Schedule Contingency

Modeling Uncertainty

Dennis Read Hanks, P.E., C.C.E

Schedule contingency is the additional time and associated costs set aside to address unforeseen circumstances that the project may encounter. This paper is focused only on risk factors, not risk events - those elements that may impact productivity.

Since these circumstances are unknown, there is no direct method available to determine the amount of time or money necessary to provide sufficient, but not excessive time and cost buffers for our project – schedule contingency.

What follows is one approach to determine this contingency, to model uncertainty.

Contents

Ground rules

Before we begin, it is imperative that we agree upon some basic requirements before attempting to model project uncertainty. The first of these is the absolute requirement that the project schedule be 'fit for purpose'. That it reflect the entire scope of time variable activities and that this scope be presented in a well-crafted schedule.

Well-crafted Schedule[1]

There is no point to performing any schedule risk assessment or schedule forecasting on an undeveloped or flawed schedule. If the schedule does not capture the intended entire project scope of work, or is artificially constrained, or improperly maintained, or poorly developed, then it has no value for this exercise.

Major flaws are:

[1] See "Schedule Quality Guidelines" in Appendix A for clarification of requirements.

1. More than two open ends. You can have a start milestone and a finish milestone without a predecessor or successor, respectively, but no more.
2. No negative float. Revise logic, because as it stands you cannot complete the project as currently planned.
3. No hard constraints – must start on, or must finish on. These restrictions severely impede activity movement and may invalidate any results.
4. No negative lags. This is a personal opinion.

Minor flaws are:

1. SS or FF relationships, was once regarded as open ends by Oracle Primavera Risk Analysis (OPRA).
2. Soft constraints – start on or before, finish on or later. Remove unless necessary.
3. Not resource loaded. Difficult to justify durations and certainly difficult to determine the cost contingency.

Further, it is advised that the analysis be performed on only the project schedule. Any specially constructed schedules that are not intended to be used to control the project are a waste of time. Schedule risk analysis is an ongoing process that needs to be concerned with identified work, not an ad hoc effort to satisfy an immediate need.

Rational durations

Durations should be derived by the application of the estimated unit rate times the crew size. In the absence of a Class 3 Estimate, where durations are given by a lead or superintendent responsible for the activity, the assumptions (crew size, scope of work) should be documented. It is ill-advised for the planner/scheduler to be the sole determinate of activity durations.

Team cooperation

It is also ill-advised to undertake and schedule risk assessment or forecast without the cooperation and support of the project team, especially the project manager. Trying to extract meaningful estimates from a unresponsive, ill-informed, and uncooperative review will be difficult and the data probably useless. If the team needs to be educated as to the value of the uncertainty modeling, take the time.

Time

As mentioned in the previous section, take the time necessary to elicit the necessary information, especially during the one-on-one meetings with the leads or superintendents. Resist the urge to get the activity ranges during the group risk seminars - Risk Register Review or development. I think it is far more productive and meaningful to work with the various knowledgeable individuals, in developing both risk events and the activity three-point estimate, reserving the group risk seminars to education and overall project risk ranking.

Why?

Why is it important that we model schedule uncertainty? Primarily because our project will exist in a world of uncertainty and the better we understand this uncertainty, the more likely that we will be able to achieve our objectives, at least have a greater understanding at to our exposure. Knowledge is power.

While uncertainty can have both negative and positive aspects, it is the more things are likely to hinder us than help us. This negative uncertainty is likely to make our project last longer than originally estimated. If it takes longer, it will probably cost more. If we are not adequately funded to deal with the extension and management was not properly prepared, we may not be able to satisfactorily complete the project. Additionally we may suffer professional embarrassment – our competence will be questioned.

While we may encounter adverse weather, disruptive labor conditions, or unforeseen site conditions, our delay will most likely be the result of productivity variances – congestion, temperature, location, labor competence or availability. Variances resulting from factors not identified nor fully understood and not incorporated into the Estimate unit rates. We know that something will probably go wrong; we just do not know what or what impact it might have. These unknown factors are what drive schedule uncertainty.

Schedule uncertainty is distinct from schedule risk, which is more closely associated with hurricanes, floods, strikes, war, receiving permits, soil contamination, – risk events. While risk events may be elements in modeling our schedule uncertainty, they are better dealt with via Risk Management and/or 'What-if' schedules; they will be ignored for the purposes of this paper.

This paper is about a method of dealing with schedule uncertainty via probability risk assessment – Primavera Risk Analysis.

Background/History

Historically, we have not had effective tools to incorporate schedule uncertainty into the project schedule and thereby forecast likely project completion dates and with it eventual labor costs. We knew that our durations were based on estimated unit rates that, while they had strong historical underpinnings were, at best, reasoned approximations. They were averages that were as likely to be lower as higher and may or may not reflect the estimators understanding of the unique project uncertainty – location, labor quality, availability – let alone, politics, and/or financing. Our only recourse was the application of an arbitrary percentage applied to the project duration – time contingency. As a result, time variable costs were generally not segregated, but addressed along with fixed costs and adjusted by the fixed estimate contingency percentage. We were not ignorant of our exposure, but powerless to do much about it.

