eliminating either the probability of occurrence or the impact if the event occurs.

In pipeline projects, risk impacts are evaluated in the five following main areas: cost, duration, scope, health, safety and environment.

This paper will present the risk management (RM) process that has been developed by a pipeline company committed to an ongoing process improvement to align with best practice industry standards and recommended practices.

Risk Management Overview

Risk management is an integral component of good management and decision-making at all levels. As per definition, risk management is a systematic approach to setting the best course of action under uncertainty by identifying, assessing, understanding, acting on and communicating risk issues, i.e., risk management (RM) is a process that addresses uncertainty [5, 6].

A successful risk management (RM) system is comprised of the risk policy, the company ownership of the process, the integration of the company values to manage risk, the risk management process and the risk management standard framework.

For instance, a RM process used by a pipeline company presents five core interdependent sub-processes:

- **Planning:** How to implement and practice the RM process and framework elements.
- **Identification:** Procedures and methods to identify, describe, and document risk.
- **Assessment:** Qualitative or quantitative risk level assessment and prioritization.
- **Response:** Create and execute mitigation actions, or monitoring and control strategies. And,
- **Monitoring and Control:** Monitor current risk, new risk, evaluate RM effectiveness, follow up on response plan status, check control points, identify and close gaps.

The risk management process map in figure 1 shows further details of a RM standard framework of a pipeline company.

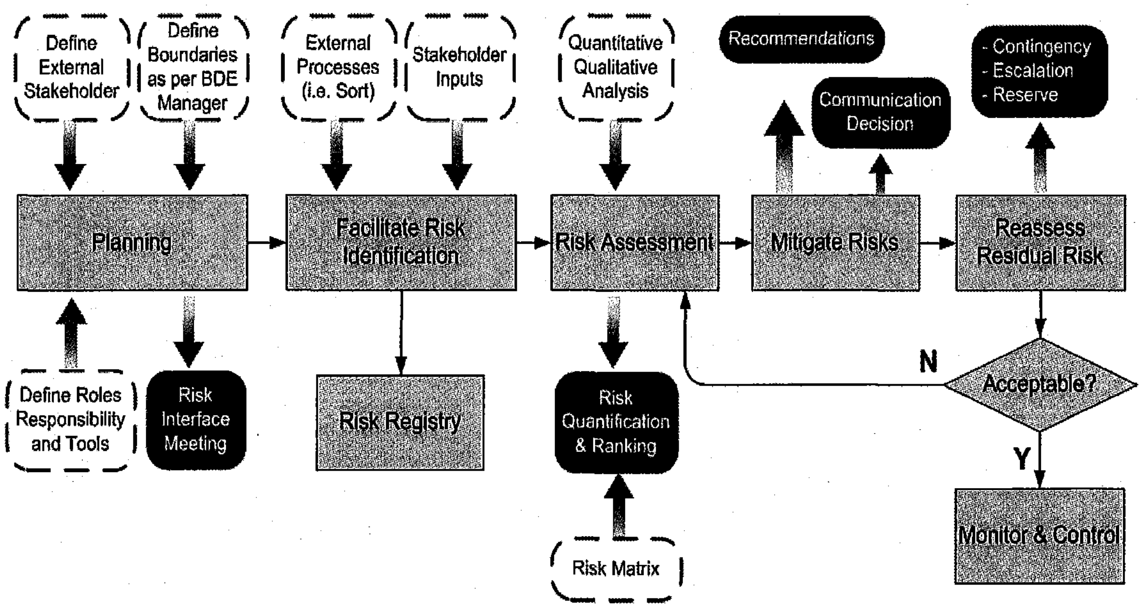

Figure 1—Risk Management Process of a Pipeline Company

Risk Implementation Plan

The risk implementation plan defines how to implement and practice the RM process and framework elements. It documents how a specific project team is to strategically implement and practice the risk management framework.

The risk implementation plan will start defining a boundary of control (i.e., the risk management roles and responsibilities of project members), indentifying and engaging stakeholders, functional leads, risk owners, subject-matter experts and communicating of the methodology, boundary and focus area for risk identification. It is important to be aware of the relevant risk areas of the project that needs to be discussed versus the irrelevant ones. Also, the risk implementation plan shall identify and engage a suitable facilitator to run risk identification sessions.

The main output of the "risk implementation plan" is the risk interface meeting which reviews the risk implementation plan inputs described above.

Table 1 shows some specific examples of pipeline project risk areas:

RISK AREAS	EXTENDED DESCRIPTION
COMMERCIAL	Commercial contracts,
COMMISSIONING	Commissioning, start up, equipment set up, FAT
COMMUNITY	Community, aboriginal affairs, local communities, associations
COMPLIANCE	Compliance, regulations
CONSTRUCTION	Construction, construction strategy, logistics
CORPORATE	Corporate, AFE, stake-holders, company approvals
ENGINEERING	Engineering, design, scope, process engineering, reliability, equipment performance envelop, maintainability, safety requirements
ENVIRONMENTAL	External environment, snow, seasons, weather, flora, wild Life, lakes, rivers, above ground level risk.
ESTIMATING	Base cost estimation, indirect and direct cost, assumed productivity base
FINANCIAL	Foreign exchange, discounted cash flow, ROE (Return on Equity)
GEOLOGY	Soil, terrain characteristics, geology, topography, below ground level risk
LEGAL	Legal, contracts, litigation,
MARKET	Price indices, currency, inflation, market competition
OPERATIONS	Operations interface, transfer to operations
PERMITS	Environmental permits, other official agencies permits
PM	Project management, gates, deliverables, scope definition, schedule, risk plans, practices and standards, training, etc
PROCUREMENT	Procurement, procurement strategy, lead time, shipping, delivery,
RESOURCES	Resources, labor, trades, skilled resources, contracts
RIGHT OF WAY	Right of way, access, condemnation, acquisitions
UTILITIES	Power, utilities infrastructure

Table 1—Risk Areas

Risk Identification

The risk identification process starts with a clear definition of the core project objectives. Core project objectives can be outlined as scope, schedule, cost, safety and environment. It is important to identify the project components that are more relevant or influential to the core project objectives i.e. to focus on project critical components (criticality assessment).

The risk identification process benefits from inputs (tools) like brainstorming sessions, checklists, review of historical records for other similar projects, stakeholders discussions (i.e., gathering all stakeholder inputs in relevant areas), collecting other risk analysis completed (i.e. system operability review, HAZOP), strengths, weaknesses, opportunities, and threats (SWOT) analysis, collecting historical information available (i.e., risk incident root cause reports), cold eyes reviews, project execution plan, and execution strategies repot.

The main output of the risk identification process is a "risk register." The risk register is the central repository for risk information of the project. It supports most of the phases of the RM standard framework. The risk register contains the risk ID, probabilities, estimated cost impacts (low, likely, high), and its categorization (systemic, project specific, escalation and others). Figure 2 shows an example of a simplified risk register.

Risk ID	Description of Risk	Probability ((VL,L,M,H,VH))	Description of Impact		Cost Impact	Schedule Impact	Mitigation Strategy
1	Construction delayed due to permits not yet approved.	L	Affect construction schedule	Low: $	13,000.00	Yes	Enough lead time has been allowed for in the schedule to ensure permits are in place. Off site fabrication could begin if permits are delayed. Cost impact should be low due to construction cannot actually start before permits are obtained. These costs are therefore more project extension delays.
				Likely: $	13,000.00		
				High: $	48,000.00		

Figure 2 – Example of a Simplified Risk Register

Identifying Systemic and Project Specific Risks

Risk management practices define systemic and project specific risks as different categories of risks. To identify systemic risks, it is important to understand their stochastic nature. It is known that the level of uncertainties in a project is inversely correlated to the level of definition of project scope, schedule and cost estimate. Even when scope is completely defined, uncertainties in cost and schedule will always exist considering the fact that the project may be impacted by factors that may not be predicted precisely such as, weather, trade skill levels, contractor project management effectiveness, price indexes, inflation, labor conflicts, community interaction, etc. Systemic risks can be identified as the drivers of project uncertainty that affects the generality of the project (i.e., they can be analyzed statistically but not predicted precisely (stochastic in nature)).

Project specific risks are driven by events or cause conditions that upon being realized in a project, produce a significant impact in a specific project activity, or resource or project component. Project-specific risk drivers result in cost impacts that are more deterministic in nature, meaning the impact to a given schedule task or cost account is more readily identifiable. Table 2 shows some examples of systemic and project specific risks of a pipeline project.

Systemic Risk Drivers	Project Specific Risk Drivers
Commercial Project Scope Project Planning /Execution Plan Overall Scope Definition Engineering Deliverables	Heater scope change due to Hazop fidings Underestimated permit processing time Facilities engineering packages late Solvent system requires vapor recovery system
Estimate Inclusiveness Estimating Data Quality Estimate Competitiveness Percent Fixed Price Prject Management Effectiveness Poor definition of rules and responsibilities	Water from hydro testing requires cleaning before disposal Incentives program missed / difficulty finding enough labor force Inexperienced project manager Underestimated steel proce
New Technology Material Properties Facility Complexity Project Execution Complexity	HDD takes longer due to geotechnical problems Critical path commiioning materials late Site congestion at pinch points Equipment failure during commisssioning, no spares available

Table 2—Systemic vs. Project Specific Risks

Risk Assessment

Once risk has been identified, the following step in the RM process is the assessment of its risk level, determination of acceptability, prioritization and definition of a target date to respond to it. The risk assessment process analyses the quantitative and qualitative information of the risk description, probabilities and impacts (low, likely, high).

Best practice historical data shows that projects that use no risk assessment experience an increase in variable cost growth, the execution schedule can become longer, they may experience start up problems, and technical problems are more likely to arise.

Risk level assessment starts with the quantification and ranking of probability and potential impacts that a risk event may originate. Probability is assessed based on information of the cause and conditions that may trigger events that originate risk drivers. Qualitative evaluation of probability or impact is based on experience and requires engagement of subject matter experts. In qualitative analysis, probability and impact are estimated within a range, the probability and impact range are related to the risk tolerance criteria managed by the company. For instance, the pipeline company cited in this paper uses probability and impact table containing 5 ranges: very low (VL), low (L), medium (M), high (H) and very high (VH).

