RISK.06

Marrying Risk Register With Project Trending

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The risk management process in conjunction with the project trending program ("trending program") can provide the project manager with an effective forewarning as well as cost and schedule forecasts. Project uncertainties and risks are identified and logged in a risk register, and their cost and schedule impact feed into the trend logs for further evaluation and analysis of the project cost and schedule impact. His data is then used to generate project forecast.

For too many years, the trending programs has been used in the EPC contractual relationships as a tool to capture cost overruns instead of as a cost warning and forecasting system, that is because most changes and costs are brought to the trend program after the fact. The lack of forethought and the lack of vision to forecast future costs are the two main reasons why cost forecasts are too often off the track or not reliable.

Marrying risk management with the trending program will identify future risks up front which can be qualified and quantified for a cost range of impact. A cost impact, with probability of occurrence being higher than 50%, shall be the basis of the trend-based cost forecast. Monthly evaluation of both the risk register and the trend log will validate and verify the status of risk associated trends, providing a sound forecast with "future" risk events as basis. The marriage of risk management with the trending Program provides a solid risk-based cost forecast.

General— A project manager once said at a conference that the essence of project management is to manage project risks - risks cause project changes, therefore, our job is to manage changes. In contradiction change can generate risk in which case change is constant, therefore, risk is constant and forever with us and as a result our job is to manage risks. Risk and change are two contradicting statements which may cause confusion among project managers as to which one would take priority in their busy schedules.

Risks are inherent to changes. Any changes to a well-planned path will generate potential risks to some degree. To implement a change management program in large oil and gas construction projects is almost mandated, whereas risk management process are just starting to be developed. The two programs are normally operated separately, however, ideally they could be married together and used as powerful and optimized cost forecasting tools.

Trending Program—The word "Trend" does not entail a proper definition in many textbooks and glossary dictionaries. Most importantly, it is not a part of the "*Cost Engineering Terminology*" in the **AACE International Practice** [1] **No.10S-90**. In reality, the word "trend" is one of the most frequently used words by cost professionals in oil and gas EPC projects.

"A trend is an idea or change, whether or not the change is fully accepted or developed, that has been directed or contemplated as a result of legislation, management action, more definitive design, design changes, field condition changes etc" [2]. Trend is a tool, a methodology, and a process to capture changes that are about to happen. These changes may have either a positive or a negative impact to overall project cost and schedule. Trending programs have been widely used in cost reimbursable EPC contractual relations and accepted by both owner and contractors as an effective tool to forecast cost growth and deviation.

"Trending" is a mechanism that is used to forewarn the project management team of any unwanted deviation from the baseline. It also provides back-up documentation for cost variance analysis. Variances are reported over time to indicate "trend" for cost control purpose [3]. Trending is a vital part of the cost management system, which is "the process of comparing actual performance with planned performance, analyzing variances, evaluating possible alternatives, and taking appropriate corrective action" [4].

Trending shall clearly record changes and the reasons why they are initiated, the cost and schedule impact of those changes, as well as categories of changes in a Trend Log. The Trend Log, shown here as an example, often serves as a discussion paper to present changes to higher management for alternatives or decision-makings.

A detailed trend notice always accompanies the trend log to provide additional back up documentation. There are many causes to trigger a trend, and the reasons why a trend is raised are always challenged. Therefore, the proper documentation and paper trail as well as documented verbal conversation, are imperative in the trending process.

Trend Inputs—In some cases, "change management" is a broader term that is often adopted as an alternate to trending program. It is defined as "an area of professional practice to cost-effectively manage project alterations from the defined scope and approved budget" [5]. Changes are made throughout the project life cycle against a baseline control budget in terms of cost and schedule. The reasons for a change can vary wildly, and the typical causes of project changes include:

Trend No.	Trend Description	Date Originated	Change Requester	$ Cost Impact	Trend Status	WBS / COA	Notes

Table A — Typical Log- Baseline of AFE Estimate

1 Client or owner initiated or requested.
Changes of expectations, scope variations, foreseeable risks
2. Home office engineering
Better ideas, value engineering, innovations, new technology.
3 Procurement and contracts
Different contracting strategy, market condition change
4. Field engineering and construction
construct-ability, execution strategy, labor availability
5. Commissioning, start-up and operation
Hazop review, production capability, improvement
6. External factors
Changes of legislation or law, competitors, uncertainty and external risks.