One attempt to address uncertainty was the original Program/Project Evaluation and Review Technique (PERT) that employed the expected duration equation: Expected Duration(E_D) = (Optimistic Duration + 4X Determined/Estimated Duration + Pessimisstic Duration)/6. While this helped to account for some uncertainty, it still left us with a single value for the activity duration and project variable cost – no method of rationally determining contingency exposure. What might be called Schedule Uncertainty was the difference between the originally estimated activity duration (D) and the new PERT duration (E_D). No real understanding of the level of uncertainty (risk) that the project was willing to accept or seek to avoid and no linkage with time variable costs. Most significantly it assumed that uncertainty was uniform across all activities.

$$\mathbf{E_D} = (\mathbf{O} + \mathbf{4D} + \mathbf{P}) \div \mathbf{6}$$

That has changed with the development of schedule risk assesment and the application of probability theory to schedule activity durations.[2]

Our sample activity is F1030 Issue Process Flow Diagrams with a remaining duration of 27 days and a Optimistic duration of 24 days and a Pessimistic Duration of 41. With PERT we would have a value for E_D of 28.8 (say 29) days. With OPRA, we can more effectively model the perceived uncertainty surrounding Activity F1030.

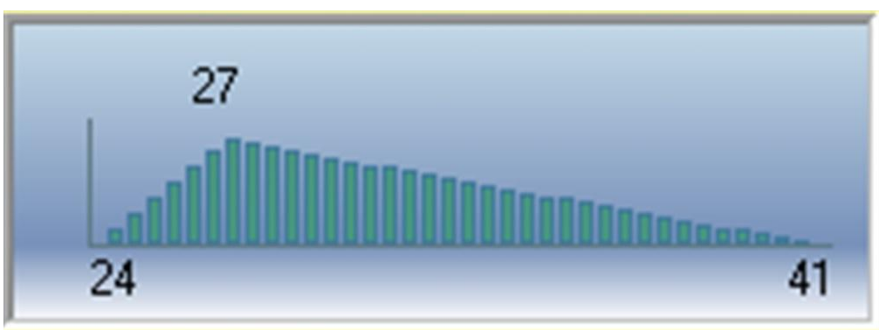


Figure 1: Triangle distribution

Instead of a single value to depict uncertainty, we have a range of values from our Optimistic to our Pessimistic possibilities with varying frequency of occurrence. We can even choose different distributions to more closely model the uncertainty of our activity[3]. We have choice, we can model.

[2] The scheduling software used in developing this paper is Primavera P6 Professional R8.2 and the risk software is Primavera Risk Analysis 8.7.0052.
[3] See Sample Distributions in Section 'Risk Profiles', page 11.

Definitions

It may be useful to agree upon some terms.

uncertainty

1. The condition of being uncertain; doubt.

2. Something uncertain: *the uncertainties of modern life.*

3. *Statistics* The estimated amount or percentage by which an observed or calculated value may differ from the true value.

Uncertainty[4] is a term used in subtly different ways in a number of fields, including physics, philosophy, statistics, economics, finance, insurance, psychology, sociology, engineering, and information science. It applies to predictions of future events, to physical measurements already made, or to the unknown.

Measurement of Uncertainty: A set of possible states or outcomes where probabilities are assigned to each possible state or outcome – this also includes the application of a probability density function to continuous variables.

> ***For our purposes, we will define Uncertainty as the range of possible durations that an activity may need.***

For contingency, it becomes a bit more complicated.

From AACEi:

CONTINGENCY – 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 (it is) 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 project; 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

[4] http://en.wikipedia.org/wiki/Uncertainty

within the scope, and variations in market and environmental conditions. Contingency is generally included in most estimates, and is expected to be expended. See: MANAGEMENT RESERVE. (1/04)[5]

Another description/definition is from PMI, to wit:

*The term **contingency** reserve refers primarily to the amount of quantity of **funds** or other financial resources that is required to be allocated at and above the previously designated estimate amount to reduce the risk of overruns to an acceptable level for the financially responsible organization. However, contingency **reserve** need not refer exclusively to monetary terms. It can also refer to a specific quantity of time in man-hours that must be allocated above and beyond the previously determined quantity of hours required to assure that any overtime or other unexpected hours of work required can be properly compensated for. Typically the contingency reserves, in terms of both finance and time, are determined at the outset of a project. However, as a project is ongoing, if it appears that the project will require additional funds or time allocation to complete, contingency reserves can be instituted or modified at any time to better prepare the organization for the possibility of their usage at some point in a projects life.*
*This term is defined in the 3rd and the 4th edition of the **PMBOK**.*[6]

> ***We will define Schedule Contingency as the additional time and monies needed to achieve stated project objectives within acceptable exposure.***

This additional time and monies were determined by a reasoned and thoughtful application of probability modeling to schedule uncertainty. It is the difference between the deterministic duration and associated cost and the forecast duration and cost.

Further, it is critical that all evaluations be made on well-crafted, resource loaded schedules and performed periodically throughout the life of the project. [7]

A 'well-crafted' schedule is defined as a project schedule passing both the Primavera Schedule Integrity Test, the Primavera Risk Analysis Schedule Check, and my guidelines for Schedule Risk Assessment (see Appendix A). Obviously, this schedule has to reflect the thinking and capabilities of all concerned and has been reviewed and accepted by them (buy-in) – simply: it is fit for the purpose intended. The 'risked schedule' is the project schedule – there cannot be a project schedule and a separate risk schedule.

Risk profiles

By definition[8], the deterministic project schedule has a 50% chance of being met, since it is based on an estimate that, itself, is an average of previous captured costs and unit rates. It is the mean of experience, adjusted for mitigating or aggravating circumstances - more or less hours/costs for location, time of year, labor availability and quality, etc. It is the best guess based upon experience, usually considerable experience, but it is still an approximation that has only 50% chance of being right (P50). It

[5] AACE International Recommended Practice No. 10S-90 COST ENGINEERING TERMINOLOGY 2009
[6] http://project-management-knowledge.com/definitions/c/contingency-reserve/
[7] Even conceptual schedules (FEL 1 and 2) should be resource loaded, if practicable.
[8] http://office.microsoft.com/en-us/project-help/estimate-activity-duration-HA001139963.aspx

may be higher or lower than eventually experienced, depending upon how well uncertainty has been captured by the estimator.[9] Our goal is to more effectively model the estimated durations.