Impact is estimated independently for each of the five main areas (cost, duration, scope, health, safety and environment). During risk-analysis sessions, estimation of impacts is not practical and may not result in a precise figure. While some impacts can be estimated without difficulty in units of cost, others, such as safety and environment, are better estimated in terms of the qualitative magnitudes of the impact. The principal of using thresholds in the impact categories is to rank them on the basis of their impact on project objectives. Schedule in and of itself has no commonality between projects in terms of its relative importance or rank. All schedule impacts should be translated to cost impact as the primary ranking criteria. There are a few exceptions, such as when it is a distinct objective set by business or an agreement with client regardless of costs. For instance, if the project slips 3 months or more, company members would be fired by board, project would be terminated by the client, or the company's reputation may be tarnished in the public eye. In all other cases, schedule shall be converted to costs, using case specific estimation. The team must first establish the project specific criteria, i.e. what the "show stopper" criteria is for the project in terms of duration (e.g., 3 months slip means project fails to meet objective). So, it can be easily converted to percent of total duration.

Table 3 shows a risk Probability – impact table, one of the most popular risk management tools. A risk assessed as highly likely to happen and as having a high impact on the project will need closer attention than a risk that is low in terms of both probability and impact. Each risk can be allocated to one of the cells in table 3.

Risk Probability and Impact			
	Low Impact	**Medium Impact**	**High Impact**
High Probability			
Medium Probability			
Low Probability			

Table 3—Risk Probability – Impact Table

Contingency Determination Process

Contingency is a cost element of an estimate to cover the probability of unforeseeable events to occur and that if they occur, they will likely result in additional costs within the defined project scope [1].

Estimating contingency is one part of the risk management process. Many methods and techniques have been proposed in the literature for estimate contingency. They are mainly risk analysis techniques. The best contingency estimating method depends on the type of risk.

Systemic risks are driven by risks that all projects face and the risk impact on most projects for a given company "system" are relatively consistent and predictable. The recommended practice to estimate a systemic risk is to use a parametric modeling [3].

The pipeline company herein cited has developed a systemic and a project specific risk tool to calculate contingency. The systemic tool uses a parametric model. It is basically a questionnaire where the team rates the status of the risk drivers in 5 categories: Level of project scope definition (i.e., scope content, planning basis, design detail, site definition, etc); Estimate basis (quality of database, conservativeness, inclusiveness, extent of fixed costs and equipment, etc); Process technology/complexity (use of new technology, qualities of feedstocks, number of process steps, etc.);Project complexity (use of new organization or execution strategies, etc.);Project management (level of management and control discipline).

The systemic risk tool is typically used alone to calculate contingency for class 5 estimates. In the early stages of the project lifecycle (i.e. screening and planning stages), scope definition, technology, and complexity risks dominate the cost outcome. The systemic risk tool will translate quantified risks into a cost distribution with the main purpose of estimating the overall capital cost of a project within a probabilistic expectation of finishing the project within a target cost (usually the P50-P55).

Project specific risks are those that are unique to a particular project's scope, strategies, attributes, and so on. The nature of these risks and extent of their impact are not consistent between projects in a given company. For these risks, risk impact must be defined and estimated uniquely. Thus, to estimate project specific risks, the recommended practice is to use "expected value model" [4]. The pipeline company herein cited has developed a project specific risk tool that together with the systemic risk tool calculates contingency for class 4 and 3 estimates. The project specific tool uses an "expected value" model, i.e., cost impact of each risk driver is explicit in an expected-value cost model. This tool requires that Monte-Carlo simulation be run to obtain the final cost distribution. The contingency determination process used by the pipeline company herein cited is shown in figure 3.

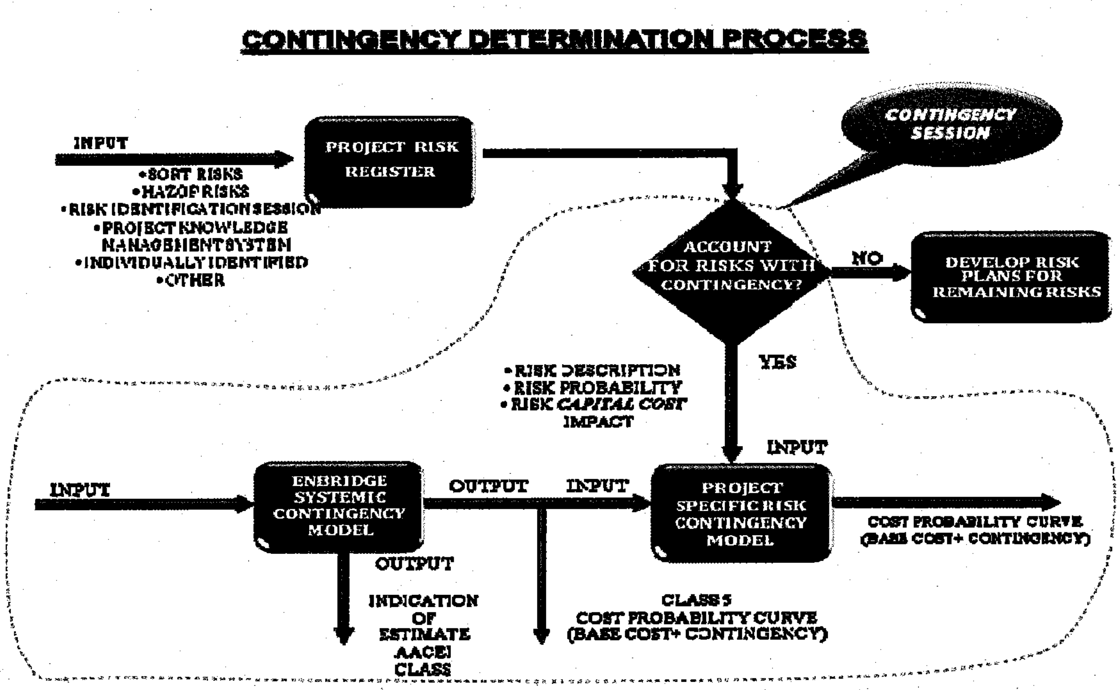

Figure 3—Contingency Determination Process

During the detailed design and procurement stages, the project increases the level of scope, schedule and estimate definition and so increases the need to detail contingency as the main purpose of manage (control) contingency during execution. Contingency is expected to be expended and it is controlled like any other "control account" in the budget contingency management during project execution shall align best practices in risk management in order to monitor and control risk responses.

Risk Response/Mitigate Risks

Once risks are identified and assessed, the next step is to mitigate the risks. To mitigate the risks, risk drivers shall be clearly understood. Options for risk response are identified and evaluated. The options can be defined by six categories: Avoidance (total elimination of the risk); Mitigation (apply methods to eliminate or reduce probability or impact of the risk); Acceptance (accept the risk, assign contingency budget or recovery plan to respond to the cost impact of the accepted risk); Research (accurate assessment of risk level through research activities, surveys or studies); Transfer (transfer of risk ownership, i.e., contracting out portion of scope execution or acquiring risk insurance); Monitoring (i.e., to decide not to take immediate response to a risk, but to track, follow up on conditions, trends or behavior of risk drivers over time). To sustain the risk response plan, it is essential to provide updates to the Risk Register by updating the assignment of a person as risk owner, and recording the specific risk mitigation or action plans linked to the risk item.

Monitoring and Control

One of the main objectives of monitoring and control risks is to assure an ongoing risk identification, assessment and response. Some best practices requirements to monitor and control risks include: periodically review the status of the identified risks in the risk register; review the effectiveness of the risk response used; identify, assess and develop risk responses for any new risks that may arise and were not included in the previously risk response plan; maintain updated tracking on contingency usage and risk drivers of contingency.

A RM process used in a pipeline company has been outlined. A RM process shall create value for the company and be an integral part of an organizational process. It should be structured, transparent and inclusive. Also it should be able of continuing improvement.

There are innumerous benefits that a structured RM process can provide to a project. It provides a structured framework for more effective strategic planning, maximizing opportunities and minimizing losses; promotes greater openness in decision making and improves communication; provides senior management with a concise summary of the major risks affecting the project; provides a framework for ensuring that risks are adequately managed; provides an effective approach which enables management to focus on areas of risk in their operations.

When a RM process is first implemented in a company, it is important to understand that it will not be perfect. Only through practice, experience, and actual loss results, the company will improve the RM process and gather contribute information to allow possible different decisions to be made in dealing with the risks being faced.

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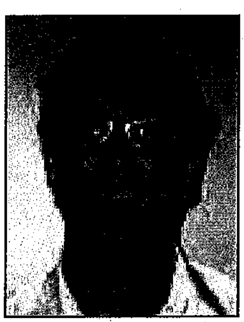

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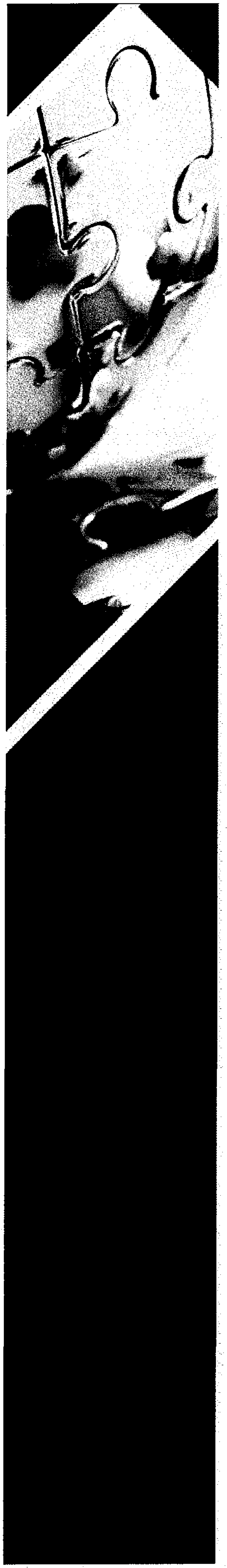
APPENDIX F

AACE INTERNATIONAL RECOMMENDED PRACTICE

40R-08

CONTINGENCY ESTIMATING - GENERAL PRINCIPLES

AACE INTERNATIONAL



AACE® International Recommended Practice No. 40R-08

CONTINGENCY ESTIMATING – GENERAL PRINCIPLES

TCM Framework: 7.6 – Risk Management

Rev. June 25, 2008

Note: As AACE International Recommended Practices evolve over time, please refer to www.aacei.org for the latest revisions.

