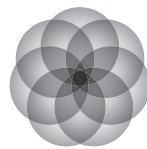


# // Improved Schedule Risk Analysis (SRA) through Metric Assessment

*Enhanced Schedule Delay Forensics through Project Metrics and Ribbon Analysis*

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# Introduction

This paper discusses the importance of establishing a sound schedule basis and ensuring valid risk inputs so as to generate an accurate and realistic schedule risk model. A technique for ensuring both of these criteria is discussed using specific metrics targeted at risk model validation.

Once a risk analysis is completed, interpreting the results can often be a challenge. This is especially true within large projects, and so a complimentary approach to interpreting risk results, pinpointing true risk exposure, understanding when in time the project is at greatest risk and providing this in a language that is easy to relay to the project team and stakeholders is also discussed.

## Background to Schedule Risk Analysis

Schedule Risk Analysis (SRA) is fast becoming an integral part of project planning.

Instead of forecasting a single deterministic completion date through CPM scheduling, more and more projects are now leaning towards providing a range of completion dates within the context of a given confidence level. The technique for calculating such information is based on an accepted approach using a Monte Carlo analysis. This simulates all possible outcomes in light of what is known as scope uncertainty and risk events (the two primary sources of schedule risk).

Unlike other forms of Monte Carlo simulation, a SRA is highly dependent on the structure and quality of the project schedule itself. In fact, the outputs from a SRA are dependent on two moving parts:

1. *The project schedule*: the CPM schedule containing activities, logic links, calendars, resources and other standard components that make up a CPM schedule.
2. *The risk inputs*: ranges of uncertainty and discrete risk events typically provided by the project team that get overlaid onto the schedule prior to running an analysis.

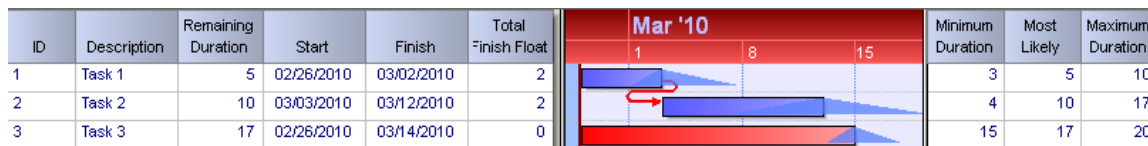
## How Does a Monte Carlo Schedule Risk Analysis (SRA) Work?

A SRA analysis is an evolution of a traditional CPM analysis. Rather than each activity having a single duration value, activities carry a range of durations (often described as a three point distribution e.g. min, most likely, max values). During each run of a simulation, values are sampled from the defined ranges of each activity duration and are then applied to a CPM analysis (calculating early and late dates). Subsequent simulations are then run so that a representative range of possible outcomes is established giving the analyst a confidence level surrounding project completion dates.

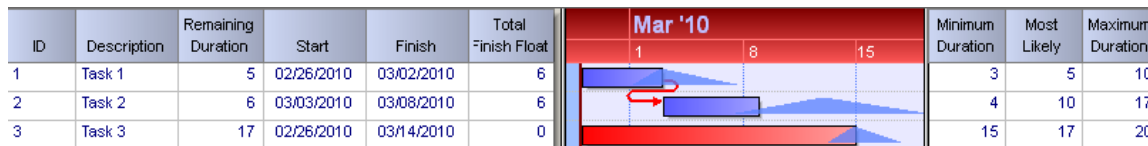
SRA is different to standard Monte Carlo analysis in that a delay on an activity does not necessarily result in a delay to the overall project. An activity with 10 days of float may incur up to 10 days of risk delay without actually becoming critical (and thus impacting the project completion). For simple networks this may seem like an obvious statement but apply this to large schedules with multiple parallel and interlinking paths and the equation can really only be solved through simulation.