After determining that the schedule is 'fit for purpose', the next step is the assignment of risk profiles – specific duration uncertainty models - to the schedule activities. This is the most important step – get this wrong and the rest does not matter. These profiles are subjective evaluations of the optimistic and pessimistic durations of the plan's activities. They can be determined from an understanding of a specific activity or as percentage range of a unit rate that applies to a group of activities. They are the 'best guesses' of seasoned, experience project members – superintendents, foremen, lead engineers, managers, and/or the estimators. Spend as much time as you think necessary to get the best possible insights.

For schedules of a less than 300 activities, direct assignment is a feasible method, especially if a Class 3 estimate has not been developed. The direct assignment is usually done by those that best know what might happen to specific activities listed in the schedule. These are generally FEED level schedules. The team will determine the optimistic and pessimistic durations for each activity (see Fig. 3). These guesses have to be moderated by the project manager or risk analyst. Care must be taken to 'prune' the guess of extremes. Generally we are looking for the P10 and P90 for the "Min" and the "Max". This means that 90% of the time we expect to finish the activity in less time than the Maximum duration and there is a 10% chance that we could finish earlier than the Minimum duration. In Figure 3, Activity 9 (Finalize PAs) had an estimated duration of 30 days, with the expectation that is could take as long as 35 days or as little as 25 days.

Generally speaking, direct assignment activities are independent of one another - they are not correlated. The factors that were the basis for the respective risk profile in one activity are usually not factors in the other activities. If this is not the case, care should be taken to note this for later application when running the risk analysis.

A variant of the Direct Assignment is the Percentage Assignment technique. It is sometimes easier for the activity reviewers to think in terms of percentages, rather than days when determining ranges. This is usually when the schedule is greater than 300 activities, but less than 1000 activities and no Class 3 Estimate or better is available. When this is the case, I use a Risk Code that reflects these percentages (see Figure 2).

This risk code is a four digit number. The first two digits represent the percentage difference of the Optimistic duration from the Estimated Duration[10]. In the case of Activity F1021, the 20 would mean the

[9] It is important that these uncertainties be delineated at the time the estimate is issued to ensure that they are not re-applied or erroneously adjusted during risk assessment.

[10] Experience suggests that when reviewers think in terms of percentages that they think +/-, not specific percentages. So responses are generally on the order of +20, -10, not 120% or 90%. It is left to the analyst to make this adjustment. It is suggested that the nomenclature reflect the thinking of the reviewers and that they understand it so that subsequent adjustments are more easily made.

Optimistic duration is 20% less than the Expected duration or 8 days. Whereas, the last two digits (50) represent a 50% increase in the Expected duration for the Pessimistic case, or 15 days.

As with the Direct Assignment, Percentage Assignment activities are generally not correlated, though this becomes less the case as the number of activities increases. Again, where correlation exists it should be noted for inclusion in the Risk Template (see Figure 4).

PRA_WBS	ID	Activity Name	Min	RD	Max	Start
1.1			129	139	161	24-Oct-11 A
1.1	1	Start	0	0	0	24-Oct-11 A
1.1	4	Project Kick Off meeting (PPP-1 Phase)		0	0	24-Oct-11 A
1.1	5	Refined cost estimate and schedule review	4	4	6	25-Oct-11 A
1.1	6	PPP-2 Phase kick off	0	0	0	19-Dec-11
1.1	7	PPP2- Develop BOD Deliverables	75	75	85	19-Dec-11
1.1	8	Binding Open Season	25	30	35	02-Apr-12
1.1	9	Finalize PAs	25	30	35	14-May-12
1.1	10	Seek BOD Approval	0	0	0	25-Jun-12
1.2			119	680	163	19-Dec-11
1.2	12	Develop narrative	5	10	12	19-Dec-11
1.2	13	Narrative mailing to all public officials	4	5	6	02-Jan-12
1.2	15	Meetings (Preliminary Outreach)	50	55	65	09-Jan-12
1.2	14	High Level State Agency Meetings	50	57	65	09-Jan-12
1.2	16	Conduct Open Houses	10	10	15	05-Jun-12
1.2	17	Ongoing outreach	0	549	0	19-Jun-12
1.3			315	684	385	01-Nov-11 A

Figure 2: Direct assignment of ranges

When the schedule is greater than 300 activities[11] and a Class 3 or better estimate is available, then it is better to range using the unit rates used in the development of the Estimate labor costs. For this I use a 'Risk Code'[12] that I apply to groups of activities that had their durations determined by a specific unit rate. This usually means by craft or discipline, so that similar functions – steel, wire, cable, large or small pipe, or disciplines like process, piping, mechanical, electrical, or instrumentation design will have the same risk code.

For construction activities, I rely upon the estimator's insight[13]. I expect him to be aware of the uncertainty surrounding his development of the unit rate used in the Estimate. This uncertainty should

[11] The 300 activity limit is arbitrary. The key determinate is whether the schedule is based on an estimate developed with unit rates (workhours).

[12] An Activity Code for discipline or craft can substitute for the risk code if it is Unit Rate specific.

[13] There is certainly no reason not to have superintendents review the range, but any disagreements should be resolved with the estimator's concurrence – goes to single-point accountability.

be beyond the variables of location and timing that are already incorporated into the craft unit rate. This should be his 'feel' for the range that his unit rate might take. Again, we are looking for the P10 and P90 – not extremes.[14]

This is form is useful when dealing with large number of activities that may not necessarily share a common unit rate, but share similar uncertainty.