Figure 1 illustrates the trend input factors and output results. Based on the estimated cost and schedule impact, a Trended Forecast is derived.

Risks and uncertainty can be an important aspect of project trend inputs to generate the trended frecast. In many occasions, trends are used to record actual cost after the fact, not as they are devised to provide management with advance forewarning and alerting functions. Whereas risks are typically identified as future events prior to their occurrence, they can be a good source of trend inputs.

Risks and Risk Management—"Project risk is an uncertain event, or condition that if it occurs, then it has a positive or a negative effect on a project objective" [6]. Risks could cause adverse impact to the project final cost and schedule achievements, but they could also be identified and recognized as opportunities, consequently generating potential project savings. In either case, those identified project risks will affect the Project Trended Forecast.

Risk is a future uncertainty and not a fact. Forecasts do not focus on the "facts", but to use facts as basis to predict "to-go" costs. Projects should be keen on identifying these future uncertainties, analysing their likelihood and assessing the impact on the project cost and schedule.

The words probability and consequence are typically used to measure the significance of a risk event, and accordingly respond with an appropriate action plan.

As an integral part of sound project management practices, risk management is a systematic and proactive approach to taking control of projects and decreasing uncertainties [7]. The process includes the following steps:

Risk identification	- the basis for risk register
Qualitative assessment	- the measurement of risk significance
Quantitative analysis	- quantification of risk impact
Risk Response plan	- actions taken to deal with risks
Risk monitoring	- the effect of residual risk

Since the risk identification is the paramount first step in knowing what may lie ahead of you, a comprehensive and complete list of risk items will definitely form a solid basis for the risk management practice. "Identifying real and presumed risks is the first step in decreasing the overall risk for the project" [8]. The list of risks forms a part of formal project risk register, which also entails risk ranking; rough-order-of magnitude cost estimate for risk impact, risk actions and finally monitoring the residual risks.

Tables B thorugh E depict a typical project risk register [9]. Many large projects have used the following terminology in register headings, though many other versions of heading titles are widely available.

In table C and D above, note that each have a cost column, which will then affect the trended forecast one way or another. These costs may well be good sources to trend inputs, alternatively triggering initiation of a trend as a result of a deviation from the original project cost objective.

Qualitative Risk Ranking—"Qualitative risk assessment based on categorization of both probability and impact provides greater insight into the absolute risk severity" [10]. A single risk acting alone is measured using the "probability x impact" matrix. Risks higher than 50% probability and with considerable cost or

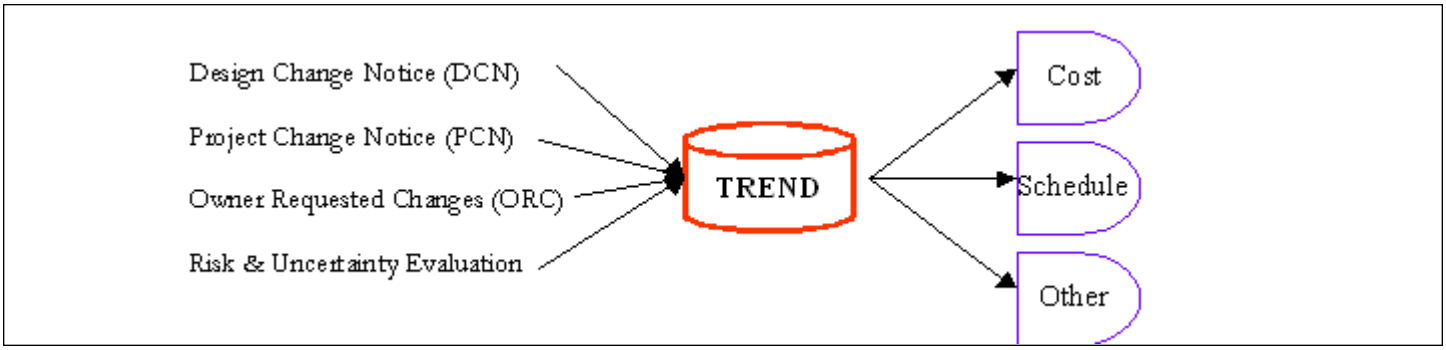

Figure 1 — Trend Inputs Diagram

schedule impact shall be brought to the attention of the project management team. There are two ways to convey the message:

1. Review with the management team as items in risk register
   - Pros: brief description, high level cost guess-mate, instant and quick; and
   - Cons: lack of details, limited space for elaboration, restricted circulation.
2. Discipline and management review as potential trend items
   - Pros: wider audience, work on details, formal sign-off process; and
   - Cons: assumption based estimate, additional efforts on background data collection, longer turn-over time

Risk matrices, shown inttable C above and figure 2 uses a grid system to evaluate risk levels and compare to the project management risk tolerability level. The management team can determine judgmentally, for example, what level of risks should go to trend log; hence it introduces flexibility to the management team to reflect the tolerability level.

Without a detailed, sophisticated and expensive risk quantification process such as monte carlo simulation, we can marry the Risk Register with the trend log in a very intuitive and simplistic manner to generate a trend-based project cost forecast. Once items in the risk register are migrated into trend log, adequate time and efforts can be afforded to further validate and evaluate their impacts to project cost and schedule, hence either to raise "alarm" or be prepared for upcoming risk event with sufficient lead time and trended funds.

Of the risk register in the table D above, an utmost attention must be given to the Response Cost when migrating to the trend log. "Risk response development is a critical element in the risk management process that determines what action will be taken to address risk issues" [11]. Risk evaluation is a continuous process during which the most appropriate action plans may be deployed; however, any action may cost the project money, time and extra effort. These "extras" are not likely included in the original project scope, cost or project schedule milestones, therefore, they will likely cause changes to the project as trended items.

Response actions include risk transfer, elimination, acceptance and mitigation (T.E.A.M.). Any one of the four actions has the potential to incur additional funds, and the only way to capturing these additions, specifically after the AFE control budget has been approved, is to go through the project change management, or trending process.

Monte Carlo Simulation—"Without numbers, risk is wholly a matter of gut!" [12]. The Monte Carlo process is an attempt to create a series of probability distributions for potential risk items, randomly sample these distributions, and then transform these numbers into useful information that would reflect quantification of the potential risks of a real project situation [13]. Monte Carlo technique can simulate a large amount of data whereas mathematical calculation is not feasible. One of the purposes is to derive quantifiable risk impacts based on probability ranges that are assigned to each variable or risky component.

Monte Carlo simulation method has gained its reputation in the area of cost estimate and project schedule contingency application. Software such as @Risk and Crystal Ball are widely used by many EPC and owner companies for cost estimate whereas Pertmaster [14] is used for project schedule risk analysis. One of the many important Monte Carlo simulation functions is the sensitivity analysis, the result of which can be used as another source of input to The project trending program.

Simulation does a few thousand iterations each run following the probability inputs to the identified variables or risks. Sensitivity analysis looks for the frequency that demonstrates how often each variable is picked up, subsequently generating a list of the most sensitive variables. Because quantitative risk evaluation

Risk Identification					
Risk Category	WBS Areas	Risk Description Symptoms and Root Causes	Risk Initiator	Date of Origin	Risk Recipient

Table B— Risk Register Identification

Initial Risk Ranking						
Probability	Impact	Priority	Stability	Initial	Risk	Cost $
(A): I – VI	(B): I - VI	I - III	I or II	Score	Level	Impact

Table C— Risk Register- Qualitative Assessment

Risk Response / Action					
Risk Trigger	Response (T.E.A.M.)	Risk Response Action Plan	Action Owner	Action Due Date	Response Cost $

Table D— Risk Register- Response Plan

Residual Risk						
Residual Probability	Residual Consequence	Residual Score	Risk Level	Action Sign-off	Residual Risk Cost $ Impact	Reserve Funds $

Table E— Risk Register- Residual Risk

is done periodically and regularly, those sensitive variables or risks common over a period of time should be fed into project Trending Program for validation and further assessment.

Typically the Monte Carlo simulation looks for the sensitive risk components identified within a cost estimate or project schedule. External risk factors that discretely affect the project objective can either be included in the Monte Carlo model for sensitivity analysis or assessed using a Risk Matrix during the qualitative risk evaluation process.