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CONTINGENCY ESTIMATING – GENERAL PRINCIPLES

TCM Framework: 7.6 – Risk Management

June 25, 2008

INTRODUCTION

Scope

This Recommended Practice (RP) of AACE International defines the expectations, requirements, and general principles of practice for estimating contingency, reserves and similar risk funds (as defined in RP 10S-90) and time allowances for project cost and schedule as part of the overall risk management process (as defined in TCM Framework Section 7.6). The RP provides a categorization framework and provides a foundation for, but does not define specific contingency estimating methods that will be covered by other RPs.

This RP does not address the general risk management "quantification" steps as might be used for screening or ranking risks in terms of their probability or impact. While the quantification methods of contingency estimating may be similar to those used for screening, the application often differs.

Purpose

This RP is intended to provide guidelines (i.e., not a standard) for contingency estimating that most practitioners would consider to be good practices that can be relied on and that they would recommend be considered for use where applicable. There is a broad range of contingency estimating methodologies; this RP will help guide practitioners in developing or selecting appropriate methods for their situation.

Background

This RP is new. It is based on discussions of the AACE Decision and Risk Management committee. There is no one best way to quantify risks or to estimate contingency; each method has its advocates. However, there is general agreement that any recommended practice should be in accordance with first principles of decision and risk management as described here.

RECOMMENDED PRACTICE

Contingency versus Risk Impact

This RP covers more than just the estimation of traditional "contingency" for cost or schedule. It also refers to the estimation of risk values in general (excluding escalation, currency, and other primarily monetary or financial risks). For example, management may want to know not only what traditional contingency to include in a project cost control budget or float to include in a schedule, but what reserves or insurance it may want to establish for catastrophic risks for the project or its capital portfolio as a whole, what ranges of impacts to consider in business case sensitivity analysis, and so on. From here forward, we will refer to the product of the estimation as quantitative risk impact.

General Principles of Estimating Quantitative Risk Impact

Any methodology developed or selected for quantifying risk impact should address these general principles:

- Meet client objectives, expectations and requirements
- Part of and facilitates an effective decision or risk management process (e.g., TCM)
- Fit-for-use

- Starts with identifying the risk drivers with input from all appropriate parties
- Methods clearly link risk drivers and cost/schedule outcomes
- Avoids iatrogenic (self-inflicted) risks
- Employs empiricism
- Employs experience/competency
- Provides probabilistic estimating results in a way the supports effective decision making and risk management

These principles are further described below.

Objectives, Expectations and Requirements

Management (or other customer of the estimate) may require traditional contingency or float values, reserves, ranges, and other information. They may also have constraints in terms of time and resource availability, and so on, or they may need quantification methods to be enhanced or validated before beginning the effort. It may also be advantageous to integrate the effort with other practices (e.g., value engineering). Therefore, a first principle is that the client's objectives, expectations and requirements must be determined.

This determination includes agreeing on the meaning of the terms "risk" and "contingency"[1]; definitions may vary somewhat among organizations and applications (e.g., does risk include both opportunities and threats?). During this discussion, the client's level of risk tolerance should be gauged. For example, is it the client's desire that the budget or schedule represent the most likely result, or a more conservative or aggressive outcome?

Decision or Risk Management Process

Estimating quantitative risk impacts is not an end in itself; it should be part of some process. Therefore, the practitioner must identify the decision or risk management process that the estimating practices are supporting, and make sure that the estimating practices and their outcomes facilitate that process (TCM being a generic model for such a process). If there is no such process in place, the practitioner should recommend that one be established as appropriate for the objectives and requirements of the customer.

Fit-for-Use

In addition to considering the general requirements of the client and the process, the practitioner must also consider any other significant contextual characteristics that may or may not affect the estimating practices selected and how they are managed and/or performed. These include, but are not limited to the following:

- Portfolio, Program or Project Type: Scope, size, complexity, level of technology
- Risk Type: Strategic versus tactical, systemic versus project-specific.
- Project Phase: Estimate/Schedule Class
- Base Estimate/Schedule Methodologies: Methods, tools, and data used to develop the estimate or schedule (without risk cost/time included)
- Skills and Knowledge: Of both the practitioner and other participants

Identifying Risk Drivers

The risk management process starts with identifying risks, and therefore, any risk estimating method must begin likewise (e.g., do not quantify ranges on a cost or activity, without first determining what is driving the range). This process needs to consider both inherent estimate uncertainty (as a result of level of definition available, methodologies employed and other systemic risks) and risk events (including both project specific and external risks that may impact the project).

[1] These terms are defined in AACE's terminology RP 10S-90 in which the "risk" definition is based on the following reference: "AACE International's Risk Management Dictionary", AACE International Risk Management Committee, Cost Engineering, Vol. 37, No. 10, AACE International, Morgantown, WV, 1995

Linking Risk Drivers and Outputs

A comprehensive risk management process requires clear understanding of each risk and its potential impact. Risks are continually reassessed throughout a project's life cycle. If management cannot explicitly see the connection between a given risk and the potential impact, then management of the risk during execution will be difficult. Therefore, it should be clear in the estimation practice how each identified risk is linked to the estimated impact.

Avoid Iatrogenic (Self-Inflicted) Risks

The estimation process itself should not introduce new risks. For example, if too many risks are considered, or too many cost items are included in range estimating, important risk drivers may not get sufficient attention, and in some cases, the cost analysis may become corrupted or obscured. If the risk impact estimate is too low, it will distort the project control process as teams try to work around inadequate plans. If the risk impact estimate is too high, history shows the excess funds or time will be consumed to the detriment of profitability or other project success measures.

Empiricism

Estimation as a general practice is based on taking experience from the past and applying it to the present and future. Any method must be informed by past experience. Empiricism implies objectively capturing experience through measurement and analysis of past practices and outcomes. For example, empirical research has shown that there are systemic risks that have fairly predictable impacts. Empiricism can be brought to bear directly through parametric quantification methods (e.g., regression based) or less directly through the use of lessons learned and/or benchmarking, or validating analysis results against historical data.

Experience/Competency

Empirically based or not, no estimating algorithm or routine will provide reliable estimates without the input of an experienced and competent estimator (in this case, a risk analyst). The probability of iatrogenic risks increases with inexperience and/or incompetence of the practitioners. The less empiricism incorporated in the methodology itself, the more critical the experience, skills and knowledge of the analyst and team become. Optimally, the risk analyst's experience and competency in risk management and quantification methods will be seasoned with relevant asset and project management experience. Competency is best obtained through both training and hands-on practice.

Probabilistic

The quantitative risk impact estimate is always part of the basis of a management decision. The client may use the risk estimate values in a business case simulation supporting an investment decision, or they may simply be deciding how much risk impact to include in a project budget or schedule (or to insure, or establish as a reserve, etc.). Probabilistic estimate outputs (i.e., distributions or ranges) help ensure that the client understands the potential consequences of their decision; point estimate values do not do this. If the risk impact estimating method does not directly generate a distribution or range (e.g., through simulation), then the analyst and team is obliged to otherwise communicate equivalent information through other means, preferably based on empirical data and experience.

General Categories and Characteristics of Methods in Practice

The definition of contingency and how to estimate it are among the most controversial topics in cost engineering. While there is consensus among cost engineers on what contingency is, there is much less consensus on how to estimate it. In general, there are four classes of methods used to estimate risk cost/time that can respect the basic principles. These include:

- Expert Judgment
- Predetermined Guidelines (with varying degrees of judgment and empiricism used)
- Simulation Analysis (primarily expert judgment incorporated in a simulation)

- Range Estimating
- Expected Value
- Parametric Modeling (empirically-based algorithm, usually derived through regression analysis, with varying degrees of judgment used)

Hybrid methods that combine several or all of the above classes are also common.

Methods that do not respect the general principles are never appropriate. Common examples of inappropriate methods includes the "Remainder" method; i.e., setting contingency as the difference between the base cost estimate or schedule duration and some pre-determined budget or duration (e.g., "We have $100M for this project; the base estimate is $98M; therefore the contingency is $2M). Also, judgment or predetermined guidelines that disregard risks and/or have no basis in empiricism or experience are inappropriate.

The following briefly discusses each of the classes of methods; however, specific methods are intended to be described in other AACE Recommended Practices.

Expert Judgment

This method is largely self explanatory. The term "expert" explicitly means that the judgment must have a strong basis in experience and be backed up by competency in risk management and analysis. The results of all methods are improved to the extent that expertise and good judgment is brought to bear (i.e., most methods are to some extent hybrid combinations employing expert judgment). However, this method is highly subject to imposing iatrogenic risk when the judgment is inconsistent or biased. Bias can be minimized by obtaining the consensus of multiple experts or an experienced team, provided there is varied, independent opinion (i.e., avoid "group-think").

Predetermined Guidelines

This method may be as simple as providing a single contingency or float value (e.g., percentage of base cost or duration) for use on all estimates or schedules of a certain type to complex tables or scoring mechanisms that employ elements of parametric modeling. A common approach is to establish a table of contingency values and ranges for each of AACE's estimate or schedule classes with alternate values and ranges provided for common risks such as the use of new technology[2].

Advantages of the method are that it is simple, understandable, and consistent, and as such, it is easy to get management buy-in. The results of guidelines are improved to the extent that empiricism, expertise and good judgment are brought to bear in development of the guidelines. Because the method is "simple," it is often used by inexperienced people; therefore, the guidelines must be clearly described and documented and supported by training.

A disadvantage is that it cannot effectively address risks that are unique to a specific project, or risks that are common, but may have inordinate impacts on a given project. For that reason it is most useful for early estimates when systemic (i.e., non project-specific) risks such as the level of scope definition are dominant. In all cases, outcomes must be tempered with expert judgment.

Simulation Analysis

This method combines expert judgment with an analytical *model* that is then used in a simulation routine to provide probabilistic output.

An advantage of modeling and simulation analysis is that it facilitates including the analyst's and team's experience and input; this makes is particularly well suited for project-specific risks. It also directly provides probabilistic output.