Layout: FEED1 | Filter All: Discipline

ID	Activity Name	Rem Dur	Risk Code	Start	Finish
1		184		02-Jul-12	24-Apr-13
Project Management		184		02-Jul-12	24-Apr-13
1.1		27		02-Jul-12	13-Aug-12
Project Management		27		02-Jul-12	13-Aug-12
F1240	Review Project Charter	2	2055	02-Jul-12	03-Jul-12
F1250	Select staff	6	1555	05-Jul-12	12-Jul-12
F1000	Project Basis	15	1050	16-Jul-12	06-Aug-12
F1010	Review & Approve Project Basis	4	1050	07-Aug-12	13-Aug-12
1.2		85		14-Aug-12	02-Jan-13
Project Management		85		14-Aug-12	02-Jan-13
F1021	Develop Project Execution Plan	10	2050	14-Aug-12	28-Aug-12
F1022	Develop Responsibility Assignment Matrix	5	2050	29-Aug-12	05-Sep-12
F1013	Develop Contract & Procurement Strategy	5	2050	06-Sep-12	13-Sep-12
F1012	Develop Approved Manufacturer's List	3	2050	14-Sep-12	18-Sep-12
F1190	Provide PM Support FEL2	57	2050	19-Sep-12	19-Dec-12
F1037	Issue Process Hazard Analysis (PHA) Report	5	2050	20-Dec-12	02-Jan-13
1.3		64		08-Jan-13	16-Apr-13
Project Management		64		08-Jan-13	16-Apr-13
F1097	Develop Detailed Contract & Procurement Plan	8	1050	08-Jan-13	18-Jan-13
F1111	Develop Safety Plan and HSE Philosophy	8	1050	21-Jan-13	31-Jan-13
F1109	Develop QA/QC Plan	8	1050	01-Feb-13	13-Feb-13
F1140	Review & Apporve P&ID IFR	3	1050	25-Feb-13	27-Feb-13
F1116	Develop Sub-contracting Plan and Contractor Selection Critera	10	1050	07-Mar-13	21-Mar-13
F1150	Review & Approve P&ID IFA	3	1050	15-Mar-13	19-Mar-13
F1117	Issue Sub-contractor Bidders List	2	1050	25-Mar-13	26-Mar-13
F1044	Conduct Preliminary HAZID Study	5	1050	10-Apr-13	16-Apr-13

Figure 3: Percentage risk codes

More generally, I use an alpha code that is applied to specific crafts or disciplines (see Figure 5). This is a reflection of the unit rates used in the estimate. Every unit rate should have a specific code. What letters or characters used is immaterial, beyond that they should make sense to you and the project team. Another advantage of using an alpha Risk Code is the implicit assumption that the code correlates

[14] This does not mean we ignore extremes only treat them as exceptions that we deal with in 'what if' scenarios.

the subject activities. Any change in productivity of one activity of a group will likely be reflected by all activities of that group.[15] Productivity is not activity specific, but shared by all group activities.

ID	Activity Name	Rem Dur	Risk Code	Start	Finish
Layout: FEED1		Filter All: Discipline, TimeRange			
1.3		59		08-Jan-13	09-Apr-13
Piping Design		59		08-Jan-13	09-Apr-13
F1160	Issue Piping Standards and Specifications	8	PD	08-Jan-13	18-Jan-13
F1080	Issue P&IDs (IFR)	30	PD	08-Jan-13	21-Feb-13
F1085	Develop Preliminary 3D Model	30	PD	08-Jan-13	21-Feb-13
F1220	Provide Piping Design Support	51	PD	21-Jan-13	09-Apr-13
F1056	Issue Line List	5	PD	25-Feb-13	01-Mar-13
F1076	Develop Utility Flow Diagrams	5	PD	25-Feb-13	01-Mar-13
F1077	Develop Basic Piperack Plan	5	PD	25-Feb-13	01-Mar-13
F1079	Develop Fire Protection System Design Basis and Design	5	PD	25-Feb-13	01-Mar-13
Mechanical Design		28		08-Jan-13	19-Feb-13
F1073	Develop Mechanical Design Criteria	5	MD	08-Jan-13	15-Jan-13
F1072	Issue Long Lead Eqpt Data Sheets and Req's	10	MD	16-Jan-13	30-Jan-13
F1088	Develop Sized Equipment List	13	MD	31-Jan-13	19-Feb-13
Electrical Design		12		13-Feb-13	01-Mar-13
F1280	Develop Electrical Standards and Specifications	8	EL	13-Feb-13	25-Feb-13
F1052	Issue Electrical Equipment List	7	EL	20-Feb-13	01-Mar-13
F1050	Issue Area Classification Drawings	4	EL	25-Feb-13	28-Feb-13

Figure 4: Alpha risk codes

If we are using Direct Assignment of risk ranges, we can merely have OPRA import the file with the appropriate columns. If we have used either the Percentage or Alpha codes, we must populate a Quick Risk Template in OPRA before running the analysis[16].