Figure 3 identifies the top 15 most sensitive variables in a project at the time when the simulation is run. For example, the "Quantity of Concrete Work" is a sensitive variable shown as an alert in this simulation run. If the same variable is again selected in the next simulation run in two months, it means the materials take-off ("MTO") for the concrete work has some potential problems. Therefore, we would be including this variable in the risk register or trend log. We perform Monte Carlo simulation runs to forecast the status of future variable events [15] based on our beliefs for their probability range, therefore, we can enlist identified risks into the Trend log ahead of the time when they may be materialized. This would forewarn the project management team.

Marrying Risk to Trend—"Project risk management shall be executed in conjunction with a project change / trending program. Together they will provide the project manager with an effective forewarning, as well as cost and schedule forecasts. Project uncertainties and risks identified and logged in the risk register shall be fed into the Trend logs for further evaluation and analysis for project cost and schedule impact " [16]. The Trending Program is the final phase and the last line of defense that extra costs could be captured in advance of the events' occurrence. Risk Register and Sensitivity Analysis are the mechanism to generate changes. It is a natural transition that changes evolve into trends, hence produce a trended forecast.

These tables show the input and output relationships between the trend log and risk register. Where the response cost may be a wild guess in the risk register, it will be in a +30% and -15% cost range once it is placed in trend log for further evaluation.

Probability of risk occurrence plays an important role in identifying which risks become the trend items. For instance, the cost to mitigate a risk with high cost impact, but with very low probability of happening may not be a trend item, rather that a risk reserve fund or crisis plan would be devised to cope with this risk by simply accepting its consequences. Risks with 50% probability of occurrence and considerable impact should be analyzed case by case before placing them into trends; the remaining risks shall be left in the risk register for continuous monitoring and tracking of their development over time.

The same project management team will likely review both trend log and risk register regularly, and the chances are that management team will objectively pick up those apparent risks in the register and move them to the trend log. And this very same team will also likely review the cost and schedule sensitivity analysis results, and may well select risky variables that appear adverse and aggressive, and place them as trend items.

The sensitivity table F as shown above is typically used for the project management team to cost-effectively manage risk drivers by assigning appropriate contingent funds should the risks materialize. However, "an important reason for using simulation for risk analyses, is the ability to conduct sensitivity analyses to understand the impacts of individual variables or their distribution assumptions on forecasts" [17]. By analyzing and comparing the incurred-to-date cost to the original budget, and measuring against progress status, an experienced cost engineer can assess whether a trend needs to be raised to cover the problematic variable, and if the contingency fund initially assigned is sufficient. Therefore, these variables identified through sensitivity analysis provide a reliable input source to project trending program.

Likely	6	12	18	24	30	36
Probable	5	10	15	20	25	30
Possible	4	8	12	16	20	24
Unlikely	3	6	9	12	15	18
Rare	2	4	6	8	10	12
Remote	1	2	3	4	5	6
MATRIX	Negligible	Low	Moderate	Serious	Critical	Fatal

Figure 2— Typical Risk Matrix

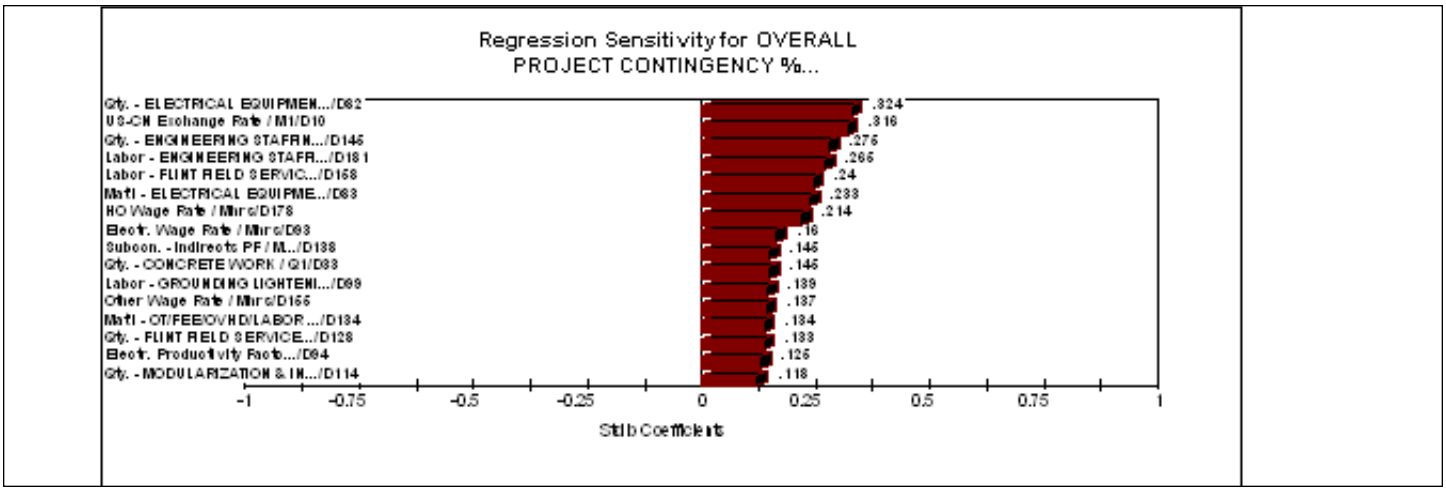

Figure 3—Tornado Sensitivity Chart

Project Management Institute ("PMI") has identified in PMBOK (Guide) 2000 The Project Risk Management as a vitally important part of overall project management practice. AACE Risk SIG committee has been vigorously promoting risk management. Project risk management practice has to integrate with project cost and schedule controls in order to produce desirable and reliable project cost and schedule forecasts. With the assistance of many readily available software packages, project controls credibility can be greatly enhanced in many ways, and marrying the risk register with trending is one way of increasing credibility, though many other options need to be explored.

Looking ahead from a project controls perspective, the following could be developed or utilized to assist marrying risk management with trending process:

- Active Risk Management (ARM) [18] system can provide management and project controls team with instant high-risk alarm, hence trigger a trend initiation process.
- Frequent Monte Carlo simulation runs on cost forecast and schedule can generate a pattern on how risky variables change as a project progresses from engineering to construction phases.
- Benchmarking data and earned value analysis can be great tools in helping risk analysis process by simplifying probability distribution and range process, hence initiating trends in a more intuitive fashion.
- Risk-savvy project controls personnel are employed and get involved in project risk identification, ranking and quantification process.

Owners, engineering firms and contractors are all looking forward to the day when risk management and project trending process are seamlessly integrated to provide a reliable cost and schedule forewarning system.

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Trend No.	Trend Description	Date Originated	Change Requester	$ Cost Impact	Trend Status	WBS / COA	Notes

Table D – Risk Response Plan

Risk Trigger	Response (T.E.A.M.)	Risk Response Action Plan	Action Owner	Action Due Date	Response Cost $

No.	Risk Drivers	Frequency	Percentile	Contingency $
1	Electrician Wage Rate / Mhrs	0.121	3.5%	$383
2	Home Office Productivity Factor / Mhrs	0.417	12.2%	$1,320
3	HO Wage Rate / Mhrs	0.307	9.0%	$972
4	Labor – ENGINEERING STAFFING / Mhrs	0.236	6.9%	$747
5	Labor - FIELD SERVICES / Mhrs	0.181	5.3%	$573
6	Mat'l – ELECTRICAL EQUIPMENT	0.153	4.5%	$484
7	Mat'l - GAS TURBINE UNIT	0.079	2.3%	$250
8	Mat'l - HEAT RECOVERY HRSG.	0.096	2.8%	$304
9	Mat'l - OT/FEE/OVHD/LABOR RETENTION	0.071	2.1%	$225
10	Other Productivity Factor / Mhrs	0.125	3.7%	$396
11	C&SU Wage Rate / Mhrs	0.098	2.9%	$310
12	Qty. – CONCRETE WORK	0.115	3.4%	$364
13	Qty. – ELECTRICAL EQUIPMENT	0.21	6.1%	$665
14	Qty. – ENGINEERING STAFFING	0.187	5.5%	$592
15	Qty. – MODULARIZATION & INSTALLATION	0.095	2.8%	$301
16	Qty. – OFFRACK PIPES / FITTINGS / VALVES	0.089	2.6%	$282
17	Subcon. - FB MGMT & PERMITS	0.072	2.1%	$228
18	Subcon. – Indirects PF	0.112	3.3%	$355
19	Subcon. – Other PF	0.096	2.8%	$304
20	US-CN Exchange Rate	0.555	16.3%	$1,757
	TOTAL	**3.415**	**1.000**	**10,814**

Table F— Monte Carlo- Sensitivity Table

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