Even more significant than the duration of a schedule changing, is the changing of the location of the critical path itself! Activities that may be non critical in the deterministic schedule often can become critical due to risk. Figure 1 shows a schedule with 2 parallel paths. Task 3 is on the critical path with tasks 1 and 2 having 2 days of float. During a risk simulation, Tasks 1 and 2 may incur delay due to risk which in turn will make their sequence of work longer than task 3, thus forcing them onto the critical path. In iteration 1, Task 1 and 2 have high float (non critical) whereas in iteration 2, risk actually causes them to become critical with Task 3 ending up with 3 days of float.

*Deterministic Schedule*



*Risk Iteration #1*



*Risk Iteration #2*

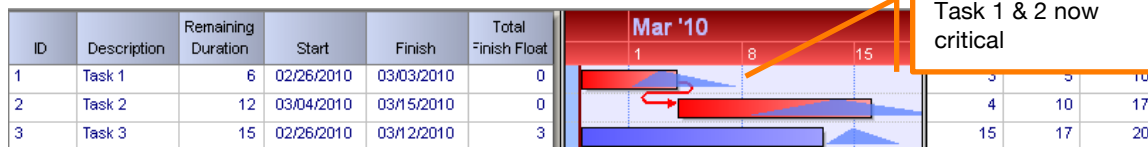


Figure 1 – SRA Analysis and the Changing Critical Path

When enough of these simulations are run, a distribution of results can be seen as per figure 2.

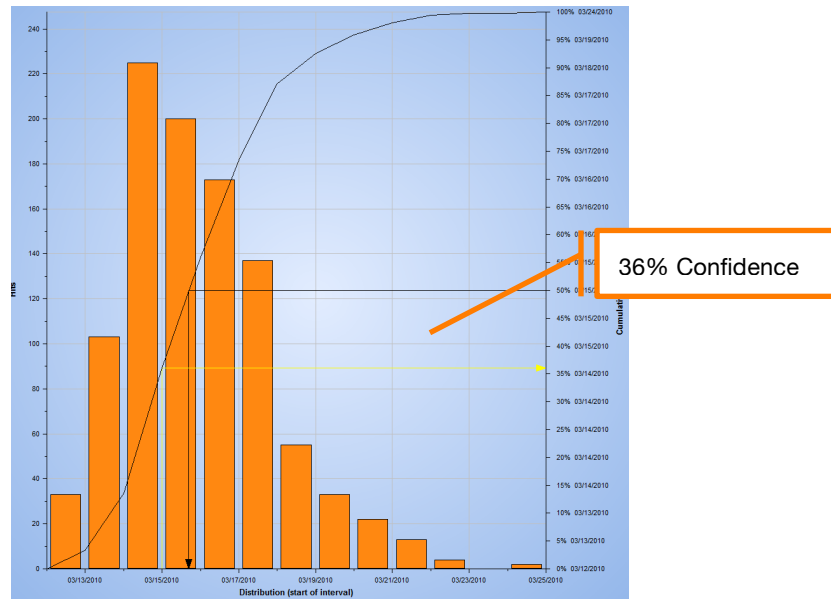


Figure 2 – SRA Results Showing a 36% Chance of Achieving the Deterministic Completion Date

## Creating a Risk-Ready Schedule

All too often, a SRA is run against a schedule that cannot sustain a valid risk analysis. That is, the schedule has structural flaws in it that prohibits a sound simulation to be run.

After spending the last decade working in the field of risk management and facilitating countless risk workshops, the most common question asked is, “Is my schedule ready for a risk analysis?” In reality, the answer is very simple: if the schedule is of sound integrity then it is ready for a risk analysis. Because SRA is little more than running a CPM time analysis, albeit running it thousands of times (see previous section), the criteria for a sound risk analysis are really the same as those required for a sound schedule.