[2] Research has consistently shown that the level of project scope definition, inherently addressed in AACE's estimate and schedule classifications, is a predominant risk driver and a good starting point for most risk analyses.

June 25, 2008

A disadvantage is the method's complexity which requires expertise in application (which also makes it subject to manipulation), and the outcomes are not highly consistent (being highly dependent on the analyst and team input). Also, because the methods are not empirically-based, they can sometimes be more challenging to apply effectively for systemic risks which are predominant for early estimates. Finally, the model requires consideration of alternate estimates or schedules (to estimate the impact if a risk happens) which requires estimating and schedule expertise throughout the exercise.

The most common methods in use are *range estimating* and *expected value*; both of which use Monte-Carlo or similar simulation routines. These methods are described below.

Range Estimating

In range estimating for a cost estimate, the cost model is usually a summary of estimated costs at some level of detail. Simplistic approaches may use a project's work breakdown and cost account structure as it is (e.g., civil construction costs for process unit X). More refined approaches to avoid iatrogenic risk may focus on the cost estimate's critical elements which are identified using a process that considers each cost element's significance to the total project cost. Each cost element in the model is then assessed with a range and distribution that is assigned by the team based on their understanding of the risks. Also, at that time significant correlations amongst cost elements are incorporated into the analysis. Then a Monte-Carlo or similar simulation program is run that uses these cost item ranges and distributions as its input. The simulation's output is a total cost distribution along with other data designed to support the decision making process.

For scheduling, the model is usually a critical path network schedule. For each activity, the duration is replaced by a duration distribution assigned by the team. Then a Monte-Carlo simulation program is run that uses these duration distributions as its input. The simulation's output is a total duration distribution.

Expected Value

The expected value method directly estimates the cost or schedule impact of each significant identified risk. The model starts with a list of risks. The probability of occurrence of each risk is estimated. Then the cost or schedule impact, if the risk happens, is estimated. The cost or schedule duration times the probability of occurrence is the "expected value." The probability and cost or schedule estimates are replaced by distributions that are assigned by the team based on their understanding of the risks. Also, at that time significant correlations amongst risks and cost or schedule activities are incorporated into the analysis. Then a Monte-Carlo or similar simulation program is run that uses these probability and cost distributions as its input. The simulation's output is a total cost or schedule distribution along with other data designed to support the decision making process.

The above are simplistic, generic descriptions for complex methods that if executed poorly can increase iatrogenic risks. This complexity mandates that practitioners refer to the specific Recommended Practices for each of these methods for more information on best practices.

Parametric Modeling

A parametric model is generally an algorithm that is derived from multi-variable regression analysis of quantified risk drivers versus cost growth or schedule slip outcomes for historical projects. For example, a risk driver such as the level of project scope definition can be given a score for each project in a dataset. This score can be regressed against the actual cost growth for those projects. The regression will provide not only an algorithm, but also statistical information about the range.

Advantages of parametric modeling include, like predetermined guidelines, being simple to use, understandable, and consistent. Further, it is empirical by nature.

A disadvantage is the complexity of developing the parametric model which requires statistical skills and historical data with a range of risks and outcomes. Fortunately, industry research of common risks and outcomes is sometimes available for use. The method also cannot effectively address risks that are unique to a specific project, or risks that are common, but may have inordinate or unusual impacts on a given project. For that reason it is most useful for early estimates when systemic (i.e., non project-specific) risks such as the level of scope definition are dominant. In all cases, outcomes must be tempered with expert judgment.

Hybrid Methods

Each of the classes of methods described above has advantages and disadvantages. Therefore, the best approach is sometimes to use two or more methods to estimate risk cost/time. The most common combination is to use expert judgment with any other method. Another combination is to use a parametric model for systemic risks and simulation analysis for project-specific risks. Parametric models may also provide the raw material used to develop pre-determined guidelines.

Summary

Table 1 below provides an overview of the primary classes of risk cost/time estimating methods and consideration for each in regards to the general principles. Practitioners should refer to the AACE RPs describing the specific methods.

June 25, 2008

First Principles	Classes of Contingency Estimating Methods			
	Expert Judgment	**Predetermined Guidelines**	**Simulation Analysis***	**Parametric Modeling**
Meets client objectives, expectations and requirements	Whether a given method or combination of methods best meets the clients objectives, expectation or requirements must be determined prior each application			
Part of a risk and decision management process	Any method can potentially be incorporated in a process.			
Fit-for-use	Any method can potentially be made to address a variety of applications, but typically each method has strengths and weakness. Hybrid approaches can take advantage of the strengths of several methods.			
Starts with identifying risk drivers	Any method can potentially be made to start with identifying risk drivers.			
Links risk drivers and cost/schedule outcomes	Requires that expert(s) make and communicate the linkages	Linkages can be directly incorporated in the guidelines	Linkages are directly used in the *expected value* method	Linkage is inherent to this method
Avoids iatrogenic (self-inflicted) risks	Bias must be tempered, often through consensus	Care must be taken with risks not considered in the guidelines	Complexity of the method increases the need for disciplined approach	Care must be taken with risks not considered in the model
Employs empiricism	Generally requires the use of lessons learned, and/or validation or benchmarking using historical information (not an inherent feature of the method)			Explicitly addressed if regression based
Employs experience /competency	Expertise explicitly required	Expertise employed in development	Expertise employed in analysis	Expertise employed in development
Provides probabilistic estimating results	Can provide subjective ranges	Can provide predetermined ranges	Direct output of most simulations	Can be a direct output of algorithm

***Including range estimating and expected value methodologies**

Table 1 – Classes of Contingency Methods and General Principle Considerations

June 25, 2008

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APPENDIX G

AACE INTERNATIONAL RECOMMENDED PRACTICE

44R-08

RISK ANALYSIS AND CONTINGENCY DETERMINATION USING EXPECTED VALUE

AACE INTERNATIONAL

AACE® International Recommended Practice No. 44R-08

RISK ANALYSIS AND CONTINGENCY DETERMINATION USING EXPECTED VALUE

TCM Framework: 7.6 – Risk Management

Rev. December 4, 2012

Note: As AACE International Recommended Practices evolve over time, please refer to www.aacei.org for the latest revisions.

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AACE® International Recommended Practice No. 44R-08

RISK ANALYSIS AND CONTINGENCY DETERMINATION USING EXPECTED VALUE

TCM Framework: 7.6 – Risk Management

December 4, 2012

INTRODUCTION

Scope

This recommended practice (RP) of AACE International (AACE) defines general practices and considerations for risk analysis and estimating cost contingency using expected value methods. This RP applies specifically to using the expected value method for contingency estimating in the risk management "control" step (i.e., after the risk mitigation step), not in the earlier risk assessment step where it is used in a somewhat different manner for risk screening. This RP is limited to estimating cost contingency; RP 65R-11, *Integrated Cost and Schedule Risk Analysis and Contingency Determination Using Expected Value* is an extension of this RP covering integrated cost and schedule risk analysis and contingency determination using expected value.

Purpose

This RP is intended to provide guidelines, not standards, for contingency estimating that most practitioners would consider to be good practices that can be relied on and that they would recommend be considered for use where applicable. There is a range of useful contingency estimating methodologies; this RP will help guide practitioners in developing or selecting appropriate methods for their situation. While integrated cost and schedule methods are generally recommended (e.g., 65R-11, *Integrated Cost and Schedule Risk Analysis and Contingency Determination Using Expected Value* or 57R-09, *Integrated Cost and Schedule Risk Analysis Using Monte-Carlo Simulation of a CPM Model*), this RP is limited to estimating cost contingency for those situations where a different method will be applied for schedule contingency determination (for example, the schedule aspects of CPM-based methods as in 57R-09).

Background

This RP is based on a method that has been in common use for both decision and risk management for many decades. Expected value in its most basic form can be expressed as follows:

Expected Value = Probability of Risk Occurring x Impact If It Occurs

Figure 1 shows a more specific example of the concept; in this case, $1,000 would be included in contingency for this particular risk[6]:

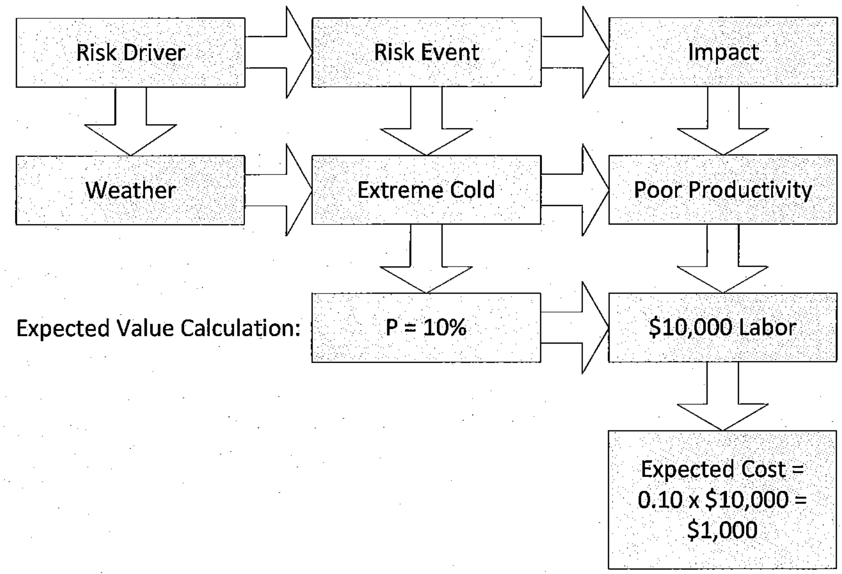

Figure 1 – Example of Expected Value Calculation

This calculation has long been a fundamental method used in decision tree analysis and risk screening [3,4,5]. Its use is common because it is quantitative, simple to understand, simple to calculate, and it explicitly links risk drivers with their impacts so that the risks can be managed. However, its use for contingency estimating has not been as common. References by Dey[4], Hollmann[6], and Mak *et al.*[7] report on applications employing expected value concepts.

While it is advantageous for risk management to use methods that explicitly link risk drivers with their impacts, the effort involved in expected value methods for contingency estimating can be seen as a challenge. At screening, minimal cost competency is needed (i.e., risk impacts are often addressed as high/low or major/minor or other loosely quantified measures) so expected value usage is common. However, for contingency estimating, expected value requires cost estimating competency (particularly conceptual estimating) to explicitly scope and estimate the risk impacts. Range estimating on the other hand[2] does not require the preparation of explicit impact estimates; this can be seen as either an advantage or disadvantage.