Field		Value	Tasks	Distribution	Min	Likely	Max	Correlation	Description
Risk Code	=	1050	39	BetaPert	90%	100%	150%	none	
Risk Code	=	2050	13	BetaPert	80%	100%	150%	none	
Risk Code	=	2055	1	BetaPert	80%	100%	155%	none	
Risk Code	=	1555	1	BetaPert	85%	100%	155%	none	
Risk Code	=	1550	0	BetaPert	85%	100%	155%	none	
Risk Code	=	IC	7	BetaPert	75%	100%	125%	100%	Instrumentation Design
Risk Code	=	CD	3	BetaPert	80%	100%	150%	100%	Civil Struct Design
Risk Code	=	EL	9	BetaPert	80%	100%	150%	100%	Electrical Design
Risk Code	=	PD	17	BetaPert	85%	100%	140%	100%	Piping Design
Risk Code	=	MD	3	BetaPert	85%	100%	145%	100%	Mechanical Design

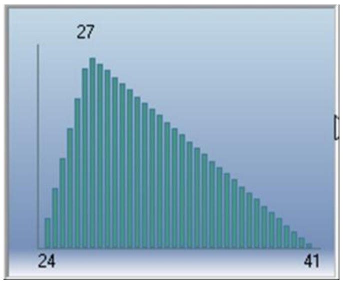
Figure 5: Sample Quick Risk Template

[15] This should minimize the effect of normalization that may be the result of multiple independent activities and the Central Limit Theorem.

[16] See Figure 4

It should be noted that we have several curve shapes that can modify the risk profile. I generally limit myself to the default the Triangle, the BetaPert (shown here), and the Trigen. I generally run each curve shape and allow the project team to choose the results that best fit their risk tolerance.[17]

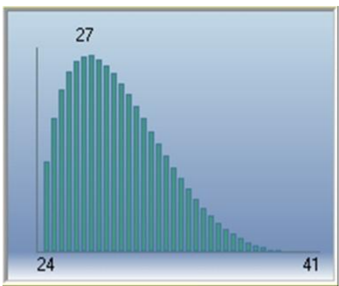
Sample distributions



Its simple set of parameters make the Triangle easy to relate to real life.

Triangular distributions are often skewed to the left. This is because a lot of tasks cannot physically be completed in less than a certain duration, but all tasks can generally be delayed for any number of reasons. This leads to the minimum duration being closer to the most likely than the maximum duration.

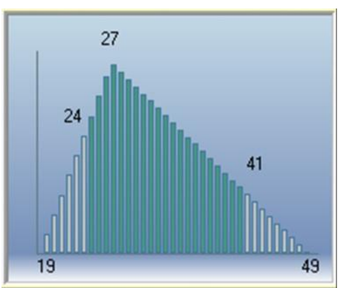
Figure 6: Triangle Distribution[18]



The BetaPert distribution uses the same parameters as the Triangular (minimum, maximum and most likely duration) and is similar to the Triangular in shape but its extremes tail off more quickly than the triangular.

Using the BetaPert distribution suggests a greater confidence in the most likely duration. It has been found that the BetaPert distribution models many task durations very well.

Figure 7: BetaPert Distribution



The Trigen distribution may be used when it is considered that the extreme values given do not approach the perceived extremes.

You may assign a percentage value to those extremes (e.g. the 10% and 90% shown below for values 24 and 41 days, respectively) and then Primavera Risk Analysis calculates the 'real' extreme values (19 and 49 days).

Figure 8: Trigen Distribution

[17] BetaPert features a left-side skew that moderates overly pessimistic ranges, whereas Trigen seems to accentuate the pessimistic to moderate overly optimistic evaluations. It is for the project team/management to decide which final curve best approximates their understanding of the situation.
[18] From Oracle Primavera Risk Analysis Help "Risk – Input Distributions available" version 8.7.0052.

Forecasting[19]

