Handling Uncertainty in Project Planning

Dmitri Ilkaev

Introduction

The majority of project planning effort today is still performed in a strictly "deterministic" manner. All project tasks and resources are assigned and executed within well defined timeframes. At the same time we all know that real life necessitates corrective actions:

- Resources are not always available
- Extra tasks pop up during the course of the projects
- What happens most frequently is the initial estimate of the time required to perform a certain task is no longer valid

It's easy to mentally grasp such uncertainties and have an accurate estimate when dealing with a few variables. With large scale projects however having multiple uncertainty factors of a different nature and character means such analysis can not be performed manually. It demands a very special effort for an accurate project assessment.

Project Planning Tools

Such uncertainty in project planning is widely recognized in a lot of industries and a wide variety of different tools exists to help optimize the planning process and minimize the associated risks. These tools cover a wide range of offerings from the mathematically rigorous and sophisticated solvers (mainly constraint based programming) to different Excel adds on (VBA macro based) doing similar things but on a simpler level. You could even find a freebie to do some optimization of your Excel based projects or dependencies.

Approach to Project Planning

In this paper we share the approach we recommend you implement when dealing with the planning, assessment and optimization of large and cumbersome projects. We focus on software development projects however this approach is valid for a wide selection of projects in all industries.

The following situation is very common for a product development organization. How to rapidly develop an accurate project plan estimate which is critical to the overall development lifecycle (resources, relation to other projects and dependencies on other deliverables should be always well defined) and at the same time minimize the time spent performing "if-then-else" analysis. Business and technical analysts and project managers have their hands full doing "real things" – implementing new customer requested functions and working on the next release of the product.

By setting up a few extra steps in your planning processes, and applying a specialized tool against our project plan, we believe that you will have the right solution and be able to define the correct approach to this problem.

Project Planning Process

The process of planning and assessment consists of the 5 main steps:

1. **Define the Project**

   During this phase we put together the regular project plan in MS Project with the main tasks, timeframes and deliverables. The project plan can be created either manually, or be generated as the result of other efforts (doing some preliminary use cases or object design or working with the cost estimate tools).

2. **Identify Uncertainly**

   In this phase we need to determine:

   - Which tasks, or their inputs in the plan are uncertain
   - What we know about these uncertainties
   - What would be the best way to describe these uncertainties
   - The behaviour and known range of values they might cover.

   During this phase we also need to identify what are the most critical results we want to look at, analyze and optimize as outputs of our plan.

3. **Apply the tool and implement the model**

   From the wide variety of the available packages we've selected Palisade's "@Risk" for Project (http://www.palisade.com) as our project optimization tool. We believe that this tool is a good match for most requirements.

   It is:

   - Integrated with the MS project
   - Easy to set up the model
   - Sufficient depth of simulation and outputs
   - Is easy to use for analysis

   A particular tool selection only affects the way an uncertainty model will be applied. The general approach to problem handling will remain the same.

4. **Run simulation**

   As the result of the Monte Carlo simulation (parameters of this simulation can be configured as well) we can obtain the ranges and probabilities of all outcomes for the outputs that we've identified during model setup. Normally it's the ranges of the duration for particular phases, or the project with the most critical dependencies, overall project timeframe, etc.

5. Make a decision

Based on the simulation results, and looking at the outputs of the model, we obtain the information about most critical characteristics of the project. This data serve as the basis for the following optimization and corrective actions.

Working with the tool

"@Risk" is tightly integrated with MS Project and looks as the additional tool set on the MS project panel (see picture below). By selecting particular project parameters (for example duration of the task) and clicking on the "Define Distribution" icon on the "@Risk" tool bar, we can set up model characteristics.