Expected value has two other significant advantages; it does not require that the team change its basic risk quantification methods between decision analysis, risk screening and control, and it can provide a contingency estimate without using Monte-Carlo (however, its use is recommended).

It is AACE's recommended practice that whenever the term *risk* is used, that the term's meaning be clearly defined for the purposes at hand. In expected value practice as described in this RP, *risk* means "an uncertain event or condition that could affect a project objective or business goal".

Background-Risk Types

Because the expected value method of contingency estimating explicitly links risk drivers with their impacts, it requires more explicit understanding and treatment of the risk types than less explicit methods such as range estimating. In respect to expected value, as with parametric contingency estimating methods[1], risk types fall into one of two categories; risks that have systematically predictable relationships to overall project cost growth outcome and those that don't. These categories have been labeled as *systemic* and *project-specific* risks for contingency estimating purposes (i.e., there will be other ways to categorize risk types for other purposes.). To use the method properly, it is important to understand the distinctions of these types.

The term *systemic* implies that the risk is an artifact of the project "system", culture, politics, business strategy, process system complexity, technology, and so on. A challenge for contingency estimating, is that the link between *systemic* risks and cost impacts is *stochastic* in nature; this means it is very difficult for individuals or teams to understand and to directly estimate the impact of these risks on particular items or activities (for example, the risks of process technology on something like site preparation or concrete foundations may be dramatic, but is not readily apparent). For this reason, the use of expected value methods, which rely on more *deterministic* estimating practice, should be limited to *project-specific* risks. Parametric risk analysis methods are generally recommended for *systemic* risks (see: RP 42R-08, *Risk Analysis and Contingency Determination Using Parametric Estimating*).

The term *project-specific* implies that the risk is, as it says, specific to the project; for example, the amount of rain that might fall on a specific project site. The link between *project-specific* risks and cost impacts is fairly deterministic in nature; i.e., these risks are amenable to individual understanding and to estimating the impact on particular items or activities (for example, the cost impacts, allowing for accuracy range, of excess rain on site preparation work can be estimated).

Another risk taxonomy distinction of value to understanding this method is fixed (or discrete) versus variable (or continuous) risk *impacts*[7]. There are two uncertainties in the expected value equation; probability and impact. If the impact is "fixed" or discrete in nature (and estimable), then most of the uncertainty is in the probability of its occurrence. If the impact is variable, then there are two levels of uncertainty; probability of occurrence, and scope and cost of the impact. Understanding this can help the user in planning how difficult the implementation will be, and may suggest alternate approaches to how to deal with the uncertainty.

The RP will explain how parametric and expected value contingency estimating methods can be used together in a way that best addresses both systemic and project-specific risks.

RECOMMENDED PRACTICE

The following steps assume that a formal risk management process is being followed and that risks have already been mitigated in the project plans to some extent. This recommended practice then addresses the residual risks that need to be controlled and managed. Often, constrained for time, teams will skip the mitigation effort and jump right to contingency estimating which defeats much of the value-adding purpose of risk management.

RISK IDENTIFICATION

Identify Residual Project-Specific Risks

This is not an RP about risk identification. However, the expected value method requires that risks that are to be "accepted" to some extent (i.e., will remain part of the project scope and plan after mitigation) be explicitly identified. To use expected value, the risk identification step must distinguish between systemic and project-specific risks. This is facilitated when parametric methods are used because the systemic risks are generally known and addressed directly in the parametric model. The remaining risks are then usually project-specific.

Typically, risk identification for contingency estimating is a separate step from risk identification for screening. Most risk management models do not make it clear that after risks have been identified, screened as to significance, and addressed in revised plans (i.e., by transferring, accepting, reducing, etc.), the team must then take a fresh look at the residual risks that may be of a somewhat different nature. This includes the possible introduction of iatrogenic risks (i.e., the mitigating action may create a new risk). Also, new risks may have come up in the time between the earlier mitigation and planning modifications and the final contingency estimating step.

Risk identification to support contingency estimating also tends to be more definitive in nature as to specifying risk events in a way that the impact can be clearly understood and estimated. Otherwise, the identification process is similar, starting with a diverse and knowledgeable team using elicitation methods such as brainstorming, then recording the risks[3]. The risks will be screened for significance during the quantification steps that follow.

QUANTIFICATION/CONTINGENCY ESTIMATING

The risk identification step will result in a list of significant risks and opportunities for which probability of occurrence and impacts need to be estimated.

Estimating the Probability of Occurrence

As with any estimating or forecasting process, experience is the best foundation. The risk analysis team should include representatives of any entity that is likely to have some control of and/or be significantly impacted by potential risks. This usually means lead individuals from business, operations, design, procurement and other functional areas of the project team. The more and broader the experience in the room, the better the analysis will be. In any case, the risk analysis participants should be familiar with the project plans and cost estimate.

For the expected value method, it is required that cost estimating expertise be part of the process and that the estimating representative be familiar with the basis and content of the estimate for the subject project and others like it. Further, the estimator should be well versed in (or know where to find) historical experience and lessons learned with cost risks and their impacts for comparable projects.

The team, usually in a workshop setting, reviews each risk and identifies the probability of each risk's occurrence. This can be a direct estimate from 0 to 100 percent probability; however, probabilities are usually given names (e.g., very high, high, etc.) with preset values to assist in getting consensus because specific values are difficult to agree on.

If Monte-Carlo is to be used later (which is recommended), then the team must also identify the degree to which the risks are dependent, and if so, the extent and nature of the correlation. For example, there may be an interaction between the risk of rain and the risk of poor slope stability (e.g., if it rains a lot, the soil slope stability is likely to be worse). Using Monte-Carlo software, the users must quantify the correlation (e.g., the slope stability and rain have a 0.5 correlation coefficient). In addition, the Monte-Carlo model can be made to address the team's confidence (i.e., the degree of consensus) in the probability rating. This is done by treating the probability of occurrence as a distribution (e.g., triangular is common) which will have wider ranges when there is less consensus in the rating.

Estimating the Impact if the Risk Occurs and Screening

Having clearly identified the risk or opportunity, the team must agree on the scope of the impact and quantify it at a conceptual level of definition (e.g., AACE Class 5). For example, if the risk was a 100 year rain event, the team may agree that the primary impact would be a flooded site that requires pumping, excavation rework, and delay with a period of poor productivity. The estimator(s) on the team then provides a quick conceptual estimate of this impact using conceptual metrics such as the typical cost of a day's delay assuming a certain man-loading and so on. The estimating knowledge required for this method is not trivial.

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This initial estimate is for screening. If a quick calculation of the probability times impact yields a value that is not significant to costs or profitability, then it is dropped from consideration (but kept in the register) and is not used in the contingency calculation. Significance can be judged using the same criticality criteria cited in AACE's range estimating RP 41R-08, *Risk Analysis and Contingency Determination Using Range Estimating* [2] as shown in the table below:

Bottom Line Critical Variances		
Bottom Line (Cost or Profit)	Conceptual Estimates (AACE Classes 3, 4, 5)	Detailed Estimates (AACE Classes 1, 2)
Cost Δ	± 0.5%	± 0.2%
Profit Δ	± 5.0%	± 2.0%

Table 1 – Suggested Critical Variance Thresholds for Screening Risks

For the remaining critical items, the estimator will then typically refine the scope and cost of the impact after the risk analysis session. The estimate is usually developed to a Class 5 summary level of detail (e.g., a breakdown such as engineering, equipment, bulk materials, labor, and so on). While the need to prepare estimates may seem onerous, there should usually be less than 15 or so risks that pass screening, and their impacts are usually limited to a few estimate items. The level of effort is not significant for a skilled estimator.

Assessing Ranges of Impact

If Monte-Carlo is to be used later (which is recommended), then the team will revisit both the scope and quantification of the impact and its costs to estimate the range for each risk or opportunity that passes the screening. Unlike range estimating for which the team must consider *all* risks that may affect a given critical item (making it difficult to see how broad the range can be without expert facilitation), expected value only needs to deal with one risk and the ranging tends to be fairly straightforward. Still, the leader of the risk analysis must strive to ensure that the worst case outcomes have been considered.

Again, the estimator will then typically refine the range estimate of the impact after the risk analysis session. For Monte-Carlo, they will also need to choose a distribution with triangle, double triangle, or beta being typical with the understanding that triangular distributions can be inappropriate for highly biased distributions (refer to RP 41R-08 regarding distributions).

To improve communication as to the nature of the impact estimate, some have found it useful to categorize each risk as either "fixed" or "variable" in terms of its impact (i.e., a similar concept is "discrete" or "binary" risks versus "continuous" risks). The impact of a fixed or binary risks has limited range (e.g., the risk is a flood that may overtop a dike, and the impact is to bring in a second pump at a known costs). A variable or continuous risk has an extent and impact with a wider possible range (e.g. the risk is severe rain with an intensity that can vary, and an impact that depends on the status of work at the time). The nature of the impact is also a consideration when evaluating contingency versus reserve funding (e.g., major fixed or binary risks are less amenable to funding with contingency; see later discussion).

Coordinate with Contingency Estimates for Systemic Risks

Parametric and expected value analysis can be easily combined because expected value models work by directly estimating the probable cost distribution of the impacts of each risk[1]. In that case, the results of the parametric model (i.e., its outcome probability distribution) are included in the expected value model as the first risk. Then other project-specific risks (e.g., heavy rain) are quantified and added to the model. Monte-Carlo simulation can then be applied to the entire combined cost risk model to obtain a combined probability distribution.

For Class 5 estimates (i.e., based on minimal scope definition[8]), parametric methods alone are generally adequate for contingency estimating, given the dominance of systemic risk impacts and lack of knowledge of project specifics. For Class 4 or better, the methods should be used in combination. The most important consideration in combining methods and outcomes is to ensure that risks are not double counted. After risks are identified in a risk analysis session, each risk must be categorized as systemic or project-specific. Each risk is then quantified in their respective analyses and contingency estimates.

Assessing Overall Outcome using Monte-Carlo

Having quantified and defined distributions to the probabilities and cost impacts, and having established dependencies between the risks (and between summary cost accounts as used in the risk impact estimates) , the cost risk model can be run through a Monte-Carlo simulation using one of the many commercial software packages available.

The cost risk model input includes the base estimate plus the parametric model outcome distribution (e.g., systemic risk impact) plus the products of the distribution of probability times the distribution of the cost impact for each project-specific risk.

An advantage of the expected value method is that the cost impact of each risk is quantified. While it is recommended that there be only one contingency account in a project cost budget, it can useful for later risk management and contingency drawdown to have the potential impact of each risk explicitly quantified (i.e., if the risk does not occur, it provides an indication of the potential contingency, pending ongoing risk analysis, that could be returned to the business).

Estimating Contingency

The Monte-Carlo output is a distribution of possible cost outcomes at different levels of confidence in underrun. Contingency is then the difference between the base estimate cost and the cost at whatever level of confidence of underrun management desires depending on their risk appetite, acceptance or tolerance level. For example, if they desire to fund the project at a 70 percent probability of underrun, then the contingency value would be the p70 value from the outcome cost distribution less that base estimate value. Management typically sets a standard level of risk tolerance as a company policy.

Note that this method can provide a cost output distribution for each risk (including the input distribution for the systemic risks). While mean outputs (expected values) can be summed for each risk to arrive at an overall mean outcome or expected value, you cannot sum the other ranges (e.g. p90).

P50 vs. Expected Value

When using the expected value method, it is important to keep in mind that the p50 value of a Monte-Carlo simulation is not equal to the expected value (mean) for asymmetric distributions. If you sum the probability weighted expected value outcomes for each individual risk, the total will exceed the p50 value of the simulation if most distributions are skewed to the high side as is most often the case. The difference may or may not be trivial depending on the skewness. As discussed in the previous section, it is management's responsibility to decide on their level of risk tolerance; the expected value sum is then another possible value to consider. For those who prefer to fund contingency at a p50 level of confidence, but still recognize that expected value is in fact "expected" to be spent, the difference may be funded as a reserve.

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Evaluating Contingency (Versus Reserves or Other Treatment)

Because the expected value method provides an estimate of the full cost impact of each risk if it occurs, the method allows users to further assess the adequacy of the contingency funds. Contingency is only useful for funding risk impacts that represent a limited portion of the overall contingency funding (usually variable or continuous in nature). High impact/low probability risks (usually fixed or binary in nature) often cannot be effectively funded with contingency because, if the risk occurs, especially at its maximum impact, it may consume all of the contingency and much more. You can never put enough in the contingency account to cover such a risk, and if you do, you will likely kill the project economics even though the risk has a low probability of occurring. Also, if you fund even a portion of this risk, it will likely be spent if project management is not disciplined (the team will know the money is unlikely to be needed, and inadequate in any case, so it is free for the taking). Therefore, these high impact/low probability risks that swamp contingency should be removed from the contingency analysis, and their assessment and treatment dealt with separately as appropriate (e.g., through reserve funding on a portfolio basis, additional mitigation, etc.).

SUMMARY

This RP is intended to guide practitioners in developing or selecting appropriate methods for their situation. Users are encouraged to study the reference materials including the RPs for alternate methods and seek ways to apply the methods that work best in their situation.

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Disclaimer: The opinions expressed by the authors and contributors to this recommended practice are their own and do not necessarily reflect those of their employers, unless otherwise stated.

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APPENDIX H

TURN/SCGC's Response to
SDG&E/SoCalGas Data Request Number 2
SDG&E and SoCalGas' 2019 GENERAL RATE CASE
A.17-10-007 and A.17-10-008

DATE: **June 5, 2018**

TO: Charles Manzuk
San Diego Gas & Electric
Southern California Gas Company
8330 Century Park Court
Mail Code : CP 32D
San Diego, CA 92123

ORIGINATOR: Evan Goldman
PHONE: 213-244-4830
E-Mail: egoldman@semprautilities.com

Request No: **SDG&E/SCG Data Request 2** **Due Date: June 5, 2018 (Expedited)**

FROM: TURN/SCGC

Testimony: Catherine E. Yap - Pipeline Safety Enhancement Program, Other Gas Transmission Costs, and Third Attrition Year

Subject: PSEP REQUEST

2. Please state your education and/or experience in estimating.
   a. Please state your education and/or experience in estimating costs of pipeline installation and pipeline hydrotesting.
   b. Please state your education and/or experience in performing detailed estimating or parametric estimating.

   RESPONSE: I have received no formal education in cost estimation but have experience in evaluating costs estimated by utility personnel in gas, electric, and water GRCs as well as pipeline certification projects and PSEP proceedings. Regarding PSEP cost estimates, I have been the witness in I.11-02-019/A.11-11-002, A.14-12-015, A.16-09-005, A.17-03-021, as well as the current proceeding.

APPENDIX I

EST.03

Exploring Techniques for Contingency Setting

Scott E. Burroughs and Gob Juntima

One of the primary areas of concern for a company's project system is the assignment of reliable contingency allowances in project cost estimates. Over the years, various contingency-setting techniques have been developed in an ongoing search for reliable approaches. These techniques vary from simple to extremely complex in their development and use, but all have the objective of improving the accuracy of project estimates. Unfortunately, very little data have been published on how successful industry contingency-setting techniques have been in improving project estimate accuracy. The goal of this paper is to objectively and quantitatively explore the historical performance of the various techniques. In addition, we will also describe a technique successfully used by Independent Project Analysis, Inc. (IPA), but little used in industry, and see how its performance compares with the common industry approaches.

CONTINGENCY VERSUS THE BASE ESTIMATE

Conflicting views exist about what contingency is. For the purpose of this paper, contingency is defined as the amount of money that experience has demonstrated must be added to the base estimate to provide for uncertainties related to (a) project definition and (b) technological uncertainty. Contingency is money that is expected to be spent. The contingency account is not intended to provide for changes in the defined scope of a project (e.g., change in capacity or product slate) or for unforeseeable circumstances beyond management's control (e.g., 100-year storms or strikes against equipment vendors). Contingency should not be viewed as a reserve or slush fund that the project team cannot spend without upper management approval. Likewise, management should not have the expectation that, if a project team does its job well, contingency will not be spent. A competitive approach is to set contingency at an amount that achieves a 50 percent probability of overrun. At a 50 percent probability, the project system, on average, is expected to spend all of its contingency.

The previous discussion assumes that the base estimate is a realistic and competitive estimate of the known scope and also assumes typical site and market conditions. A competitive base estimate is free of excessive allowances and markups for general unknowns. Allowances to cover specific, but uncertain, items are expected within a base estimate. The competitiveness of the base estimate is a key factor to consider in contingency setting.

THE TECHNIQUES

The vast majority of projects set their contingencies using techniques that can be grouped into one of three categories: predetermined percentage, expert's judgment, and risk analysis. We will also explore a fourth technique called regression analysis, or ordinary least squares regression, that IPA and a few others use. The first three categories will be the focus of our historical analysis. Because numerous publications describe the three most common contingency-setting techniques, we will only discuss those methods briefly.

Predetermined Percentage

Many company or site project systems use predetermined or mandated percentages of the base estimate as the project's contingency. We found that many project systems mandate that all projects will include contingency of either 5 or 10 percent of the base estimate. Although the basis for the percentage may seem arbitrary, 5 to 10 percent is a reasonable average for contingency use in the process industries.

The advantages of this technique are its ease of use and consistency. Using a consistent percentage removes subjectivity from the process. Because of the ease with which it is implemented, a fixed contingency percentage is often the technique applied to smaller projects. The disadvantage of the technique is the fact that it removes specificity and subjectivity from the process; it is inflexible to potentially important risk drivers, such as process complexity, use of new technologies, and level of project definition. Because of this, the method tends to underestimate contingency needs for complex and poorly defined projects and to overestimate for simple or well-defined projects. By failing to take project risk drivers into account, the predetermined percentage method produces large variations in the probability of overrun or underrun from project to project.

Expert's Judgment

A more advanced and flexible methodology for determining contingency is to use the educated judgment of experts to assist in setting a contingency level. In this technique, skilled estimators and project team members use their experience and expertise to assign a level of contingency that they believe is appropriate for the project at hand. Unlike the predetermined percentage technique, expert judgment considers specific risk factors and base estimate competitiveness.

The degree of structure to this contingency-setting process varies widely. Typically, the experts must consider bounds or norms (formal or informal) for contingency outcomes. These bounds may be expressed by using an expanded version of the predetermined contingency approach whereby the experts must select from contingencies that are predetermined for discrete risk levels (e.g., 15 percent for high risk, 10 for average, and 5 for low risk). If the process is more highly structured than this, it tends to be classified as a risk analysis approach, which is discussed in the next section.

By using specificity and subjectivity in setting each project's contingency level, a project system is more likely to have more accurate estimates. However, subjectivity is also the main disadvantage of this method in that the skill, knowledge, and motivations of the experts may vary widely. Typically, only a few experts are available whose understanding of project cost risk and estimate competitiveness can be relied on. This expertise is not easily transferable, which makes turnovers a primary concern.

Risk Analysis

Risk analysis techniques examine risk factors in a more structured way than expert judgment and apply specific quantitative methods of translating the assessed risks into contingency values. The quantitative methods are usually probabilistic in nature and allow the statistical confidence level of cost outcomes to be considered.

The most commonly used form of risk analysis employs Monte Carlo simulation as the quantitative method. In this technique, a probability distribution is assigned to each estimate line item or subtotal, and the simulation tool (typically a spreadsheet add-on) randomly selects a possible outcome from each item's distribution and aggregates the item outcomes into a total expected project cost outcome. This process is repeated many times (e.g., 1,000 iterations) to obtain an average total cost. The distribution of the iterative outcomes can then be used to select a contingency value that provides the level of statistical confidence desired. Using Monte Carlo analysis or similar risk analysis techniques allows estimators to examine the risk of individual project cost elements in a highly structured way.