Risk-ready schedules should have certain characteristics. Some of these are described below:

### Sound Logic

The backbone of a sound CPM schedule is the sequence of activities and the links between them (precedence logic). Omit these and the dates calculated by the CPM engine become overly optimistic and schedule forecasts become unrealistic. Equating this to a risk analysis, any activities that have, for example, open ends (missing logic) and are exposed to schedule delay due to risk will not have a true knock-on effect on any successor activities and thus the impact of the risk will not be reflected in the schedule.

Take the example schedule shown in figure 1 and let's consider the impact of Task 1 having missing logic. Everything in this new scenario is the same except there is a missing FS relation between Task 1 and Task 2. When the SRA is run, any delay on Task 1 will have zero impact on the rest of the schedule because it is 'open ended'. What may seem like a minor flaw in the schedule has a massive negative impact on the risk results – in effect making them invalid.

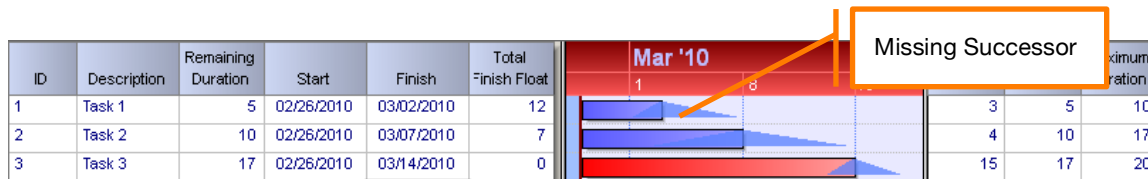


Figure 3 – Example Schedule with Missing Successor on Task 1

Figure 4 is now wrongly reporting that our example project has a 57% chance of completion on time (was originally 36%). In short: the results are overly optimistic due to the missing logic.

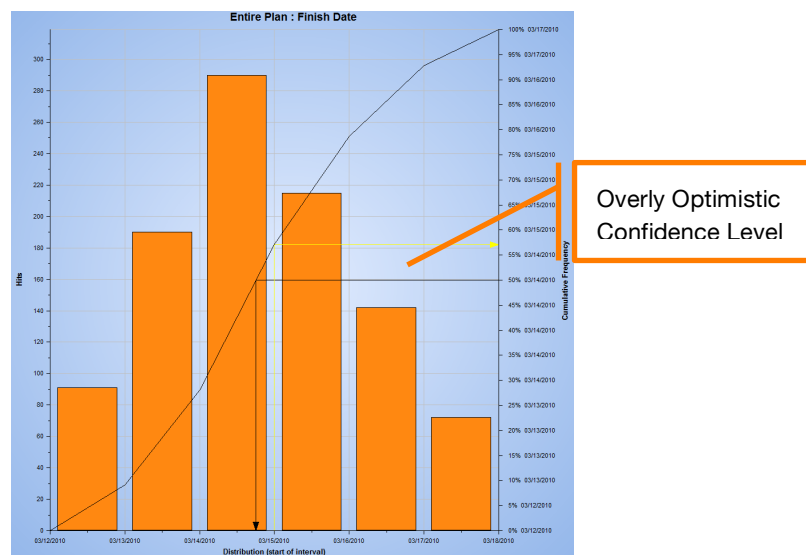


Figure 4 – Flawed Risk results due to Missing Logic

## Minimal Use of Constraints

The use of constraints generally goes against the principle of CPM analysis (as the CPM calculation cannot freely calculate dates because the activities are already artificially held in place with the constraint). This is an even bigger issue for SRA. Again, take our example project from figure 1 but this time consider task 2 having a constraint applied to it. By adding an artificial constraint to Task 2, during the SRA iterations, any knock-on effect of task 1 being delayed does not get reflected through to task 2, in essence making that network path irrelevant to the risk analysis. Any upstream delay gets reflected as negative float rather than being cascaded down through to the end of the project as a true delay.

## Deterministic

ID	Description	Remaining Duration	Start	Finish	Total Finish Float	Minimum Duration	Most Likely	Maximum Duration
1	Task 1	5	02/26/2010	03/02/2010	2	3	5	10
2	Task 2	10	03/03/2010	03/12/2010	2	4	10	17
3	Task 3	17	02/26/2010	03/14/2010	0	15	17	20

## Risk Iteration #1

ID	Description	Remaining Duration	Start	Finish	Total Finish Float	Minimum Duration	Most Likely	Maximum Duration
1	Task 1	9	02/26/2010	03/06/2010	-4	3	5	10
2	Task 2	9	03/03/2010	03/11/2010	3	4	10	17
3	Task 3	17	02/26/2010	03/14/2010	0	15	17	20

Negative float created due to constraint

Figure 5 – Constraints Invalidating a Network Path During a SRA

## Other Criteria for Risk-Ready Schedules

There are numerous other checks that should be applied to a schedule in order to validate that it is risk ready. These include but are not limited to:

- Consistent Level of Detail
- Appropriate use of Calendars
- Avoidance of Lags

## Risk-Check Metric Analysis

To help with such validation, a library of risk-check metrics has been developed based on over ten years of research and hands-on experience with developing risk models. These risk-check metrics are now an integral part of Acumen Fuse and should be used when validating any schedule prior to running a SRA.

Figure 6 shows an example Fuse analysis looking at whether a schedule is sound and is risk ready or not prior to an analysis. By grouping activities (and analyzing) by the likes of project discipline, we can quickly pinpoint which areas of the schedule need addressing.

Discipline	Ribbons / Phases	Time Line				Ribbon Analyzer							
		2009	2010	2011	2012	1. Logic	3. Lags	5. Hard Const	6. High Float	7. Negative Fl	8. High Durat	Logic Density	Av Rem. Dur.
Discipline	5. Hard Constraint	0 (0%)				2 (67%)	0 (0%)	0 (0%)	1 (33%)	0 (0%)	1 (33%)	1.67	27.67
	Concept	0 (0%)				2 (67%)	0 (0%)	0 (0%)	1 (33%)	0 (0%)	1 (33%)	1.67	27.67
	Construction	0 (0%)	0 (0%)	1 (50%)	1 (33%)	1 (20%)	0 (0%)	1 (20%)	1 (20%)	0 (0%)	2 (40%)	1.80	81.00
	Engineering	0 (0%)	0 (0%)			0 (0%)	0 (0%)	0 (0%)	2 (29%)	0 (0%)	5 (71%)	2.86	53.29
	Post Implementation					1 (50%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (50%)	1.50	22.00
	Procurement	0 (0%)	0 (0%)	0 (0%)		0 (33%)	0 (0%)	0 (0%)	1 (33%)	0 (0%)	2 (67%)	2.33	80.33

Pinpointed Hard Constraints

Figure 6 – Analysis of Schedule Assessing Risk-Readiness

In addition to validating the schedule, a second library of risk-check metrics has been developed that actually validates and critiques the risk inputs themselves! Anyone with experience of SRA will know that the results can quickly be changed (read ‘skewed’) simply by going back and ‘tweaking’ or adjusting the risk inputs. While SRA is a powerful analysis, it is terribly prone to the inputs fed into the model.

To help give structure and provide a framework for objective and accurate risk range inputs, new metrics have been developed. Examples of some of the checks include looking at those activities that have one-way risk ranges or flagging those activities that have a large percentage of aggressive risk ranges (ranges that indicate large downside but little scope for upside).

Typically, if there are a large number of overly-aggressive or conservative activities, then this is an indication that the underlying schedule estimates may need to be revised (or the team aren’t bought into the schedule).

Additional checks (metrics) include looking at the range of uncertainty. Those activities that have a very broad risk range should be re-estimated and reviewed prior to a risk analysis.

Likewise, activities with very large uncertainty range skews often reflect the presence of a risk event. This then becomes an issue if risk events are also being tracked in a risk register as their impact ends up getting ‘double-counted’ in a risk analysis.

Ribbons / Phases	2009		2010		Ribbon Analyzer				
	Aggressive	Conservative	Questionable Range	Broad Risk Range	Average Risk Range	Aggressive	Conservative	Questionable Range	Broad Risk Range
Concept	1 (33%)				1 (33%)	2 (67%)	3 (100%)	0 (0%)	9 (34%)
Construction	0 (0%)	0 (0%)	0 (0%)	1 (33%)	1 (20%)	4 (80%)	5 (100%)	1 (20%)	27 (34%)
Engineering	7 (100%)		1 (100%)		7 (100%)	0 (0%)	7 (100%)	5 (71%)	26 (49%)
Post Implementation				1 (50%)	1 (50%)	1 (50%)	2 (100%)	0 (0%)	8 (34%)
Procurement	0	0 (0%)	1 (100%)		1 (50%)	1 (50%)	2 (100%)	0 (0%)	40 (33%)

Figure 7 – Example of Risk Input Metrics Applied to a Project

One of the most valuable forms of risk input validation is to look at the project team’s perception of risk over the entire duration of the project. By examining risk input metrics such as average risk range, we can determine whether the team need to revisit their inputs either with respect to a specific discipline or for a specific period of time.

Figure 8 shows an example project being analyzed for average risk range. The early stages of the project have a low average risk range but then this increases dramatically in late 2010 before dropping back down in 2012. Further, by looking at average risk range by discipline (through the ribbons), the construction discipline can be seen to carry the largest perceived risk

range. This type of insight is invaluable when it comes to determining which areas/periods within a project to focus risk reduction efforts.

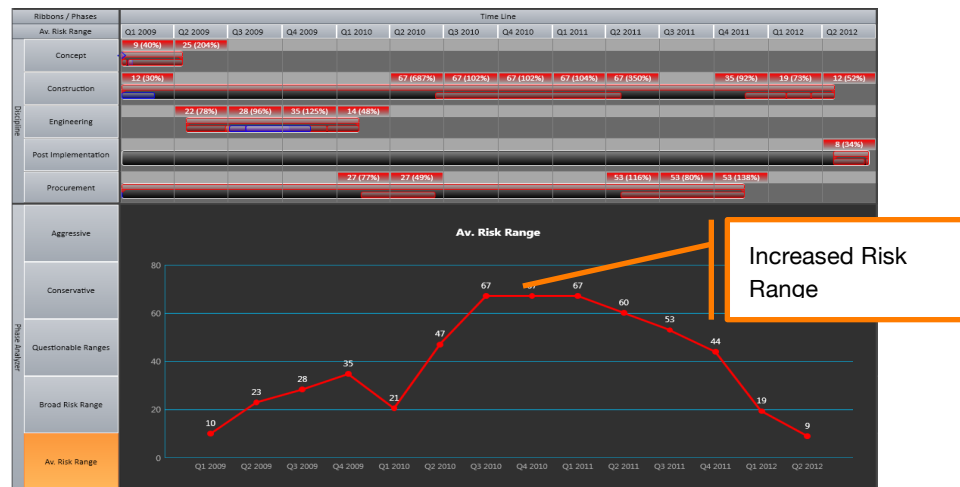


Figure 8 – Analysis of Risk Inputs Looking at Average Risk Range

## Risk Exposure Metric Analysis

In addition to analyzing the quality of the schedule and the quality of the risk inputs, metrics can also be used to interpret the results from a risk analysis (i.e. risk exposure).

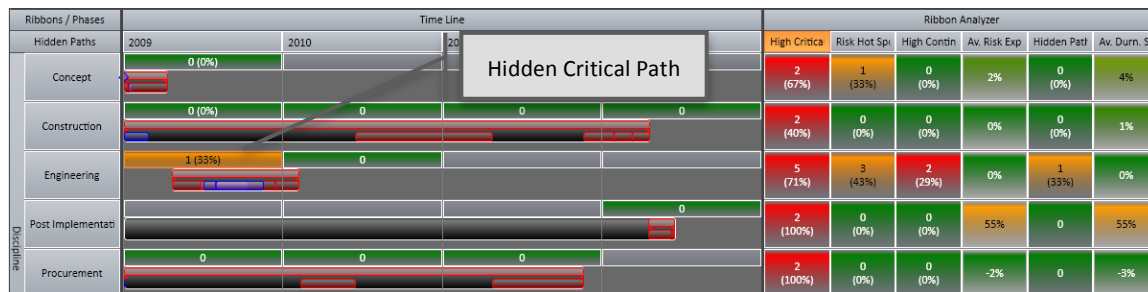


Figure 9 – Risk Exposure Analysis by Discipline

Figure 9 shows various risk exposure metrics including:

- **High criticality:** those activities that often fall on the critical path (thus having an impact on the completion date of the project).
- **Risk Hot Spots:** activities that are high risk and that have a high number of successors. These characteristics combined are an indication of a risk hot spot that should be monitored very closely and ideally eliminated.
- **High Contingency:** Those activities that require a large amount of contingency in order to resolve them.

- *Hidden Paths*: those activities that are not on the critical path but become critical due to risk.

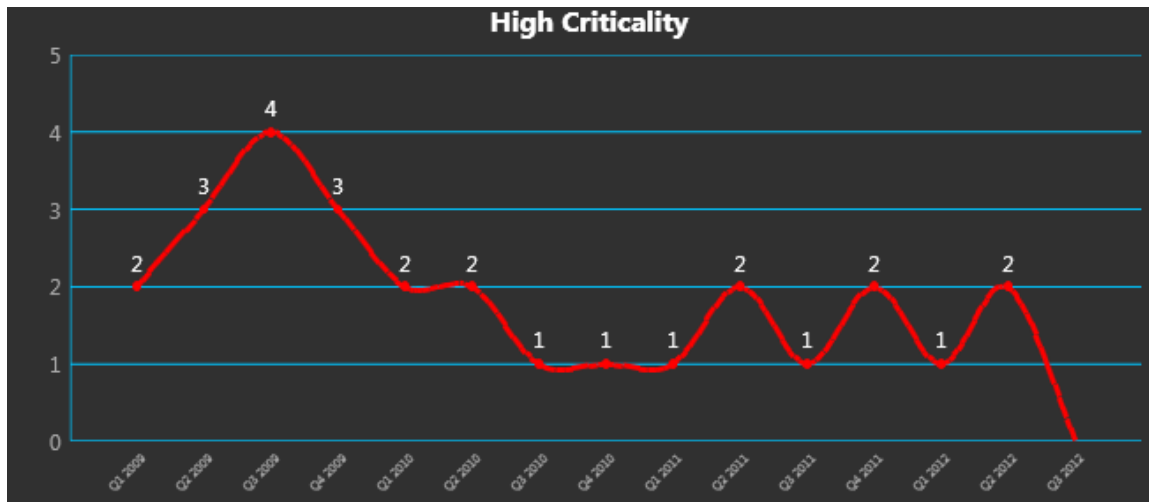


Figure 10 – Risk Exposure Analysis by Discipline

Further, looking at risk exposure over time is a very useful insight. Figure 10 shows the average criticality (an indication of risk exposure) over time. Interestingly, the number of activities with high criticality is higher at the start of the project than at the end. This is showing a front-end loaded risk schedule. In reality, it means that it is extremely important that risk control and mitigation measures are put in place early in the project otherwise these up-front risks will have a hard-to-recover impact on the rest of the project.

Even more interesting is the fact that when we re-review the team’s risk inputs (figure 8), the perception of risk was actually back-end loaded towards the end of the project. In reality, the most risk is actually front-end loaded. How can this be given the team provided larger risk ranges towards the end of the project? The explanation for this lies in the structure and logic of the project. While the early activities may have smaller ranges, due to their logic and inter dependences, they actually are more prone to risk exposure than some of the latter activities that are carrying more float.

In addition, one further time-phased metric looking at risk hot spots shows that these lie not only in the early phases of the project but also that they lie specifically within the engineering discipline.

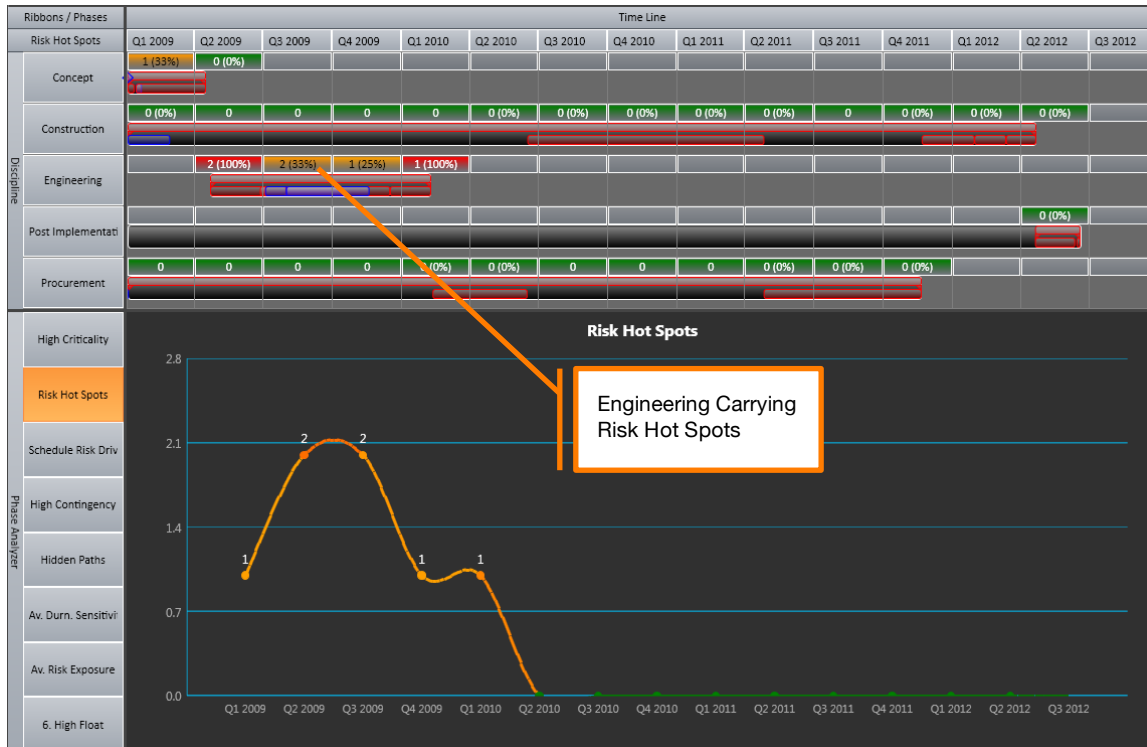


Figure 11 – Risk Hot Spots

This type of insight can only be obtained through metric analysis and is an excellent example of how true risk exposure can be understood by slicing and dicing schedule and risk data through ribbons and metrics.

## Concluding Comments

Schedule Risk Analysis (SRA) is a powerful forecasting technique yet relies heavily on having a sound basis of schedule and accurate risk inputs. Through the combined use of schedule-check and risk-check metrics, risk models can now be validated prior to a risk analysis, ensuring that the results generated are sound and representative of the project's true risk exposure.

By slicing and dicing projects by ribbons and phases using analysis tools such as Acumen Fuse, a unique insight into the root causes of schedule delay, risk hot spots and areas of focus for mitigation can now be identified.

## Additional Information

Acumen specializes in project analytics and is the author of Acumen Fuse, a project assessment tool. More information on project assessment through metric analysis and Fuse can be found at [www.projectacumen.com/fuse](http://www.projectacumen.com/fuse) or by calling +1 512 291 6261.