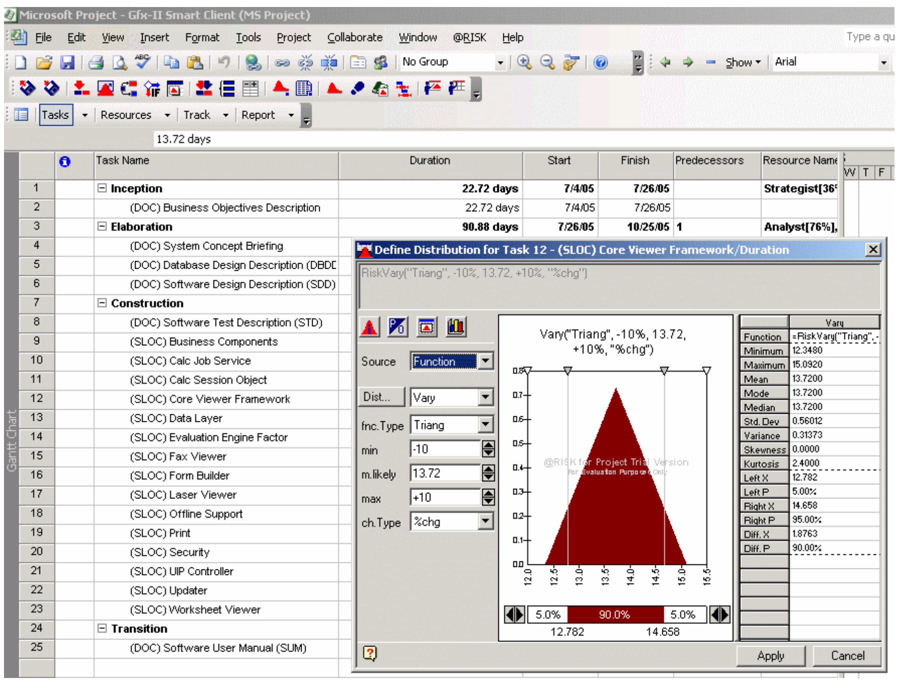


Figure 1. Model Setup

The tool is quite flexible in definition of the distribution widows. Out of the box it's easy to find anything