The main advantage of risk analysis techniques is that they are probabilistic in nature. They allow confidence levels to be explicitly considered, and they are also very flexible. Monte Carlo analysis can be applied to any estimate or cost analysis that can be totaled or modeled in a spreadsheet; the spreadsheet model can be as simple or complex as desired. For any given model, the estimator then has almost infinite flexibility in assigning probability distributions to estimate elements

Risk analysis techniques have another advantage if the risk assessment step is done in a group setting wherein the project team reviews the entire estimate from a risk perspective. This is often the only team review of the estimate, and the outcome of the review is almost always an improved base estimate, as well as a probabilistic-based contingency value.

A major disadvantage of risk analysis techniques as typically applied is that the estimate items for which probable outcome distributions are being assigned are not, in themselves, risk drivers. The distributions assigned, therefore, tend to be somewhat meaningless. For example, the typical cost model is a spreadsheet tabulation of estimate elements, such as piping and electrical line items. The estimator is expected to assign a probability distribution (e.g., triangular distribution with +50/-30 percent high-low range) to "piping." However, if the major risk driver is level of project definition, few, if any, estimators will have a really good idea of how project definition (or weather or labor markets, etc.) will affect any particular line item.

Risk analysis also requires more time and resources to implement compared with predetermined percentages or an expert's judgment. The Monte Carlo technique is also deceptively complex. For example, it requires that dependencies be established between elements of the cost model, which is almost always skipped by users because few understand cost item dependencies (e.g., if the electrical cost outcome is on the high end of its range, what is the probability that the piping cost outcome will also be on the high side). The complexity also allows outcomes to be easily manipulated, so the results are often inconsistent. The time and complexity of risk analysis techniques often mean that they are reserved primarily for larger projects or projects of increased business importance.

Regression Analysis

Regression analysis is a statistical technique for estimating the equation that best fits sets of observations of a response variable and multiple explanatory variables in order to make the best estimate of the true underlying relationships between these variables. IPA uses regression analysis to establish contingency requirements. This technique was formulated by collecting detailed histories of projects and identifying key factors that drive differences between project estimates and actual cost outcomes. As with risk analysis techniques, regression analysis is based on quantitative modeling. However, the explanatory variables in the regression model are quantified risk drivers, not estimate line items or subtotals. Regression analysis is empirical and objective, and regression models produce consistent results no matter who applies them.

Similar to risk analysis techniques, regression models are probabilistic in nature and allow the statistical confidence level of cost outcomes to be considered. However, unlike risk analysis techniques, regression analysis is based on actual data, not assumed probability distributions and risk driver-cost outcome relationships. Because regression models are based on historical data, they bring expert knowledge to contingency setting without the need for a skilled expert on every project.

Through regression analysis, we have found several project risk drivers, both controllable and uncontrollable, to be the strongest drivers of project cost deviation or the amount of contingency used. The following is a list of these risk drivers.

Project Definition Level—The objective of project definition or Front-End Loading (FEL) is to gain a detailed understanding of the project and to minimize the number of execution uncertainties. Project definition level is an important driver that can have a direct effect on the level of contingency used by a project. It is one of the most important elements in our model.

Use of New Technology—Projects involving new technology—that is, technology that has no commercial history either within the owner company or elsewhere—have been historically proven to require more contingency. New technology may involve the use of new chemistry, first-of-a-kind major equipment, or existing equipment performing a new service. New technologies are associated with more risk than proven technologies because Industry has little or no experience with a new technology. As a result, the use of new technology increases the amount of contingency required.

Process Complexity—Complexity can be measured in many ways. We define complexity as the number of continuously linked process steps, counted on a block basis, in a facility. Parallel trains are counted only once, and the control system and off-sites are not included. As project complexity increases, the need for increased contingency also increases.

Contracting and Execution Strategy—Projects executed using lump-sum contracts typically require less explicit contingency than other contracting strategies because they move much of a project's risk from the owner to the contractor. Execution strategy affects contingency use because, if a project is cost driven, it is less likely to take actions and make changes that will put cost at risk. If a project is schedule driven (i.e., the project team is willing to spend money to achieve its schedule objective), more risk may be acceptable, and costly changes may be tolerated.

Equipment Percentage—Because the majority of major equipment estimates are based on firm quotes, equipment cost experiences the least cost growth. Even for early estimates using historical data or budget quotes, equipment cost estimates tend to be more accurate than the estimates for other cost accounts. Therefore, projects that have a high equipment percentage typically require less contingency.

Other inputs that should be considered when creating a regression model are company cost culture, estimate inclusiveness, process impurity problems, project management practices, project scope characteristics, and estimate quality.

HISTORICAL PERFORMANCE

The objective of this section is to present the results of our historical analysis of the process industry's contingency data over the last 10 years. Before we discuss our methodology and findings, we need to introduce our dataset of projects.

The Database

The dataset used for this research is a subset of the IPA Downstream Project Evaluation System (PES®) Database. The PES database currently consists of more than 8,000 projects, each with more than 2,000 pieces of information. These data points capture detailed project-specific information, including project definition, technology, project management, cost, schedule, operating performance, and safety. The database contains projects in a wide range of industrial facilities that were executed by more than 200 companies around the world. From this database, we selected a subset of 1,500 projects on which we have detailed information regarding cost, scope, contingency level, and contingency-setting technique. Because we are primarily interested in more recent projects, about half of the selected projects in our dataset were completed after January 2000. Including a wide spectrum of project costs was also important. To that end, projects in the dataset range in size from less than $100,000 to greater than US$1.5 billion. All costs are adjusted to 2002 United States (U.S.) dollars, which allows us to compare projects executed in different years.

Historical Measure of Contingency

In order to quantitatively evaluate the accuracy of each project's contingency, we needed to create some type of measurement, which we called the Contingency Performance Indicator (CPI). The CPI is defined as the absolute value of percent of contingency used minus the percent of contingency estimated. For example, Project A has a base estimate of $8 and a contingency of $4. The actual cost of the project is $10. In this example, the CPI = absolute[(10-8)/8 - (4/8)] = 25 percent. For this project, the estimated contingency (50 percent) is different from the contingency used (25 percent) by 25 percent.

The perfect CPI of 0 percent is a result of the estimated contingency exactly predicting the actual amount used. Because the CPI is an absolute measure, any deviation from the estimated contingency, whether it is an overrun or an underrun, is treated in the same way and results in a positive score. For the purposes of this study, we are concerned only with the accuracy of the predicted contingency, not the direction of deviation.

EVOLUTION OF CONTINGENCY TECHNIQUES

When we examined whether the industry was improving in contingency estimation over the last 10 years, we found that the CPI has, on average, been increasing. Figure 1 indicates that contingency estimates are, on average, getting further from the actual contingency required. This decline in performance is driven by dramatically worse performance for smaller projects. The CPI for large projects has been largely constant over the last 10 years, with a median of about 7 percent. During the same time period, small projects have gotten dramatically worse in contingency estimation, with the CPI measure going from a median of about 6 percent in 1994 to 1995 to a median of about 10 percent in 2002 to 2003. In essence, the average difference between estimated contingency and the actual contingency required on small projects has almost doubled in the last 10 years.

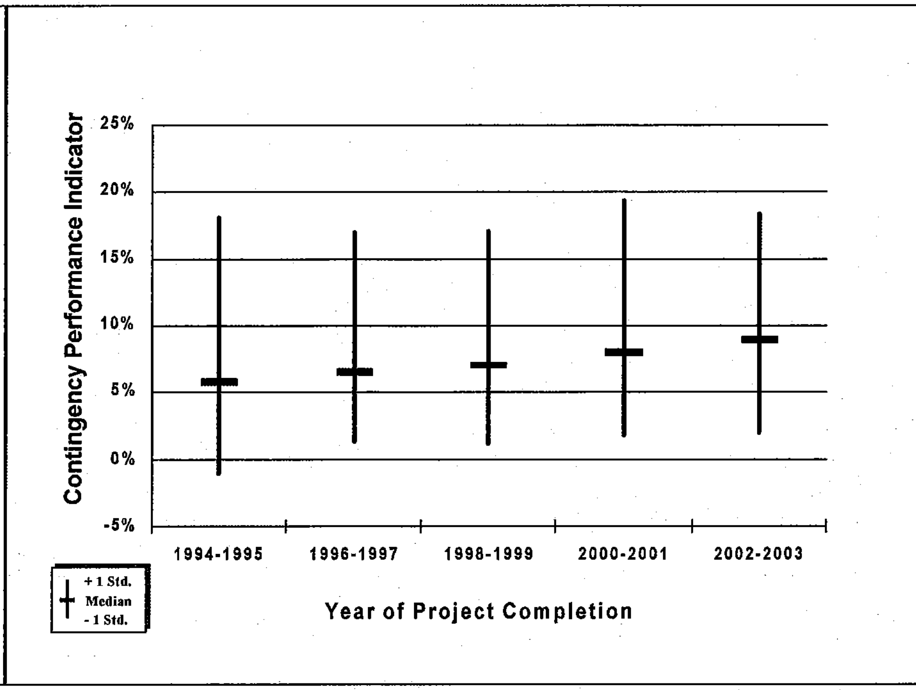

Figure 1—Contingency Performance Over the Last Ten Years

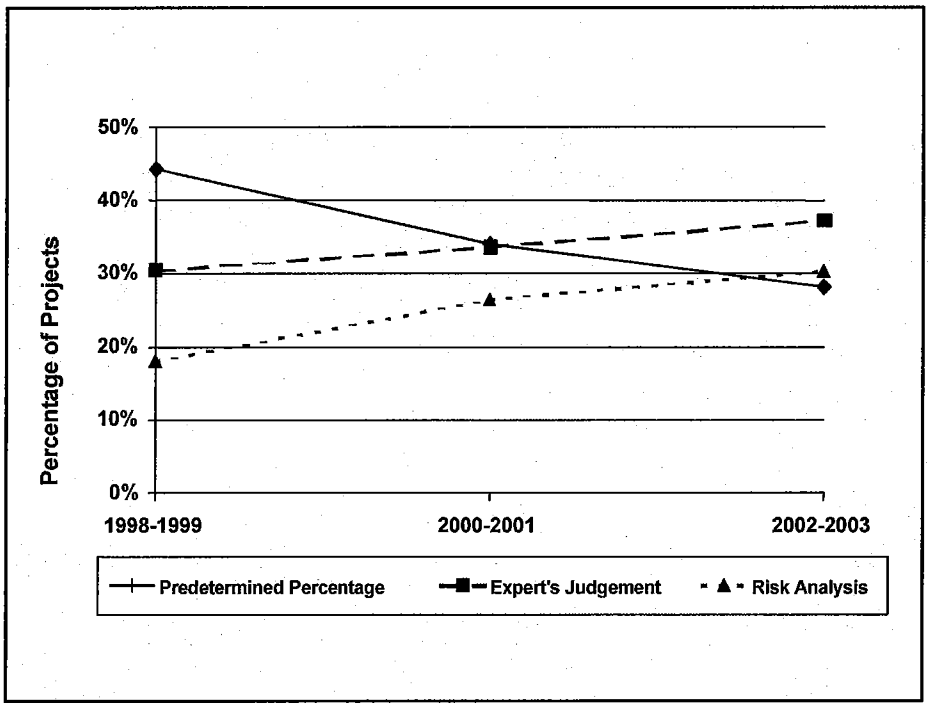

Figure 2—Use of Contingency Techniques

This result is especially surprising considering that the percentage of projects using more sophisticated approaches to contingency setting has been increasing. As shown in Figure 2, about 20 percent of projects used risk analysis techniques prior to the year 2000. In the post-2000 period, project teams' use of risk analysis has increased to more than 30 percent. During the same period, the use of predetermined percentages has dropped from almost 50 percent to 30 percent.

COMPARING THE TECHNIQUES

To better understand the decline in contingency-estimating performance, we evaluated projects executed using the three commonly used estimating methods. The industry belief has been that projects that use a risk analysis technique to estimate contingency will achieve better accuracy (i.e., lower CPI). In fact, all three of the techniques produce results that are essentially the

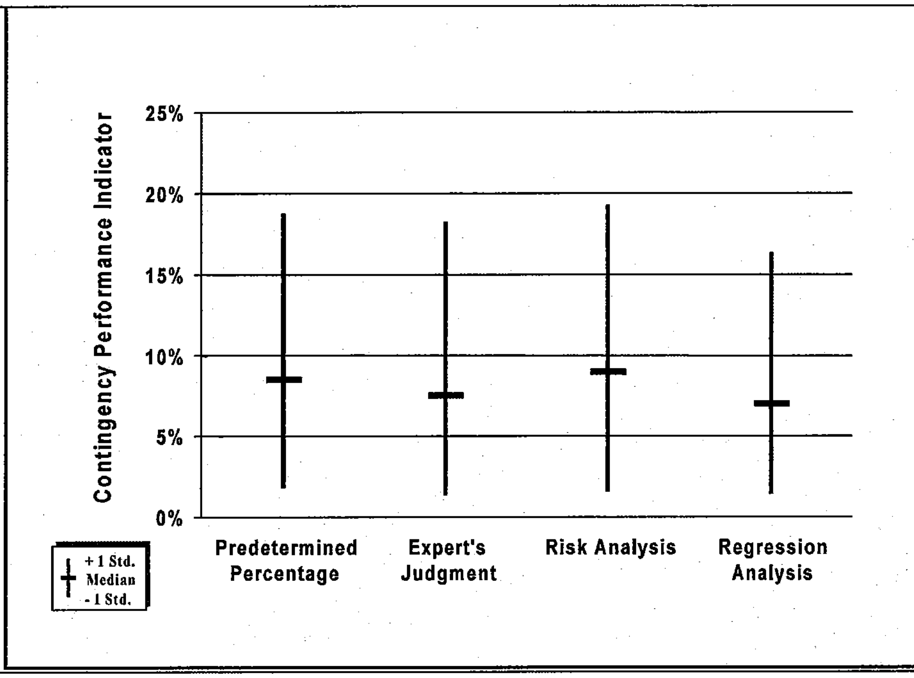

Figure 3—CPI for the Three Contingency Setting Techniques

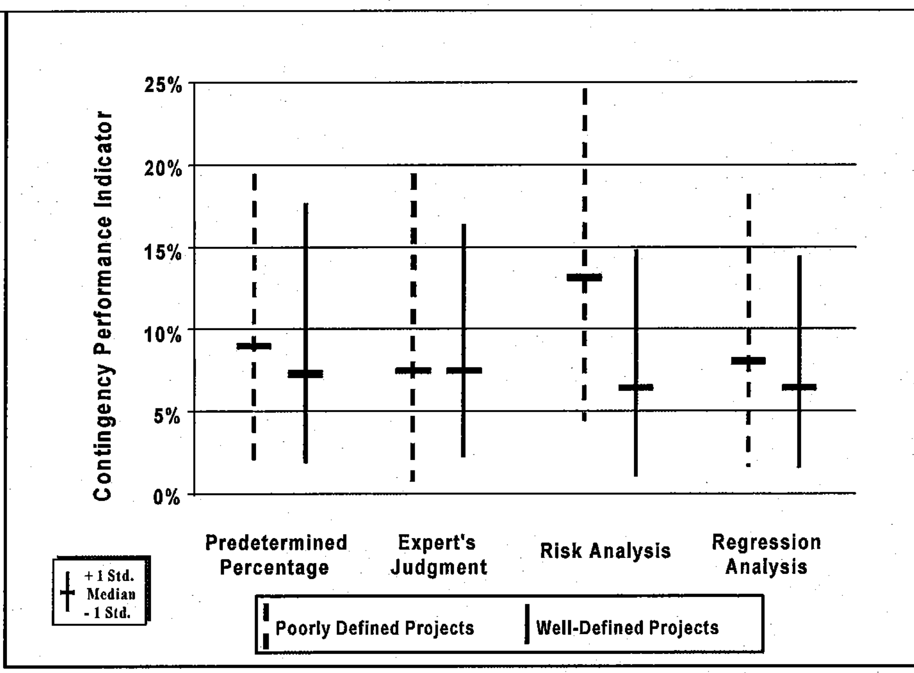

Figure 4—CPI for Well-Defined Projects vs. Poorly Defined Projects

same, as shown in Figure 3. No statistically significant difference exists between the three techniques. This is true for both new technology and off-the-shelf projects and is independent of project size and complexity. As previously stated, Monte Carlo analysis as typically applied, does not explicitly address how risk drivers link to cost outcomes; therefore, there is no reason to believe it would yield better results than the other techniques. As a means of comparison, IPA's regression model produces a median CPI of 7 percent for the same group of projects.

The most important risk driver is the level of project definition at the time of authorization. When we examined CPI by project definition level and contingency estimation technique, the results were dramatic. Figure 4 shows CPI medians for projects, split by level of project definition. For well-defined projects that used either a predetermined percentage or an expert's judgment, the median difference between estimated contingency and actual contingency requirements is almost 7.5 percent. However, when the project team used risk analysis techniques, the median difference is reduced to less than 6.5 percent. When we looked at projects that were poorly defined, using a risk analysis technique is a disaster. The median CPI for risk analysis balloons to 13 percent when used on poorly defined projects. In addition, the variance of CPI results also increases by 50 percent, indicating that risk analysis is inconsistent and unpredictable for these projects. Projects that used either a predetermined percentage or an expert's judgment are indifferent to project definition level, with the median CPI still below 9 percent. We believe that the risk analysis results reflect the fact that teams are attempting to address both the poor quality of the base estimate, as well as other risk factors, and they are overly optimistic. When a technique does not explicitly address risk drivers, too much flexibility does not yield improved contingency setting performance.

Regression analysis yields a similar CPI regardless of the level of project definition. This is due to the fact that regression analysis uses the level of project definition as an explicit factor when estimating contingency requirements.

As we have seen, assigning contingency to capital projects is one of the greatest challenges faced by project teams and estimators. Although the various techniques that are used to assist in that decision are similar, each has strengths and weaknesses. Through our historical analysis, we have found that certain techniques are more reliable under certain project risk conditions. Using an expert's judgment as the basis for setting contingency levels invariably outperforms the use of predetermined percentages. This is true regardless of project size, definition level, or complexity. Both of these techniques are stable enough, however, that they can be used on any type of project without the worry of drastically reduced performance for a given set of risk factors. This is not necessarily true for risk analysis techniques. This research has shown that risk analysis techniques can deliver slightly better contingency accuracy for projects that have good levels of definition prior to authorization. The use of risk analysis techniques on projects that are not well defined produces considerably worse results than other methods. For these projects, using a different contingency estimating method is preferable. Because the difference in performance is so drastic, choosing what technique to use, given differing project risk factors, is an extremely important decision.

Another technique discussed was regression analysis. Regression analysis directly addresses the factors that drive project risk, and these are the factors that drive the consumption of contingency. In order to use this technique, detailed project data, including cost and project drivers, must be collected. These data, taken from actual projects with quantifiable results, form the foundation for regression analysis. Although this technique takes time to develop, the finished product is easy to use and produces consistent and accurate results. This technique, if implemented correctly, can be a viable alternative or an excellent supplement to the traditionally used methods for contingency setting.

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APPENDIX J

INDICATED SHIPPER DATA REQUEST
IS-SCG-007
SOCALGAS 2019 GRC – A.17-10-008
SOCALGAS RESPONSE
DATE RECEIVED: MARCH 23, 2018
DATE RESPONDED: APRIL 6, 2018

7-1. Please refer to the Direct Testimony of Richard Phillips at page 14.

b. Please explain how SoCalGas determined that the Valve Enhancement Plan must be completed by 2021. Please provide any workpapers supporting this decision.

SoCalGas Responses 7-1:

7-1.b. SoCalGas objects to "explain how SoCalGas determined that the Valve Enhancement Plan must be completed by 2021," on the grounds that it lacks foundation and is misleading. Subject to and without waiving the foregoing objection, SoCalGas responds as follows:

Execution of the Valve Enhancement Plan began in 2012 and is anticipated to be complete in 2021. This schedule is consistent with the Commission requirement set forth in D.11-06-017 on page 19 that PSEP be completed "as soon as practicable," the requirement in Public Utilities Code section 957 that "[t]he commission shall additionally establish action timelines, adopt standards for how to prioritize installation of automatic shutoff or remote controlled sectionalized block valves pursuant to paragraph (1), ensure that remote and automatic shutoff valves are installed as quickly as is reasonably possible," and the directive in the Natural Gas Pipeline Safety Act of 2011 that the plan "shall include a timeline for completion that is as soon as practicable" (Pub. Util. Code § 958).