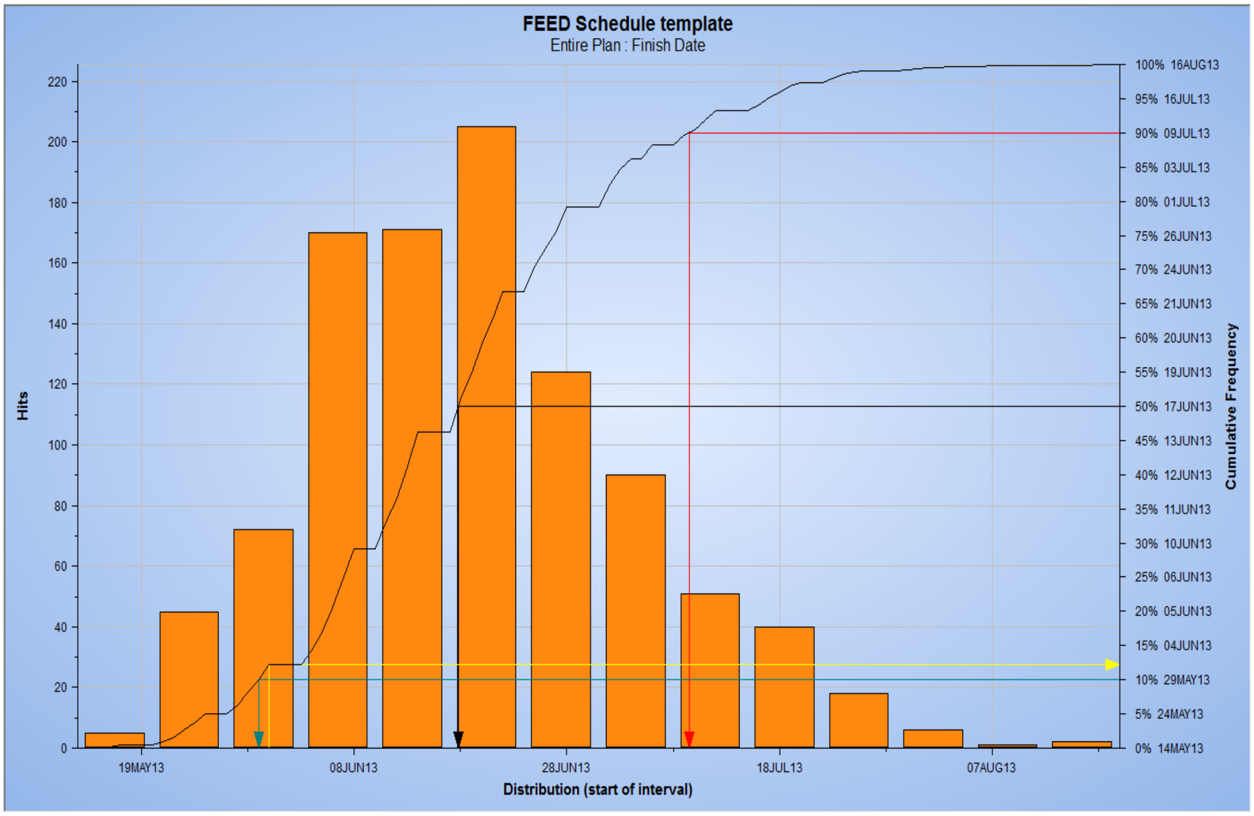


Figure 9: Forecast completion dates

For those of you who have used or seen the output from Primavera Risk Analysis, Figure 5 is no surprise. Figure 5 is a histogram of the Forecast to Complete for the sample project. It says that we have a 90% chance of finishing the project by 09Jul13. Whereas we have only a 13% chance of finishing on our original expected (scheduled) date.

Obviously these results are only as good as the original schedule, the estimate, and the insight of the project team. Given that, there is no other comparable tool that can translate schedule uncertainty into a comprehensible report.

[19] No attempt will be made to describe the actual process for developing the following Histograms and Charts, nor the mechanics of probability theory applied via Monte Carlo simulations. It is assumed that the reader knows this process and the mechanics.

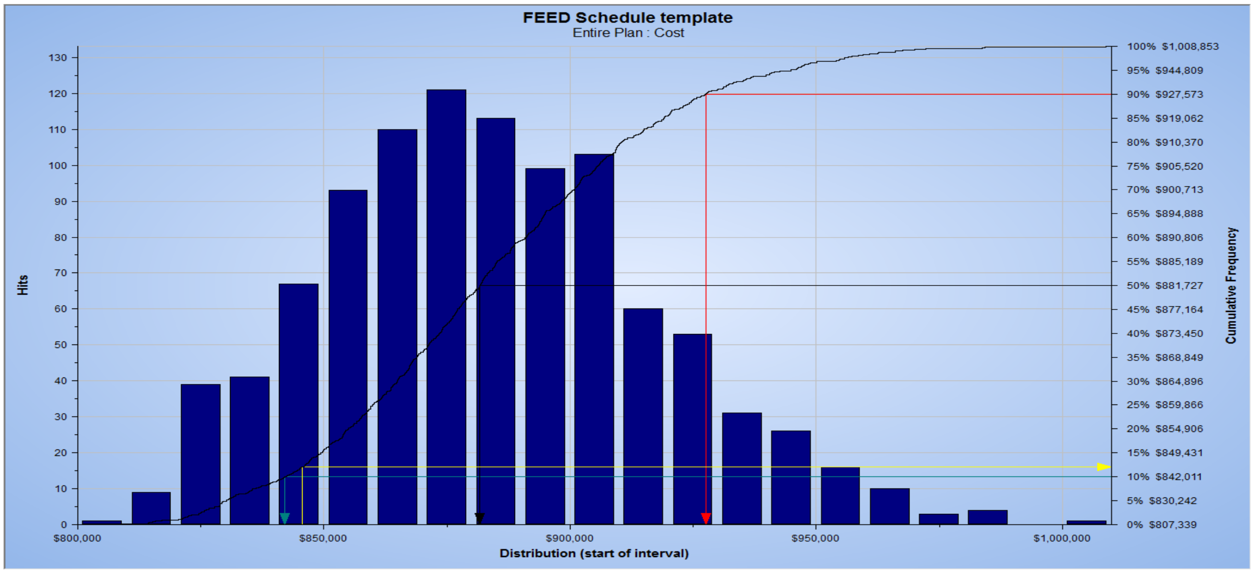


Figure 10: Forecast variable costs

Similarly Figure 6 shows the corresponding expected variable costs – costs resulting from extended durations.