from the uniform or normal distribution, up to the more exotic ones, see picture below.

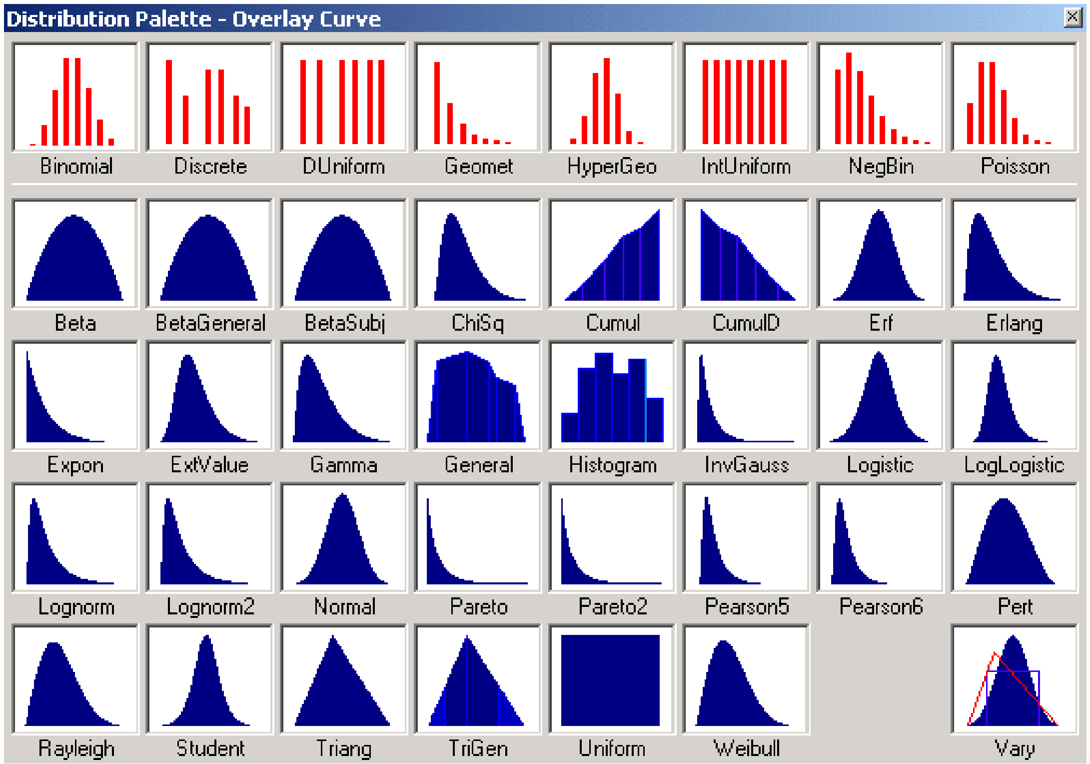
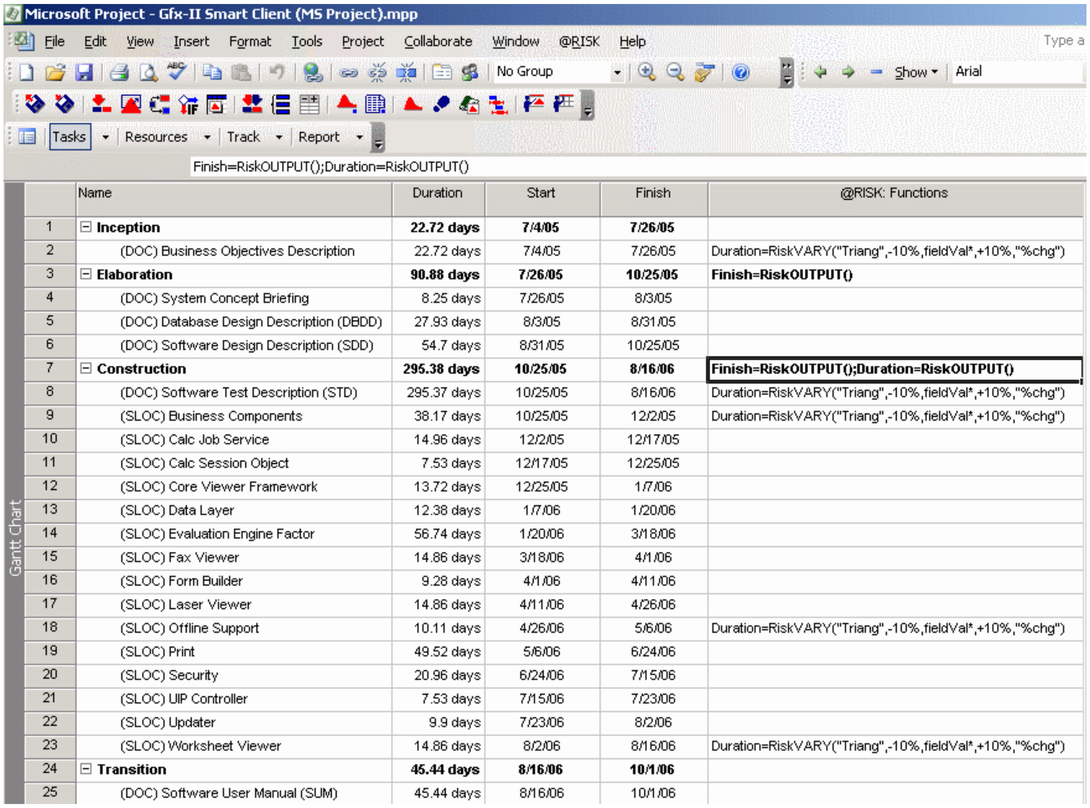


Figure 2. Different available distribution functions

Establishing Project Parameters

We use our past projects experience and "historical" knowledge to define the possible ranges for different tasks and distribution functions. For any distribution function we can define its "fine structure", like average value, standard deviation, etc. There is also another advanced feature which allows us to add additional "custom" uncertainties to the selected tasks or group of tasks.

Model outputs are specified in the same manner. Click on the selected cell (for example, finish date or duration) and specify it as the output. You can see the corresponding notations in the @Risk:Functions column of the Project, see picture below.



	Name	Duration	Start	Finish	@RISK: Functions
1	**Inception**	**22.72 days**	**7/4/05**	**7/26/05**	
2	(DOC) Business Objectives Description	22.72 days	7/4/05	7/26/05	Duration=RiskVARY("Triang",-10%,fieldVal*,+10%,"%chg")
3	**Elaboration**	**90.88 days**	**7/26/05**	**10/25/05**	**Finish=RiskOUTPUT()**
4	(DOC) System Concept Briefing	8.25 days	7/26/05	8/3/05	
5	(DOC) Database Design Description (DBDD)	27.93 days	8/3/05	8/31/05	
6	(DOC) Software Design Description (SDD)	54.7 days	8/31/05	10/25/05	
7	**Construction**	**295.38 days**	**10/25/05**	**8/16/06**	**Finish=RiskOUTPUT();Duration=RiskOUTPUT()**
8	(DOC) Software Test Description (STD)	295.37 days	10/25/05	8/16/06	Duration=RiskVARY("Triang",-10%,fieldVal*,+10%,"%chg")
9	(SLOC) Business Components	38.17 days	10/25/05	12/2/05	Duration=RiskVARY("Triang",-10%,fieldVal*,+10%,"%chg")
10	(SLOC) Calc Job Service	14.96 days	12/2/05	12/17/05	
11	(SLOC) Calc Session Object	7.53 days	12/17/05	12/25/05	
12	(SLOC) Core Viewer Framework	13.72 days	12/25/05	1/7/06	
13	(SLOC) Data Layer	12.38 days	1/7/06	1/20/06	
14	(SLOC) Evaluation Engine Factor	56.74 days	1/20/06	3/18/06	
15	(SLOC) Fax Viewer	14.86 days	3/18/06	4/1/06	
16	(SLOC) Form Builder	9.28 days	4/1/06	4/11/06	
17	(SLOC) Laser Viewer	14.86 days	4/11/06	4/26/06	
18	(SLOC) Offline Support	10.11 days	4/26/06	5/6/06	Duration=RiskVARY("Triang",-10%,fieldVal*,+10%,"%chg")
19	(SLOC) Print	49.52 days	5/6/06	6/24/06	
20	(SLOC) Security	20.96 days	6/24/06	7/15/06	
21	(SLOC) UIP Controller	7.53 days	7/15/06	7/23/06	
22	(SLOC) Updater	9.9 days	7/23/06	8/2/06	
23	(SLOC) Worksheet Viewer	14.86 days	8/2/06	8/16/06	Duration=RiskVARY("Triang",-10%,fieldVal*,+10%,"%chg")
24	**Transition**	**45.44 days**	**8/16/06**	**10/1/06**	
25	(DOC) Software User Manual (SUM)	45.44 days	8/16/06	10/1/06	

Figure 3. Specifying model outputs

Creating the Implementation Model

An implemented model could be enhanced by putting additional conditions (see on the previous picture (e.g. a “@Risk” icon with an “IF” on it, 6th from the left on the tool bar). For example, we know that if we’d spent all available time on doing one particular task another dependent task should happen only within strictly limited timeframe and that’s exactly what “If-Then” function of the model is supposed to take into account.

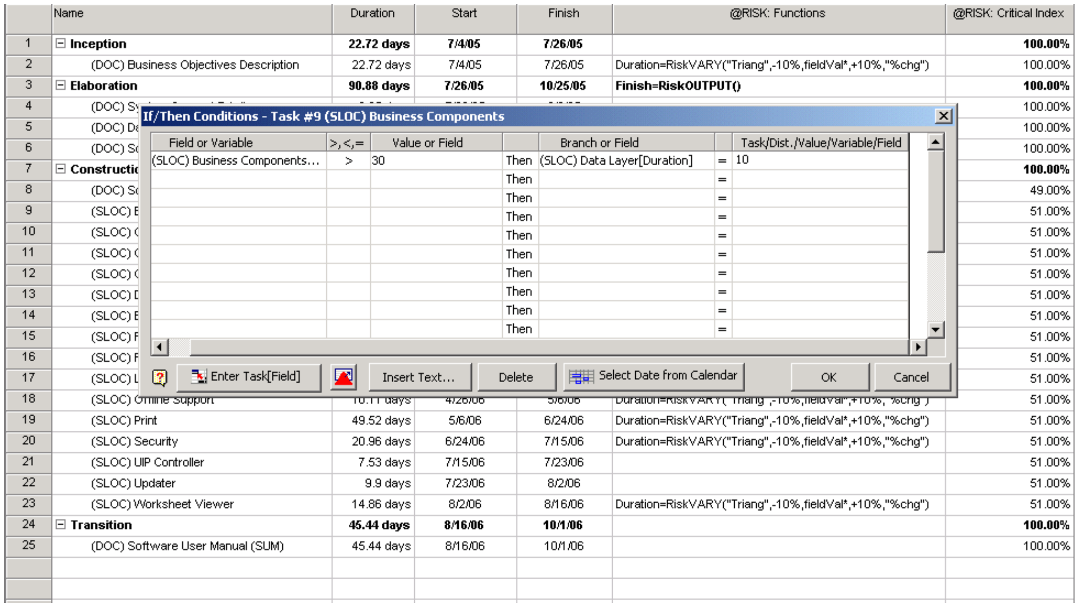
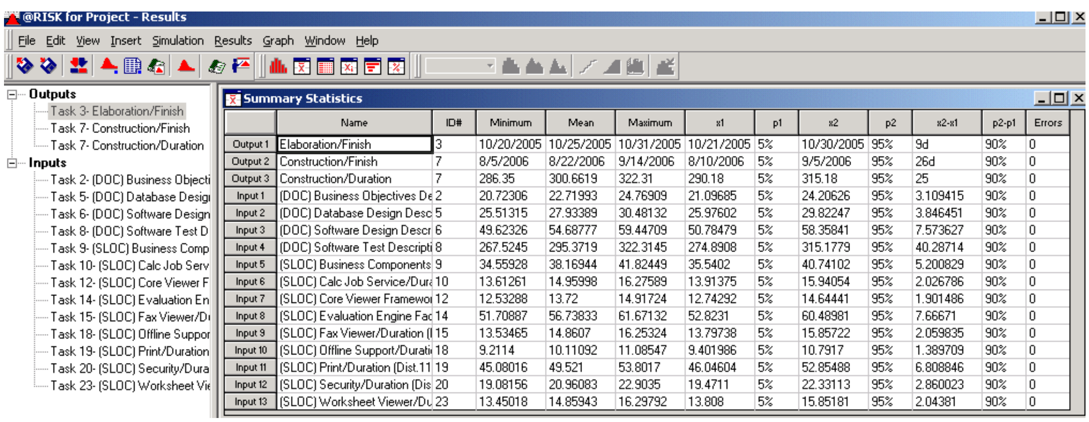


Figure 4. Model enhancement with "If/Then" conditions

Project Model Output

After running the simulation, the output window will look like the one presented below.

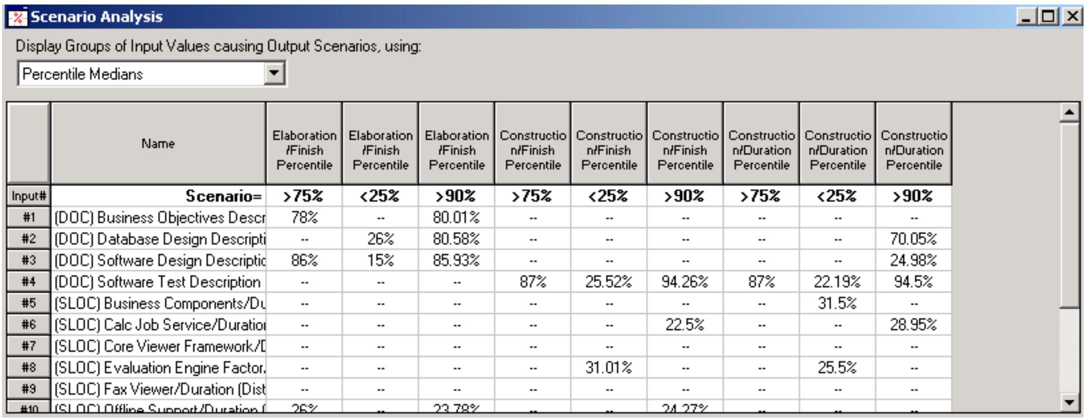


	Name	ID#	Minimum	Mean	Maximum	x1	p1	x2	p2	x2-x1	p2-p1	Errors
Output 1	Elaboration/Finish	3	10/20/2005	10/25/2005	10/31/2005	10/21/2005	5%	10/30/2005	95%	9d	90%	0
Output 2	Construction/Finish	7	8/5/2006	8/22/2006	9/14/2006	8/10/2006	5%	9/5/2006	95%	26d	90%	0
Output 3	Construction/Duration	7	286.35	300.6619	322.31	290.18	5%	315.18	95%	25	90%	0
Input 1	(DOC) Business Objectives De	2	20.72306	22.71993	24.76909	21.09685	5%	24.20626	95%	3.109415	90%	0
Input 2	(DOC) Database Design Desc	5	25.51315	27.93389	30.48132	25.97602	5%	29.82247	95%	3.846451	90%	0
Input 3	(DOC) Software Design Descr	6	49.62326	54.68777	59.44709	50.78479	5%	58.35841	95%	7.573627	90%	0
Input 4	(DOC) Software Test Descripti	8	267.5245	295.3719	322.3145	274.8908	5%	315.1779	95%	40.28714	90%	0
Input 5	(SLOC) Business Components	9	34.55928	38.16944	41.82449	35.5402	5%	40.74102	95%	5.200829	90%	0
Input 6	(SLOC) Calc Job Service/Dura	10	13.61261	14.95998	16.27589	13.91375	5%	15.94054	95%	2.026786	90%	0
Input 7	(SLOC) Core Viewer Framewo	12	12.53288	13.72	14.91724	12.74292	5%	14.64441	95%	1.901486	90%	0
Input 8	(SLOC) Evaluation Engine Fac	14	51.70887	56.73833	61.67132	52.8231	5%	60.48981	95%	7.66671	90%	0
Input 9	(SLOC) Fax Viewer/Duration (I	15	13.53465	14.8607	16.25324	13.79738	5%	15.85722	95%	2.059835	90%	0
Input 10	(SLOC) Offline Support/Durati	18	9.2114	10.11092	11.08547	9.401986	5%	10.7917	95%	1.389709	90%	0
Input 11	(SLOC) Print/Duration (Dist.11	19	45.08016	49.521	53.8017	46.04604	5%	52.85488	95%	6.808846	90%	0
Input 12	(SLOC) Security/Duration (Dis	20	19.08156	20.96083	22.9035	19.4711	5%	22.33113	95%	2.860023	90%	0
Input 13	(SLOC) Worksheet Viewer/Du	23	13.45018	14.85943	16.29792	13.808	5%	15.85181	95%	2.04381	90%	0

Figure 5. Simulation results

You can see the defined outputs of the finish dates for the elaboration and construction phases, as well as the total duration of the construction phase (as they were defined as the outputs of the model). Results show quite a significant range in the finish date for the construction phase (overall more than a month uncertainty in the final date) and we might want to re-evaluate the project setup (sequence and task dependencies as well as resource allocation).

The simulation data provide answers to the additional questions. For example to give the probability that the project or its phase will be finished before the certain date together with providing more granular information about project dynamics and showing the most critical parameters for the project cycle (sensitivity analysis)



Scenario Analysis

Display Groups of Input Values causing Output Scenarios, using:

Percentile Medians

Input#	Name	Elaboration /Finish Percentile	Elaboration /Finish Percentile	Elaboration /Finish Percentile	Constructio n/Finish Percentile	Constructio n/Finish Percentile	Constructio n/Finish Percentile	Constructio n/Duration Percentile	Constructio n/Duration Percentile	Constructio n/Duration Percentile
	Scenario=	>75%	<25%	>90%	>75%	<25%	>90%	>75%	<25%	>90%
#1	(DOC) Business Objectives Descr	78%	--	80.01%	--	--	--	--	--	--
#2	(DOC) Database Design Descripti	--	26%	80.58%	--	--	--	--	--	70.05%
#3	(DOC) Software Design Descriptic	86%	15%	85.93%	--	--	--	--	--	24.98%
#4	(DOC) Software Test Description	--	--	--	87%	25.52%	94.26%	87%	22.19%	94.5%
#5	(SLOC) Business Components/Du	--	--	--	--	--	--	--	31.5%	--
#6	(SLOC) Calc Job Service/Duratio	--	--	--	--	--	22.5%	--	--	28.95%
#7	(SLOC) Core Viewer Framework/[	--	--	--	--	--	--	--	--	--
#8	(SLOC) Evaluation Engine Factor.	--	--	--	--	31.01%	--	--	25.5%	--
#9	(SLOC) Fax Viewer/Duration (Dist	--	--	--	--	--	--	--	--	--
#10	(SLOC) Offline Support/Duration (	26%	--	23.78%	--	--	24.27%	--	--	--

Figure 6. Scenario and Sensitivity Analysis

There are multiple ways to display the graphical representation of the simulation results. This also makes the analysis tasks easier, see picture below.

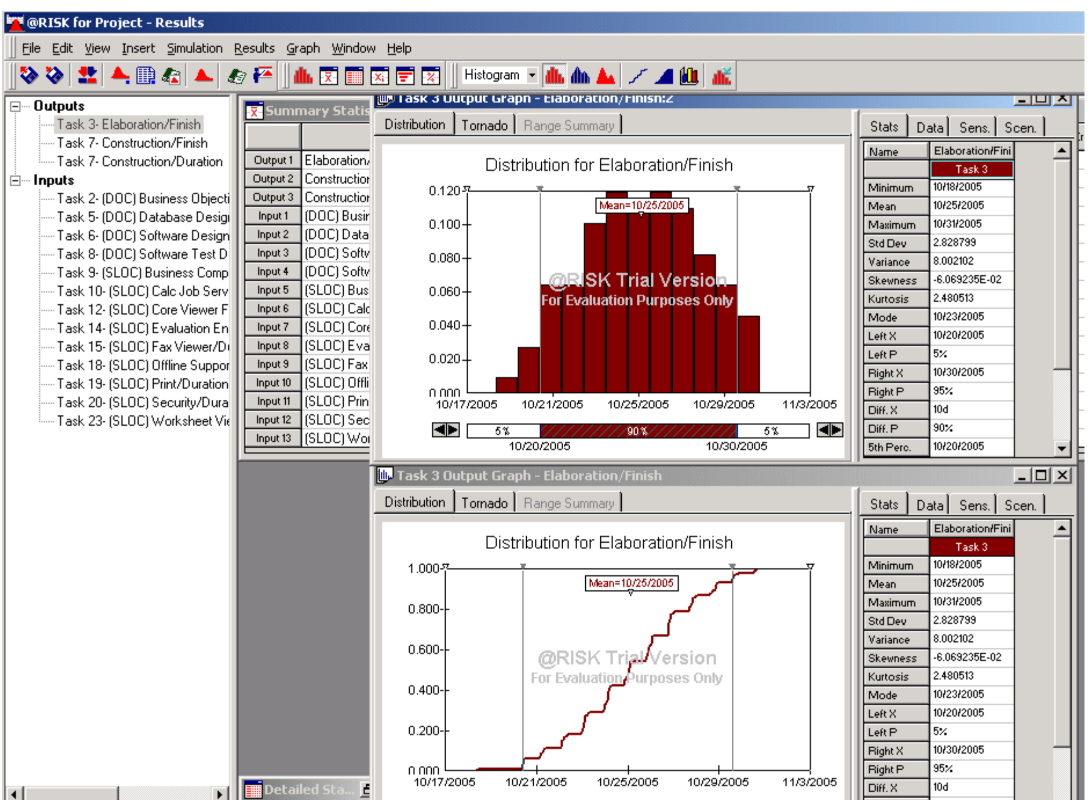


Figure 7. Graphical representation of results

Excel Project Planning Tools

Since we mentioned an Excel based enhancements, its worth saying a few words about them. Palisade also has another version working for Excel. For these set of add-ins, we would import our project plan into an Excel spreadsheet and then use similar logic for setting up a model with the risks and uncertainties. We could then co the simulation. We'd tried "What's Best" from Lindo Systems, "OptiRisk" from "OptiGroup" and they all work in a similar fashion. Recognized leaders like "Solver" or "Crystal Ball" add more functionality and better user interface.

As we discussed above, the general approach will stay the same regardless of the tool being used. There are two other tools similar to "@Risk":

- "Risk" + from http://www.cs-solutions.com
- "Pertmaster" from http://www.pertmaster.com/.

Pertmaster

For due diligence we did set up of the same model in "Pertmaster", see below:

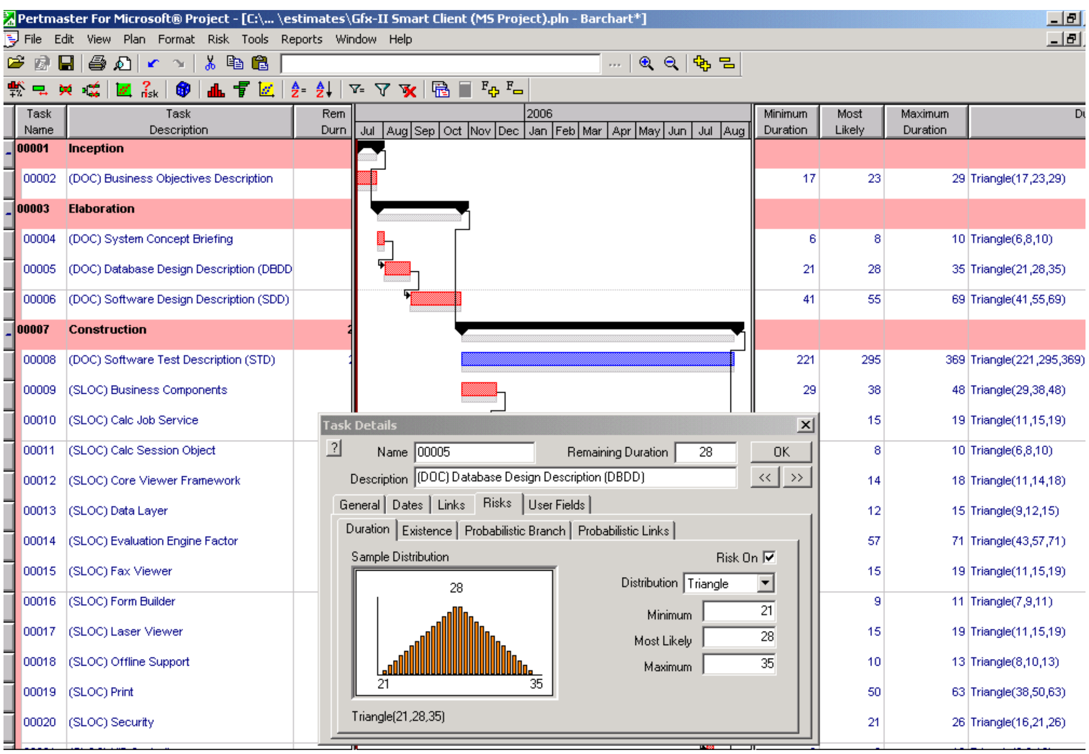


Figure 8. Model setup in PERTMASTER

The simulation shows very similar results. Graphical output from this tool is slightly different and just for the sake of illustration we've selected different model output and criteria to show. On the picture below you can see the projected finish date of the project and associated probability of this event.

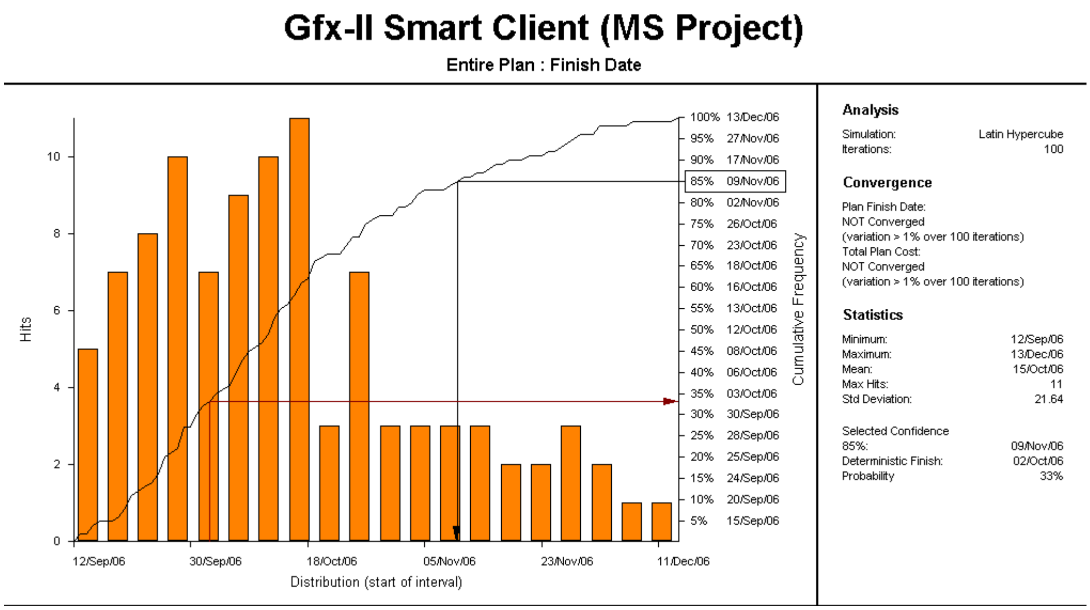


Figure 9. Results graphical representation in Pertmaster

Conclusion

In this paper we have described the approach to handle uncertainties in project planning. This approach includes development and implementation of the risk model which describes these uncertainties followed by running a simulation to generate predefined project outcomes or the most critical parameters. We also touched briefly on several available tools and provided some examples on how they function (mostly "@Risk" from Palisade and "Pertmaster").

About the Author

Dmitri Ilkaev has almost twenty years of experience in software and technology development. He holds Ph.D. in Computer Sciences from Moscow Institute of Physics and Technology. Dmitri is the Chief Technologist at Tier Technologies (http://www.tier.com) in Scottsdale, AZ. He can be reached at DILkaev@tier.com

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