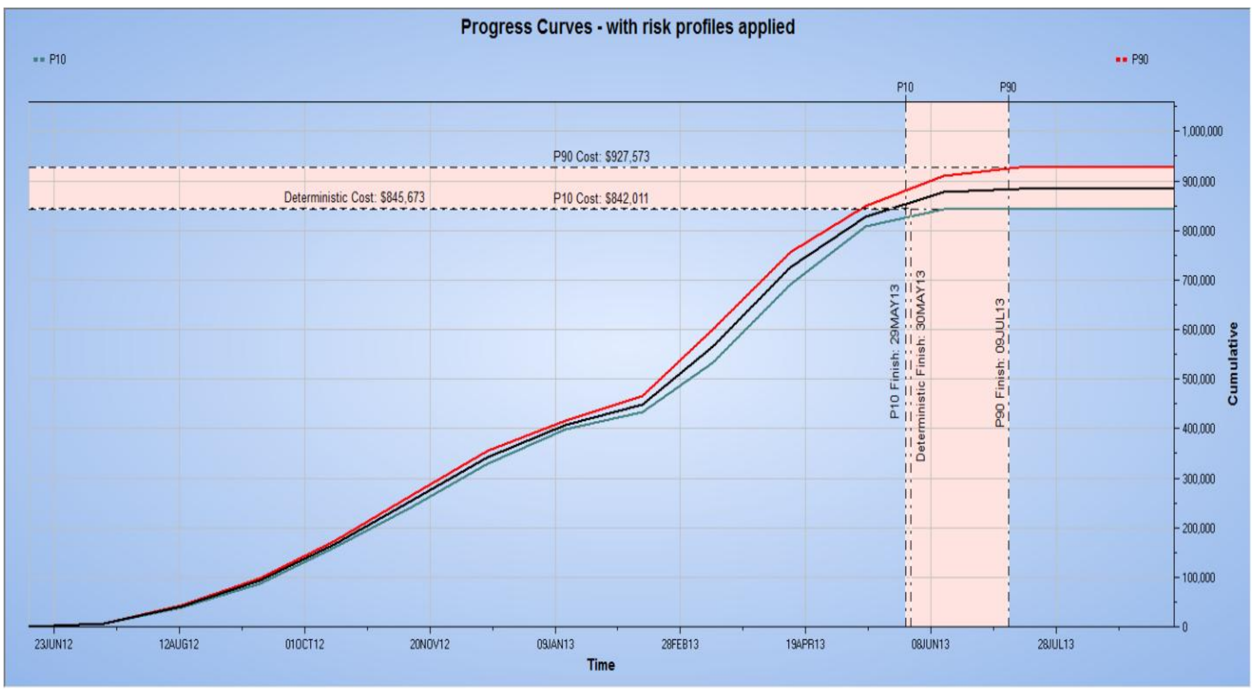


Figure 11: Composite cost and schedule chart

Figure 7 is a single chart synthesis of Figure 5 and 6 and represents the results from the application of our understanding of the uncertainties that confront our schedule. Notice that we no longer have any reasonable expectation of meeting our expected finish date (deterministic).

Two courses of action are open to you. Adjust your original durations to account for the uncertainty - not advised, because you may lose linkage to the rational basis for their development (the estimate), or present your analysis to management to prepare them for the 'likely' outcome.[20]

Another point that I want to make is that a single application of Schedule Risk Assessment is not, by itself, an adequate forecasting exercise. Just as we update the schedule with new information, we should update the forecast with new insights and understandings. The forecast should reflect all of our current knowledge and be continually updated. We need to periodically (every schedule update) re-run our analysis incorporating any 'new' data or insights that we have gained in the interim. Our model has to reflect all that we know.

Results

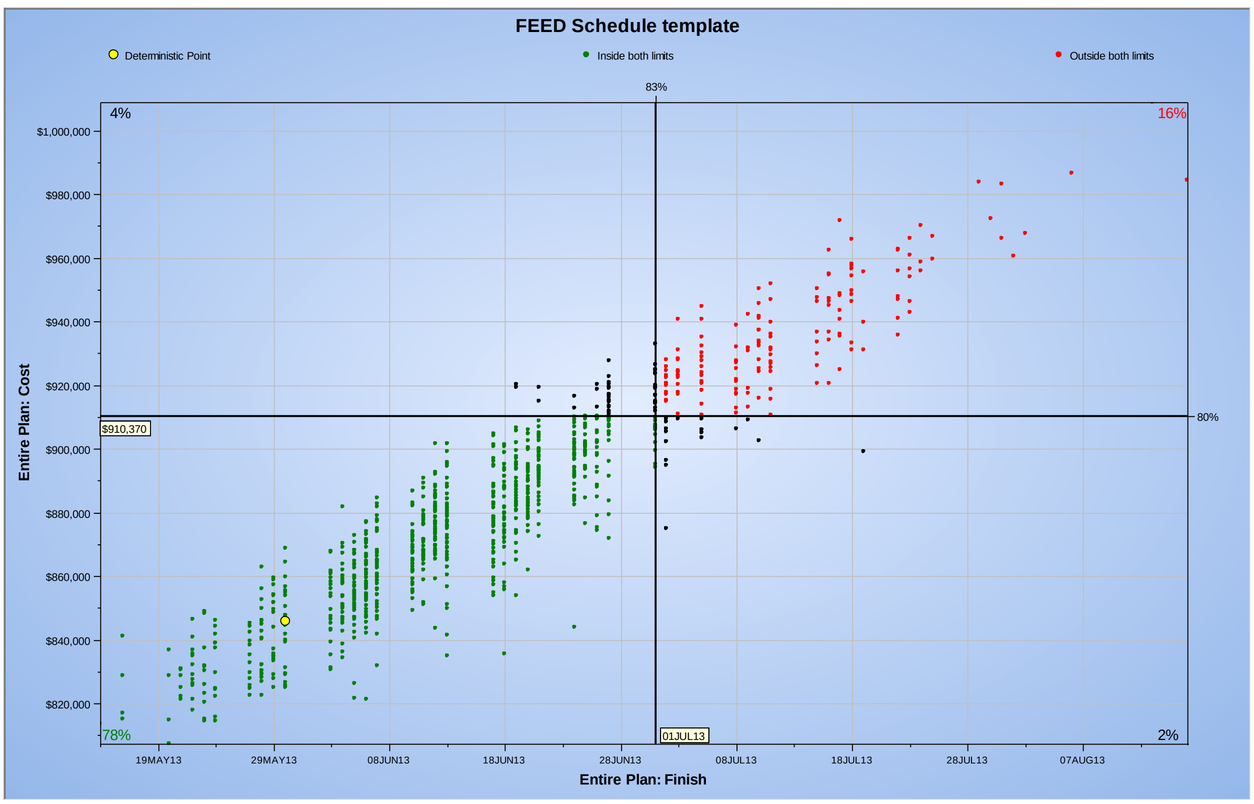


Figure 12: Scatter plot at 80% confidence level

[20] It is assumed that all risk mitigation strategies listed in the risk register are to be employed and that the only question is the value of the uncertainty assessments – risk profiles.

Figure 8 represents all possible outcomes of our 1000 iterations. Each dot is the date and cost for each run. In this case, I have selected an 80/80% confidence level. This means that we have an 80% chance of finishing the project and this date and at this cost. Management will tell you with which confidence level they are most comfortable.

The Schedule Contingency is determined by the following simple mathematics. Contingency = Forecast Date/Cost – Deterministic Date/Cost. Deterministic is the original data from our 'unrisked' schedule. From this relationship, we get:

Deterministic date = 30May13
Deterministic cost = $845,673

Forecast date (80% confidence level) = 01Jul13
Forecast cost (80% confidence level) = $910,370

Schedule contingency (additional time) = 33 days
Cost contingency (additional monies required) = $64,697

With this, we would go back to management and inform them that we think we should plan on the project taking a month longer and costing an additional $65, 000. It is important that this additional cost is added to the 'Estimate Contingency' already developed for the fixed costs – land, equipment, materials – any cost that will not vary with time. It is also important to check that this 'Estimate Contingency' has not already been applied to, or include labor or other time variable costs.

Recommendations

Start with a well-crafted, resource-loaded schedule. It serves no useful purpose to risk a flawed schedule. Likewise, a non-resource loaded schedule will only tell part of the story. If management is to be able to make a reasoned decision, they need all the data.

Take time to get the best insights from project members. Do not rush this process. You are after insights and understanding. Take a measured approach and resist trying to do too much in too little time. Reserve the right to re-visit any of your respondents should you think something amiss. If you encounter contrary opinions, try for consensus.

Repeat, repeat, repeat. To be truly effective, we must constantly re-assess our assumptions. As the project gains experience, we need to feed that experience back into our risk profiles. If we were too optimistic or pessimistic, we need to reflect that new understanding onto our profiles and adjust the forecast accordingly. Obviously, as new Estimates are developed, new Schedules will be developed, and these new Schedules will be 'risked' anew.

I strongly suggest that a Schedule Forecast[21], along with uncertainty evaluations, be reviewed at every schedule update. It is folly to think that what was once true will remain so

Contingency is time sensitive. It will recede with time and the unused portion should be returned to the program office. With each new run, re-submit the results of the contingency analysis.

[21] I think we should regard the development of the Risk Register and mitigation plans as Project Risk Assessment and what has been described, as Schedule Forecasting, rather than Schedule Risk Assessment.

Appendix A – Schedule Quality Guidelines

Issue	Description	Benchmark	Comment/Recommendation
1	Number of Activities	Optimal < 3000	Too many activities will make risk assignment more onerous and the schedule unmanageable. Consider tracking commodities (drawings, procurement, piping, steel, etc.) off schedule via Soft Logic and excel/access
2	Negative Float	0	Correct logic - signals project is already in trouble
3	Open Ends	=2 Start and Finish Milestones only	For a schedule risk analysis to be meaningful, it is important that tasks' dates are set by logic (e.g. Finish-to-Start links) rather than constraints. This is so that the risk analysis will recognize the effect of delays. An open-ended task is one that does not have at least one predecessor and one successor – it indicates a possible lack of logic. Consider closing open-ended tasks: • If a task has no predecessor, try to find some other tasks which could potentially delay it. Leave it as open-ended if it is the project start milestone. • If a task has no successors, try to find some other tasks which it could potentially delay. Leave it as open-ended if it is a project finish or reporting milestone.[i]
4	Resources	All estimated variable costs (labor) are captured in the schedule	All durations must reflect reasonable staffing levels. Check for over-allocation – crowding/congestion Schedules based on Class 4 or 5 estimates may be exceptions – read FEL1 or FEL2 schedules
5	Logic Types (avoid SS and FF relationships)	FS >90%	Correct logic - OPRA regards SS/FF relationships as open ends
6	Mandatory Constraints	Optimal = 0	Schedule constraints have a significant effect on risk analysis results since they do not permit activity/task movement. They should be used sparingly, and only when the constraint reflects reality. Constraints to be particularly aware of are: • Must start on and Must finish on – task does not move with progress changes, preceding delays will not delay the task, and preceding time savings will not move activity forward • Start on or after (SNET) and Finish on or after (FNET) – preceding time savings will not advance the task Consider removing these constraints and

Issue	Description	Benchmark	Comment/Recommendation
			replacing them with logic (e.g. Finish-to-Start links) instead. Other types of constraints are less significant because they do not influence the tasks' dates, only their floats. For example, you can use a Finish on or before constraint to indicate a desired completion date of a task – this will not force the task to finish on that day, but the shortfall will be indicated in the task's float.
7	Negative Lags	0	A negative lag is an overlap in the logic between two tasks – often it is used to represent a task starting earlier, with sufficient time to allow some other work to happen. Lags cannot have risk or uncertainty. In reality it is likely that the negative lag represents a necessary overlap, whose duration is uncertain. Consider replacing a negative lag with another kind of link that does not need the lag. For example: • Replace a negative lag on a Finish-to-Start link with a positive lag on a Start-to-Start link. • Split the tasks so that the overlap is explicitly represented by a task.
8	Activity Duration	Optimal 1 – 3 reporting periods 75% of active activities meeting this guideline	May make statusing more difficult. Consider breaking into smaller discrete activities Some long duration activities acceptable if underlying data is addressed off schedule via Soft Logic – see Guideline 1
9	High Float	TF > (2 + schedule update periods)	Signals opportunity to improve activity sequencing – tighten logic
10	Redundant Logic	< 5 links per activity	Test for too many relationships – delete extraneous ties redundant logic)

Note[ii]: Issues listed in order of importance

[i] Comments in smaller type are from Pertmaster Schedule Check Report version 8.5.0049

[ii] Chart originally based on DCMA Schedule Metrics: 14 Point Assessment Rev. 10: