

Predict! Risk Analyser

User Guide

Risk Decisions Ltd makes no representations or warranties with respect to the contents hereof, and specifically disclaims any implied warranties of merchantability or fitness for any particular purpose. Further, Risk Decisions Ltd reserves the right to revise any part of this product and to make changes from time to time in the contents hereof without obligation to notify any person or organisation of any such revision or change.

© Risk Decisions Ltd, 1996-2022

All rights reserved.

No part of this document may be reproduced or transmitted in any form or by any means, electronic or mechanical, for any purpose, without the written permission of Risk Decisions Ltd.

Companies, names and data used in examples herein are fictitious unless otherwise noted. Risk Decisions and Predict! are registered trademarks of Risk Decisions Ltd. Primavera and P6 are registered trademarks of Oracle Inc., Microsoft, Microsoft Office, Microsoft Excel, Microsoft Project and Windows are trademarks of Microsoft Corporation. All other trademarks are acknowledged.

Risk Decisions Ltd
Email: support@riskdecisions.com
Web: www.riskdecisions.com

Document version 6.3
05 April 2023

Contents

1. Introduction	5
Welcome to Predict! Risk Analyser	5
Introduction to Predict! Risk Analyser	5
Installing Predict! Risk Analyser	5
Risk Decisions' Training and Coaching Services	5
Technical Support	5
Running Predict! Risk Analyser	6
The Home Screen	6
2. Schedule Risk Analysis	8
Preparing your plan for risk analysis	10
Opening a schedule in Risk Analyser with no uncertainty	11
Using the Schedule Check Report	15
Adding uncertainty to your schedule risk analysis	18
Viewing Slice Results	21
The Project End Date Graph	22
Criticality versus Cruciality	23
The Advanced Options tab	25
The Reports & Display Options	27
Using percent complete	28
Cost risk analysis on a project plan	35
Importing Quick Risk Information from Schedules	37
Before You Open a Project Plan in Predict! Risk Analyser	41
3. Integration with Predict! Risk Controller	42
Predict! Risk Analyser and Predict! Risk Controller	42
Performing Cost Risk Analysis through Risk Controller	42
The Risk Dashboard	45
Other Model Outputs	46
Performing Schedule Risk Analysis through Risk Controller	49
Revisiting the project plan	54
Deciding whether schedule risks should work in series or parallel	55
4. Predict! Risk Analyser Basics	56
Using Formulas	56
References	56
Naming Cells and Sheets	57
Creating a Distribution	57
Choosing a Distribution	58

Creating a Distribution Graph	58
Sensitivity and Tornadoes	59
Creating a Sensitivity Sheet.....	59
The Sensitivity Report Window	60
Creating a Sensitivity Tornado Chart	61
Controlling Calculation.....	62
Slices	62
Advanced Simulation Options.....	63
Understanding Correlation.....	64
Representing Correlation.....	64
Entering Correlation.....	66
Turning Correlation On or Off	68
Tiers	68
Modelling Risk	68
Sheet Display Options	68
Working with Calendars.....	69
Scenarios	70
Impact and Mitigation Analysis	71
5. Troubleshooting	72
Mean and Other Statistical Functions	72
Confidence Intervals.....	72
Simulation is Very Slow	72
Project activities appear in a different order than in the project planning tool	72
Different Dates from the planning tool	73
6. Tutorial – building simple models	75
Creating a budget, Part 1 - The model.....	75
Creating a budget, Part 2 – Adding uncertainty	77
7. Appendix: Reference	81
Commonly Used Distributions in Predict! Risk Analyser	81
Index of functions	86
8. Appendix. User Defined Fields in Primavera	121
Fields for writing data to Predict!.....	121

1. Introduction

Welcome to Predict! Risk Analyser

This Getting Started Guide is designed to provide a quick introduction to Risk Analyser and to act as a reference for the basic features and operations you will use.

Introduction to Predict! Risk Analyser

Risk Analyser is a spreadsheet-based risk analysis tool. Unlike other spreadsheet applications, it has been designed specifically to allow you to express uncertain values and analyse risk. It contains a powerful Monte Carlo simulation engine that can generate thousands of 'what-if' results in seconds and help you assess the risks you are taking.

Risk Analyser appears similar to other spreadsheet software and can be used to build traditional spreadsheet models. Where Risk Analyser comes into its own, however, is in allowing you to describe any cell value with a range of values, which relate to a probability distribution. These can range from simple 3-point estimates to more complex statistical measures specific to your industry sector or application.

When you are viewing results in Risk Analyser, it is important to remember that you may be looking at a random number from a range of outcomes that have been generated by the uncertainty. Therefore, you must ensure that you review and report the results of your risk analysis using graphs and their associated statistical information, making sure that any values used from the spreadsheet are analysis results and not random distribution values.

This guide is designed to give you a first introduction to the methods used. You will also find some example models in the 'examples' folder that show further techniques.

Risk Analyser is available either as a standalone system or fully integrated with Predict! Risk Controller, the risk and action database. For more information on integration, please see the Predict! Risk Controller Integration section later in this guide.

Installing Predict! Risk Analyser

If you are installing Predict! Risk Controller, Risk Analyser will come packaged with it. If you are installing standalone Risk Analyser then please follow the installation instructions provided to start the installation process.

Risk Decisions' Training and Coaching Services

Risk Decisions offer training courses as well as desk-side coaching to help users get up to speed with using Predict! Risk Analyser for cost and schedule analysis. We also offer services to provide support if you are preparing or defending a bid submission. For more information please contact your account manager or email us on enquiries@riskdecisions.com.

Technical Support

If you require any assistance using Predict! Risk Analyser, please contact our Customer Support help desk:

- Email: support@riskdecisions.com

Running Predict! Risk Analyser

To run the standalone version of Risk Analyser on Windows choose Start, All Programs, and select Risk Analyser from the Predict! group. For later versions of Windows, you can also search for "Risk Analyser" using the Search facility.

To run Risk Analyser from a centrally licensed version of Predict! Risk Controller, log into Predict! Risk Controller and select the Risk Analyser button on the home page. Risk Analyser uses the same username and password to log in as you use to access Risk Controller.

NOTE: A centrally licensed version of Predict! may limit the number of people using Risk Analyser at once. If too many other users are already using Risk Analyser, you will not be able to log in. Make sure that you close Risk Analyser when you have finished working to free up the licence for other users.

The Home Screen

Predict! Risk Analyser opens with the Home screen. This contains shortcuts to useful functionality and links to files that you have worked on recently in Risk Analyser.

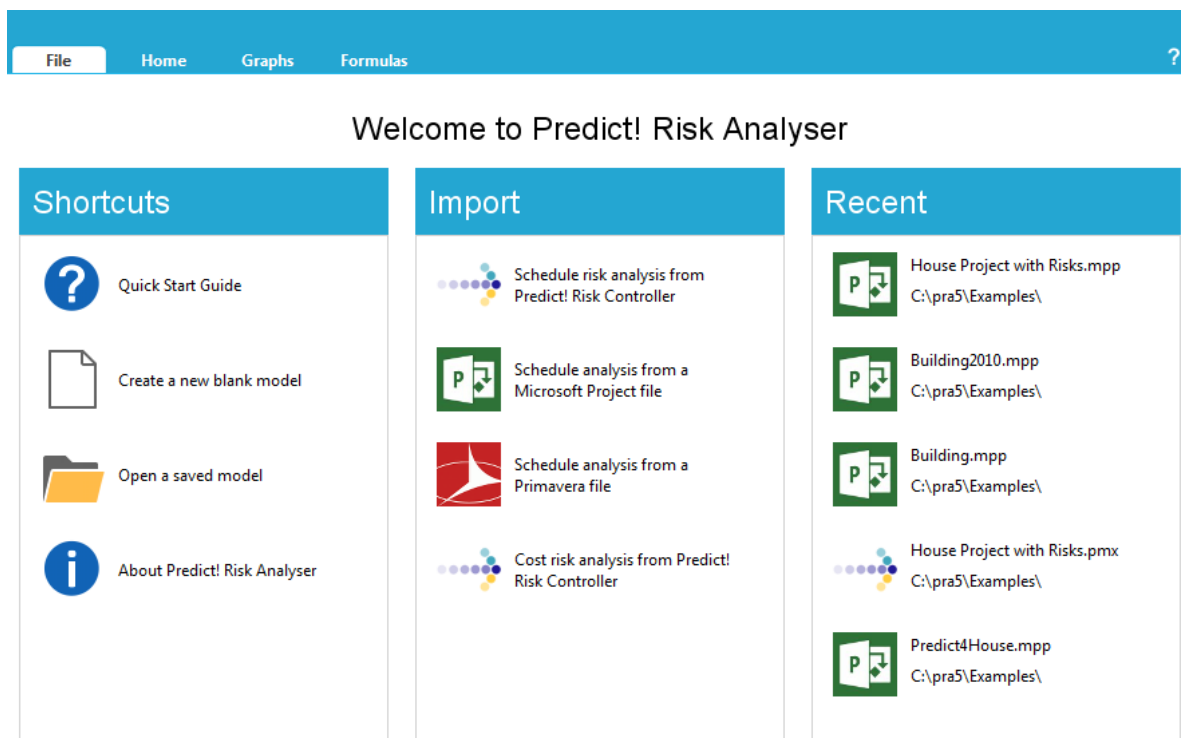


Figure 1. Predict! Risk Analyser Home screen

Clicking the tabs at the top of the screen will display the tool ribbon. You will return to this screen whenever you close all your current models. The Predict! Risk Analyser workspace Select Create a new blank model from the Shortcuts section of the Home screen. Predict! Risk Analyser will open a blank worksheet.

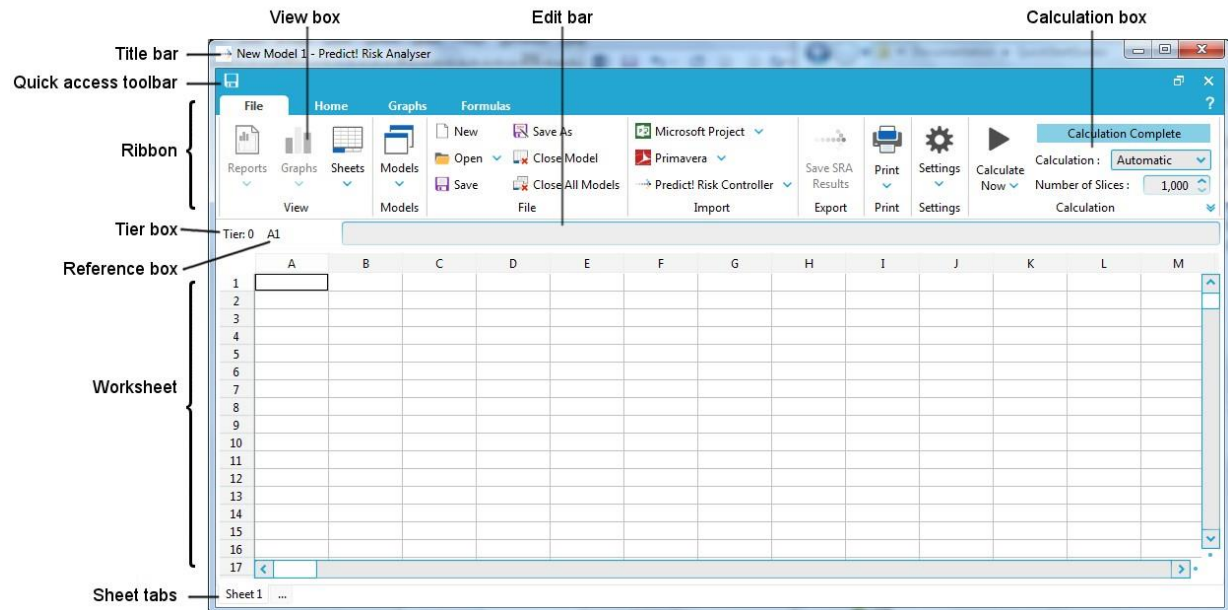


Figure 2. The Predict! Risk Analyser workspace

Item	Description
Title bar	Shows the current model. The sheet names within the model appear in the bottom left-hand corner, as in Microsoft Excel.
Quick access toolbar	Provides easy access to the most common commands. Commands here are always visible.
Ribbon	Contains tools to help you create your Risk Analyser Model. The ribbon is divided into tabs. When you first open Risk Analyser the File tab is shown. Click on a tab marker at the top of the ribbon to show the tools on that tab.
View box	Allows you to switch between the different graphs, reports, and sheets in your model. This box is available on every tab in the ribbon.
Calculation box	Allows you to set your calculation options and tells you about the current state of Predict! Risk Analyser. For example, when you are running a model it will show the percentage completion of the simulation, or whether an error has been detected in the model. This box is available on every tab in the ribbon.
Tier box	Shows which tier the cell is on. Data and simple formulas are on Tier 0, distributions automatically appear on Tier 1, and statistical information about analysis results appears on Tier 2.
Reference box	Shows the reference or name of the active cell.
Edit bar	Displays the contents of the active cell.
Worksheet	Enter data, distributions and functions into the spreadsheet to create a model.
Sheet tabs	Switch between the different sheets in your model. Select '...' to create a new sheet.

2. Schedule Risk Analysis

Risk Analyser can read Microsoft Project plans and Primavera and Deltek Open Plan schedules in the following formats:

- MPP (from Project 2000 or later).
- MPX (saved from Project 4.0 and Project 98)
- XER (saved from Primavera P6 version 5 or later)
- OPP (saved from Open Plan 8.1)

NOTE: MPX is the Microsoft transfer file format for project plans in versions prior to Project 2000. If you import from a different planning package via either MPX or MPP format, then you need to ensure the file is fully Microsoft Project compatible. If the plan cannot be opened in Microsoft Project, or errors are highlighted by Microsoft Project when trying to open it, then Risk Decisions cannot support its use with Predict!

NOTE: Primavera .XER files must only contain a single project. If the file contains multiple projects (for example if the primary project has links to external tasks), the first project read will be the only one imported. If the first project is not the primary one, this can cause unpredictable results including errors in the analysis. It is strongly recommended to remove any links to other projects before saving the .XER file.

NOTE: Importing Open Plan files requires additional licensing and configuration, please contact Risk Decisions if you wish to use this option. OPP files produced in other versions of Open Plan may also be compatible when correctly configured.

A high-level Microsoft Project plan relating to the building of a house has been prepared and is in the Examples folder within the Risk Analyser directory. It has been stored as a Microsoft Project .MPP file called Building.mpp. Alternatively, for import into other planning tools, a copy of Building.mpx is also available.

To examine the building project plan in Microsoft Project:

1. Start Microsoft Project.
2. Browse to the Examples directory inside the Risk Analyser installation folder. The default location is C:\pra\Examples.
3. Select the File called Building.mpp (or Building2010.mpp if you are running Microsoft Project 2010 or later), and click OK.

NOTE: The building project has a constraint and a 'dangling' task - you will be warned about these on the Import Log sheet once it is opened in Risk Analyser.

4. Examine the plan and note the date given for the completion of the project.

To examine the building project in Primavera, import the Building.xer file using the Primavera Import utility. To define uncertainty for tasks, you will need to add user defined columns to represent minimum, likely and maximum durations. For detailed information on this, see the Appendix: User Defined Fields in Primavera.

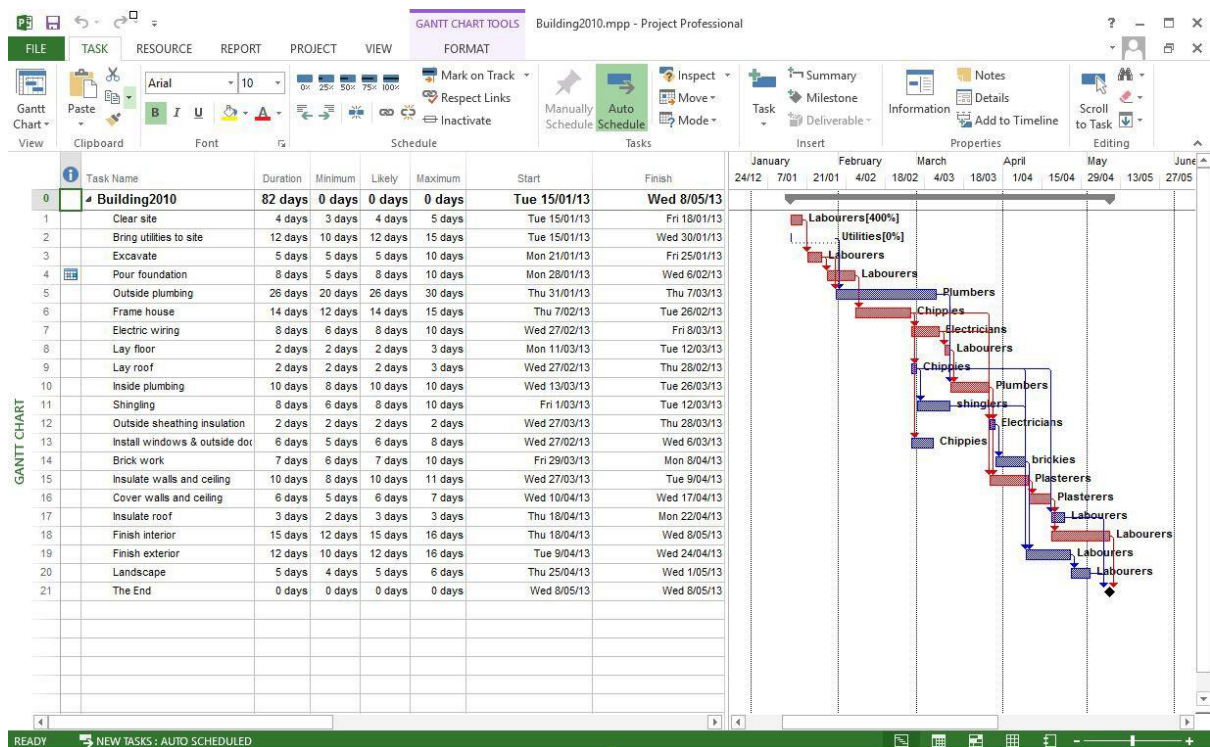


Figure 3. Building project plan in Microsoft Project

Preparing your plan for risk analysis

There are a few fundamental requirements of your schedule to ensure successful risk analysis:

1. Ideally your plan should have no more than 150 tasks, but the maximum should be 500 to 600 if possible. This is not a Risk Analyser restriction; it is a practical consideration, because you must have a 'clean' schedule that is properly logic linked for risk analysis to generate meaningful results. If the schedule is poorly constructed, then uncertainty and risk applied to it will not flow through to later tasks in the plan. With a smaller number of tasks, you can see "the wood from the trees" when you examine the results. It is also easier to maintain the correct logic when you update it to reflect progress of the project.

This begs the question 'How do we turn a schedule of 3000+ tasks into one of 80-200?' The solution is to create an 'Analysis Schedule'. This is a schedule based on the project schedule but abbreviated. There are several techniques that can be used:

- a) by rolling continuous logic chains into single tasks
- b) by considering part of the schedule at a time, perhaps a critical part

The answers from several analyses can be combined into an overall model later, if required.

2. Every task should have a predecessor and a successor. Any uncertainty or risk applied to a task that has no successor will not be incorporated into the analysis results.
3. Avoid using constraints (particularly Must Start On and Must Finish On) because they reduce the true range of outcomes of the analysis. This is because any task that has a constraint instead of a predecessor will prevent uncertainty, opportunities or threats impacting on it.
4. Do not use large lags and leads. Uncertainty cannot be applied to them - instead you should insert tasks to represent the elapsed time, with appropriate logic to describe the relationships.
5. Avoid tasks utilising SS and FF logic links. These so called 'umbrella' tasks often have no inherent uncertainty or risk but depend on other tasks for their results. Instead, the effect of risks within areas of the plan built using SS and FF logic will typically be subsumed or hidden within the plan.
6. Do not use the normal Duration column to describe the most likely value for risk analysis. Using Duration 1, Duration 2 and Duration 3 for your minimum, likely and maximum values will provide more flexibility (even if you start by copying the Duration value to Duration 2). Importantly, when you apply progress to your plan, you will need to leave Duration as the original task duration and use Duration 2 to describe remaining duration for your activities.

Failure to follow the rules above is likely to produce unrealistic or misleading results, so you must pay careful attention to the way you prepare your plan for analysis.

Opening a schedule in Risk Analyser with no uncertainty

First, import the plan into Risk Analyser using the No Uncertainty option, to check it against your project plan dates and investigate any dangles, constraints or other issues reported by Risk Analyser in the Schedule Check report.

To open the building project in Risk Analyser from Microsoft Project or a Primavera XER file:

1. Start Risk Analyser
2. From the Imports section, select Schedule analysis from a Microsoft Project/Primavera file
3. Browse to your Risk Analyser installation folder and open the Examples folder.
4. Choose the file called Building.mpp (Building.xer for Primavera) and click 'Open'.
5. When the Schedule Analysis Options window appears, first click the 'Reset' button to clear previously selected settings (if any). Then on the General tab choose the None option for Uncertainty. The settings should match those shown below.

The screenshot shows the 'Schedule Analysis Options' dialog box with the 'General' tab selected. The 'Project to import' section has a text box containing 'C:\pra\Examples\Building.mpp' and a 'Change' button. The 'Schedule check' section has a label 'Select schedule check reporting options:' and an 'Options' button. The 'Progress' section has a checkbox 'Use percent complete' and an 'Options' button. The 'Uncertainty' section has three radio buttons: 'None' (selected), 'Global', and 'By task'. Below these are two dropdown menus: 'Single point estimate' (set to 'Duration') and 'Costs' (set to 'Fixed Cost'). The 'Distribution shape' is set to 'Triangular' with a 'Change' button. The 'Number of slices' is set to '1,000'. The 'Risks' section has a checkbox 'Import risk probabilities from:' and a dropdown menu set to 'Text 1'. On the right side of the dialog are three buttons: 'OK', 'Cancel', and 'Reset'.

Figure 4. Schedule Analysis Options, General tab

- Click on the Advanced tab and tick the 'Work in whole days' option. Check the settings match those shown below.

The screenshot shows the 'Advanced' tab of the Predict! Risk Analyser interface. The 'General' section includes options for 'Work in whole days' (unchecked), 'Always round days up' (selected), 'Round days up at: 0.5 of a day', 'Exclude Constraints' (unchecked), 'Sort by Task ID' (checked), and 'Correlations defined in: Text 2'. The 'Custom Fields' section has 'Include Custom Text Fields (MPP/MPX Only)' (unchecked) and a list of text fields (Text1 to Text5). The 'Results & Milestones' section shows 'Confidences' set to 10%, 50%, and 90%, 'Calculate mean values' (checked), and a 'Milestones to report against:' section with a 'Choose milestones' button and a list box containing 'None selected'. On the right, there are 'OK', 'Cancel', and 'Reset' buttons.

General Advanced Reports & Display

General

☐ Work in whole days

☒ Always round days up ☐ Round days up at: 0.5 of a day

☐ Exclude Constraints

☒ Sort by Task ID

☐ Correlations defined in: Text 2

Custom Fields

☐ Include Custom Text Fields (MPP/MPX Only)

Text1
Text2
Text3
Text4
Text5

Results & Milestones

Confidences: 10 % 50 % 90 %

☒ Calculate mean values

Milestones to report against: Choose milestones

None selected

OK
Cancel
Reset

Figure 5. Schedule Analysis Options, Advanced tab

For more information on the Advanced tab settings, see the Advanced Options section below.

7. Select the Reports & Display tab and tick the option to display the Calculation sheet. The settings should match those shown below.

General Advanced **Reports & Display**

Create report sheet

☒ Report

Include: ☐ Durations ☐ Start data

Create graphs

☐ Gantt chart

☒ Tornado chart

☒ Distribution graph

Display sheets

☐ Calculation

☐ Calendars

☒ Report

☐ Sensitivity

Display columns

☐ Calculations

☐ Calendar

☐ Ids and WBS

☒ Distributions

☐ Constraints

Note:
Hidden sheets can be displayed by selecting Hidden Sheets from the Sheets list in the View section. Hidden columns can be displayed by highlighting the columns either side of them and selecting Format, then Unhide Column from the Cells section of the Home tab.

OK
Cancel
Reset

Figure 6. Schedule Analysis Options, Reports & Display tab

For more information on the remaining options on this tab, see the Reports & Display Options section below.

8. Click OK to accept the options chosen and import the project.
9. Before the model opens Risk Analyser will warn you about the dangling tasks and the constraint in the plan. Click OK to close the warning. The model opens showing the Schedule Check report, which gives more details about the potential problems in the plan. For now, use the View box to switch to the Summary sheet.

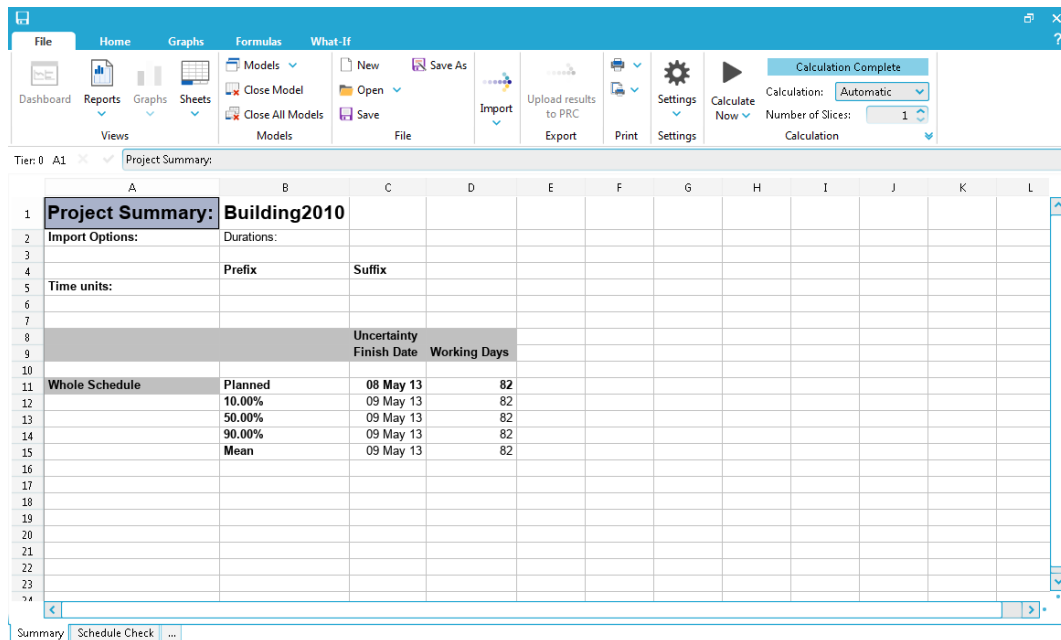


Figure 7. Analysis with no uncertainty to check any differences

10. Check that the Planned Finish Date at the top (taken from the project) matches the confidence and mean dates displayed.
11. In the Calculation sheet, check the activity start and end dates match your project schedule. You can use the Difference columns to help (values in these columns should be zero).

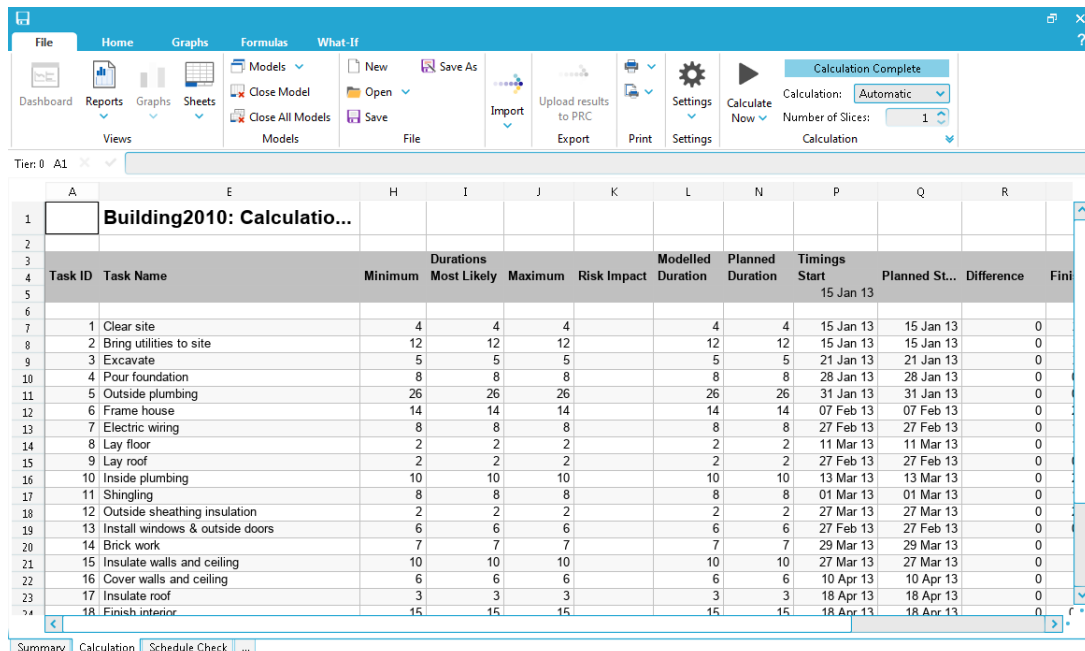


Figure 8. Calculation sheet

NOTE: You may find it useful to split the screen to keep the task names on the screen while scrolling to the right. To do this, hover at the right-hand end of the horizontal scroll bar until you see a double ended arrow. You can then drag and split the screen using the mouse.

NOTE: If there are differences in the dates, consult the 'Troubleshooting' section later in this guide.

12. Return to the Schedule Check report. Check the dangling tasks and constraints information and clean up your project schedule where possible.

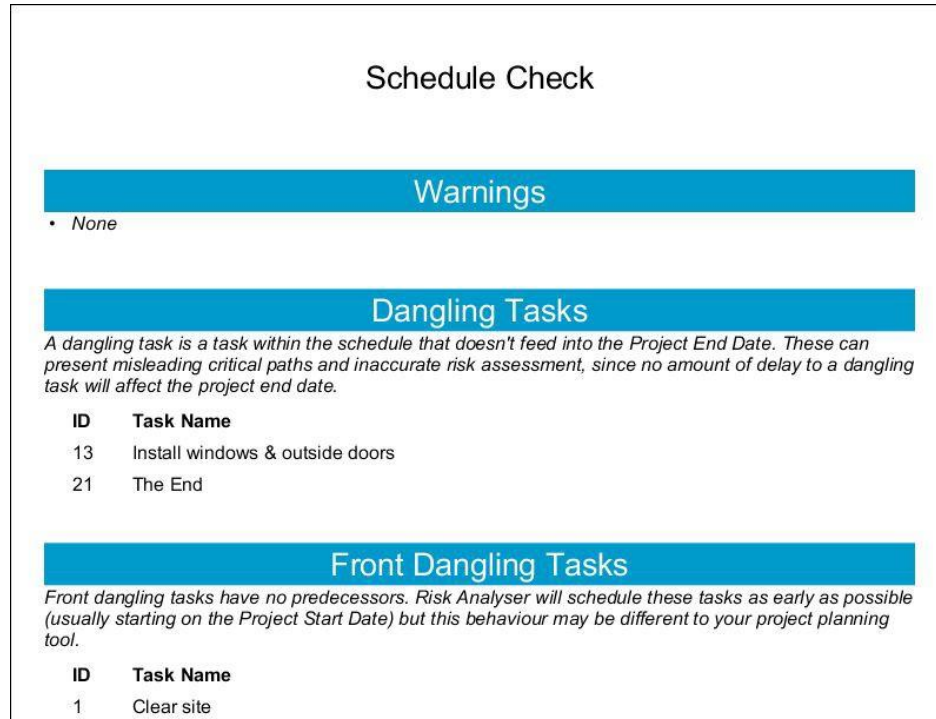


Figure 9. Schedule Check showing constraints and dangles

HINT: Use the arrow buttons in the report toolbar to see different pages in the report.

Using the Schedule Check Report

Schedules imported to Risk Analyser may contain errors, data anomalies or other features of the plan data (such as constraints, lags, dangling tasks etc.) that affect the accuracy or validity of the analysis results, or stop it from running altogether. The Schedule Check and associated report functionality allow you to see any such issues with the plan at a glance, to allow you to correct or reduce their impact.

The schedule is automatically checked for issues when you import a schedule for analysis, and you will be warned of any problems when the model opens. You can see more details about the issues found by selecting the Schedule Check Report from the View box.

The report contains information on any possible issues listed by type of issue and order of severity. It has a general warnings section at the top, followed by sections for Dangling Tasks, Constraints, Incorrect Progress Settings, Non-Standard Relationships, Lags, and Incorrect Three Point Estimates. You can move between the different pages of the report by using the arrow keys below the ribbon.

Each section of the report starts with a short explanation of why the issue reported may cause problems in the schedule analysis model. This is followed by a list of tasks (both ID and name) that have that issue, and any extra information required.

Schedule Check Options Window

You can choose what types of issues are reported by the Schedule Check by selecting options in the Schedule Check Options window, accessed from a button on the Schedule Analysis Options, General tab.

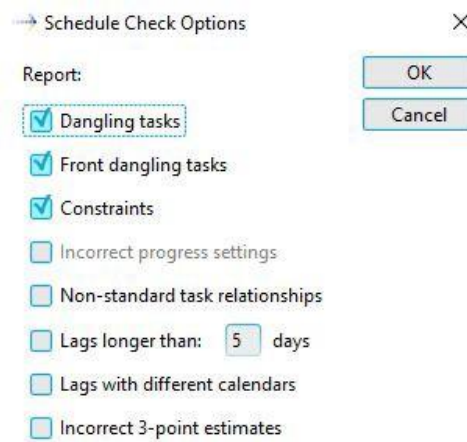


Figure 10. Schedule Check Options

The following types of issues can be reported:

- Dangling tasks

A list of tasks that have no logic links controlling the end date, and therefore don't feed into the Project End Date. These can present misleading critical paths and inaccurate risk assessment, since no amount of delay to a dangling task will affect the project end date.

- Front dangling tasks

Tasks that have no predecessors. Risk Analyser will schedule these tasks as early as possible (usually starting on the Project Start Date) but this behaviour may be different to your project planning tool.

- Constraints

A list of tasks that have constraints attached. A third column shows the type of constraint such as Must Start On, Start No Later Than, etc. Constraints of the same type are grouped together, with the most inflexible (Must Start On, Must Finish On) at the top, and the most flexible (Start No Earlier Than) at the bottom.

NOTE: Some constraints (such as "Start No Earlier Than") should be avoided if possible but are not as bad as others, since they do allow negative uncertainty analysis, but they do not allow positive opportunity analysis. Others, such as 'Start No Later Than' and 'Must Start On' should not be used, since they do not allow the logic to determine task start and end date. Any uncertainty described for such tasks is effectively ignored, rendering the risk analysis results invalid.

- Incorrect progress settings

This option is only displayed if the option to 'Use % Complete' was selected during the import, and includes three lists:

1. Tasks that are 0% complete (i.e. not started), but have an Actual Start date set - these act as Must Start On constraints
2. Tasks that have a % complete setting higher than 0%, but no Actual Start date

3. Tasks that are 100% complete, but have no Actual Finish date

- Non-standard task relationships

Lists relationships (logic links) that are not the standard Finish-to-Start link. A non-Finish-to-Start relationship may result in differences in dates when modelled in Risk Analyser. Risk Analyser will always start a task as early as possible, creating float if necessary. This may be different to the project planning tool.

- Lags longer than...

Tasks with logic links that have lags or leads longer than the number of days specified, sorted in order of longest lag/lead first. Lags artificially lengthen a task duration, with no opportunity to apply uncertainty to the lag. Consider implementing the lag as a separate task.

- Lags with different calendars

Tasks with lags or leads and calendars that are different from their successor (or predecessor). A predecessor task with a different calendar and a lag can cause date differences when modelled in Risk Analyser, if the calendars have different working hours or holidays. Risk Analyser will use the predecessor's calendar to model the lag.

- Incorrect 3-point estimates

Tasks where the minimum, likely, and maximum values (for either duration or cost) are in the wrong order (Minimum value must be less than or equal to the Likely value, and the Likely value must be less than or equal to the Maximum value). Separated into 'Duration' or 'Cost' sub-sections depending on which estimate is the problem for that task.

Tasks with no uncertainty (where all three values are equal) are also listed for information.

General Warnings section

The 'General Warnings' section always appears and cannot be turned off. It shows warnings related to the import options chosen, for example:

- 'Use percent complete' is selected, but the schedule has no Status or Data Date;
- 'Use percent complete' is selected, but Remaining Durations are not being imported;
- 'Work in whole days' is selected, but the schedule has part-day durations.

Adding uncertainty to your schedule risk analysis

Next, import the building project into Risk Analyser to see what effect uncertainty has on the likely completion time.

This time, in the Schedule Analysis Options window, General tab, choose 'By task' in the Uncertainty section and click OK. This will import a Minimum, Likely and Maximum duration value for each task, from the Duration 1, Duration 2 and Duration 3 custom columns in Microsoft Project (or RDL_MinDuration, RDL_MLDuration, RDL_MaxDuration user defined columns in Primavera).

The screenshot shows the 'Schedule Analysis Options' dialog box with the 'General' tab selected. The 'Project to import' field contains 'C:\pra\Examples\Building.mpp'. The 'Schedule check' section has an 'Options' button. The 'Progress' section has a checkbox for 'Use percent complete' and an 'Options' button. The 'Uncertainty' section has three radio buttons: 'None', 'Global', and 'By task' (which is selected). Below these are three columns for 'Optimistic', 'Likely', and 'Pessimistic' durations, each with a dropdown menu. The 'Costs' section has a checkbox and three dropdown menus for 'Cost 1', 'Cost 2', and 'Cost 3'. The 'Distribution shape' is set to 'Triangular' with a 'Change' button. The 'Number of slices' is set to '1,000'. The 'Risks' section has a checkbox for 'Import risk probabilities from:' and a dropdown menu set to 'Text 1'. On the right side of the dialog are 'OK', 'Cancel', and 'Reset' buttons.

Figure 11. Import project with uncertainty

HINT: Alternatively, you can use the Global option, which calculates an optimistic and pessimistic duration as a % of the likely duration value for each task.

HINT: When importing with uncertainty, you can choose how many slices to calculate in the model by changing the value in the 'Number of slices' box. This is found in the Uncertainty section of the General tab. The number of slices must be a number between 1 and 65,000.

When the building project opens, Risk Analyser displays the project dashboard. The dashboard shows the distribution graph of possible project end dates and a tornado graph of the project's tasks ranked by sensitivity.



Figure 12: The project dashboard for tasks

Model results can be exported in the Summary Report. This report gives an overview of the important statistics for the Project End Date. These include the 10%, 50%, 90% confidences (as set in the Advanced tab of the Schedule Analysis Options window) and the chance of achieving the deterministic Planned Finish Date (the finish date shown in the project schedule). This report will only show results once the simulation is complete.

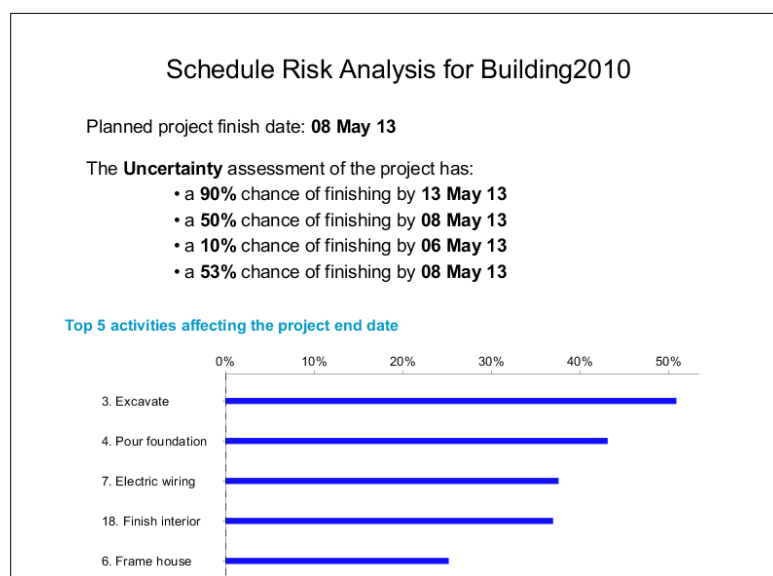


Figure 13. Summary report showing project end date statistics

HINT: You can export reports by clicking on the save button in the report toolbar. This will display the save report window. Choose a name and location to save the report to and set

the report format using the Files of Type option. Click the Save button to save the report.

A Report sheet is also created, containing the results from running the Monte Carlo analysis against each task, including the mean value and confidences (as on the Summary sheet) for the start dates, finish dates and durations, plus the criticality and cruciality values.

HINT: If the Report sheet is not visible, it can be displayed by choosing 'Unhide Sheet...' from the Sheets section of the View box. Alternatively, right-click on any sheet tab and choose 'Unhide...'.

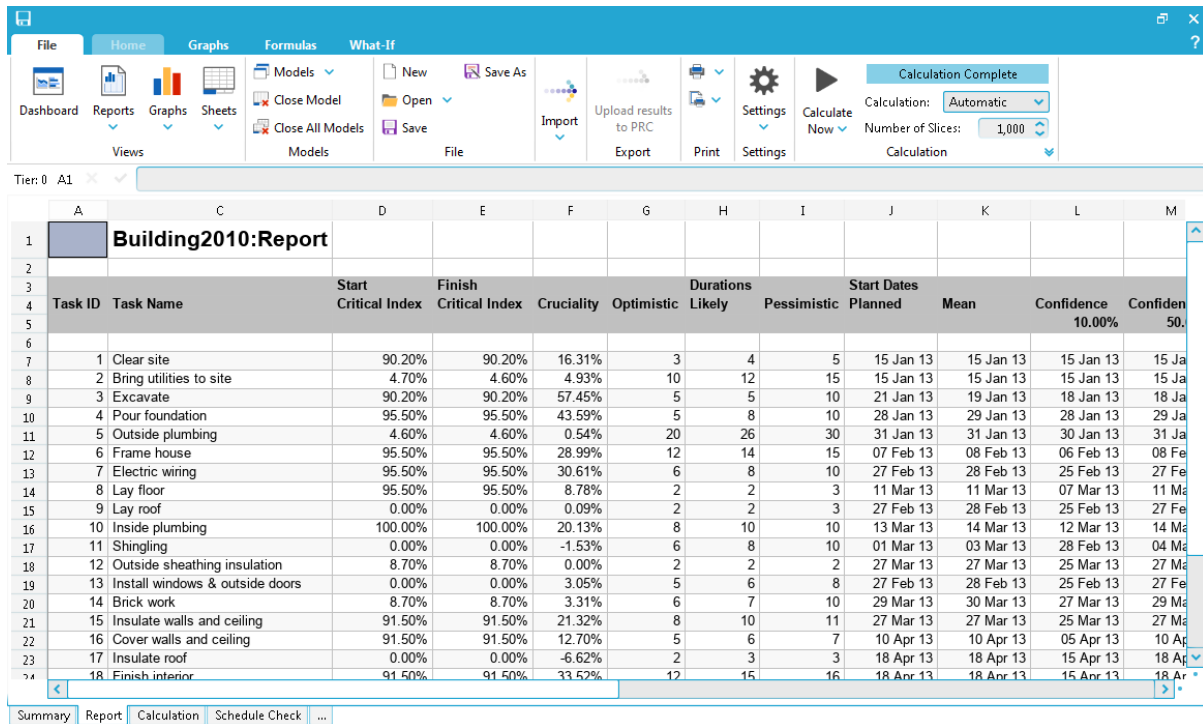


Figure 14. Report sheet showing analysis results

NOTE: The progress of the simulation is shown in the Calculation box. Calculation Complete indicates that Risk Analyser has successfully finished the simulation.

The Calculation sheet contains working formulas that generate the slices for each activity's duration, start and finish dates, float, costs (optional) and the criticality and cruciality indexes. The Project End Date is shown in the summary line of the Finish column. If you want to change your model, to correct errors or to do a what-if analysis, you can do so here.

NOTE: The values displayed in the Calculation sheet show the LAST SLICE and are therefore not indicative of the average or mean value. Results information should be read from the Report or Summary sheets.

Some sheets in the model are hidden by default, and others are only created if the option is selected on the Schedule Analysis Options, Reports & Display tab. The available sheets, reports, and graphs for an imported project with uncertainty are described below.

- The Schedule Check report, to check for constraints, dangles, or other issues which should then be fixed where possible.
- The Project End Date graph, a distribution graph of the project end date (optional - see below for further information)
- The Tornado Chart, showing the cruciality values for each task, ordered by importance
- The Gantt Chart graph, which shows the 10%, 50% and 90% confidence ranges (as set

in the Advanced tab of the Schedule Analysis Options window) for the start dates and end dates of the schedule, with the Gantt bars colour coded to indicate the level of cruciality (Optional).

- The Summary sheet, which gives you summary statistics for the Project End Date (and optionally Project Total Cost).
- The Report sheet, showing statistical values for each task (Optional).
- The Calculation sheet, containing the working formulas (hidden by default). The Sensitivity sheet, which displays the cruciality values (your uncertainty drivers), from which the Tornado Chart is produced (optional, hidden by default).
- The Calendars sheet, showing the calendars imported from your planning tool (hidden by default).

Viewing Slice Results

View the Calculation sheet.

Task ID	Task Name	Minimum	Most Likely	Maximum	Risk Impact	Modelled Duration	Planned Duration	Timings Start	Planned Start	Finish	Planned Finish
1	Clear site	3	4	5		3.95	4	15 Jan 13	15 Jan 13	18 Jan 13	18 Jan 13
2	Bring utilities to site	10	12	15		12.8	12	15 Jan 13	15 Jan 13	31 Jan 13	30 Jan 13
3	Excavate	5	5	10		5.33	5	18 Jan 13	21 Jan 13	28 Jan 13	25 Jan 13
4	Pour foundation	5	8	10		8	8	28 Jan 13	28 Jan 13	07 Feb 13	06 Feb 13
5	Outside plumbing	20	26	30		20	26	31 Jan 13	31 Jan 13	28 Feb 13	07 Mar 13
6	Frame house	12	14	15		13.7	14	07 Feb 13	07 Feb 13	27 Feb 13	26 Feb 13
7	Electric wiring	6	8	10		7.65	8	27 Feb 13	27 Feb 13	08 Mar 13	08 Mar 13
8	Lay floor	2	2	3		2.07	2	08 Mar 13	11 Mar 13	12 Mar 13	12 Mar 13
9	Lay roof	2	2	3		2.51	2	27 Feb 13	27 Feb 13	01 Mar 13	28 Feb 13
10	Inside plumbing	8	10	10		9.16	10	12 Mar 13	13 Mar 13	25 Mar 13	26 Mar 13
11	Shingling	6	8	10		9	8	01 Mar 13	01 Mar 13	14 Mar 13	12 Mar 13
12	Outside sheathing insulation	2	2	2		2	2	25 Mar 13	27 Mar 13	27 Mar 13	28 Mar 13
13	Install windows & outside doors	5	6	8		6.12	6	27 Feb 13	27 Feb 13	07 Mar 13	06 Mar 13
14	Brick work	6	7	10		7.71	7	27 Mar 13	29 Mar 13	08 Apr 13	08 Apr 13
15	Insulate walls and ceiling	8	10	11		10.9	10	25 Mar 13	27 Mar 13	09 Apr 13	09 Apr 13
16	Cover walls and ceiling	5	6	7		5.88	6	09 Apr 13	10 Apr 13	17 Apr 13	17 Apr 13
17	Insulate roof	2	3	3		2.82	3	17 Apr 13	18 Apr 13	22 Apr 13	22 Apr 13
18	Finish interior	12	15	16		15.4	15	17 Apr 13	18 Apr 13	09 May 13	08 May 13
19	Finish exterior	10	12	16		11.3	12	08 Apr 13	09 Apr 13	23 Apr 13	24 Apr 13
20	Landscape	4	5	6		5.45	5	23 Apr 13	25 Apr 13	01 May 13	01 May 13
21	The End	0	0	0		0	0	09 May 13	08 May 13	09 May 13	08 May 13
Summary						82.1		15 Jan 13	15 Jan 13	09 May 13	08 May 13

Figure 15. Building Analysis Calculation Sheet

The Minimum, Most Likely, and Maximum Durations columns on the Calculation sheet contain the original durations imported from Microsoft Project. The 'Modelled Duration' column shows the duration of the very last slice sampled.

Move right to the Finish column and double click on the cell named Project End Date (in the Summary line at the bottom of the model) to list all the slices created.

You are presented with the project finish date in each of the 1000 possible outcomes Risk Analyser has generated. By default, the values are shown in Data order.

Scroll to the top of the list to see the most favourable finish date. Scroll to the bottom to see the worst.

You can choose whether the slices are shown in:

- Slice Order, i.e. the order in which they were calculated.
- Data Order, so that the slices are shown in ascending order of the data.

Change the list to Slice Order and check that the last slice at the bottom of the list is the same value as that shown for the cell in the spreadsheet. If you choose to Reseed the model (under Calculate Now in the Calculation box), to generate a whole new set of slices, this last slice value will change, and so it should not be relied on as a representative value for the cell - this is indicated by the grey text in the cell.

With your slices in Data Order you can also select any slice in the list by its confidence value:

- Select 5%, 10%, 50%, 90%, 95% or 100%. (All confidences are the probability that the result for the selected cell will be less than the slice shown).
- Or choose Custom Confidence, enter a percentage in the box, and select the Show Custom button to select the slice with a chosen confidence.

Click on the 95% button and Select 'Show custom'. This will tell you the date that we can be 95% confident the project will be completed by.

The Project End Date Graph

The easiest way to interpret the effect of the uncertainty in the project is to look at a distribution graph of the project end date. A graph has been created automatically for you and can be viewed by selecting Project End Date from the Graphs section of the Views box.

HINT: If the 'Distribution graph' option was not ticked when importing the project, or the graph has been deleted, it can be created manually by following the steps below.

1. Click on the Project End Date cell (at the bottom of the Finish column on the Calculation sheet). Click and drag to select both this cell and the cell immediately to the right (at the bottom of the Plan Finish column)
2. Select Create Graph from the Graphs tab. This will launch the Graph Wizard.
3. On the Graph type screen, select the 'Column' graph type, select the only graph type shown, tick the 'Include s-curve' box, and click Next.
4. On the Graph data screen, check that the list shows both Plan Finish Date and Project End Date (the name of the cell is used rather than its reference). You can change the settings for the different graphs by selecting them from the Graphs box. For now, just click Next to use the default colours and graph names.
5. On the Chart options screen, fill in the labels to title, sub-title and label the axes on your graph.
6. Un-tick the Grid lines and legend tick boxes if preferred.

The graph shows the probability distribution for the completion date for the whole project (over all the 'slices of the future' that you have just created). The original 'planned' finish date taken from the project is shown as a solid marker. Note that the Quick Graph button to the left of the Create Graph button produces a graph more quickly but with default titles and colours.

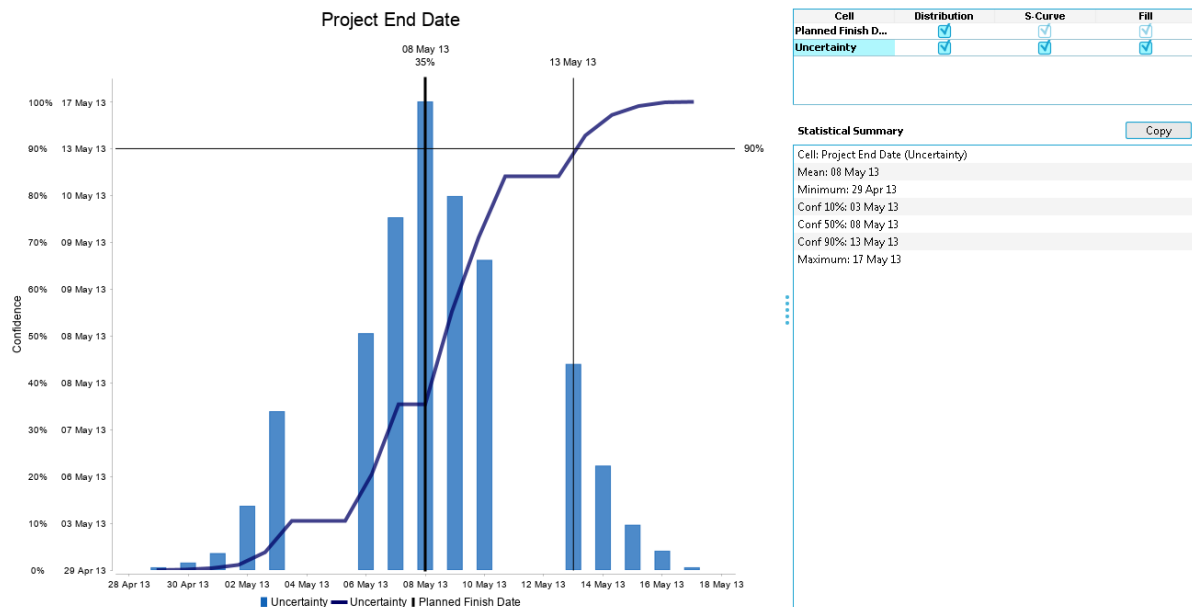


Figure 16. Distribution Graph of the Project End Date

Interpreting the graph requires care. Drag the horizontal line so that the label to the right of it reads approximately 90%, to identify the date which you can be '90% confident' that this project will be completed by.

There is a significant difference between the estimated finish date in the original Microsoft Project plan (shown as a solid marker on the graph) and the date you can now give with 90% confidence. The date you are now using reflects the uncertainty that has been defined for the plan. It will be more accurate as a forecast than the original figure. The confidence of finishing before the original 'planned' date is shown as a label attached to the Plan Finish Date marker - in this case you can see that the confidence is only 35%.

Criticality versus Cruciality

Criticality and cruciality are two important measures that help you identify high risk areas in your plan. These measures are calculated as a value between 0% and 100%, indicating low to high risk. Generally, a high cruciality indicates a high risk task, whereas a high criticality but low cruciality indicates a task that might become high risk in the future.

Criticality

The Criticality of an activity tells you the chance that a delay in the activity will affect the timing of the whole project. It measures the chance that the activity will have an impact on the Project End Date. If an activity is highly critical but not highly crucial, its uncertainty will still not have a large impact on the end date. Such tasks should be reviewed regularly, since any changes to their assessment (such as new risks being identified) could well impact on the end date.

Cruciality

The Cruciality of an activity tells you how much correlation there is between the activity's duration and the duration of the whole project. It measures how much impact the activity will have on the project end date. Because tasks that aren't on the critical path don't affect the end date, cruciality also considers a task's criticality, and so is the more commonly used measurement.

The 'Gantt Chart' graph displays colour coded bars to indicate the cruciality level, set by thresholds which can be redefined on the right-hand side to re-distribute the colours. You can also hover over the bars to display the cruciality value for each task.

Bars are also displayed to show how uncertain the start and end dates are for each task, using 10% and 90% confidence values as calculated in the Project Report sheet, as set on the Advanced tab of the Schedule Analysis Options window. If you import the plan from Risk Controller, these confidence values can be set on the detail screen for the project's folder.

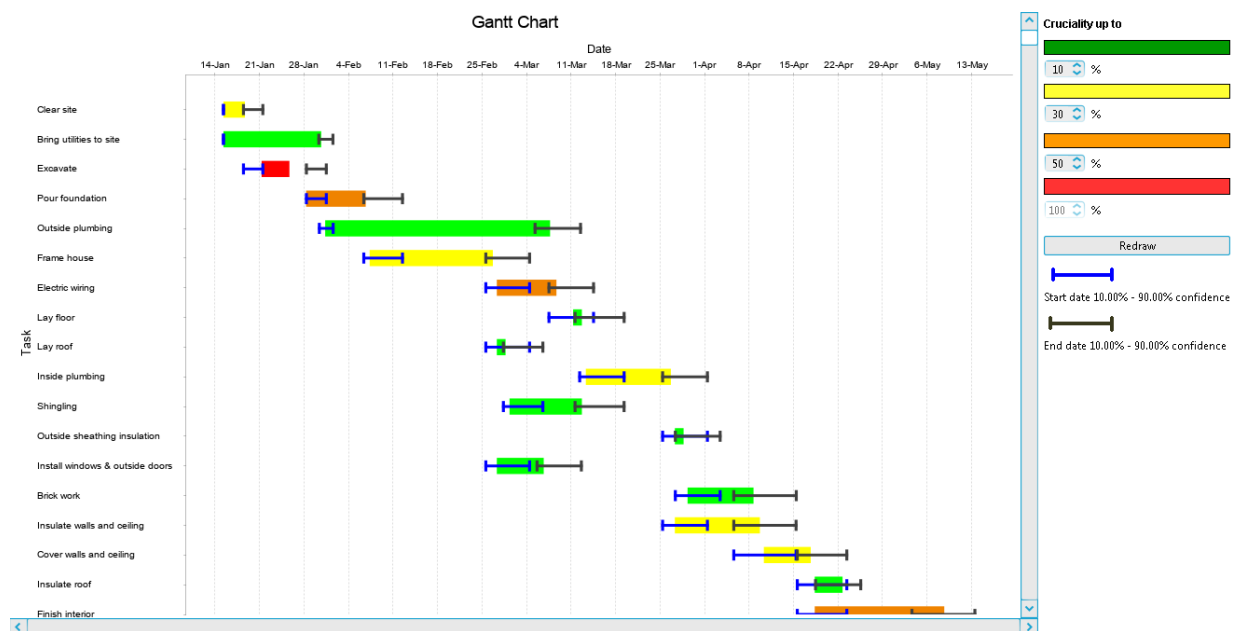


Figure 17, Building Project Gantt Sheet

NOTE: The labels for the bars on the Gantt Chart are taken from the task name, limited to the first 50 characters.

The Cruciality values for all activities can also be viewed on the automatically produced Tornado Chart.

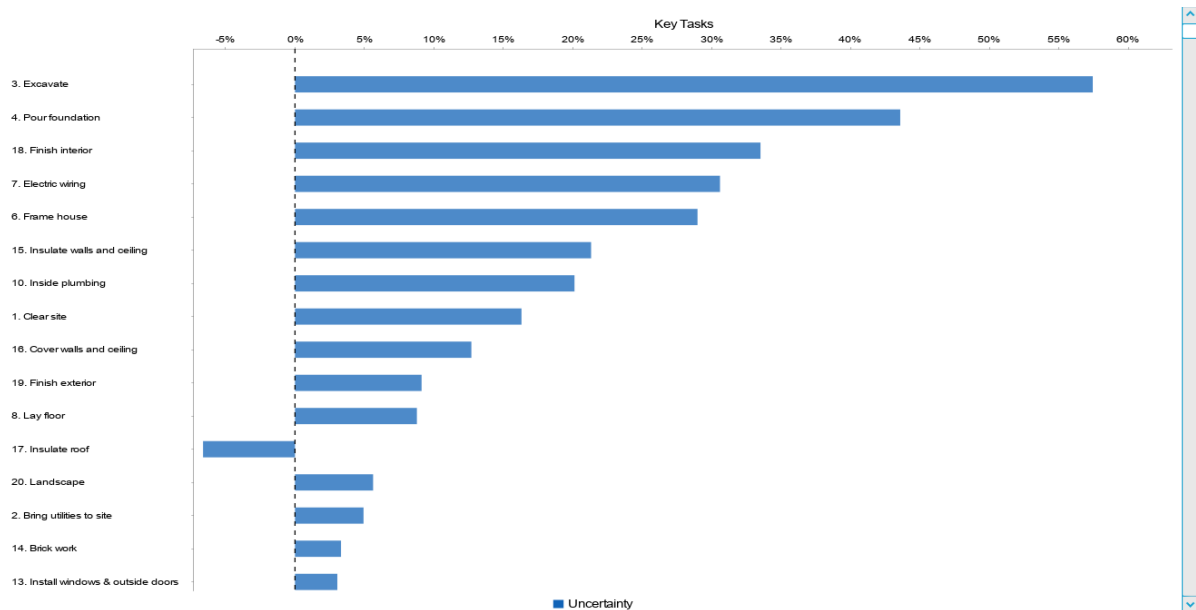


Figure 18. Building Project Tornado Sheet

The Advanced Options tab

When you are opening your project schedule, you can use additional settings in the Advanced Options tab to define how the project data is analysed.

General

- ☐ Work in whole days
 - ☒ Always round days up
 - ☐ Round days up at: 0.5 of a day
- ☐ Exclude Constraints
- ☒ Sort by Task ID
- ☐ Correlations defined in: Text 1

Custom Fields

- ☐ Include Custom Text Fields (MPP/MPX Only)
- Text1, Text2, Text3, Text4, Text5

Results & Milestones

Confidences: 10%, 50%, 90%

☒ Calculate mean values

Milestones to report against: Choose milestones

None selected

Figure 19. Schedule Analysis, Advanced Options

Work in whole days

The work in whole days option indicates that Risk Analyser should finish each task at the start or end of the day, regardless of the time at which it is actually completed. This option is typically used for projects with tasks lasting for weeks rather than for a few days. There are two choices to control how partial days are rounded:

- Always round days up. The Modelled duration is rounded up to whole days, even if the task completed during the morning.
- Round days up at... Modelled duration is rounded up at the fraction specified and above, otherwise it is rounded down.

If the work in whole days option is not ticked, Risk Analyser will start the next task immediately after completion of its predecessor, whatever time it finishes during the day. You should untick this option if your task durations are short, or are defined in hours or part days, in order to avoid adding a disproportionate amount of time to your project finish date as a result of rounding.

Exclude constraints

The Exclude constraints tick box provides the option to ignore constraints when importing the project plan, so that the model is allowed to apply uncertainty without being constrained by rules such as Must Start On and Must Finish On.

Correlations defined in

Select this option to import correlations between tasks from a custom text field in the project plan. For example, if your project is for building a new house and it takes a long time to complete the electric wiring on one floor, it may also take a long time to complete the wiring on other floors. Relationships such as this can be recorded in the project schedule, and automatically imported into Risk Analyser and used during the model simulation.

Correlations can be added in a custom text field in the project planning tool. For Microsoft Project, this can be any of the fields Text1 to Text30, but in Primavera a user defined text field named RDL_Correlation must be created and used for this data (see Appendix: User Defined Fields in Primavera for further information).

Correlations must be entered as the Task Unique ID (Activity ID in Primavera) followed by the correlation coefficient in square brackets. For example, to define a correlation to a task with the unique Id 4 at 85%, enter: 4[85%]

These are modelled as in-cell correlations in the Modelled Duration column.

NOTE: When importing from Microsoft Project, the Task Unique Id must be used to define a correlation, NOT the Task Id. Task Ids may change automatically as new tasks are inserted into the project or obsolete ones removed, but a task's Unique Id will never change even if it is cut and pasted elsewhere in the project. When importing from Primavera, the Activity Id can be used as this does not adjust automatically if a task's position in the project is changed. However, if you manually change the Activity Id of a task, remember to also update any correlations that reference it.

Sort by Task Id

Tick to ensure that tasks appear on the Calculation and Report sheets in ascending task id order (which should match the order in the project planning tool). This is a cosmetic adjustment that does not affect the validity of results gained from the model.

Include Custom Text Fields

The Include Custom Text Fields (MPP/MPX only) tick box allows you to import extra task data (such as notes or assumptions) contained in custom text fields. This information is displayed to the far right of the Calculation sheet. This option is only available when importing from Microsoft Project.

Results - Mean and Confidences

Select the Mean tick box to calculate a mean value on the Report and Summary sheets. If selected, mean values are shown for start, finish, duration, and cost on both sheets.

The Confidences values are used in the Summary report and the Summary sheet to calculate confidence results.

Results - Milestones to report against

Risk Analyser can report mean and confidence values at interim project milestones as well as for the whole project. These will be shown on the Summary sheet listed beneath the whole project values. Click the Select milestones button to see a list of milestones in this plan, then select those you wish to report against. You can choose as many milestones as required - hold down the Ctrl key on your keyboard and click to select multiple entries in the list.

The Reports & Display Options

This tab contains options that control how the model is displayed and what reports or graphs are automatically generated.

The screenshot shows the 'Reports & Display' tab of the Predict! Risk Analyser interface. It contains several sections with checkboxes for configuring reports and displays. The 'Create report sheet' section has 'Report' checked. The 'Include' section has 'Durations' and 'Start data' checked. The 'Create graphs' section has 'Gantt chart', 'Tornado chart', and 'Distribution graph' checked. The 'Display sheets' section has 'Calculation', 'Report', and 'Sensitivity' checked. The 'Display columns' section has 'Distributions' checked. A note at the bottom explains how to display hidden sheets and columns.

Create report sheet

☒ Report

Include: ☒ Durations ☒ Start data

Create graphs

☒ Gantt chart
☒ Tornado chart
☒ Distribution graph

Display sheets

☒ Calculation
☐ Calendars
☒ Report
☐ Sensitivity

Display columns

☐ Calculations
☐ Calendar
☐ Ids and WBS
☒ Distributions
☐ Constraints

Note:
 Hidden sheets can be displayed by selecting Hidden Sheets from the Sheets list in the View section. Hidden columns can be displayed by highlighting the columns either side of them and selecting Format, then Unhide Column from the Cells section of the Home tab.

Figure 20. Schedule Analysis, Reports & Display Options

All available reports and graphs are created automatically by default. You can choose not to

create any of these by unticking the relevant box in this section.

Create Report Sheet

This section contains options that control how the Report sheet is created in the model. This applies to the Report worksheet only, the Summary Report is always created and is not affected by these options. There is a tick box to choose whether the Report sheet is created or not, and options to include statistics on start dates and durations for each task. The Report sheet always includes statistics for finish dates and costs (if imported).

Create Graphs

The Create Graphs section allows you to specify whether to create Gantt charts, Tornado charts, and Distribution graphs.

If choosing to create distribution graphs, a separate graph tab is created for the Project End Date and the Project Total Cost (if costs are imported), with plots added to each graph tab for each assessment type being modelled (uncertainty only/current risk/target risk), and a marker for the deterministic plan finish date or plan cost.

If creating tornado charts, a separate chart is created as required for task durations, task costs, risk time impacts, and risk cost impacts. Each chart displays a set of bars for uncertainty, current, and target analysis types as appropriate.

Display sheets

Risk Analyser automatically hides its 'behind the scenes' worksheets, displaying only the results sheets that you should report from. You can tell Risk Analyser to display the hidden sheets by selecting boxes in this section, for example to perform 'what-if' analysis or check differences to plan dates in the Calculations sheet.

If you are importing from Risk Controller, choosing to show or hide a sheet here will apply to all sheets of that type in the model - for example, showing the 'Calculations' sheet will display all the uncertainty only, current, and target Calculation sheets. You will also see another option to show the Risks sheet(s).

The Summary sheet, distribution and Tornado charts (if created), and Schedule Check sheets cannot be hidden.

Display columns

Risk Analyser also automatically hides some columns in worksheets that contain supplementary data or perform calculations that feed into the main results formulas. You can display these columns by selecting tick boxes in this section. The options are:

- Distributions – display the Modelled duration column on calculation sheets, Bernoulli and distribution columns on risks sheets (if importing from Risk Controller).
- IDs and WBS - displays columns showing supplementary IDs such as the Task Unique ID, Risk Controller folder ID, and WBS. The Task ID and Risk ID are never hidden.
- Task Calendar – displays the Calendar column on the Calculation sheets.
- Constraints – display the Constraints column on Calculation sheets.
- Calculations – display the Early Start to Cruciality columns inclusive on the Calculation sheets.

Using percent complete

If your project is underway and you want to analyse complete or partially complete tasks, you must ensure the project plan is properly set up with appropriate progress information for Risk Analyser to use. The following example is designed to explain how to set up and use

the percent complete option. The project schedule used is available in the Risk Analyser example files, named PercentComplete.

A simple project plan

A plan has three sequential 10 day tasks; the first is complete, the second is partially (30%) complete and the final task has yet to be started. The project has a standard 5 day week calendar.

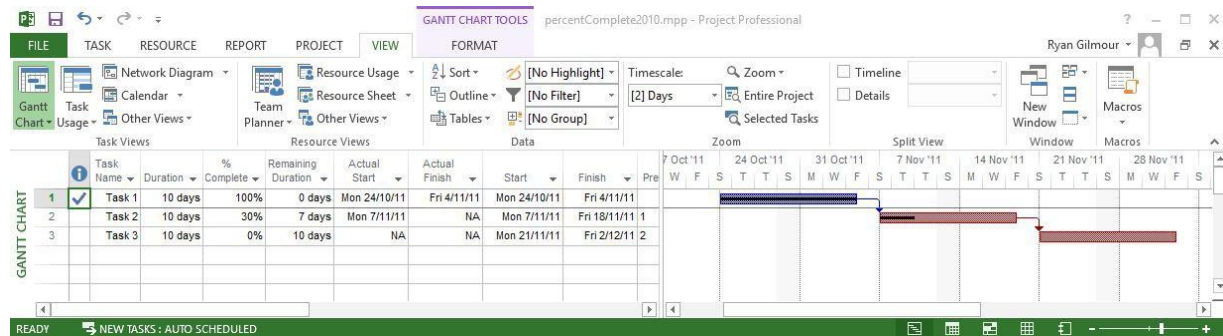


Figure 21. Progressed project activities

As shown above, project dates are as follows:

- Project Start Date: Mon 24th Oct
- Task 1 is complete and lasted for 10 days: Actual Start Mon 24th, Actual Finish Fri 4th Nov
- Task 2 has completed 3 days (30% of the 10 days): Actual Start Mon 7th Nov
- Task 2 has 7 days Remaining Duration: continuing on Thu 10th its Finish Date is Fri 18th Nov
- Task 3 is not yet started: Start and Finish Dates are currently Mon 21st to Fri 2 Dec

Analysis of Tasks 1 and 3 is straightforward. By choosing to use percent complete, Risk Analyser will use the Actual Start and Actual End Dates from Microsoft Project for 100% complete tasks. For tasks not yet started, the analysis will use the logic of the plan (predecessors and successors) to calculate start and end dates.

Analysis of partially complete tasks, such as task 2, is a little more involved as the Actual Start Date and time so far is fixed, but the Remaining duration needs to be analysed. Risk Analyser uses the Actual Start date of the task, and then schedules the Remaining Duration from the plan Status Date, which tells us 'when' the task was that amount complete.

Prepare your plan

It is very important to set Status Date when you update progress in your plan, as you may perform your risk analysis on the schedule some time after entering the progress information into the plan. Many planning tools enforce setting of this date, but Microsoft Project allows this to be left undefined. If you do not set the Status Date, Risk Analyser will use today's date and current time (taken from the system date on your computer) to continue progress of partially complete tasks. This may result in the analysis producing different results from that which you expected (the difference will be equivalent to the number of days/hours etc. since the progress update).

The Progress Date

We use the term Progress Date in Risk Analyser to mean the date and time Risk Analyser

will progress the project from. This Progress Date is taken from the Status Date field in Microsoft Project, and Risk Analyser will progress the project from that date and time. To update the Status Date in Microsoft Project, choose the Project Menu, then select Project Information.

Risk Analyser uses today's date as the Progress date if the Status Date is not set in Microsoft Project. Therefore, it is very important to set the Status Date in Microsoft Project if you want progress to continue from the date you last updated (and saved) the plan.

In our example plan above, Status date is 10th Nov.

Project Information for 'percentComplete2010'

Start date: Current date:

Finish date: Status date:

Schedule from: Calendar:

All tasks begin as soon as possible. Priority:

Enterprise Custom Fields

Department:

Custom Field Name	Value

Help Statistics... OK Cancel

Figure 22. Enter project information

Set 'Percent complete' for each task in the Task information screen or in the '% complete column' in the project sheet. For task 2, below, this is set to 30%; the Duration remains at 10 days.

Task Information

General | Predecessors | Resources | Advanced | Notes | Custom Fields

Name: Duration: ☐ Estimated

Percent complete: Priority:

Schedule Mode: ☐ Manually Scheduled ☒ Auto Scheduled ☐ Inactive

Dates

Start: Finish:

☐ Display on Timeline
☐ Hide Bar
☐ Rollup

Help OK Cancel

Figure 23. Task information

Microsoft Project automatically calculates the Remaining Duration (for tasks that are 0% complete, the Remaining Duration is the same as Duration). You can see from the screenshot below, Task 1 has 0 Remaining duration, as it is 100% complete; Task 2 has 7 days Remaining Duration as Microsoft Project has calculated it as being 30% through a 10 day task.

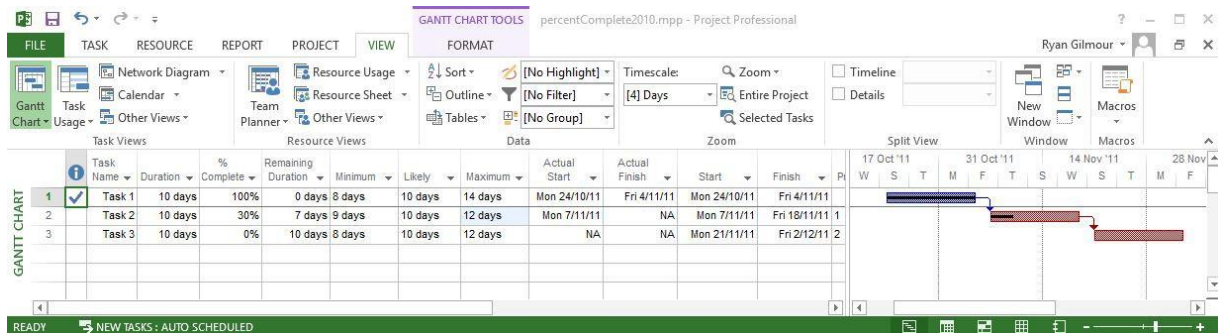


Figure 24. Remaining duration

NOTE: To display the Remaining Duration column in the main Microsoft Project screen, right-click on any column header and choose 'Insert Column', then choose Remaining Duration from the list of available fields.

Microsoft Project calculates the Remaining duration automatically for progressed tasks; however if you are using 3 point estimates for your risk analysis, you will need to update these fields manually e.g. Duration 1, 2 and 3 for your Minimum, Likely and Maximum. So, for our plan, we should set all three values to zero for Task 1, re-estimate how much work is still to be done for Task 2 (this may not be 7 days!) and leave Task 3 as is.

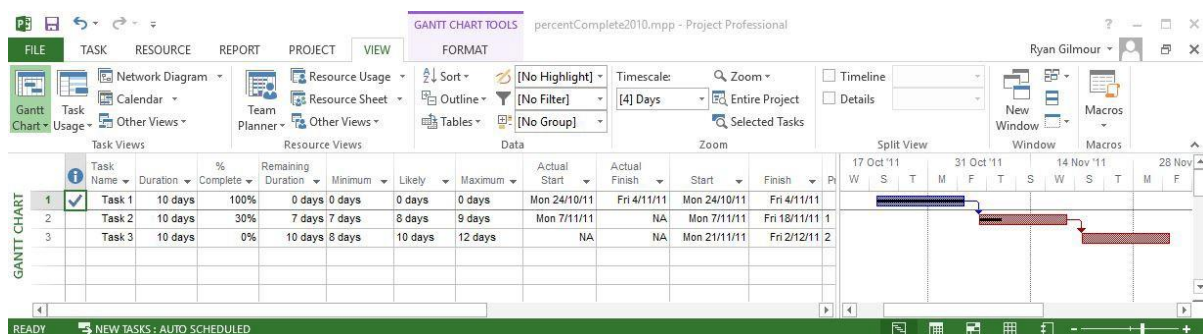


Figure 25. Update the 3-point estimates in the project plan

NOTE: You must not use the Microsoft Project 'Duration' field for the likely value of your 3 point estimates if you intend to use the Percent complete option in Risk Analyser; instead, you should use a field such as Duration 2, that can be updated to represent Remaining Duration (as Microsoft Project will always use 'Duration' to represent the total duration of the task).

Run the analysis with progress included

To apply progress to activities in Risk Analyser, in the Schedule Analysis Options screen, tick the 'Use percent complete' setting on the General tab, Progress section:

The screenshot shows the 'Schedule Analysis Options' dialog box with the 'General' tab selected. The 'Project to import' field contains 'C:\pra\Examples\Building2010.mpp'. The 'Schedule check' section has an 'Options' button. The 'Progress' section has a checked checkbox for 'Use percent complete' and an 'Options' button. The 'Uncertainty' section has three radio buttons: 'None', 'Global', and 'By task' (which is selected). Below these are three columns of dropdown menus for 'Optimistic', 'Likely', and 'Pessimistic' values, labeled 'Duration 1', 'Duration 2', and 'Duration 3'. There are also three dropdown menus for 'Costs' labeled 'Cost 1', 'Cost 2', and 'Cost 3'. The 'Distribution shape' is set to 'Triangular' with a 'Change' button. The 'Number of slices' is set to '1,000'. The 'Risks' section has a checkbox for 'Import risk probabilities from:' with a dropdown menu showing 'Text 1'.

Figure 26. Select the Use percent complete option

When using the percent complete option, you must import remaining durations:

- If you run the analysis with 'No uncertainty' or 'Global uncertainty', you must either choose Remaining Duration or the field containing your Likely value, which you have updated to represent remaining duration for partially complete tasks. DO NOT use the 'Duration' to store this value, as this is the total duration of the task, some of which will already have been accounted for when modelling partially complete tasks.
- If you use 'Values from project', then make sure your Minimum, Likely and Maximum durations for all partially complete tasks have been updated to represent remaining duration rather than total duration for the task. Again, DO NOT use the 'Duration' field to store any of these values.

Selecting the 'Use percent complete' tick box enables the Options button in the Progress section. Clicking this button displays the Progress Options window, with further settings to control how in-progress tasks are handled in Risk Analyser.

Progress Options

Choose how to model Remaining Durations for in-progress tasks:

☒ The selected duration fields are remaining durations (recommended)
 Remaining duration values are taken directly from the duration fields chosen on the General tab. Please ensure that these durations have been updated in the project to reflect the remaining duration of each individual task.

☐ Reduce duration estimates by % complete
 Remaining duration values are taken from the fields specified on the General tab, but are reduced by the task's % complete value. For example, if the task's original duration estimates are 10, 20, 30 days and the % complete is 50%, Risk Analyser will use values of 5, 10, 15 days.

☐ Calculate remaining durations for in-progress tasks
 Ignore the duration values in the plan for in-progress tasks, and replace them with calculated durations based on the settings below.

Optimistic Likely Pessimistic

80 % Remaining Dur... 120 %

OK Cancel

Figure 27. Progress Options

There are three choices:

1. The selected duration fields are remaining durations - (recommended).

Remaining duration values are taken directly from the duration fields chosen for all tasks on the General tab. You must ensure that these durations have been updated in the project to reflect the remaining duration of each individual task, as described in this tutorial.

2. Reduce duration estimates by % complete.

Remaining duration values are taken from the fields specified on the General tab but are reduced by the task's % complete value. For example, if the task's original duration estimates are 10, 20, 30 days and the % complete is 50%, Risk Analyser will use values of 5, 10, 15 days.

3. Calculate remaining durations for in-progress tasks.

If the duration fields in the plan have not been updated to reflect remaining durations, this option allows you to ignore the duration fields chosen on the General tab and instead apply global values to any tasks that have started but not yet finished. The Likely drop-down list contains the same entries as the Likely dropdowns on the General tab, and defaults to Remaining Duration.

NOTE: It is **strongly** recommended that you use the first option (selected duration fields are remaining durations), as this will provide the most accurate analysis. This is the option that is used for this tutorial.

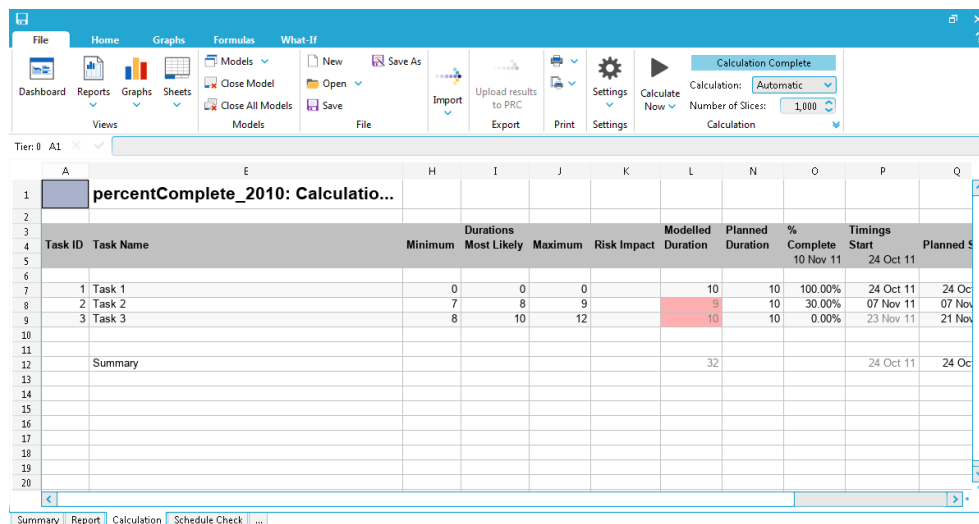


Figure 28. Durations in Risk Analyser

The Minimum, Most Likely and Maximum Durations columns on the Calculation sheet show the remaining duration we entered in Microsoft Project. The % complete column includes progress for each task, with the status date at the top. Task 1 does not have a distribution in the Modelled Duration column, because it uses Actual Start and Finish dates.

NOTE: The Project End Date selected above is only one result (the last slice) of many generated by the analysis. The correct view of the statistical results should either be viewed as a graph of this cell, or be taken from the Project Report sheet which displays confidence, mean, criticality and cruciality values for each task and the Project End Date.

Using Percent Complete for plans imported from Primavera

Using percent complete when importing from Primavera is similar to the above information. However, the progress date in Primavera is called Data date (in Microsoft Project it is called Status Date).

Note: Some versions of Primavera do not specify time as part of their Data Date as well as certain other date fields e.g. milestones, constraints and calendars. If Risk Analyser cannot find a valid time to use from Primavera, then it defaults to a 9am start time.

For more information on using Primavera with Risk Analyser, please refer to the Appendix - User Defined Fields in Primavera.

Advice on using Remaining Duration and global uncertainty in Risk Analyser

Microsoft Project assumes that if 30% of a 10 day task has passed, then 3 days are complete and 7 days are remaining. However, it is invalid to apply the 30% in the same way to the minimum and maximum values of a 3-point estimate, for the reasons explained in the following example.

Let's say that you have a minimum of 8 days and maximum of 14 days around your 10 day likely value. Applying a factor of 30% complete assumes that the range of uncertainty reduces as the task proceeds, so that the original spread of 6 days uncertainty (8 to 14 days) is reduced by 30% to 4.2 days (5.6 to 9.8 days). In fact, by the time you have completed 3 days and are 30% through the task, you may find you are more uncertain about the outcome, rather than less, so it may be far more realistic for your remaining duration 3 point estimate to be min = 5, likely = 7, max = 11, which maintains the spread of 6 days. For this reason, we recommend you use 3-point estimates for your uncertainty and not Global values.

Cost risk analysis on a project plan

If you wish to perform integrated cost analysis on your project, you need to enter cost information into your plan. There are two types of costs that are generally associated with each task: a resource cost (the fee for a person or people to carry out the task, which usually varies depending on the length of the task); and a fixed cost (e.g. materials, or other one-off costs). In Microsoft Project, you enter resource costs by creating resources and assigning these to the task, and enter fixed costs directly in to the Fixed Cost column or the columns you have chosen to store a 3-point estimate of fixed costs (typically Cost1, Cost2, and Cost3).

Risk Analyser then interprets this data into (a) a Cost Per Day for each task (equating to the cost per day of the resources assigned to the task); and (b) a 3-point estimate of fixed costs for the task, either taken directly from your Minimum, Likely, and Maximum values in the schedule if you choose to import uncertainty 'By task' or by applying global percentage values around the Fixed Cost value, in the same way as for Durations.

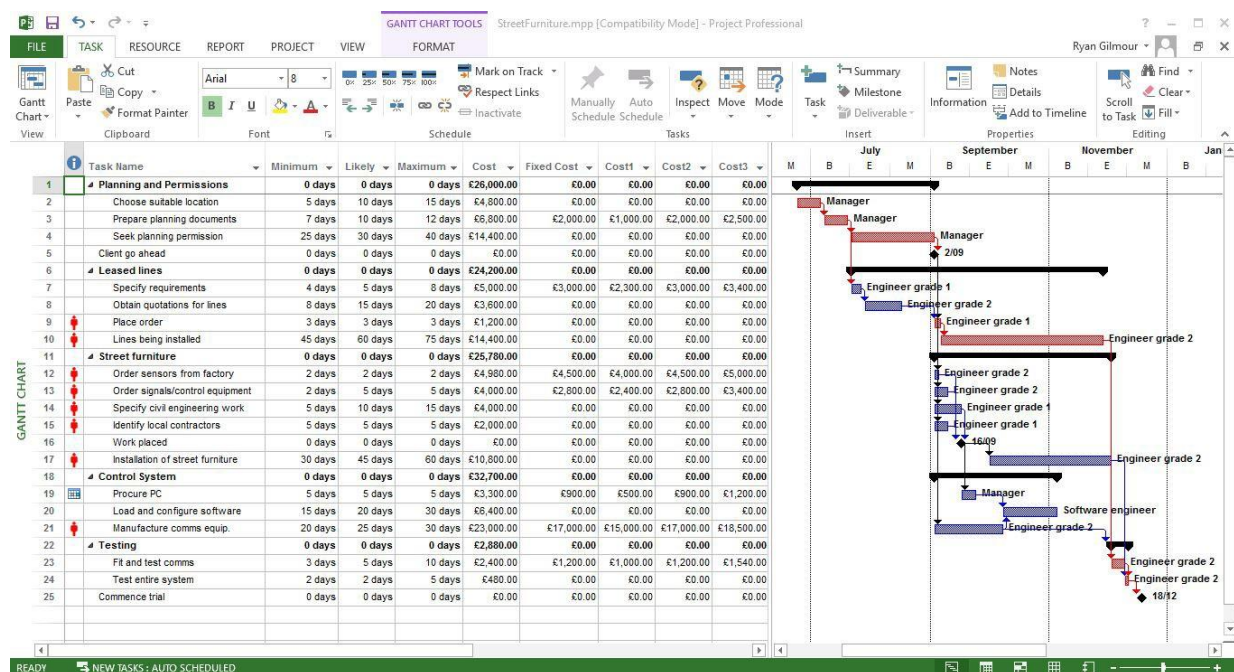


Figure 29. Project schedule with resources and fixed costs

The project schedule above shows tasks with resource costs and additional costs in Cost1, Cost2 and Cost3 for import into Risk Analyser.

How Risk Analyser uses Cost Per Day

Risk Analyser takes the Cost for each Microsoft Project task, then deducts the task Fixed Cost and divides by the task Duration to produce its Cost Per Day.

For the example above, the Cost for the Specify Requirements task is £5,000. Included in this amount is £3,000 of Fixed Cost. Risk Analyser deducts the £3,000 from £5,000 to get £2,000 and divides by Duration (5 days) to get a Cost per day of £400.

The Cost Per Day is then multiplied by the uncertain duration generated by Risk Analyser to produce an overall uncertain task cost.

How Risk Analyser uses Fixed Costs

If you are importing uncertainty using the None or Global settings, you should take the value from the Fixed Cost column in Microsoft Project, or the Planned Expense Cost or Budgeted Expense Cost (depending on version) in Primavera. If you are importing uncertainty using By task, you must enter Fixed Cost data into your chosen Minimum, Likely and Maximum columns (e.g. Cost1, Cost2, Cost3 in Microsoft Project).

If you have resources in your plan, it is very important that you do not choose to take costs from the standard Cost column. This amount includes the resource costs in addition to the fixed costs, which results in the resource costs being counted twice in your Risk Analyser model - once in the Cost Per Day column, and once in the Fixed Cost columns.

Importing costs into Risk Analyser

To import Costs, in the General tab of the Schedule Analysis Options window tick the Costs box and specify which field(s) in Microsoft Project or Primavera to take the cost data from. The Costs controls on this screen are always for the same uncertainty type as the Duration controls – it is not possible to select different uncertainty types, for example By task for Durations and Global for Costs, using this screen.

Separate uncertainty settings for costs can be set on the Costs tab. The Costs tab is displayed when the Costs tick box is selected on the General tab.

Figure 30. Schedule Analysis Options, Costs tab

If 'Use cost controls on General tab' is selected, costs will use the same uncertainty settings as specified for durations. However, the 'Use the following uncertainty settings for costs' option enables you to specify separate settings (including distribution to be used) for costs, that can be different to those chosen for durations on the General tab. For example, you can choose by task uncertainty for durations but Global uncertainty for costs, or triangular distributions for durations and uniform distributions for costs. This is useful if your project has 3-point estimates for durations but has not been set up for costs yet.

Task ID	Task Name	Planned Finish	Minimum	Most Likely	Maximum	Risk Impact	Fixed Cost	Cost Per Day	Total Cost	Planned Total Cost
1	Planning and Permissions	13 02 Sep 13	0	0	0		0		0	0
2	Choose suitable location	13 05 Jul 13	0	0	0			480	6,240	4,800
3	Prepare planning documents	13 19 Jul 13	1,000	2,000	2,500		2,130	480	7,410	6,800
4	Seek planning permission	13 02 Sep 13	0	0	0		0	480	18,200	14,400
5	Client go ahead	13 02 Sep 13	0	0	0		0	0	0	0
6	Leased lines	13 28 Nov 13	0	0	0		0		0	0
7	Specify requirements	13 26 Jul 13	2,300	3,000	3,400		3,040	400	5,040	5,000
8	Obtain quotations for lines	13 16 Aug 13	0	0	0		0	240	2,880	3,600
9	Place order	13 05 Sep 13	0	0	0		0	400	1,200	1,200
10	Lines being installed	13 28 Nov 13	0	0	0		0	240	14,600	14,400
11	Street furniture	14 02 Dec 13	0	0	0		0		0	0
12	Order sensors from factory	13 04 Sep 13	4,000	4,500	5,000		4,110	240	4,590	4,980
13	Order signals/control equipment	13 09 Sep 13	2,400	2,800	3,400		2,540	240	3,500	4,000
14	Specify civil engineering work	13 16 Sep 13	0	0	0		0	400	3,200	4,000
15	Identify local contractors	13 09 Sep 13	0	0	0		0	400	2,000	2,000
16	Work placed	13 16 Sep 13	0	0	0		0	0	0	0
17	Installation of street furniture	14 02 Dec 13	0	0	0		0	240	13,700	10,800
18	Control System	13 04 Nov 13	0	0	0		0		0	0
19	Procure PC	13 23 Sep 13	500	900	1,200		824	480	3,220	3,300
20	Load and configure software	13 04 Nov 13	0	0	0		0	320	6,080	6,400
21	Manufacture comms equip.	13 07 Oct 13	15,000	17,000	18,500		17,300	240	23,700	23,000
22	Testing	14 11 Dec 13	0	0	0		0		0	0
23	Fit and test comms	14 09 Dec 13	1,000	1,200	1,540		1,330	240	3,010	2,400
24	Test entire system	14 11 Dec 13	0	0	0		0	240	720	480
25	Commence trial	14 18 Dec 13	0	0	0		0	0	0	0

Figure 31. Costs modelled in Risk Analyser

If you choose to import costs, the cost data will appear on the right-hand side of the Calculation sheet. First the Minimum, Likely and Maximum fixed costs data are entered from your three chosen columns (e.g. Cost1, Cost2, Cost3), with a column to enter any cost risk impact and a distribution to calculate the fixed cost. The Cost Per Day column is next, followed by the Total Cost column, which is calculated as the Cost Per Day column multiplied by the Modelled Duration column, with the value sampled from the Fixed Cost distribution added to give the total modelled cost for the task.

Confidence and mean values for the Project Total Cost, and a comparison to the planned total cost taken from the schedule, are shown on the Summary sheet. Detailed cost statistics for each individual task are also shown on the Report sheet, if created.

Importing Quick Risk Information from Schedules

'Quick Risk' allows users to create risk models quickly and easily without using Risk Controller. Risks are entered into the project plan as tasks or activities, but are given a probability value in a custom text field. Risk Analyser will then interpret the task as a risk, and the task's duration and cost 3-point estimates as the impact values for the risk.

Entering Data in the Project Plan

The risk probability can be entered in a custom text field or custom number field in the plan. For Microsoft Project, this can be any of the existing custom fields (Text1 to Text30, or Number1 to Number20).

An example MPP file is provided that has some quick risks included in the project. This file is in the Examples directory inside the Risk Analyser installation folder (usually C:\pra4\Examples), and is called House Project with risks.mpp. This file is shown opened in Microsoft Project with the risks highlighted in orange, below. Risk probabilities have been entered in the custom text column Text1 (renamed here to 'Risk Probability'). For 'normal'

tasks, this column has been left blank.

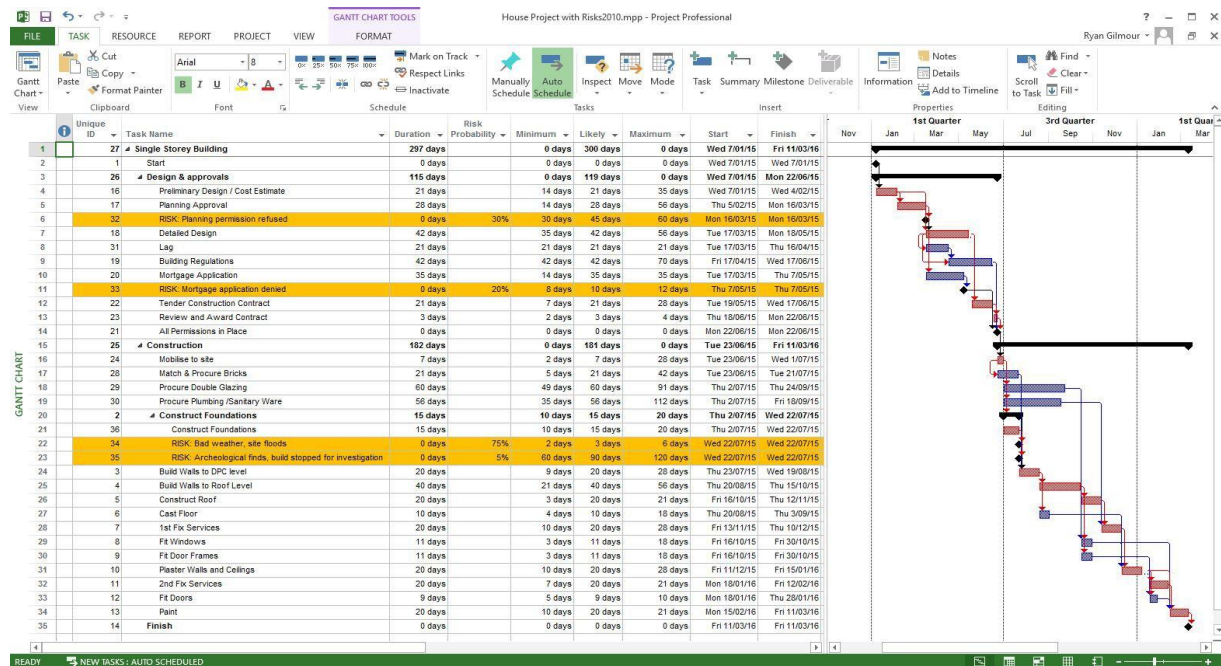


Figure 32. House Project with risks project plan in Microsoft Project

To mark a task in the schedule as a risk, enter a value in the chosen custom field. If the value is a number in the range 0-100, or a text value that can be converted to a percentage (a number in the range 0-100 followed by a % symbol), then that task is treated as a risk. The value in this field is the risk probability, and the duration/cost values are treated as risk impacts.

NOTE: Make sure that you leave the standard cost and duration fields of your quick risks as 0, so that they don't interfere with the results in your planning tool. Use the 3-point estimate fields instead.

NOTE: For Primavera imports you must create a User Defined Field in the Primavera database named 'RDL_RiskProbability' to hold the probability values (see Appendix: User Defined Fields in Primavera). It can be either a text field or number field, but it must have this exact name.

Importing Quick Risks to Risk Analyser

To import Quick Risks, select the 'Import risk probabilities from' tick box in the Schedule Analysis Options, General tab, Risks section. Next choose the custom field from the drop-down list that you used to contain your risk probability values (in this example project Text1).

Project to import

C:\pra\Examples\House Project with Risks.mpp Change

Schedule check

Select schedule check reporting options: Options

Progress

☐ Use percent complete Options

Uncertainty

☐ None ☐ Global ☒ By task

Optimistic Likely Pessimistic

Durations: Duration 1 Duration 2 Duration 3

Costs: Cost 1 Cost 2 Cost 3

Distribution shape: Triangular Change

Number of slices: 1,000

Risks

☒ Import risk probabilities from: Text 1

Figure 33. Select the Quick Risks option, Schedule Analysis Options

HINT: Make sure that the Risks sheet is selected on the Reports & Display tab so that you can see the imported risks.

How Quick Risks are modelled in Risk Analyser

Risk tasks are added to a new sheet named 'Quick Risks', laid out as a standard risk sheet with columns for probability, Occurs?, impacts (taken from the duration/cost values in the plan) and a risk distribution. The Quick Risks sheet for our example project is shown below.

Risk ID	Risk Name	Include?	Probability	Occurs?	Time Impact: Minimum	Likely	Maximum	Impact
6	RISK: Planning permission refused	TRUE	30.00%	TRUE	30	45	60	36.008
11	RISK: Mortgage application denied	TRUE	20.00%	TRUE	8	10	12	9.362
22	RISK: Bad weather, site floods	TRUE	75.00%	TRUE	2	3	6	3.033
23	RISK: Archeological finds, build stopped for investigati...	TRUE	5.00%	FALSE	60	90	120	0
								Time Impact: Total
								48.4

MODEL SUMMARY

Figure 34. Example Quick Risks sheet

The Quick Risks sheet will not be visible if have not ticked the 'Risks' tick box in the 'Display sheets' section on the Schedule Analysis Options, Reports & Display tab. (This tick box appears when quick risks are being imported and disappears when they are not). In this case, select Hidden Sheets... from the Sheets list in the View box to unhide it.

The minimum, likely, and maximum impact values are taken from the project or calculated in the same way as for 'normal' tasks. For example, if the uncertainty options were for Global Uncertainty of minimum = 75%, likely = Duration1, and maximum = 125% - these are also the values that are used for the risk impact. If a risk task is marked as in-progress and 'Use percent complete' is ticked, the risk impact values are calculated in the same way as the uncertainty estimates for normal tasks – i.e. imported, reduced, or calculated as global values depending on the option chosen in the Progress Options window.

Risk tasks are also included as rows on the Calculation sheet but have no duration or cost 3-point estimates. The Risk Impact columns on the Calculation sheet for these tasks reference the corresponding risk distribution on the Quick Risks sheet, and all other columns are filled out as for normal tasks. Keeping the risk tasks in place on the Calculation sheet allows the logic of the plan to remain intact. If the risk does not occur, the task will have a duration or cost of zero and will not impact the project end date or total cost.

Task ID	Task Name	Minimum	Most Likely	Maximum	Risk Impact	Modelled Duration	Planned Duration	Timings Start	Planned Start	Finish	Planned Finish
1	Single Storey Building					304	297	07 Jan 15	07 Jan 15	23 Mar 16	11 Mar 16
2	Start	0	0	0		0	0	07 Jan 15	07 Jan 15	07 Jan 15	07 Jan 15
3	Design & approvals					118	115	07 Jan 15	07 Jan 15	26 Jun 15	22 Jun 15
4	Preliminary Design / Cost Estimate	14	21	35		18	21	07 Jan 15	07 Jan 15	30 Jan 15	04 Feb 15
5	Planning Approval	14	28	56		28	28	02 Feb 15	05 Feb 15	11 Mar 15	16 Mar 15
6	RISK: Planning permission refused				0	0	0	11 Mar 15	16 Mar 15	11 Mar 15	16 Mar 15
7	Detailed Design	35	42	56		44	42	12 Mar 15	17 Mar 15	15 May 15	18 May 15
8	Lag	21	21	21		21	21	12 Mar 15	17 Mar 15	13 Apr 15	16 Apr 15
9	Building Regulations	42	42	70		51	42	14 Apr 15	17 Apr 15	25 Jun 15	17 Jun 15
10	Mortgage Application	14	35	35		34	35	12 Mar 15	17 Mar 15	30 Apr 15	07 May 15
11	RISK: Mortgage application denied				0	0	0	30 Apr 15	07 May 15	30 Apr 15	07 May 15
12	Tender Construction Contract	7	21	28		17	21	18 May 15	19 May 15	10 Jun 15	17 Jun 15
13	Review and Award Contract	2	3	4		4	3	11 Jun 15	18 Jun 15	16 Jun 15	22 Jun 15
14	All Permissions in Place	0	0	0		0	0	25 Jun 15	22 Jun 15	25 Jun 15	22 Jun 15
15	Construction					186	182	26 Jun 15	23 Jun 15	23 Mar 16	11 Mar 16
16	Mobilise to site	2	7	28		17	7	26 Jun 15	23 Jun 15	20 Jul 15	01 Jul 15
17	Match & Procure Bricks	5	21	42		28	21	26 Jun 15	23 Jun 15	04 Aug 15	21 Jul 15
18	Procure Double Glazing	49	60	91		57	60	21 Jul 15	02 Jul 15	08 Oct 15	24 Sep 15
19	Procure Plumbing /Sanitary Ware	35	56	112		63	56	21 Jul 15	02 Jul 15	16 Oct 15	18 Sep 15
20	Construct Foundations					18	15	21 Jul 15	02 Jul 15	14 Aug 15	22 Jul 15
21	Construct Foundations	10	15	20		14	15	21 Jul 15	02 Jul 15	07 Aug 15	22 Jul 15
22	RISK: Bad weather, site floods				3.8	4	0	07 Aug 15	22 Jul 15	13 Aug 15	22 Jul 15
23	RISK: Archeological finds, build stopped for investigation				0	0	0	07 Aug 15	22 Jul 15	07 Aug 15	22 Jul 15
24	Build Walls to DPC level	9	20	28		26	20	14 Aug 15	23 Jul 15	21 Sep 15	19 Aug 15
25	Build Walls to Roof Level	21	40	56		31	40	22 Sep 15	20 Aug 15	03 Nov 15	15 Oct 15
26	Construct Roof	3	20	21		8	20	04 Nov 15	16 Oct 15	13 Nov 15	12 Nov 15
27	Cast Floor	4	10	18		7	10	22 Sep 15	20 Aug 15	30 Sep 15	03 Sep 15

Figure 35. Example Calculation sheet showing quick risks (highlighted)

Before You Open a Project Plan in Predict! Risk Analyser

Before you can open a project plan in Risk Analyser, you must carefully prepare your project plan so that Risk Analyser can use it. These preparations involve making sure all tasks are logic linked (with predecessors and successors), removing unnecessary constraints (and replacing with logic links), removing resource levelling, and creating files in the required formats.

If you are using an MPX format to load into Risk Analyser, you must set up the Microsoft Project export table with the following fields (minimum recommended information):

1. Task Id or Task Unique Id (or both).
2. Task Name.
3. Predecessor Ids or Predecessor Unique Ids (or both, in which case Predecessor Ids will be used).
4. Outline Level, WBS (or both - default import uses Outline Level).
5. Duration, Duration1, Duration2 and Duration3.

If you plan to analyse cost risk, then you will also need to export:

1. Cost (cost per day is calculated by subtracting Fixed Cost and dividing by
2. Duration).
3. Fixed Cost.
4. Cost1, Cost2, Cost3.

If your plan is already underway and you want to analyse complete or partially complete tasks:

1. Remaining Duration.
2. Actual Start.
3. Actual Finish.
4. Status Date.

If your plan includes Quick Risk or correlation information, you will also need to export the custom fields that contain this.

A full Risk Analyser analysis gives you much more information than has been shown here. Statistical functions are available and project costs can also be analysed in terms of uncertainty. Risk Decisions offers training courses designed especially for users of Risk Analyser. Please contact your account manager for more details.

3. Integration with Predict! Risk Controller

Predict! Risk Analyser and Predict! Risk Controller

Risk Controller is a risk and action register that provides a structured environment for organising, communicating, managing, and controlling risks through actions across a company, business units, programmes and projects. Its comprehensive functionality includes direct links to leading project and requirements tools, enabling users to link risks to the project Work Breakdown Structure.

It is web-based, providing easy deployment and user access from anywhere, without needing to install software locally on the user's machine. It also offers a Microsoft Excel interface, automated e-mail reminders, an audit trail, plus fully configurable data input and reporting facilities.

Seamless integration between Risk Analyser and Risk Controller allows risk and action data to be extracted from the Risk Controller database and incorporated into cost and schedule risk impact models in Risk Analyser. This enables users to assess the overall cost and time exposure, to determine the effect of mitigation and to perform cost-benefit analysis of mitigation actions.

NOTE: Some of the terminology and functionality used in this section can be configured in Risk Controller, and so may be different in your installation. For example, your organisation may not use Issues, or may use different words for Current and Target assessment.

Performing Cost Risk Analysis through Risk Controller

Your risk register contains risks, each with a risk assessment, usually of cost and time impact. To assess overall risk exposure, you need to model these risks in a Cost Risk Analysis. The Cost Risk Analysis can analyse time impact as well as cost impact but will not integrate it into a schedule.

To run a Cost Risk Analysis click on the Cost risk analysis from Predict! Risk Controller option on the Home screen. You can also run a Cost Risk Analysis by going to the File tab of the ribbon, selecting Predict! Risk Controller, then Cost Risk Analysis.



Login to Predict! Risk Controller

Host: Predict!Server

Username: FredBloggs

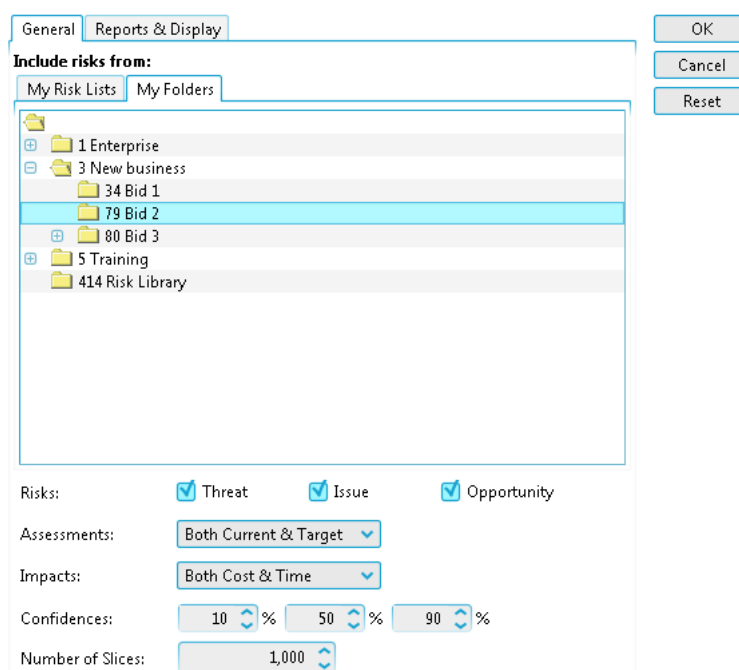
Password: ●●●●●●●●

OK Cancel

Figure 36. Log into Risk Controller

Use your Risk Controller login to access data in the risk database. If you opened Risk Analyser from Risk Controller then, if possible, Predict! Risk Analyser will open without asking you to log in again. If you are asked to log in, the Host details will already be filled in, otherwise enter the address (URL or IP address) of your Risk Controller server.

In the Risk Analysis options window, browse the Risk Controller folders or lists, and choose where to import risks from. Tick the Threat, Issue or Opportunity boxes to indicate which types of risk you want to include in the analysis.



General Reports & Display

Include risks from:

My Risk Lists My Folders

- 1 Enterprise
- 3 New business
 - 34 Bid 1
 - 79 Bid 2
 - 80 Bid 3
- 5 Training
- 414 Risk Library

Risks: ☒ Threat ☒ Issue ☒ Opportunity

Assessments: Both Current & Target

Impacts: Both Cost & Time

Confidences: 10% 50% 90%

Number of Slices: 1,000

OK Cancel Reset

Figure 37. Select from the Risk Controller folders

Choose whether you want to import Current, Target or both Current and Target impact values. These are imported into separate Current and Target sheets in the Risk Analyser model. Then select Cost Impacts, Time impacts or both. You can choose which confidence levels to report on. If you select a folder then the confidence levels configured against the folder in Risk Controller will be used by default. Finally choose the number of slices to calculate initially in the model; this can be changed in the usual way after importing.

The Reports & Display tab contains options that control how the model is displayed and what reports or graphs are automatically generated.

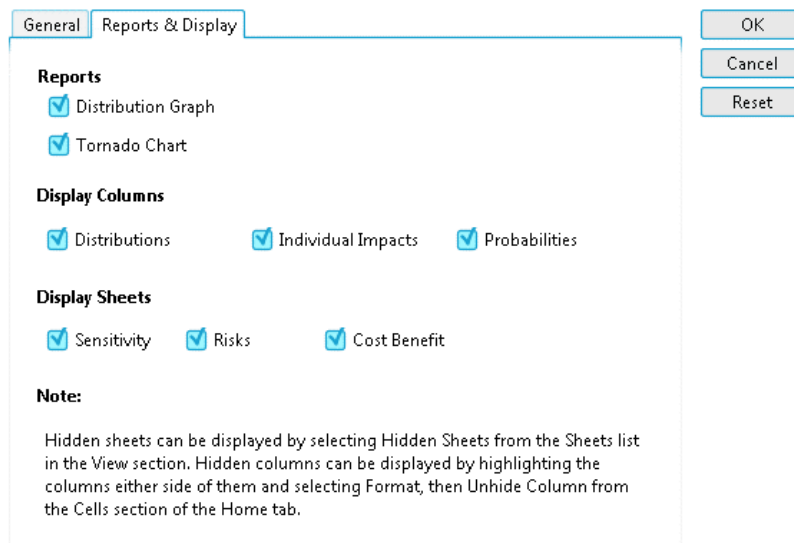


Figure 38. Risk Analysis Options, Reports & Display tab

A distribution graph of the total risk impact can be created automatically by selecting the 'Distribution graph' tick box. Separate graphs are created for cost and time impacts if they are selected. Plots are added to each graph for Current or Target assessment types if they are included in the model.

Select the 'Tornado chart' option to automatically create bar graphs of the sensitivity analysis. Threats, issues, and opportunities, if imported, are combined on the same chart(s) – you can use the Sensitivity Analysis tool on the Graphs tab to create separate charts if required.

The Display Sheets and Display Columns sections allow you to choose which sheets and columns are shown in the model. Note that deselecting an option here does not mean that that sheet or column is not created - it is just hidden from view, and can be unhidden if desired. To show hidden sheets in a model, select Sheets, then Hidden Sheets from the View box. To show hidden columns, highlight the columns either side of the hidden column and select Format, then Unhide Column from the Cells section of the Home tab.

Once you are happy with your selections, select OK to run the simulation. The Risk Analysis Model will be created by importing all risks of your chosen types that are attached to your chosen folder, and its entire branch down through the tree.

The Risk Dashboard

The model opens showing the risk impact dashboard, this will show the results of the model once simulation is complete.

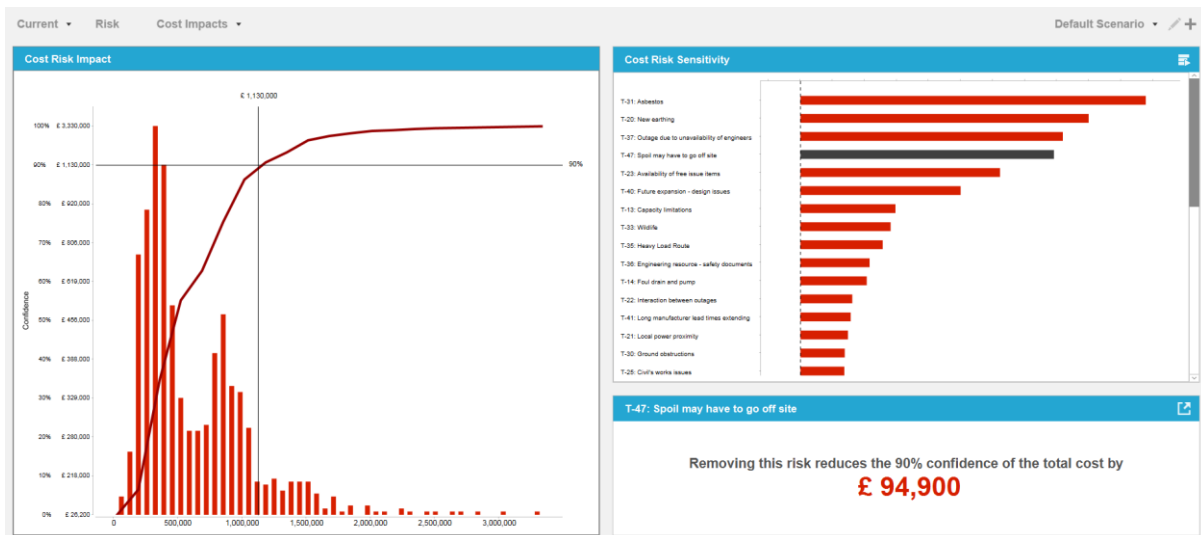


Figure 39: The risk impact dashboard

The risk impact dashboard shows the risks which have the biggest effect on the total cost or time. If you include both current and target impacts in your import then the impact dashboard will use the current assessment. The dashboard contains a distribution graph of the sum of the risk impacts for the model and a tornado graph of the risks ranked by sensitivity.

If you select one of the bars in the tornado graph then the panel in the bottom right will display how much the risk is contributing to the selected confidence level. By default, the reported confidence level is the highest of the three confidence percentages chosen in the import options. The confidence percentage can be changed by dragging the marker lines on the distribution graph or by selecting the down arrow in the bottom right corner of the Scenarios section of the What-If menu.

The displayed impact is calculated by running an impact analysis for the selected risk. Risk Analyser calculates the model with the selected risk turned off and compares that to the result with all the risks turned on.

The  button will run an impact analysis for each risk in the model, the results are plotted on a tornado graph that replaces the sensitivity tornado.

The  button will take you to the selected risk's detail page in Predict! Risk Controller.

You can switch between cost and time impacts and current and target assessments using the drop-down lists at the top of the dashboard. If your import included both current and target assessments, then switching to target will display the mitigation dashboard.

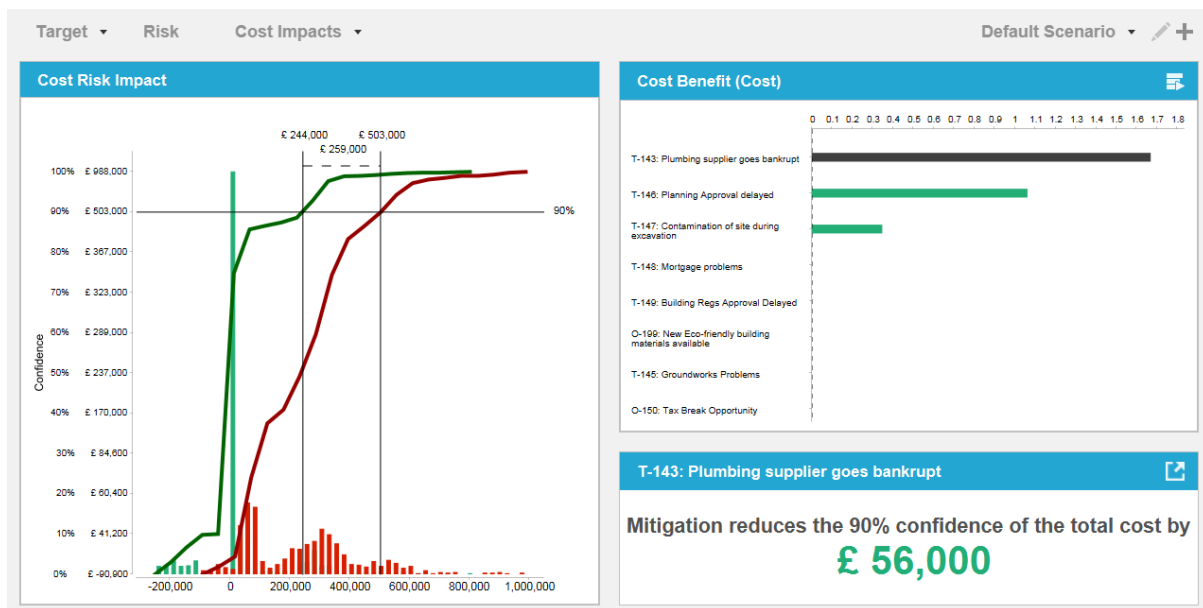


Figure 40: The mitigation dashboard

The mitigation dashboard shows the value of the mitigation actions you have planned for each risk. On the mitigation dashboard the distribution graph shows the distributions for both the current and target assessments. The tornado graph shows the cost-benefit analysis results for each risk. The cost-benefit analysis shows the mean reduction in the impact from the current to the target assessment divided by the total cost of the risk's actions.

NOTE: If you do not have any action budgets set in Risk Controller for the risks in your import, then the target sensitivity graph will be displayed rather than the cost-benefit graph.

Selecting a bar in the tornado graph will cause the panel in the bottom right to show the effect of the planned mitigation actions on the selected risk on the total risk impact. This is calculated by running a mitigation analysis on the risk. The risk's mitigation is turned off, the results of the model are then calculated and compared to the case where the risk's mitigation was turned on.

The  button will run a mitigation analysis for each risk in the model, the results are plotted on a tornado graph that replaces the cost-benefit tornado.

Other Model Outputs

The Summary Report gives an overview of the important statistics for the risks in your chosen folder. These include the 10%, 50%, 90% confidences (as set in the Advanced tab of the Schedule Analysis Options window).

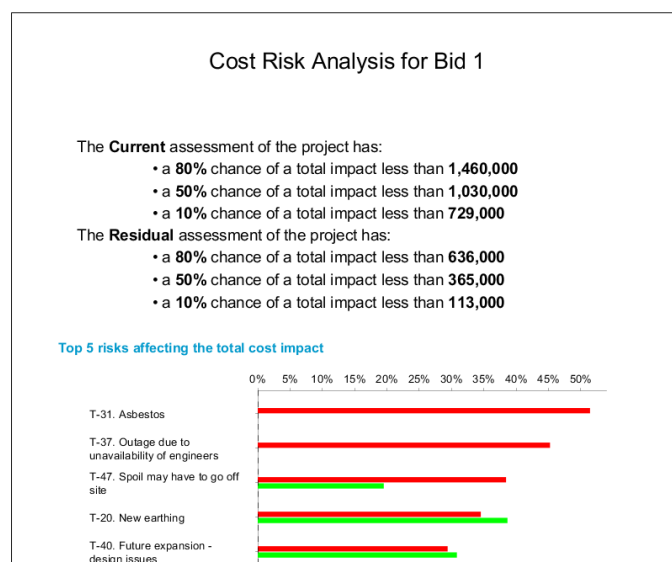


Figure 41. Summary report showing statistics for the risks in the selected folder

HINT: If you chose to import both time and cost impacts these will be displayed on separate pages of the Summary report. Use the arrow buttons in the report toolbar to see different pages in the report.

HINT: You can export reports by clicking on the save button in the report toolbar. This will display the save report window. Choose a name and location to save the report to and set the report format using the Files of Type option. Click the Save button to save the report.

Distribution graphs showing both Current and Target total impacts are created automatically for each impact type imported (cost or time) if you selected the option to do so.

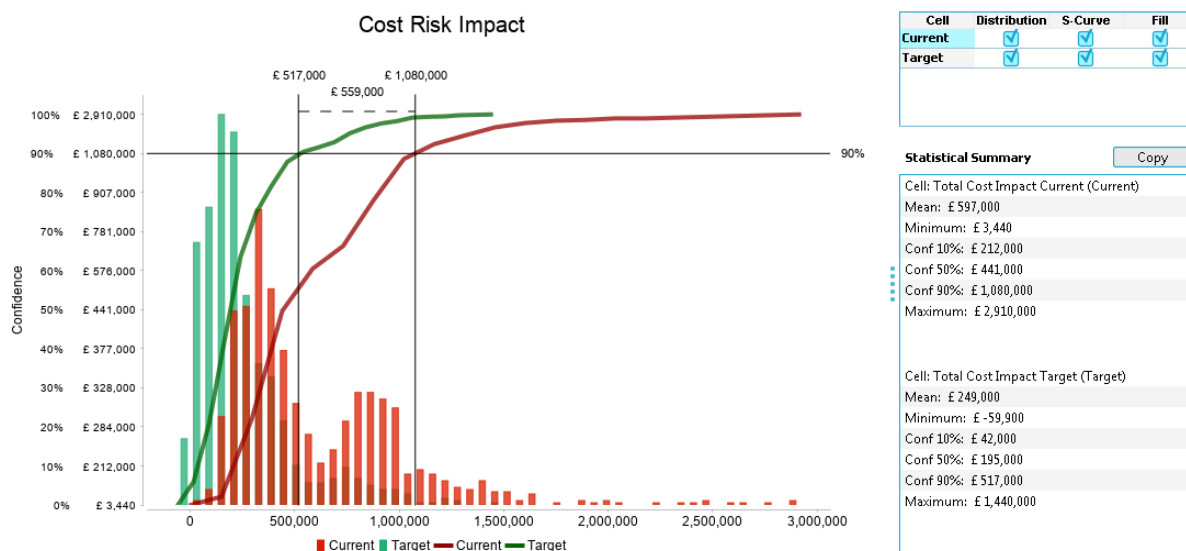


Figure 42. Graph of both current and target risk impact

The distribution graph shows the range of possible cost risk provision you may need to put in place to cover risks that may happen, both before and after putting any mitigation actions in place. The graph shows the possible benefit of your mitigation actions.

The tornado chart displays the risks in order of cruciality, in other words, how much effect that risk has on the overall cost. The most significant risks (the ones with the highest cruciality) are listed at the top of the chart. By default, when both Current and Target values are included, the risks on the tornado chart are sorted by their Current assessment.

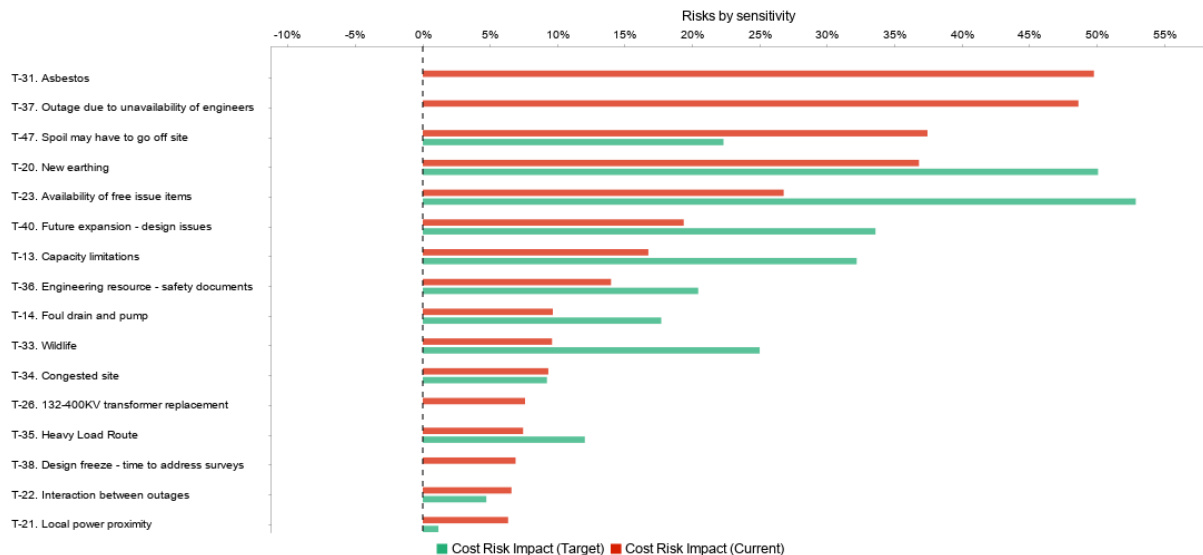


Figure 43. Tornado chart of current and target cruciality values

The detailed results of your Cost Risk Analysis are displayed on the Summary sheet, shown below. If a folder was imported, this sheet provides statistics for each folder included in the model (the example here shows only one folder). Otherwise, for lists statistics are shown for each group that the list displays in Risk Controller.

File

Home

Graphs

Formulas

What-If

Dashboard

Reports

Graphs

Sheets

Views

Models

Close Model

Close All Models

File

New

Open

Save

Import

Export

Print

Settings

Calculate Now

Calculation Complete

Calculation: Automatic

Number of Slices: 1,000

Tier: 0

D2

	A	B	C	D	E	F	G	H	I	J
1	Risk Analysis Summary									
2	User:	John Smith								
3	Folder ID:	3								
4	Folder Name:	New business								
5	Access level:	98								
6	Including risk types:	Threat, Issue, Opportunity								
7										
8		Prefix	Suffix							
9	Cost units:	£								
10										
11										
12										
13	COST									
14	Folder	Current	Confidences		Target	Confidences				
15		Mean	10.00%	50.00%	90.00%	Mean	10.00%	50.00%	90.00%	
16	34 Bid 1	£ 604,000	£ 230,000	£ 456,000	£ 1,090,000	£ 244,000	£ 47,600	£ 184,000	£ 507,000	
17	TOTAL	£ 604,000	£ 230,000	£ 456,000	£ 1,090,000	£ 244,000	£ 47,600	£ 184,000	£ 507,000	
18										
19										
20										
21										
22										

Summary

Current Risk

Target Risk

Risk Sensitivity

Cost Benefit Analysis

Cost Impact Analysis Current: 1

Cost Impact Analysis Target: 1

...

The top section of the sheet provides some information about the parameters used to create the model. This includes information about the Risk Controller user who created the model, the list or folder imported, and the types of risks included.

The risk data is located on the Risks sheets - Current Risk or Target Risk, depending on the impact values you chose to import. These sheets may be hidden if the option to display Risks sheets was not selected on the Risk Analysis Options, Reports & Display tab.

Risk ID	Risk Type	Risk Reference	Risk Name	Include?	Probability	Occurs?	Cost Combined Impact	Cost Impact: Direct Cost Minimum
10	Threat	Bid 1_1T	Water table	TRUE	30.00%	FALSE	£ 0	£ 0
11	Threat	Bid 1_2T	Soft spots	TRUE	5.00%	FALSE	£ 0	£ 0
12	Threat	Bid 1_3T	Existing area	TRUE	10.00%	FALSE	£ 0	£ 0
13	Threat	Bid 1_4T	Capacity limitations	TRUE	10.00%	FALSE	£ 0	£ 0
14	Threat	Bid 1_5T	Foul drain and pump	TRUE	50.00%	FALSE	£ 0	£ 0
15	Threat	Bid 1_6T	Storm drain	TRUE	15.00%	FALSE	£ 0	£ 0
16	Opportunity	Bid 1_7O	Existing covers	TRUE	5.00%	FALSE	£ 0	£ 0
17	Threat	Bid 1_8T	Piling	TRUE	75.00%	TRUE	£ 24,400	£ 0
18	Opportunity	Bid 1_9O	Existing platform does not need replacing	TRUE	10.00%	FALSE	£ 0	£ 0
20	Threat	Bid 1_11T	New earthing	TRUE	10.00%	FALSE	£ 0	£ 0
21	Threat	Bid 1_12T	Local power proximity	TRUE	20.00%	FALSE	£ 0	£ 0
22	Threat	Bid 1_13T	Interaction between outages	TRUE	90.00%	TRUE	£ 109,000	£ 0
23	Threat	Bid 1_14T	Availability of free issue items	TRUE	3.00%	FALSE	£ 0	£ 0
24	Threat	Bid 1_15T	Disconnecter problems	TRUE	5.00%	FALSE	£ 0	£ 0
25	Threat	Bid 1_16T	Civil's works issues	TRUE	50.00%	TRUE	£ 37,800	£ 0
26	Threat	Bid 1_17T	132-400KV transformer replacement	TRUE	5.00%	FALSE	£ 0	£ 0
27	Threat	Bid 1_18T	Power station outages	TRUE	5.00%	FALSE	£ 0	£ 0

Figure 45. Cost Risk Analysis Model, Current Risk sheet

Performing Schedule Risk Analysis through Risk Controller

You can import project plans from Microsoft Project and Primavera into Predict! Risk Controller. This stores the task information in Predict!, including all of the task duration and cost information, predecessor / successor logic, lags, leads, constraints and so on. You can then add risks to these tasks and automatically load a complete risk and uncertainty schedule model into Risk Analyser.

NOTE: You can attach risks to summary (hammock) tasks as well as standard tasks in Risk Controller. These risks impact at the end of the summary task, contributing to the overall uncertainty of the plan.

We have put together a high-level plan of a house building project we have just won a contract for.

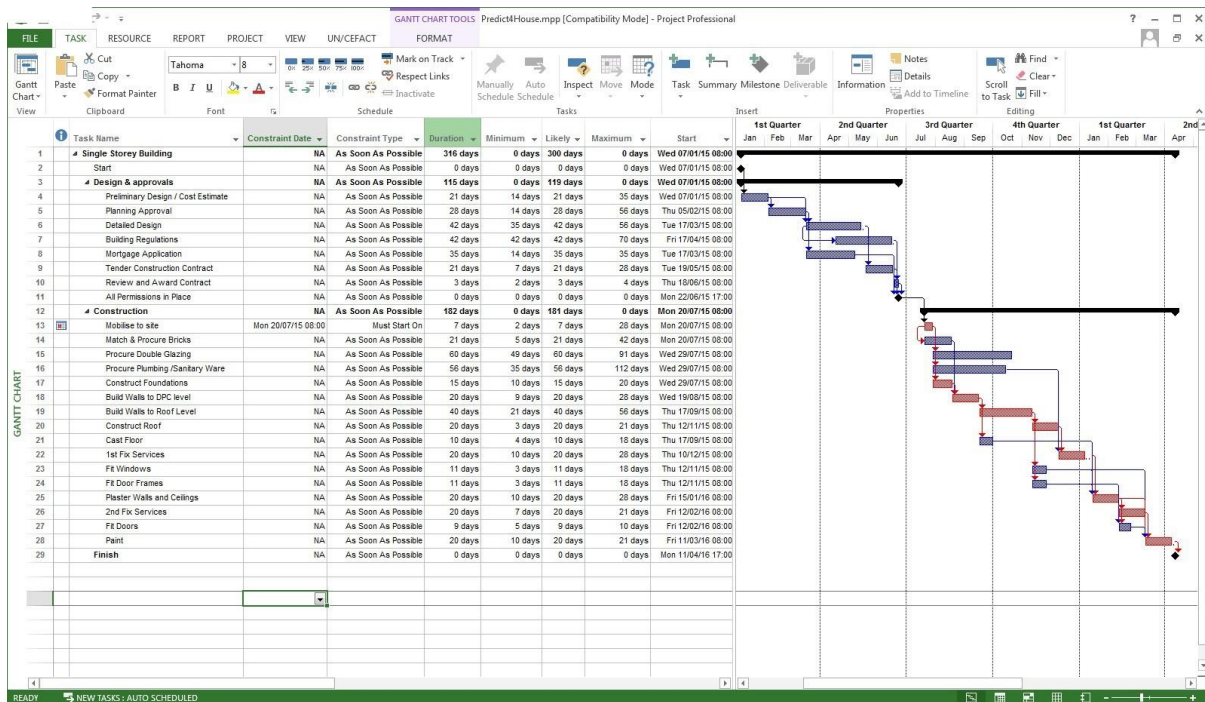


Figure 46. High level plan of House project

We have imported this plan into Risk Controller and brainstormed some risks against the tasks.

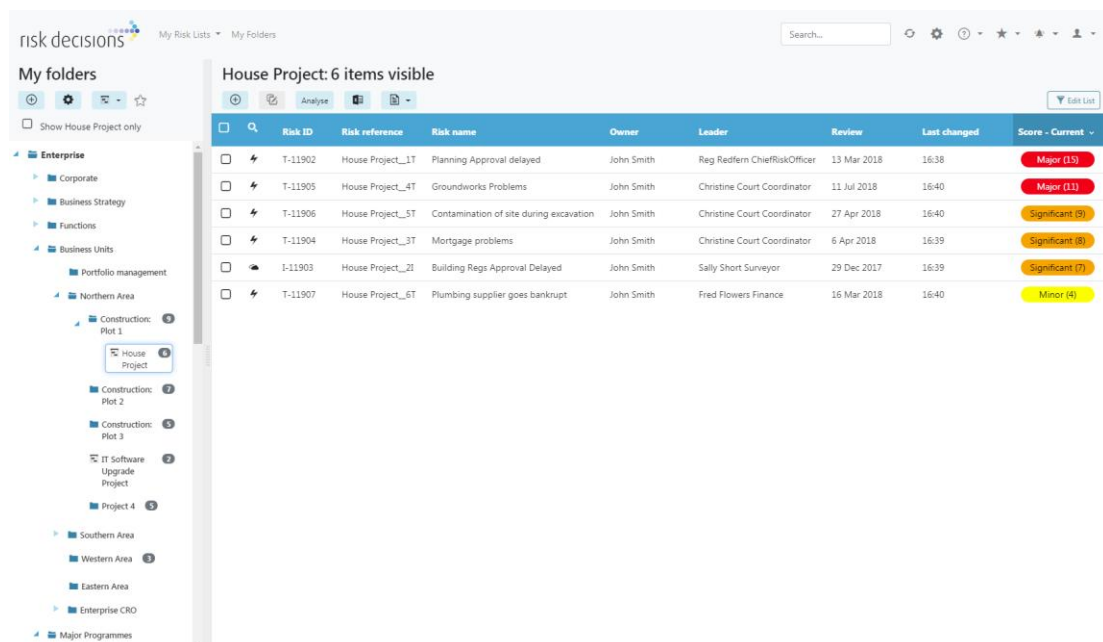


Figure 47. House project imported into Risk Controller, with risks attached

To run the analysis, importing both uncertainty and risks for the Building project, select Predict! Risk Controller, Schedule Risk Analysis from the File tab.

If you haven't already logged in, use your Risk Controller login to access data in the risk database. If you opened Risk Analyser from Risk Controller then Risk Analyser will log in automatically. If not, the Host details will already be filled in, otherwise enter the name of your Risk Controller server (name or IP address).

The Schedule Risk Analysis Options window appears, with a list of projects that are available to you in Risk Controller. Clicking on a project in the list will show its path in the Risk Controller folders below the list window.

Project to import

Id	Reference	Project	Import date
90	Street Furniture	Street Furniture	12/05/2015, 17:32
312	IT Software Upgrad...	IT Software Upgrade ...	06/06/2017, 16:29
434	Compliance	Compliance	30/11/2017, 19:58
11173	House Project	House Project	15/08/2019, 15:38

Project Location
<I. Enterprise >

Schedule Report Options
☐ Use percent complete Options

Uncertainty Options
☐ None ☒ From Risk Controller

Optimistic Likely Pessimistic
 Durations: Minimum Dur... Likely Duration Maximum Dur...
☒ Costs: Minimum Cost Likely Cost Maximum Cost

Risk Options
 Risks: ☒ Threat ☒ Issue ☒ Opportunity
 Assessments: Both Current & Target
 Impacts: Both Cost & Time
 Time risks act in: ☐ Series ☒ Parallel
 Number of Slices: 1,000

OK
Cancel
Reset

Figure 48. Selecting the project to import from Risk Controller

The Schedule Check and Progress sections of this window work in the same way as importing projects from file to Risk Analyser - see the sections 'Using the Schedule Check function' and 'Using percent complete' earlier in this guide for further information. Similarly, the Risk options section works in the same way as the Cost Risk Analysis controls (see 'Performing Cost Risk Analysis through Risk Controller').

The Uncertainty section offers two options - None, or From Risk Controller. When uploading the project to the Risk Controller database, you can choose at that point whether to take 3-point estimates from global values or values from the project file (e.g. from Duration1, Duration2, Duration3). Risk Controller then stores these duration and cost estimates in its own database as Minimum, Likely, and Maximum values. It is important to realise when importing from Risk Controller into Risk Analyser, the Minimum, Likely, and Maximum fields will contain the values that were uploaded to Risk Controller and will not reflect any later edits you make to the project file.

The duration drop-down lists also include Duration (Deterministic) and Remaining Duration options. These values were taken from the project when it was uploaded to Risk Controller and stored separately from the 3-point estimates. The same is true of Fixed Cost and Cost in the cost drop down lists.

The Advanced tab and Reports & Display tab contain the same options as importing from file directly to Risk Analyser. The exception is that the Reports & Display tab has an extra 'Display analysis types' section that controls which sheets are visible when the model is first opened - Uncertainty Only (i.e. without any risks), Current, or Target. Risk Analyser will create the same set of sheets (Report, Calculation, Risks, and Tornado and Gantt charts) for each of these risk analysis types. This is a lot of sheets to display, so you may find it helpful to focus on the analysis type you want to see by checking these boxes - for example, you may wish to hide the Uncertainty Only sheets and only see the Current and Target data.

General Advanced Reports & Display

Create report sheet

☒ Report

Include: ☐ Durations ☐ Start data

Create graphs

☐ Gantt chart

☒ Tornado chart

☒ Distribution graph

Display analysis types

☒ Uncertainty only ☒ Current ☒ Target

Display sheets

☐ Calculation

☐ Calendars

☐ Risk

☒ Report

☐ Sensitivity

Display columns

☐ Calculations

☐ Calendar

☐ Ids and WBS

☒ Distributions

☐ Constraints

Note:
Hidden sheets can be displayed by selecting Hidden Sheets from the Sheets list in the View section. Hidden columns can be displayed by highlighting the columns either side of them and selecting Format, then Unhide Column from the Cells section of the Home tab.

OK Cancel Reset

Figure 49. Reports & Display tab with extra Display options

NOTE: Sets of sheets hidden using these options still exist in the model and can be displayed by selecting Hidden Sheets from the Sheets list in the View box.

Risk Analyser automatically creates the Schedule Risk Analysis model, with sheets showing Uncertainty only, Current and Target risk impact scenarios.

The import opens on the Schedule Risk Analysis dashboard. The Schedule Risk Analysis dashboard has the option to display both task and risk results, see the sections on Schedule Risk Analysis and Cost Risk Analysis for further details.

The Summary report gives an overview of the important statistics for the Project End Date. These include the 90% confidences (as set in the Advanced tab of the Schedule Analysis Options window) and the chance of achieving the deterministic Planned Finish Date. This report will only show results once the simulation is complete.

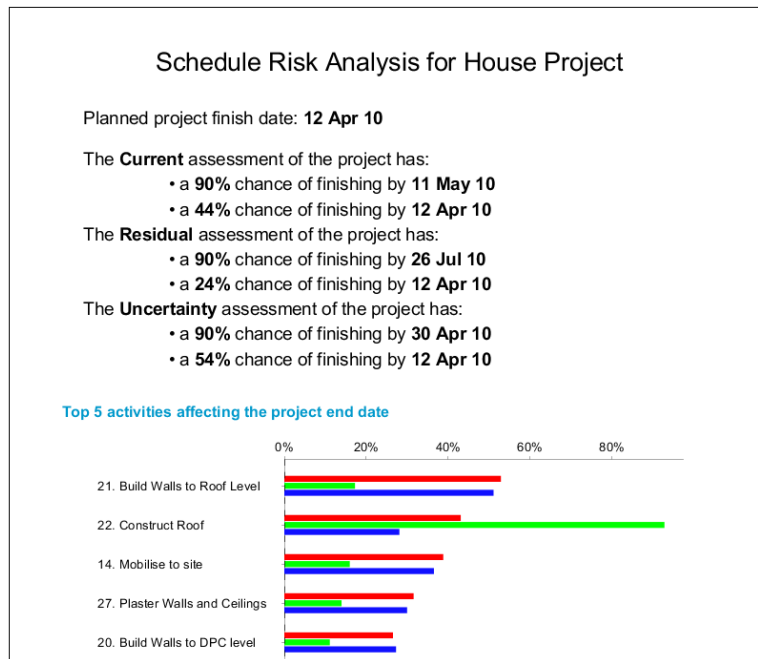


Figure 50. Summary report showing project end date statistics

HINT: You can export reports by clicking on the save button in the report toolbar. This will display the save report window. Choose a name and location to save the report to and set the report format using the Files of Type option. Click the Save button to save the report.

If you selected the option to create distribution graphs when importing, these will be available from the Graphs list in the View box. On the Project End Date graph, Uncertainty, Current and Target project end dates are shown on the same graph. The original planned finish date (from the project) is shown as a black solid line marker. If you also imported costs, the Project Total Cost graph shows the overall cost of the project in all of risk impact scenarios modelled.

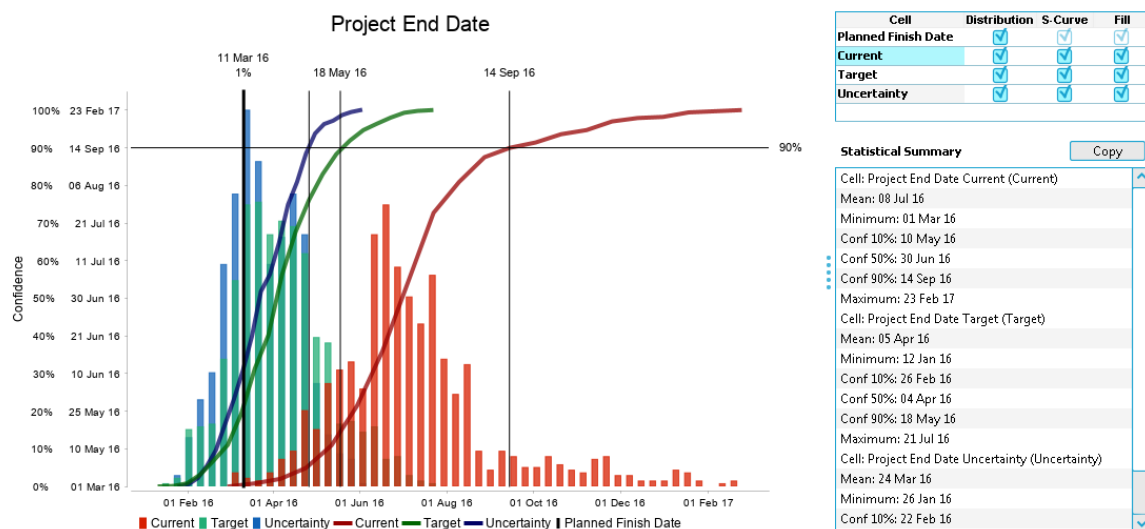


Figure 51. Graph comparing Uncertainty Only, Current, and Target Project End Dates

The Summary sheet shows statistical information for the whole project, comparing these different scenario outcomes against the original Plan Finish Date.

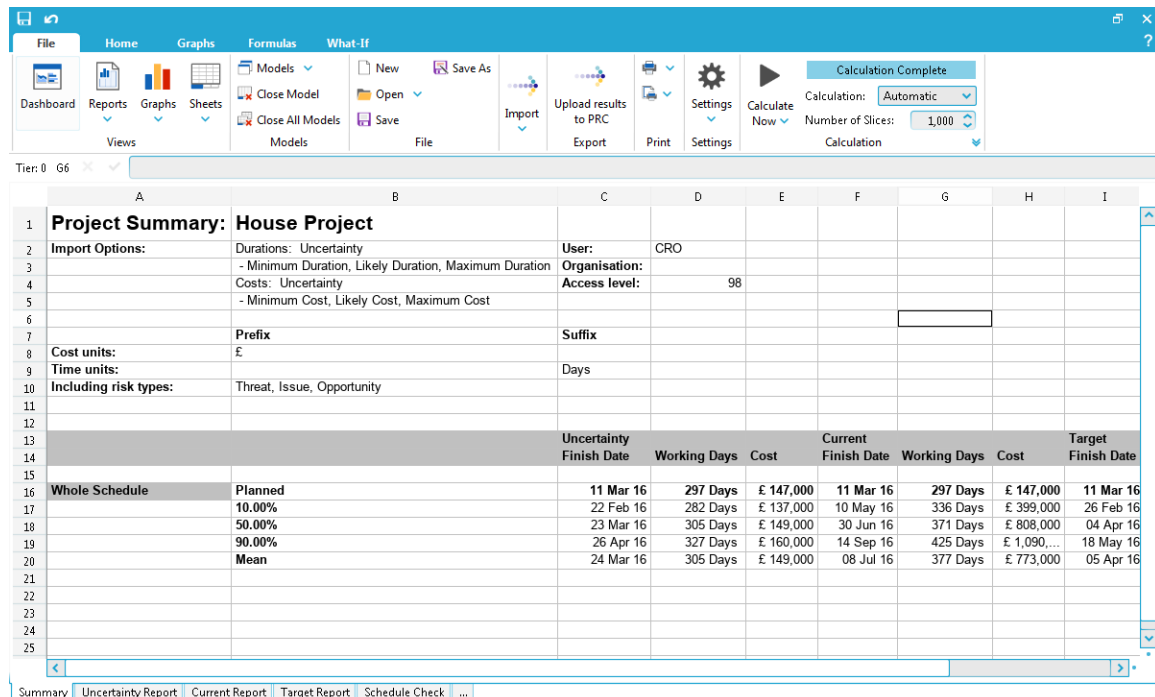


Figure 52. Summary of the schedule risk analysis

The Uncertainty Report, Current Report, and Target Report sheets calculate criticality, cruciality, mean and confidence values for each task and for the whole project, for each scenario that has been modelled.

The risks imported from Risk Controller are listed on the Risks sheets (one each for current impacts and target impacts, sorted by the task that the risk is attached to). The total risk impact for each task is referenced on the Calculation sheet, in the Risk Impact column, and included in the Modelled Duration formula for that task.

Revisiting the project plan

You now need to consider whether your planned finish date is acceptable. If it is not, you must revisit your project plan to see whether you can improve the underlying schedule and attempt to put further mitigation actions into place to reduce the risk.

Having changed your project plan, you should re-import it into Risk Controller and re-assess the risks attached to any changed tasks. Risk Controller will handle the changes by adding new tasks, updating existing ones and moving obsolete ones into a "DELETED ITEMS" folder. Once you have updated the risks, then you can re-import the plan into Risk Analyser to review the new Project End Date, and confidences of achieving milestones and budgets.

Deciding whether schedule risks should work in series or parallel

For project tasks with more than one risk associated with them, you need to decide whether the risks (if they happen) act one after the other (in series) or both together (in parallel). If you choose to import the project with Risks act in 'Series' selected, the risk sheet uses a 'SUM' function to add the duration of the risks. If you use Risks act in 'Parallel', then the 'MAXIMUM' function is used instead.

As an example, if you are building a house and you have two risks while you are digging the foundations:

- Extremely bad weather delays excavations (1 – 2 – 3 weeks)
- Contaminated ground discovered requiring clean up before further work can progress (1 - 2 months)

These might well act in series, as you cannot decontaminate while the bad weather continues.

Whereas, at the time you are putting in the utilities:

- Change in electricity supply regulations
- Plumbing contractor goes bust

Will probably act in parallel, as there is no relationship between them and so they could easily happen at the same time.

In Predict! you can choose either one or the other i.e. all tasks act in series or all tasks act in parallel. You can then modify the setting for an individual task by editing the cell that has SUM or MAXIMUM in it in the Risks Current or Risks Target sheets. In practice, the difference between the two settings tends not to be as major as you might think, because two risks each with 20% of happening, will only have 4% (20% multiplied by 20%) chance of both happening, so these events tend only to happen in the extreme tail of the results distribution.

NOTE: Cost risks always act in series (are always summed together). The series/parallel setting only applies to schedule risk impacts.

4. Predict! Risk Analyser Basics

Using Formulas

The basic parts of a formula are:

- The equals sign (=).
- Operators.
- Functions.
- Arguments.
- Parentheses (brackets).

For example, in the formula `=SUM(B6~B10) * SQRT((C4 + D4) / 2)`

SUM and SQRT are functions; ~, *, + and / are operators; B6~B10 and ((C4+D4) / 2) are arguments.

Risk Analyser's operators and functions are listed in the Reference section of this guide.

HINT: It is a good idea to enter functions in lower case letters as it allows you to see spelling errors easily; unrecognised functions will not be converted to upper case.

References

Referring to a single cell	e.g. <code>=A1</code>
Referring to a range of cells	e.g. <code>=SUM(A1~A4)</code>
Referring to a cell's slices	e.g. <code>=MEAN(A1\$)</code>
Referring to a cell on another sheet	e.g. <code>=Sheet 2:A1</code>
Referring to a cell or range of cells by name	e.g. <code>=Profit</code>
Making a reference absolute using single quotes	e.g. <code>=A'1'</code>

In a formula, you can refer to cells using either absolute or relative referencing. Most of the references above are relative references e.g. `=A1`. When you copy a cell containing a relative reference, the reference is translated so that it points to a cell in the same position relative to the cell you copy in to.

For example, if a cell contains the formula `=A1` and you copy it to a cell two rows down, the reference 'A1' is increased by 2 rows and becomes 'A3'. If you copy three columns to the right, 'A1' becomes 'D1'.

In order to keep the column or row part of the reference unchanged when copying, you will need to use single quotes after the column or row respectively.

For example, copying a cell containing the formula `=A'1'` one cell to the right and down will translate the row only to `=A'2'`. Whereas copying `=A1'` will only translate the column to `=B1'`. Copying `=A'1'` will keep the reference `=A'1'`.

Absolute referencing is useful when you are referring to cells containing data such as a confidence level of 50%, or an interest rate, that you want to copy within cells in a table or across the whole model.

HINT: You can easily enter references in a formula by selecting the cell or range of cells using the mouse.

Naming Cells and Sheets

To name cells:

- Select the cell or range of cells you want to name.
- Choose the 'Define Name' tool from the Formulas tab.
- In the Name box, type the name, and select the Define button.
- Select OK to save your changes and close the Name box.

To Auto Name cells:

- Type the name into the cell to the left of the cell you wish to name.
- Select the cell you wish to name.
- Select the Auto-name tool from the Formulas tab.

NOTE: Defined cell names are not case sensitive. Therefore, you can use =Hello and =HELLO to refer to cell A1 which is named 'hello'. Cell names must be unique, you cannot define both "Hello" and "HELLO" as cell names in the same model. If you attempt to do this, for example when using Auto Name on multiple selected cells, then the second cell will be named HELLO1.

NOTE: Cell names must follow these rules: (1) must start with a letter or underscore (_); (2) may only contain letters, numbers, and underscores; and (3) must not be reserved words such as function names or cell references

To name sheets:

- Select the sheet you want to name.
- Right-click on the existing sheet name, at the bottom left of the sheet, and select Rename.
- Type the new sheet name, and choose OK.

Creating a Distribution

Select a cell, then either:

- Choose the 'Create Distribution' command from the Formulas tab.
- Choose a distribution from the list.
- Enter the parameters.
- Choose OK.

Or:

- Type the formula into the cell directly.

Choosing a Distribution

The most commonly used distributions are as follows.

Distributions	Description
Triangular distributions	Used wherever a 3-point estimate is appropriate (e.g. between 1,000 and 1,200 but most likely 1,050).
Uniform (continuous) distributions	Used where a range of values is possible, but no one value is more likely than any other (e.g. between 200kg and 350kg).
Uniform (discrete) distributions	Used where there are a limited number of equally likely outcomes (e.g. 8,9,10 or 11 people).
Bernoulli distributions	Used where something either happens or doesn't (we win/don't win this contract). This is often used in conjunction with an IF statement.

Risk Analyser has many more distributions. All the available distributions are described in the appendices.

Creating a Distribution Graph

Select the cell(s) you want to create the graph of. Then either:

- Select Quick Graph from the Graphs tab to produce a graph with default colours and no titles (unless you have named the cell or cell range, in which case this name is used as the graph title).

Or:

- Select Create Graph from the Graphs tab to open the Graph Wizard.
- On the Graph type screen, select the Area graph type, then select Normal (the picture on the left) and click Next.
- On the Graph data screen, enter a graph name, check the data range, choose a colour and click Next.
- On the Graph options screen, fill in the labels to title your graph and the x and y axes. Then click Finish.

To put multiple plots on one graph, use the Graph Wizard instead of the Quick Graph tool. On the second page of the wizard, you can add extra plots by clicking the add button, followed by the ... button next to the Data Range and select the source cell for the new plot. You can also set colours and titles (used in the legend) or each plot individually on this screen and choose whether the plot should be transparent or not.

You can also add solid marker lines to distribution graphs. To do this, add a new plot as above but select a cell that contains a single value (not slice data). Risk Analyser will automatically add cells containing a single value as markers instead of distribution plots.

When the graph is created, use the tick boxes on the upper right-hand side to control which plots to display, and which is currently 'on top'.

HINT: A shortcut, if the cells you want to graph are adjacent to each other, is to select all the cells then go into the Graph Wizard - on the second page you'll see it automatically adds plots for each cell.

HINT: You can edit a graph once you have created it by selecting Edit Graph from the Graphs tab, or by right clicking on the graph itself and selecting Edit Graph. This then takes you back through the Graph Wizard. Right-clicking on the graph also allows you to auto range the axes, copy, save, zoom and print the graph.

Sensitivity and Tornado

Tornado charts are a good way to view the high-risk areas or activities in your risk analysis model. The tornado chart displays correlation figures for a chosen result cell compared with all the distribution variables in the model.

The correlation data used in the tornado chart is commonly referred to as a sensitivity analysis. This is because the results indicate how sensitive the result cell is to a change in each input variable.

The tornado chart below shows how the profit varies with the number of each product sold and the various production costs.

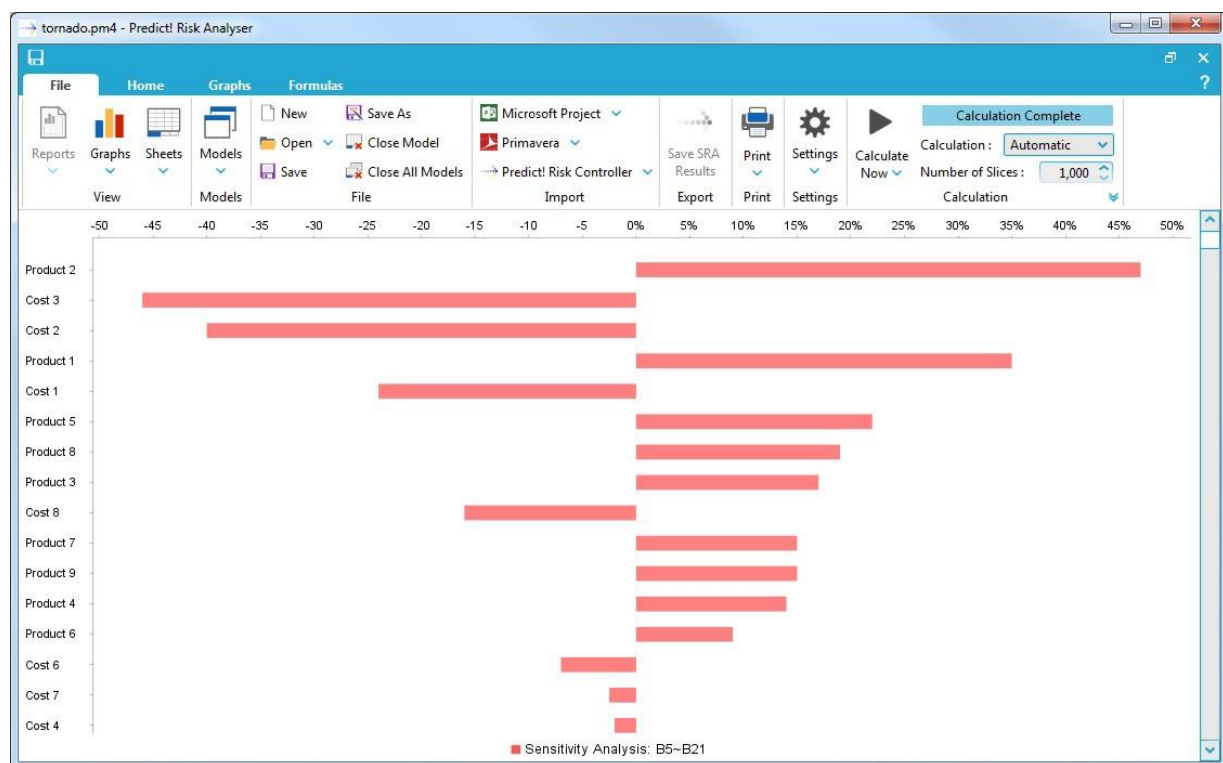


Figure 53. Tornado chart showing different variables influence on profit

The results displayed show that profitability is most sensitive to Product line 2 and costs 2 and 3. The positive correlation results (product sales) are displayed to the right and negative ones (costs) to the left, sorted from largest to smallest influence.

Creating a Sensitivity Sheet

When you run a schedule risk analysis, a sensitivity report is automatically produced,

showing the cruciality results for tasks. This is calculated as the correlation between the whole project duration and each task's duration. This provides useful information on which tasks have most influence on making the project run late (or come in early).

The Sensitivity sheet created for your schedule specifically reports on cruciality values for each task (but not for summary / hammock tasks, which are displayed but left blank). Additionally, you can create a general sensitivity report for any cell in a model. A new sheet named Sensitivity Report is created, showing the correlation between your chosen cell and all distribution cells in the model. To create a sensitivity report sheet:

- Right-click on any non-constant cell on Tier 1.
- Select Quick Analysis, then Quick Sensitivity Analysis from the menu.

Or:

- Select any non-constant cell on Tier 1.
- Select Sensitivity Analysis from the Graphs tab to open the Sensitivity Report window.

The Sensitivity Report Window

Figure 54. The Sensitivity Report window

The Sensitivity Report window can be used to create custom sensitivity reports.

1. Choose a cell or range of cells to create a sensitivity report for in the Compare these cells... section.

Each cell that contains slices in any of the ranges in the list will be added as a column in the sensitivity report. If the range of cells you have selected when opening the window contains one or more cells with slices then the range will be added to the list. Clicking the Add button adds a new range of cells to the list. To edit a range or to add labels to a range select the range you want to edit in the list and click the Edit button. To remove a

range from the list select it and click the Remove button.

2. Choose the cells that you want to compare against in the ...with these cells section.

The cells selected in this section will make up the rows in the sensitivity report.

Input distributions - includes all of the distribution cells in the model.

Computed distributions - includes all of the cells in the model that contain multiple slices but not distribution cells.

All distributions - includes all of the cells in the model that have multiple slices in them including both distribution cells and non-distribution cells.

Choose cells - select ranges of cells in the same manner as in the Compare these cells... section. Labels can also be added using this option.

3. Select filters to apply to the cells selected in the ...with these cells section.

Named cells only - only cells that have been named using the define names window, the auto name command, or during a project import are included in the sensitivity report. This only applies to individual named cells, cells in named ranges are not included.

Only cells from sheet(s) - only cells on the selected sheets will be included in the sensitivity report. Select a sheet by clicking on it in the list. Hold Ctrl and click to select multiple sheets, hold Shift and click to select a range of sheets.

4. Select whether you would like tornado charts to be created with the sensitivity report. A different tornado chart will be created for each column in the report.

HINT: The settings you choose in the Sensitivity Report window are stored when you close the window. The next time you use it the window will have the previous settings entered by default. To create a sensitivity report again, select an empty cell and then select Sensitivity Analysis from the Graphs tab.

Creating a Sensitivity Tornado Chart

Select the sensitivity report sheet and select the range of % values to appear on your tornado chart (you can safely include blank items, as these will be skipped when the graph is drawn).

Either:

- Select Quick Graph from the Graphs tab to produce a tornado chart with default colours and labels.

Or:

- Select Create Graph from the Graphs tab to open the Graph Wizard.
- On the Graph type screen, select the 'Bar' graph type, then select the 'Sensitivity tornado' option (the picture on the right) and click Next.
- On the Graph data screen, enter a Graph Name, check the data range, choose a colour and click Next.
- On the Graph options screen, fill in the labels to title your graph and the x and y axes. Ensure that the Show Data Label box correctly selects the activity names. Untick the Grid lines and legend tick boxes if preferred. Then click Finish.

NOTE: On the Graph type screen in the Graph Wizard there is also a Tornado option. Unlike the Sensitivity Tornado, this graph type allows ranges of values, such as confidence values, to be plotted.

Unless you specify otherwise in the Graph Wizard, Y axis labels for the tornado chart are taken from the column to the left of the selected data (if they exist) or labelled by cell reference (if they do not exist).

Multiple plots can be displayed on one Tornado Chart, for example to display Current and Target values in risked models. Use the Graph Wizard to add multiple plots to a tornado graph. On the second page of the wizard, you can add extra plots by clicking the add button, followed by the ... button next to the Data Range and select the source cell for the new plot. You can also set colours and titles (used in the legend) or each plot individually on this screen, and choose whether the plot should be transparent or not.

Tornado graphs with multiple plots are sorted by the first item in the graphs list. To change the sort order, go to the second page of the Graph Wizard. Click an item in the Graphs list to select it and click on the Move up button until the selected item is at the top of the list.

HINT: You can edit a graph once you have created it by selecting Edit Graph from the Graphs tab, or by right clicking on the graph itself and selecting Edit Graph. This then takes you back through the Graph Wizard. You can change the graph's appearance and labels by right-clicking on the graph itself and selecting Properties. Right-clicking on the graph also allows you to auto range the axes, copy, save, zoom and print the graph.

Controlling Calculation

Predict! Risk Analyser automatically recalculates your model as you make changes to it, updating the results as you type. You can choose to control when calculation occurs by setting Calculation to Manual in the Calculation box. When calculation is set to Manual, simulation does not happen until you select Calculate Now from the Calculation box.

NOTE: When Calculation is set to Manual, Risk Analyser will still report any errors in your model as you type. Once you have corrected an error, you must select Calculate Now before the status will change from Error Detected.

At any time, you can recalculate your results by selecting Recalculate All from the Calculation box. You may wish to do this after you have been editing a model and want to make sure your changes have been incorporated into the simulation. The calculation will proceed using the same random numbers for uncertainties in the model as were used for previous simulations.

To generate a different set of Monte Carlo results, select Reseed from the Calculation box. Each cell containing a distribution will be allocated a new random number seed, to calculate a new random set of slice values for that distribution.

When you save a model, the random number seeds for each distribution cell are saved for reuse when the model is reopened. Therefore, until you reseed or add / remove distributions, you can guarantee that the model will continue to use the same set of random numbers.

Slices

When you create a distribution, Risk Analyser automatically calculates slices, or samples, from that distribution. The number of slices calculated is set in the Calculation box.

You may wish to increase or decrease the number of slices in your model. Using more slices

helps smooth out your model, making sure that the individual random results don't get undue prominence. This is also achieved by having lots of distributions feeding into the end result, so in general the more complicated your model the fewer slices you will need to get an accurate result.

HINT: To save time when working on a large model, reduce the number of slices until you are ready to run a final simulation.

NOTE: If you don't have enough slices in your final simulation, your model may not be robust. This is covered on the Risk Analyser Training Course.

NOTE: You can only change the number of slices for Tier 1. Other Tiers always have 1 slice.

You can view the individual slices that make up a cell's results by double-clicking that cell.

1. Then choose to view slices in slice or data order.
2. Use the confidence buttons to view particular slices.

You can save slice data for a cell or a range of cells into a new sheet, by right-clicking the cell and selecting Quick Analysis, then selecting Save slices to sheet. A new sheet is created, listing the result of that cell for each slice as a row.

Advanced Simulation Options

Advanced simulation options can be accessed from the down arrow in the bottom right corner of the Calculation box

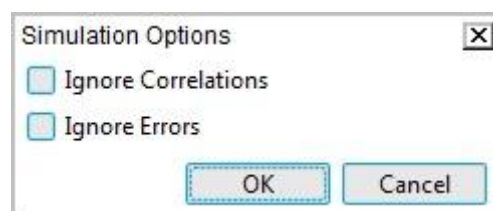


Figure 55. The Advanced Simulation Options window

Ignore Correlations

You can choose to ignore all correlations in your model by selecting this option. See the section on Understanding Correlation below for further information.

NOTE: Changing the setting of this menu option will cause the model to automatically perform a full recalculation.

Ignore Errors

If you have errors in your model, you can choose to ignore them during simulation. This may help you to investigate the cause of the error. However, we strongly recommend that you do not use the feature as a default setting. You should always investigate and fix errors as soon as you can.

NOTE: The setting of Ignore Errors is not saved with your model, or remembered between sessions. This helps avoid errors in models going unnoticed and reduces the possibility of reporting incorrect data.

Understanding Correlation

Correlation is used to observe or describe a relationship between two variables, to determine whether they behave in a similar way. For example, a shopkeeper may observe that he sells more umbrellas on a rainy day, and fewer ice-creams. So we can say that umbrella sales and rain are said to be positively correlated, whereas ice-cream sales and rain are negatively correlated.

NOTE: Note that there will also be a strong negative correlation between umbrella sales and ice-cream sales, even though it is not buying umbrellas that is directly responsible for customers not buying ice-creams. Not stocking umbrellas wouldn't increase ice-cream sales! Make sure that you understand the root cause of a correlation when building and interpreting your model.

In a business environment an example of correlation might be the time to write and test a software program – the more lines of code you write, the longer it takes to test the resulting program.

Representing Correlation

You can show correlation pictorially (as a scatter diagram) or numerically (as a number between -100% and +100%). A 0% correlation indicates that there is no relationship between the variables, so there is no obvious way to draw a line between the dots on the scatter diagram. Whereas 100% correlation (negative or positive) means you can join the dots to form a perfect line.

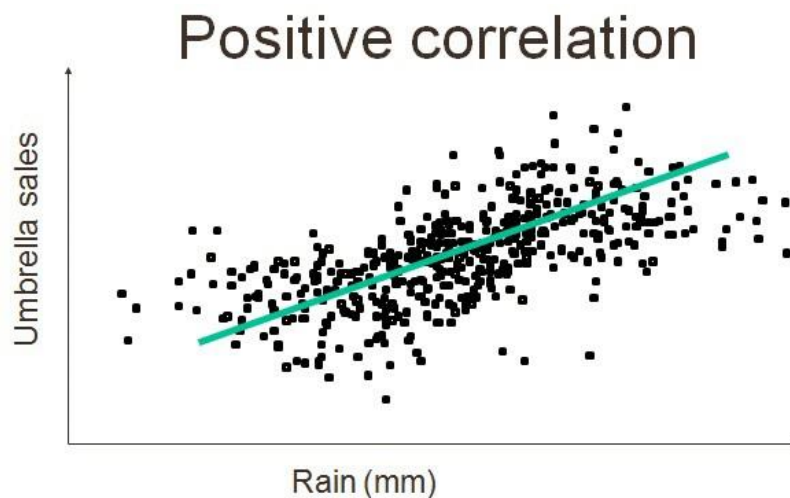


Figure 56. Positive correlation of 90% between umbrella sales and amount of rain

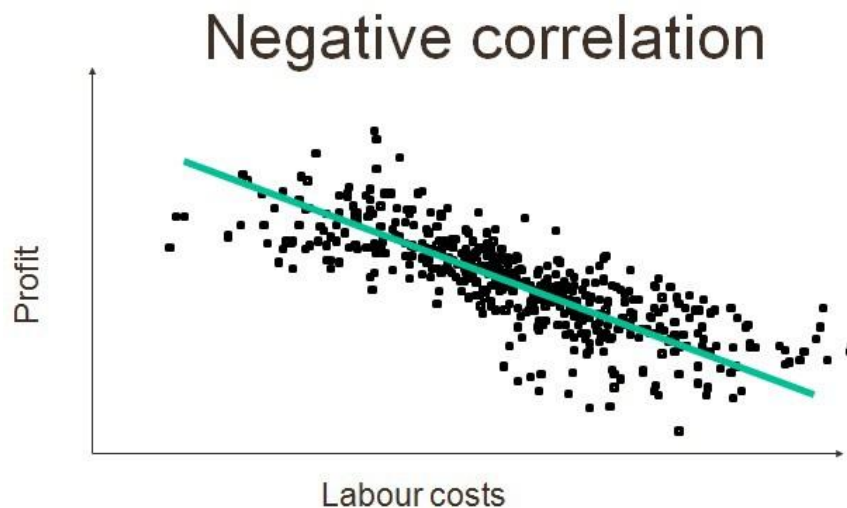


Figure 57. Negative correlation of -90% between profit and labour costs

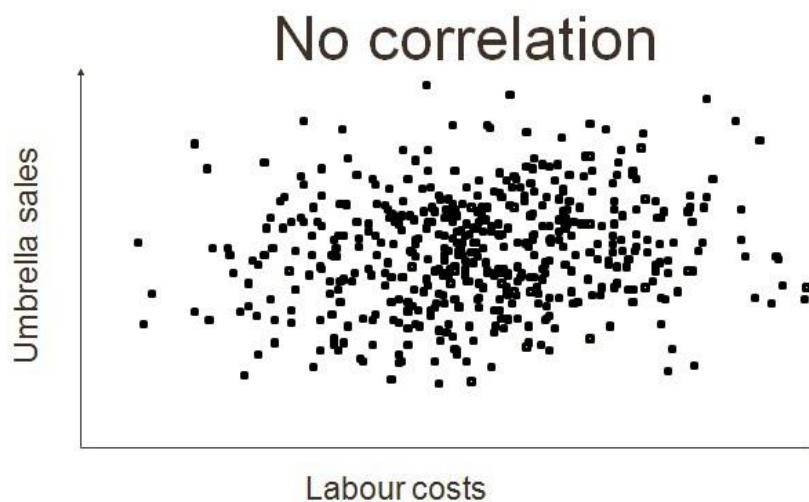


Figure 58. No correlation between umbrella sales and labour costs

To draw a scatter graph of the correlation between two distributions:

- Select Create Graph from the Graphs tab.
- On the Graph type tab, select Scatter and click Next.
- Enter a Graph name and select the two cells that you want to see the correlation between as the X-axis data range and the Y-axis data range. Click Next.

HINT: If you select the cells before selecting Create Graph, the data ranges will be filled in for you.

- Enter Labels and set the chart options as appropriate. Click Finish.

Entering Correlation

You can define correlation between two variables in your Risk Analyser spreadsheet model as illustrated by the example below.

In this example, the amount of rain and umbrella sales variables have been entered into cells B2 and B3 as `=UNIFORM(1,10)` and `=TRIANGULAR(5,7,10)`. They are automatically highlighted pink to show that they are distributions.

There are two ways to define correlation in Risk Analyser: using the Manage Correlations tool (on the Formulas tab), or by adding extra parameters to one of the distribution cells to be correlated.

Entering a correlation method 1:

- Select Manage Correlations from the Formulas tab.
- Specify the two distribution cells that you wish to correlate and the percentage correlation between them. Then click the Add button to create the correlation.

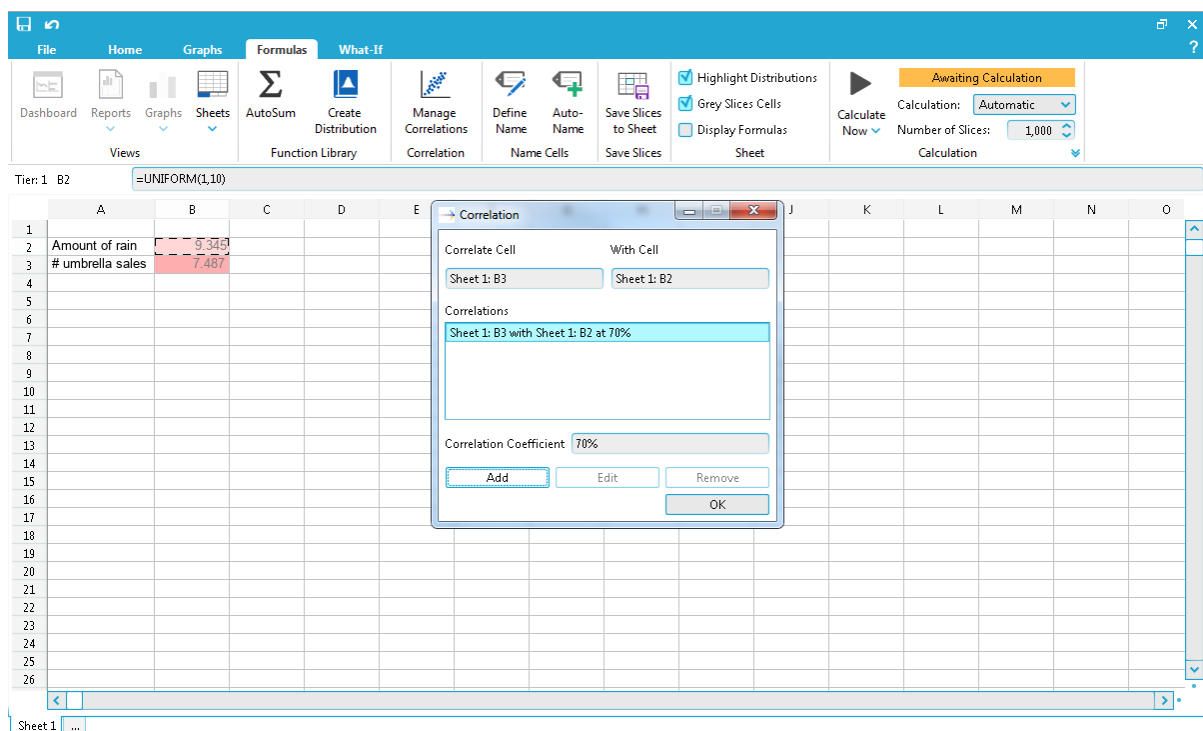


Figure 59. Defining correlation via the Manage Correlations tool

Entering a correlation method 2:

- Enter the distribution formula as usual.
- After the last parameter of the formula (but before the closing bracket) type the cell reference of the distribution to which the current distribution is to have a correlation.
- Type the desired correlation coefficient.
- For example, in B4 enter the formula: `=TRIANGULAR(20,65,95,B2,85%)`. This correlates the variable in B4 with the one in B2, using a correlation coefficient of 85%.

In either case (Manage Correlations or in-cell correlation), to check that the correlation has been applied correctly you can use the function `=CORRELATION(B2$,B4$)`.

To view the correlations in your model, select Manage Correlations from the Formulas tab. In-cell correlations are displayed with the prefix [In Cell]; all other correlations have been input via the Manage Correlations tool.

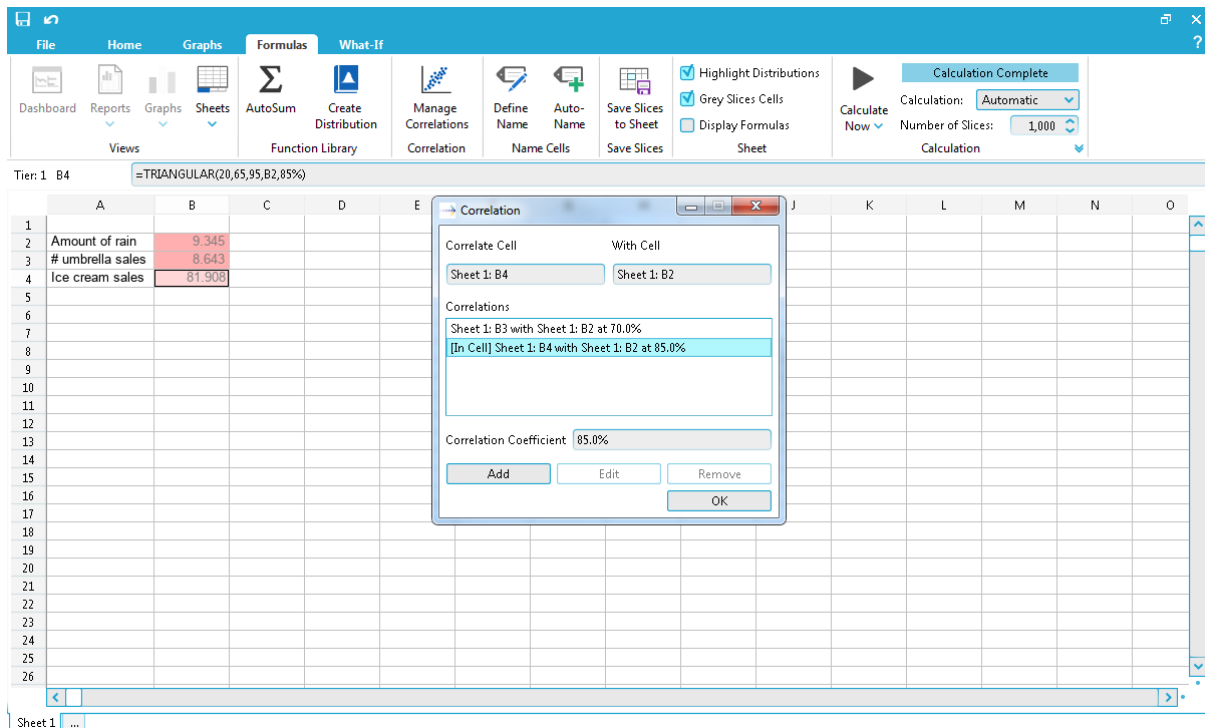


Figure 60. Viewing correlations in Manage Correlations

To edit any correlation, select the item in the list, then change the Correlate Cell, With Cell and/or Correlation Coefficient fields and click the Edit button to save the changes. Similarly, you can remove the correlation by selecting it and clicking on the Remove button.

NOTE: You cannot edit or remove In-cell correlations shown in this list (you will see that the Edit and Remove buttons are greyed); instead you must edit the function in the cell itself.

There is no limit to the number of correlations you can put in a model. However, you must take care not to introduce circularities by correlating a chain of cells with each other. If you introduce a circularity, a circularity error message will be displayed.

NOTE: To correlate the likelihood of risks happening together, you need to correlate BERNOULLI distributions using in-cell correlation. The discrete outcomes (TRUE or FALSE) are aligned with each other, with as much accuracy as possible. Note, this requires the probabilities of the two risks being not too dissimilar (the extreme case: you cannot correlate a risk with 0% probability with another that has 100% probability).

NOTE: Risk Analyser does not currently support in-cell correlation for the UNIFORM_DISCR distribution.

Turning Correlation On or Off

You can turn all correlations in the model on or off by selecting or deselecting the 'Ignore Correlations' option on the Advanced Simulation Options window accessed from the Calculation section of the ribbon menu. When this option is ticked, all correlations in the model (both in-cell and menu) will be ignored and all cells will be free to calculate independently. This is a useful check to see the effects that correlation is having on your model, by comparing the results of a calculation with correlations to the results of one without.

Tiers

Risk Analyser has a tier structure, which allows you to isolate significant variables while still allowing them to remain an integral part of the overall model. The unique tier structure is ideal for scenario analysis.

You should consider attending a Risk Analyser training course if you intend to build more complex models.

Modelling Risk

When representing events that have a probability of occurrence, use a Bernoulli distribution in combination with an IF statement rather than a simple multiplication:

SIMPLE: $=1000 * 80\%$

BETTER: $=IF(BERNOLLI(80\%), 1000, 0)$

The result is a distribution of slices where the event does (1000) or doesn't happen (0) in the defined proportions, rather than a single misleading figure of 800.

It is possible to model opportunities in this way by subtracting the impact of your risk from your end result. However, when working with dates, make sure that your opportunities can't result in a task ending before it has begun. Consider using a MAXIMUM statement to limit the benefit of the opportunity to no more than x days less than the duration of the task in any given slice.

For example, if your task distribution is in A6 and your opportunity distribution is in B6, you could ensure that your (80% chance) opportunity benefit was never more than two days less than the task duration by using this formula for the task outcome:

$=IF(BERNOLLI(80\%), MAXIMUM(A6-B6, 2), A6)$

Sheet Display Options

You can customise the appearance of your worksheet using the tools in the Sheet section of the Formulas tab.

- ☒ Highlight Distributions
- ☒ Grey Slices Cells
- ☐ Display Formulas

Sheet

Figure 61. The Sheet tools

- Highlight Distributions. If selected, cells containing distributions will be highlighted pink.
- Grey Slice Cells. If selected, cells on tier 1 (those cells either containing or referencing distributions) will display with grey text.
- Display formulas. If selected, the sheet will display the formula as the contents of each cell. Otherwise, the value (calculated result) of the cell's formula will be displayed.

Selected options apply only to the currently displayed sheet, not the entire model. To create the same display options on every sheet in a model, select each sheet in turn and apply settings individually.

Working with Calendars

When you import a schedule into Predict! Risk Analyser, each task is assigned to a calendar. The calendar defines which days are working days, and how many hours are worked on each day.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Calendars													
2														
3		Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday						
4	PRAStandard	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	Default hours					
5			9	9	9	9	9	9						
6			8	8	8	8	8	8						
7														
8	PRA24hour	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	Default hours					
9		0	0	0	0	0	0	0						
10		24	24	24	24	24	24	24						
11														
12	Standard	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	Default hours					
13			8	8	8	8	8	8						
14			8	8	8	8	8	8						
15		26 Aug 13	26 Aug 13	FALSE										
16		25 Dec 13	01 Jan 14	FALSE										
17														
18	Calendar 1565943687258	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	Default hours					
19		8	8	8	8	8	8	8						
20		8	8	8	8	8	8	8						
21														
22	Engineer grade 1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	Default hours					
23		8	8	8	8	8	8	8						
24		8	8	8	8	8	8	8						
25		8	8	8	8	8	8	8						

Figure 62. The Calendars sheet

The calendars used are defined and set in your planning tool, and you will not normally need to adjust them in Risk Analyser. The Calendars sheet where calendar information is stored, and the Calendar column (column F on the Calculation sheet) which defines which calendar each task uses, are normally both hidden.

Each calendar on the Calendar sheet is made up of the following information.

- The calendar name in column A.
- Seven TRUE or FALSE statements in columns B to G. These tell Risk Analyser whether each day of the week (from Sunday in column B to Saturday in column G) would normally be a working day.
- For each day of the week, two numbers. The first is the time of day when the working day begins; the second is the number of hours worked that day.

- In columns B to D, immediately below the hours per day, any calendar exceptions are listed. These are days like public holidays where no work will be done, or weekends where extra work is being scheduled. Column B is the start date of the exception, column C is its end date (the same as the start date for one-day exceptions). In column D, TRUE shows that the exception is a working period, or FALSE that it is a non-working period.
- A blank row signifies the end of the information for that calendar.

Scenarios

Scenarios are a way of quickly toggling risks on and off for the purposes of what-if analysis. If your model contains risks that have been added automatically as part of an import, then you will have the option to use scenarios. You can add a new scenario by selecting Create New Scenario... in the Scenarios drop-down options in the What-If menu. You can also add a new scenario by clicking the  button on the dashboard.

Edit Scenario
Σ

Name:
Scenario 1

Select which risks to include in the scenario and whether to apply the effect of risk mitigation actions.

ID	Risk	Cost Cost Benefit	Current Cost Sensitivity	Target Cost Sensitivity	☒ Include?	☒ Mitigate?
143	Plumbing supplier goes bankrupt	1.44	49%	0%	☒	☒
145	Groundworks Problems		4%	2%	☒	☒
146	Planning Approval delayed	1.15	12%	4%	☒	☒
147	Contamination of site during excavation	0.291	42%	53%	☒	☒
148	Mortgage problems		71%	66%	☒	☒
149	Building Regs Approval Delayed		10%	7%	☒	☒
150	Tax Break Opportunity		-17%	-52%	☒	☒
199	New Eco-friendly building materials available		4%	4%	☒	☒

Save and Run
Cancel
Delete

Figure 63: The Edit Scenario window

Unticking the Include? tick box for a risk removes its impact from the model. Unticking a risk's Mitigate? tick box sets its target assessment to be equal to its current assessment, removing any planned mitigation.

Clicking the Save and Run button will save any changes you have made to the scenario will be saved and the settings applied to the model.

If you opened the Edit Scenario window from the ribbon menu and have made changes to the scenario, when the model has calculated, the results will be plotted on the Scenario Results graph. The Scenario Results graph shows the saved result from when each scenario was last run. On schedule risk analysis models, the Scenario Results graph will plot the project end date. On cost risk analysis models, the Scenario Results graph will plot the total cost impact. The results on the dashboard are updated to match the current scenario.

Impact and Mitigation Analysis

If your model includes imported risks then the Impact Analysis and Mitigation Analysis options can be used to find the effect of each risk on the outcome. Impact and mitigation analyses can be triggered using the options in the Scenarios section of the What-If menu. The impact analysis works by turning off a risk, calculating the model, and then saving the results; this is repeated for each risk in the model. The results where each risk was turned off are then compared to the baseline case taken from when the analysis was triggered. The mitigation analysis works in the same way, but the mitigation is turned off for each risk rather than the risk itself. If you have a scenario set then this is used as the baseline for the analysis so, for example, any risks that are turned off in your current scenario will stay turned off when running an impact analysis.

Impact or mitigation analyses can also be triggered from risk dashboards by selecting the



button. Selecting a bar on the risk dashboard tornado graph will run an impact or mitigation analysis unless one has been run for that risk already.

5. Troubleshooting

This section is designed to help you overcome some of the most common problems and questions encountered by the Risk Decisions Help Desk.

Mean and Other Statistical Functions

When performing statistical calculations on a cell's slices you need to ensure that the formula refers to the slices rather than just the cell. To do this you need to use the slice operator (\$).

- E.g. =MEAN(A1\$)

Confidence Intervals

When examining confidence intervals for a distribution, you may get different answers depending on whether you use the confidence selectors in the View Slices window, or the CONFIDENCE function. When you use the View Slices window, the value that is shown for the 50% confidence interval will be the one closest to the calculated value (it is highly improbable that a slice will contain the actual 50% confidence interval).

Simulation is Very Slow

The maximum number of slices may be dependent on machine RAM. If the number of slices is too large for the RAM then you will get an error.

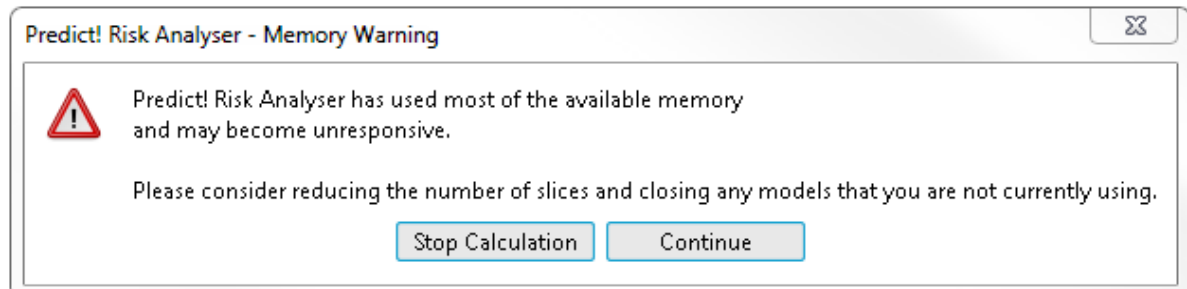


Figure 64: Low memory warning

Project activities appear in a different order than in the project planning tool

Change the sort and grouping order in your project plan. For example, a common way of viewing a project plan in Primavera uses Organize (Format menu) to group and sort activities by certain activity data. These group and sort options may not be available in Risk Analyser. Therefore, you will temporarily need to remove the 'group by' and 'sort by' items and click the Organize Now button to change the display in Primavera.

NOTE: Make sure you don't save the changed layout when you close your project plan if you want to keep the groupings for when you next open the project.

Different Dates from the planning tool

The imported project plan gives different dates from those in my planning tool when I load it using the 'No Uncertainty' option.

There are several different reasons why this might be the case:

1. Import options:
 - a. Your project plan may be calculating in or rounding up to whole days, while Predict! Risk Analyser is using hours and minutes to calculate durations. When importing your project file, use the Advanced button on the Project Import Options window to set the option to work in whole days.
2. Not using up-to-date schedule information
 - a. Your project planning tool may be scheduling the plan from the project's 'Today date' (for example, the Status Date in Microsoft Project or the Data Date in Primavera). To do the same in Risk Analyser, tick 'Use % Complete' on the General tab of the Schedule Analysis Options window when importing your plan and remember to use **Remaining Duration** if applicable.
 - b. If your planning tool has been set to schedule manually, it may give misleading dates for progressed tasks, and differ from Risk Analyser's calculated results when importing using the percent complete option. Either make sure you have updated your project so that it contains correctly progressed tasks before importing into Risk Analyser; or turn on automatic scheduling in your planning tool.
 - c. In Primavera, use F9, and in MS Project, use **Update Project** to ensure that tasks have up-to-date information.
3. Your planning tool:
 - a. Sometimes project planning tools show early finish dates as the beginning of the day following the day on which the activity is completed. Others show the end of day on the date completed. Risk Analyser always shows the latter.
 - b. In Primavera, you may encounter problems in plans with progressed activities. By default, Primavera exports the Original Duration as the activity's duration and this is not necessarily consistent with the sum of activity's Actual and Remaining Duration. You must update the Original Duration in Primavera to be equal to this sum (and ensure the percentage complete is also consistent). Alternatively, enter your 3-point estimate for each activity using custom fields and export them to spare custom text fields.
 - c. Some files saved by planning tools become corrupt after saving many times. If you have unexplainable results when importing into Risk Analyser, try using **Save As** in your planning tool to save a fresh copy of your schedule. This can sometimes solve problems with differences in MS Project files.
4. Calendars
 - a. Note that Risk Analyser does not take lunch breaks into account, so instead of allowing an hour for lunch and finishing at 5pm, Risk Analyser will ignore the lunchbreak and finish at 4pm.
 - b. Check that the calendar in your project plan matches the calendar in the Risk Analyser sheet. For example, Primavera does not export US statutory holidays such as Christmas Eve, New Year's Eve and Independence Day (4th July). You can enter these manually by inserting the dates in extra rows in the calendar sheet. You will need to reseed the model (Calculation box) to re-run the plan with

the changed calendars.

- c. Check that each activity is assigned the correct calendar. Some project planning tools can export a different calendar for each activity (e.g. Microsoft Project 2000, PowerProject, Open Plan). Others can only use one calendar for the whole project (e.g. Microsoft Project 4 and 98).

5. Logic links

- a. Ideally, if a schedule is to be analysed, all tasks should be linked to each other using finish-to-start relationships. Other types of relationships can have unforeseen pitfalls when analysed. For example, using start-to-start and finish-to-finish relationships, often referred to as “stretch logic”, can create the effect of float or stretch in the dates of the tasks.
6. Risk Analyser does not import resource information, and therefore cannot perform automatic resource levelling in the same way as some planning tools. Risk Analyser will schedule a task according to its predecessor and successor information and any constraints applied and assume that a resource will be available to carry it out at that time. If this is not the case, consider adding some logic to the plan to describe resource availability, for example a 'wait for resource' task linked as a predecessor.
7. Risk Analyser does not support the use of inactive tasks (from Microsoft Project 2010 onwards) and will treat them as 'normal' tasks. Inactive tasks should be removed from the plan before importing.
8. Risk Analyser supports file import from Microsoft Project 98, 2000, 2003 and later via MPX and MPP files. If the MPX file you are importing has been generated by another planning tool and you are having problems loading it into Risk Analyser, check first whether it can be loaded into Microsoft Project without errors and gives the expected end dates etc. If there is a problem, contact your planning software vendor for help.

NOTE: Remember that some scheduling tools allow you to filter your view. It is important to make sure you are not missing any key tasks in your schedule when checking the above items.

6. Tutorial – building simple models

Creating a budget, Part 1 - The model

You are moving to a new house and want to make sure you can afford to make various home improvements. You decide to put together a simple budget.

1. Start Predict! Risk Analyser. Risk Analyser will start with the Home screen. Select Create a new blank model - a new model will appear called New Model 1. You can rename this model by selecting Save As from the File tab.
2. The sheet name (Sheet 1) is displayed on the tab at the bottom left-hand corner of the sheet. Right-click on the sheet tab and select Rename. Call the sheet Home Improvements.
3. Click on cell A1, type Budget.

NOTE: You can format cells using the tools in the Format section of the Home tab.

4. Click on cell B3, type New kitchen.
5. Click on cell C3, enter the new kitchen cost, 8000.
6. Click on cell B4, type Carpets and curtains.

NOTE: If a column is not wide enough to show all its contents, drag or double click on the line between column headings to change the width.

7. Click on cell C4, enter the cost of carpets and curtains, 2100.
8. Click on cell B5, type Decorating.
9. In cell C5, enter the cost of Decorating materials, 800.
10. In cell B6 type Replacement windows.
11. In cell C6, enter the cost of windows, 15000.
12. In cell B7 type Landscaping.
13. In cell C7, enter the cost of landscaping, 4000.
14. In cell B8 type Home improvement budget.
15. Double click on the line between column headings to auto fit the column width.
16. Click on C8 and select AutoSum from the Formulas tab to enter a SUM formula to calculate the budget. The formula in C8 should now read =SUM(C3~C7).
17. To format the budget cell C8, right-click it and choose 'Format Cells...'. Set Decimal places to 0 and check the 'Use 1000 Separator (,)' box.
18. Click OK to accept the format changes. Click on cell C8 and choose AutoName from the Formulas tab. The name 'Home improvement budget' will appear in the Reference box.

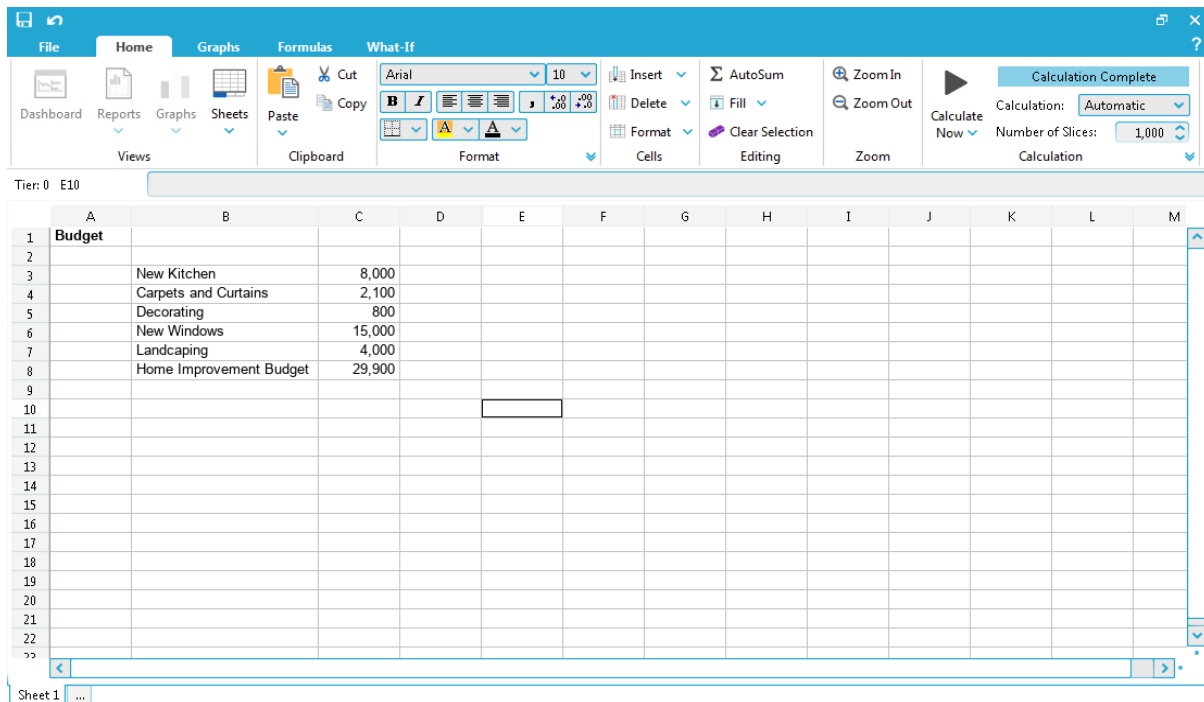


Figure 65. Completed Budget Model without Uncertainty

The model shows the required budget is 29,900, so you decide to add 30,000 to your mortgage to pay for the work.

Creating a budget, Part 2 – Adding uncertainty

We now want to make the model more realistic. So far, we have given a fixed estimate for each of the items identified, these estimates involve uncertainty. Our estimate of 8,000 for the new kitchen is our best guess, but we know that it could cost as little as 7,500 and may cost as much as 10,500. We can describe this using a triangular distribution.

1. In cells E2, F2 and G2 enter Minimum, Likely and Maximum respectively.
2. In cells E3, F3 and G3 enter 7500, 8000 and 10500.
3. Click on C3 and choose Create Distribution from the Formulas tab. Choose Triangular distribution and click in turn on the Minimum, Likely and Maximum boxes, using the mouse to point to the data cells E3, F3 and G3. Click on OK.

HINT: You can also type `=triangular(7500,8000,10500)` to create a triangular distribution in a cell. When entering numbers into formulas like this, make sure that you don't use a separator to mark the 1000s (e.g. type '8000' not '8,000'), as commas are used to separate the arguments.

NOTE: If your regional settings use a comma as a decimal separator, you should use a semi-colon (;) rather than a comma to separate the arguments. This is true with all Risk Analyser distributions and functions.

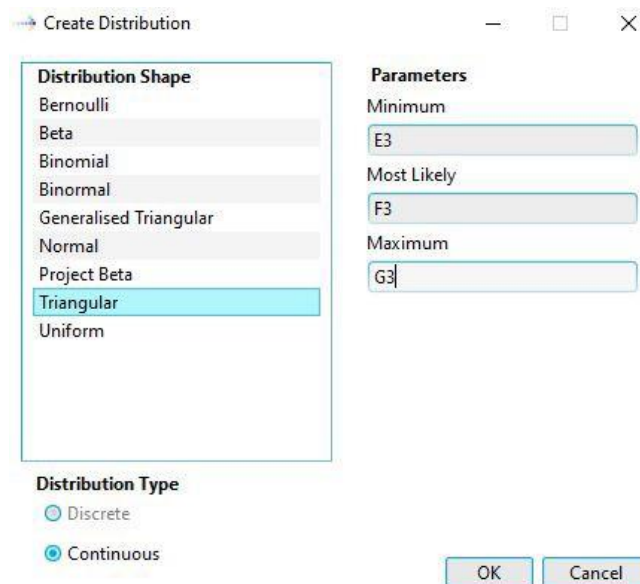


Figure 66. Creating Distributions

Cell C3 is now shaded pink and has grey text, to indicate that it contains a formula with a distribution in it (in this case triangular).

4. Format C3 as comma separated and to 0 decimal places.

NOTE: You can use the Comma tool and Decrease Decimal tool on the Home tab as a quick way to format numbers.

5. Continue to enter minimum, likely and maximum data for all items shown in the figure below.
6. Copy cell C3 and paste it to C4 through C7.

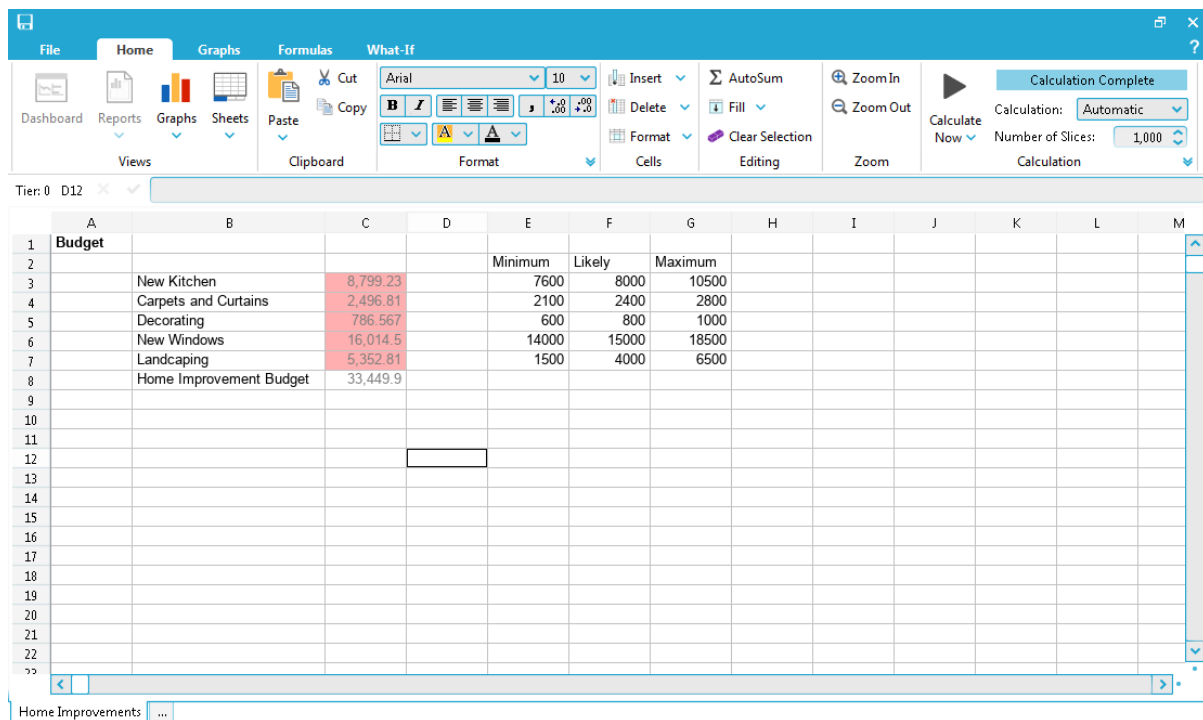


Figure 67. Highlighted distribution cells, using Minimum, Likely and Maximum data

7. Risk Analyser automatically runs the model 1000 times to produce Monte Carlo slices of different potential outcomes for your budget.
8. To see the 1000 slices generated for the uncertainty describing the cost of the new kitchen, double click on cell C3. Scroll up and down to see that the data lies between the minimum and maximum cost. By default, the slices are shown in Data order, but you can also view them in Slice order. Close the View Slices window.

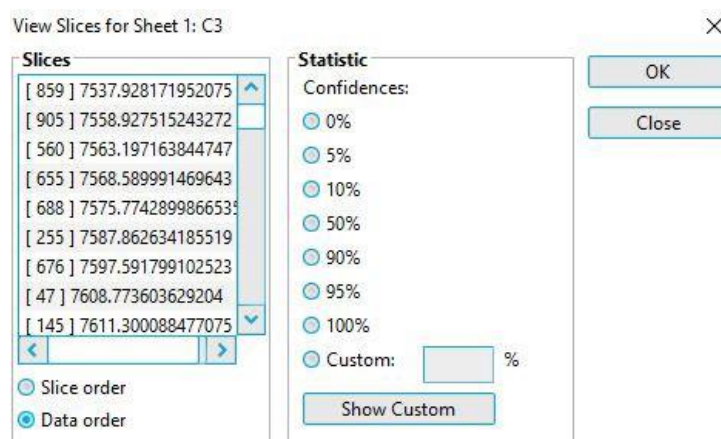


Figure 68. Viewing slices

NOTE: It is important to understand that the values displayed in column C show the last slice value of the 1000 slices generated, which is not necessarily a representative result. You **MUST NOT** use this as your result but instead do an analysis of all the slices by creating a graph or calculating statistical information about all the slices. Cells that display last slice data always have grey text, so they are easy to see in the worksheet.

9. You can choose how many slices Risk Analyser generates during simulation. In the Calculation box at the right of the ribbon, change the Number of Slices from 1000 (the default) to 5000 and press Enter. Note how the status indicator at the top of the Calculation box changes as Risk Analyser calculates the additional slices.
10. Click on cell C8 and then select Create Graph from the Graphs tab. This will launch the Graph Wizard.

On the Graph type screen, select the Column graph type, tick the Include S-curve box, and click Next.

On the Graph data screen, enter a Graph Name, check the data range (the cells the graph is based on - in this case cell C8 on the Home Improvements sheet), choose colours, and click Next.

On the Chart options screen, fill in the labels to title, sub-title and label the axes on your graph (for example, type Home Improvement Budget in the Title box). Tick the Grid lines and legend tick boxes if preferred. The number of strips controls the level of detail in the graph, with fewer strips giving you a smoother but less precise curve. Change this if required, and then click Finish.

The graph shows a range of potential costs based on the uncertainty in the budgeted items. You can switch between graphs and sheets using the View box.



Figure 69. Distribution graph of possible costs

NOTE: The graph can be edited by right-clicking and selecting Edit Graph. The undo button does not work on changes to the graph but will be applied to your previous instruction on a non-graph sheet.

11. We want to work out the confidence of staying within our budget. Drag the vertical line, moving it to the left so its label shows about 30,000. The label for the horizontal line shows the chance of staying within your budget of 30,000. This is because it shows the area of the graph that lies between the Minimum value and the 30,000 value.

12. The results show that you have less than 20% probability of staying within the 30,000 budget forecast in the original model (and hence more than 80% likelihood of overspending).

13.



Figure 70. Results show less than 15% chance of staying within budget

14. In the Statistical Summary box on the right-hand side, the mean value shows that, on average, you can expect costs to be around 31,500. The minimum, maximum, 10%, 50% (median) and 90% confidence values are also shown.

NOTE: The figures given here are approximate. The exact figures seen will vary slightly from simulation to simulation.

To the left of Create Graph on the Graphs tab is the Quick Graph tool. This will automatically create a distribution graph with default colours and no labels, titles, etc. (unless you have named the cell, in which case this name is used as the graph title).

This very simple addition of uncertainty to the model allows you to see the different type of result that is generated using Risk Analyser. These real-world uncertainties can be built into any spreadsheet model by expressing your input figures as distributions.

7. Appendix: Reference

This section provides a basic reference for Risk Analyser's Toolbar buttons, and distributions.

Commonly Used Distributions in Predict! Risk Analyser

Distributions are used to describe uncertainty in Predict! Risk Analyser. The distributions available in Risk Analyser are listed in the table below:

NOTE: If your regional settings use a comma as a decimal separator (so that you would write 1.000,00 rather than 1,000.00), you should use a semi-colon (;) rather than a comma to separate the arguments. This is true with all Risk Analyser distributions and functions.

Distribution	Description	Example
Bernoulli	Describes something with 2 outcomes: happens, does not happen. BERNOULLI(probability)	Tossing a coin: =BERNOULLI(50%)
Beta	The beta distribution is a family of different shapes. The BETA function returns a percentage between 0% and 100% inclusive. BETA(alpha1, alpha2)	Market share: =BETA(5, 5)
Binomial	The binomial distribution describes the number of successes in a given number of events (successes and failures) of a discrete process. BINOMIAL(trials, probability)	The number of times a six appears in fifty rolls of a fair die: =BINOMIAL(50, PERCENTAGE(1/6))
Binormal	A normal distribution where the deviation need not be symmetrical. BINORMAL(left deviation, most likely, right deviation)	Market share: =BINORMAL(12%, 45%, 4%)

Continuous	Returns a sample from a given custom continuous distribution. The function has two alternative forms: CONTINUOUS(values, cumulative probabilities) CONTINUOUS(samples) In the first form, values is a list of outcomes (numbers or dates/time) of the distribution. Cumulative probabilities is a list of percentages, each between 0% and 100% inclusive. Each cumulative probability is the probability that the distribution will be less than the corresponding value. The values and cumulative probabilities lists must be the same size. If they are not, or if one of the cumulative probabilities is outside the range, the CONTINUOUS function returns an Argument error. Both the values lists and the cumulative probabilities list must be in ascending order, otherwise the Continuous function returns an Argument error.	You estimate that the chance of achieving unit sales of 10,000, 35,000, 50,000, 90,000 for a new product has cumulative probability values 0%, 25%, 60%, 100%. These are recorded in a table in C6~D9. =CONTINUOUS(C6~C9, D6~D9) constructs a continuous distribution based on the figures, and takes a random sample from it for each slice. Using samples, suppose you have a production line set up to make capsules of pain killer. You select and record the weight of a capsule every hour for 500 hours and record them in column H in Risk Analyser. =CONTINUOUS(H1~H500) gives the distribution of weights of capsules coming off the production line.
Cauchy	Describes the ratio of two normal distributions. Alpha can be any number. Beta must be a positive number. The CAUCHY function returns a number. CAUCHY(alpha, beta)	The standard cauchy distribution: =CAUCHY(0, 1)
Chi-squared	Describes the sum of the squares of a number of independent standard normal distributions. CHI_SQUARED(degrees) Returns a sample from the chi-squared distribution with a given number of degrees of freedom.	The chi-squared distribution with 6 degrees of freedom: =CHI_SQUARED(6)

Discrete	Returns a sample from a given custom discrete distribution. As with all distribution functions, if a cell's formula uses this function, then the function returns a different sample in each slice of the cell. DISCRETE(outcomes, probabilities) Outcomes is a list of all possible outcomes of the distribution. Probabilities is a corresponding list of the probability of each outcome. It must be a list of percentages that adds up to 100%. It must also be the same size as the outcomes list (if they are not the same size, the discrete function returns an Argument error).	Cells A1~A2 contain 99 and 0, and B1~B2 each contain 50%. =DISCRETE(A1~A2, B1~B2) returns either 99 or 0 with a 50/50 chance. Cells G5~G8 contain a set of market brands (Mud Zapper, Boring Wash, Dull, Other brands) and cells H5~H8 contain the market share of each of these brands (45%, 25%, 20%, 10%). =DISCRETE(G5~G8, H5~H8) returns one of the 4 brand names according to their probability.
Exponential	Describes the amount of time that passes between two consecutive events of a continuous process. EXPONENTIAL(mean) Where mean is the average time between events.	Buses arrive at a bus stop on average every fifteen minutes. The following formula represents the time between buses: =EXPONENTIAL(15)
F	Describes the ratio of two chi-squared distributions. F(first distribution, second distribution) The F function returns a probability between 0% and 100%.	To perform an F test on this year's and next year's profit: =F(Profit\$, Next Profit\$)
Gamma	Returns a sample from the gamma distribution with given parameters alpha and beta, which must both be positive. GAMMA(alpha, beta)	To describe the uncertain time it takes to perform a task: =GAMMA(3,1)

Generalised Triangular	The generalised triangular distribution is an enhancement of the triangular distribution which allows you to give different information about your 3 point estimate. You can give the low and high estimates at confidence intervals rather than the extremes of the distribution. The generalised triangular distribution makes an estimate by considering three cases: a low estimate, the most likely outcome, and a high estimate. GEN_TRIANGULAR(low, most likely, high, [low probability, high probability])	=GEN_TRIANGULAR(8,10,14,10%,90%) The last two arguments are optional, and specify which confidence values the low and high arguments represent. If low probability and high probability are omitted, they are assumed to be 10% and 90% respectively.
Geometric	The geometric distribution describes the number of events of a discrete process until a successful one occurs. The geometric distribution is discrete. Note: The geometric distribution describes the number of events until a success. Zero means that the first event was a success, one means that the second was a success and the first was not, and so on. GEOMETRIC(probability) Probability is the chance that any particular event will be successful.	The number of times you have to roll a die before you roll a six: =GEOMETRIC(PERCENTAGE(1/6))
Laplace	The Laplace distribution is a symmetric version of the exponential distribution. The two halves are "mirrored" exponential distributions. LAPLACE(mean, beta) Mean is the centre of the distribution, and beta is the mean of the right hand exponential distribution.	The standard Laplace distribution: =LAPLACE (0,1)
Logistic	The logistic distribution is an approximation to a normal distribution that is useful in experiments with insufficient trials for the normal approximation to be suitable. It is similar to the normal distribution but has heavier tails. LOGISTIC(alpha, beta)	The logistic distribution is used as an approximation in certain circumstances. =LOGISTIC(0,2)

Lognormal	The lognormal distribution is often used to describe physical quantities. LOGNORMAL(mean, standard deviation)	It has been found to accurately describe certain aspects of property valuation. =LOGNORMAL(5,1)
Normal	Describes a symmetrical distribution with a given mean and standard deviation. NORMAL(mean, standard deviation)	Project cost could be represented by =NORMAL(90000, 2000) The delivery date of a key part could be represented by =NORMAL(10/06/2012,5)
Poisson	Describes the number of events of a continuous process that occur in a given space of time. POISSON(rate) where rate is the average rate at which the events happen	The number of buses that arrive at a bus stop in an hour, assuming that, on average, four buses arrive per hour: =POISSON(4)
Project beta	An enhancement of the beta distribution, described using minimum, most likely and maximum outcomes. PROJECT_BETA(minimum, most likely, maximum)	The duration of a project activity in days =PROJECT_BETA(7, 10,15)
T	Returns a sample from the T distribution with a given number of degrees of freedom. T(degrees)	The formula below gives the T distribution with 5 degrees of freedom. =T(5)
Triangular	Describes the best, worse and most likely outcomes of something and fills in the gaps. TRIANGULAR(minimum, most likely, maximum)	Forecast sales figures: =TRIANGULAR (10000, 20000, 25000)
Uniform	Describes equal probability between a lower limit and an upper limit. UNIFORM(low, high)	The expected date of payment of an invoice: =UNIFORM(1/11/12, 30/11/12)
Uniform Discrete	Returns a sample from the discrete uniform distribution with given outcomes. UNIFORM_DISCR(outcomes)	The example uniform discrete distribution, describes the outcome of rolling a fair die: =UNIFORM_DISCR (1,2,3,4,5,6)
Weibull	The Weibull distribution is a general purpose distribution which has been found to accurately describe lifetime expectancies in reliability models. WEIBULL(alpha, beta)	The WEIBULL function returns a positive number. =WEIBULL(1,1)

Wobbly House	An enhancement of the triangular distribution which allows you to give two more outcomes either side of the most likely outcome. =WOBBLY_HOUSE(minimum, first quartile, median, last quartile, maximum[, quartile confidence])	Describe the duration of an activity: =WOBBLY_HOUSE (22, 25, 30, 41, 48, 5%)
--------------	--	--

Index of functions

The table below contains Predict! Risk Analyser functions:

Function	Description and Syntax	Usage
ABS	Returns the absolute value of a given number. ABS(number) Number can be any number, currency figure or percentage.	If cell B16 contains the number 17.5, then =ABS(B16) gives the number 17.5, because it is already positive. =ABS(-£35.00) gives the currency £35.00, because the argument is negative.
ACOS	Returns the angle which has a given cosine. The angle returned is called the arccosine of the given cosine. ACOS(cosine) Cosine can be any number between -1 and 1 inclusive. If it is outside this range, the ACOS function returns an Argument error. The ACOS function returns an angle between - 90 and 90 degrees inclusive. Note: All angles in Predict! Risk Analyser are shown in radians, and must be entered as radians. To convert degrees to radians, multiply by pi/180.	The formula =ACOS(3.4641/4) gives 0.52 which is Pi/6 and is the radian value corresponding to 30 degrees. =ACOS(-0.5)*180/PI Gives 120 degrees.
ACOSH	Returns the inverse hyperbolic cosine of the given number. ACOSH(number) Number can be any number greater than or equal to 1. If it is less than 1, the ACOSH function returns an Argument error. The ACOSH function returns a number.	The formula =ACOSH(5) gives approximately 2.292. =ACOSH(COSH(2)) gives 2 because the ACOSH function is the inverse of the COSH function.

AND	Returns TRUE if all given logical values are TRUE. Otherwise it returns FALSE. This is called the logical "and". For example, if you have seven cells which calculate whether it rained on respective days of a week, then the logical "and" of the seven cells calculates whether it rained every day that week. Note: The same effect can be achieved using the logical "and" operator (&). AND(logical 1, logical 2,.....) Each logical is a list of logical values. The AND function returns a logical value.	The formula =AND(TRUE,TRUE,TRUE,TRUE) gives TRUE, whereas the formula =AND(TRUE,TRUE,FALSE,TRUE} gives FALSE. If the seven cells D1 to D7 calculate whether it rained on each respective day of the week, then the formula =AND(D1~D7) gives TRUE if it rained every day, otherwise it gives FALSE. If all of B17's slices are logical values, then the formula =AND(B17\$) gives TRUE if all B17's slices are TRUE. If one or more slices are FALSE, the formula gives FALSE.
ASIN	Returns the angle which has a given sine. The angle returned is called the arcsine of the given sine. ASIN(sine) Sine can be any number between -1 and 1 inclusive. If it is outside this range, the ASIN function returns an Argument error. The ASIN function returns an angle between -90 and 90 degrees inclusive. Note: All angles in Predict! Risk Analyser are shown in radians, and must be entered as radians. To convert degrees to radians, multiply by pi/180.	The formula =ASIN(0.5) gives 0.52 which is Pi/6 and is the radian value corresponding to 30 degrees. =ASIN(0.5)*180/PI gives 30 degrees.
ASINH	Returns the inverse hyperbolic sine of the given number. ASINH(number) Number can be any number. The ASINH function returns a number.	The formula =ASINH(5) gives approximately 2.312 =ASINH(SINH(2)) gives 2 because the ASINH function is the inverse of the SINH function.

ATAN	Returns the angle which has a given tangent. The angle returned is called the arctangent of the given tangent. ATAN(tangent) Tangent can be any number. The ATAN function returns an angle between -90 and 90 degrees inclusive. Note: All angles in Predict! Risk Analyser are shown in radians, and must be entered as radians. To convert degrees to radians, multiply by pi/180.	The formula =ATAN(2/3.4641) gives 0.52 which is Pi/6 and is the radian value corresponding to 30 degrees. =ATAN(2/3.4641)*180/PI gives 30 degrees.
ATANH	Returns the inverse hyperbolic tangent of the given number. ATANH(number) Number can be any number between (but not including) 1 and -1. If it is outside this range, the ATANH function returns an Argument error. The ATANH function returns number.	The formula =ATANH(0.5) gives approximately 0.549 =ATANH(TANH(2)) gives 2 because the ATANH function is the inverse of the TANH function.
CEILING	Returns the first whole number above a given number. CEILING(number) Number can be any number, currency figure or percentage. If number is a percentage, it is rounded up to 100%.	If cell B16 contains the number 4.23, then =CEILING(B16) gives the number 5. =CEILING(-\$35.40) gives the currency -\$35.00.
CHANCE_LESS	Given a distribution, returns the probability that a random sample will fall below a given outcome. CHANCE_LESS(upper, distribution) Upper is the upper limit (exclusive). Distribution is the distribution. It must be a list of elements of any data class, as long as they are all the same. The CHANCE_LESS function returns a percentage between 0% and 100% inclusive.	If you have a cell called Profit that calculates your company's profit next year, you can calculate the chance of making a loss using the formula =CHANCE_LESS(£0, Profit\$) If you have a cell called Finish date that calculates the finish date of a project, the formula =CHANCE_LESS (1/1/14, Finish date\$) calculates the chance of finishing the project before the beginning of January 2014.

CHANCE_MORE	Given a distribution, returns the probability that a random sample will fall above a given outcome. CHANCE_MORE(lower, distribution) Lower is the lower limit (exclusive). Distribution is the distribution. It must be a list of elements of any data class, as long as they are all the same. The CHANCE_MORE function returns a percentage between 0% and 100% inclusive.	If you have a cell called Profit that calculates your company's profit next year, you can calculate the chance of making a profit using the formula =CHANCE_MORE(£0, Profit\$) If you have a cell called Finish date that calculates the finish date of a project, the formula =CHANCE_MORE(31/3/14, Finish date\$) calculates the chance of the project overrunning into April 2014.
CHANCE_OF	Given a distribution, returns the probability that a random sample will fall within a given range. CHANCE_OF(lower, upper, distribution) or CHANCE_OF(outcome, distribution) In the first form, lower is the lower limit of the range (inclusive), and upper is the upper limit of the range (inclusive). If lower is bigger than upper, the CHANCE_OF function returns an Argument error. In the second form, outcome is the single outcome. Distribution is the distribution. It must be a list of elements of any data class, as long as they are all the same. All of lower, upper and outcome must be the same data class as the elements of the distribution list. The CHANCE_OF function returns a percentage between 0% and 100% inclusive.	If you have a cell called Finish date that calculates the finish date of a project, the formula =CHANCE_OF (1/1/14, 31/3/14, Finish date\$) calculates the chance of the project finishing between the beginning of January and the end of March 2014.

CHAR	Returns the single character with a given ASCII code. CHAR(ascii code) Ascii code must be a number between zero and 255 inclusive. If it is outside this range, the CHAR function returns an Argument error. If it is not a whole number, it will be rounded using the INT function The CHAR function returns text consisting of a single character.	The formula =CHAR(80)+"redict"+CHAR(33) gives the text "Predict!".
CODE	Returns the ASCII code of a given single character. CODE(text) Text must be text. Only the first character will be considered, the rest will be ignored. The CODE function returns a number between zero and 255 inclusive.	The formula =CODE("Predict!") gives the number 80, which is the ASCII code for the capital letter "P".
COLUMN	Returns the column number of a given cell. COLUMN(cell) Cell is a reference. It can be a name or cell reference. If cell refers to a range, only the top left cell of the range is considered. The COLUMN function returns a number between 1 and 256 inclusive.	=COLUMN(D6) gives the number 4, which is the column number of column D. If the cell A1 contains the reference C5, then the formula =REFERENCE(COLUMN(A1)+1, ROW(A1)+1) gives the reference D6. Note that in the above example, it is a constant in cell A1, not a formula. Cell A1 contains the reference to C5, not the contents of C5.
COLUMNS	Returns the width in columns of a given reference. COLUMNS(array) Array is a list. The COLUMNS function returns a number between 1 and 256 inclusive.	=COLUMNS(B7~G25) gives the number 6. The formula =COLUMNS(A1~IV1) gives the number 256.

CONFIDENCE	Returns a given confidence of a distribution. CONFIDENCE(confidence, distribution) Confidence represents the confidence you want, and must be a percentage between 0% and 100% inclusive. Distribution is the distribution. It must be a list of elements all of the same data class. It calculates the outcome of the distribution such that there is a confidence% chance that the distribution will be less than that outcome.	If cell G25 contains the costs you incur in a particular business venture, then the formula =CONFIDENCE(90%,G25\$) gives £1.2m This means that 90% of all the slices of cell G25 are less than £1.2m, and only 10% are more. If cell H28 contains the profit of a project being modelled, and a cell called Confident contains the confidence you require in your results, then the formula =CONFIDENCE(100%-Confident, H28\$) gives the profit that you can be confident of getting more than. If the Confident cell contains 80% for example, then the above formula might calculate £5,600. This means that 20% of all slices of cell H28 are less than £5,600, and 80% of them are more. =CONFIDENCE(50%,1,2,5,7,8,13,20) gives 7, the median (middle item) of the ordered list
CORRELATION	Returns the correlation coefficient of two given distributions. CORRELATION(first distribution, second distribution) The distributions can be different data classes, but both lists must be of the same length. If they are not, the CORRELATION function returns an Argument error. The CORRELATION function returns a percentage between -100% and 100% inclusive. It returns an Argument error if the correlation coefficient does not exist.	Suppose you are modelling the launch of a new product. You have a cell called Marketing Spend which calculates the amount of money you spend on marketing the product, based on a number of factors. You also have a cell called Profit which calculates the ultimate profit the product makes in its first year. The formula =CORRELATION(Marketing Spend\$, Profit\$) gives the extent to which your marketing spend affects your profit. If the formula gives a high percentage, then you can justify spending more on marketing. If it gives a low percentage, then marketing spend does not seem to be helping the profits very much. If it gives a negative percentage, then you would be advised to change your marketing methods (or at least, the way they are represented in the model)!

COS	Returns the cosine of a given angle. <code>COS(angle)</code> Angle can be any angle. The COS function returns a number between -1 and 1 inclusive. Note: All angles in Predict! Risk Analyser are shown in radians, and must be entered as radians. To convert degrees to radians, multiply by $\pi/180$.	The formula <code>=COS(30*PI()/180)</code> gives 0.866 <code>=COS(1.047)</code>, 1.047 represents 60 degrees in radians gives 0.5.
COSH	Returns the hyperbolic cosine of the given number. <code>COSH(number)</code> Number can be any number. The COSH function returns a number greater than or equal to 1.	The formula <code>=COSH(5)</code> gives approximately 74.21 <code>=COSH(ACOSH(2))</code> gives 2 because the COSH function is the inverse of the ACOSH function.
COUNT	Returns the number of numeric data items given. <code>COUNT(Array)</code> Array can be any list. The COUNT function returns a number.	The formula <code>=COUNT(1,2,3,4,5)</code> gives the number 5. The formula <code>=COUNT(1,2,"text",3,4,5,A5~B5)</code> Gives the number 8, assuming that none of the cells in the range A5~B5 are blank or contain text.
COUNTA	Returns the number of data items given. You can count the total number of elements in a number of lists. You can also use the COUNT function to count only the number of numeric elements. <code>COUNTA(Array)</code> Array can be any list. The COUNTA function returns a number	The formula <code>=COUNTA(1,2,3,4,5)</code> gives the number 5. The formula <code>=COUNTA(1,2,"Text",3,4,5,A5~B5)</code> gives the number 9, assuming A5~C5 contains one number, one text cell and one date.

DATE	Converts some non-time data into a date. A date can be specified in two ways: 1. By specifying the day, month and year. 2. By giving the date as text or a date number. This function has two alternative forms: 1. DATE(day, month, year) or 2. DATE(non-date) In the first form, day, month and year must be positive numbers. If they are not positive the DATE function returns an Argument error. Year can be expressed as a two or four digit number. Two digit years are converted to four digits by taking the current year +/- 50 years. For example, if the current year is 2013: 13 is assumed to mean 2013; years in the range 14 to 63 are assumed to be in the future and become 2014 to 2063; years in the range 64 to 99, and 00 to 12 are assumed to be in the past, becoming 1964 to 2012. In the second form, text is converted to a date in the same way as Risk Analyser converts dates and times entered in the edit bar. If the text cannot be recognised as a date or time, the DATE function returns an Argument error. A number is converted to a date by using the number as a date number. The date number is the number of days since 31st December 1899. For example, the date number 41142 represents 21st August 2012.	The formulas =DATE(21,8,2012) =DATE(41142) =DATE("21/8/12") each give the date 21st August 2012. The formula =DATE("21/8/12 1:53 PM") gives the date 21st August 2012.
DELTA	Returns the Kronecker delta of two numbers. DELTA(i, j) The numbers i, j should be whole numbers. If they are not, they will be rounded using the INT function. The Kronecker delta of two numbers is defined to be the number 1 if the numbers are the same, and 0 otherwise. The DELTA function returns either the number zero or the number 1.	The formula =DELTA(5,6) gives zero. =DELTA(6,6) gives 1.

DEVIATION	Returns the standard deviation of a given distribution. This function assumes that the samples in the distribution are merely samples, and that they do not include every possible outcome of the distribution. DEVIATION(distribution) Distribution is the distribution to be measured. It must be a list of elements of one of the following data classes: currency, percentage, number, or date/time. The DEVIATION function returns the same data class as the elements of the distribution, unless they are times, in which case it returns a number of days. If all the elements of the distribution list are exactly the same, the DEVIATION function returns zero.	If cell G6 calculates the profit of a proposed venture, the formula =DEVIATION(G6\$) gives the standard deviation of the profit.
DIV	Returns the number of whole times a given divisor goes into a given number. The DIV function is sometimes called the quotient. It is used in modulo arithmetic. DIV(number, divisor) Number can be any number, currency figure or percentage. Divisor can be any number, currency figure or percentage. If divisor is zero, the DIV function returns an Argument error. The DIV function returns a number.	The formula =DIV(16,3) gives the number 5. As long as there is a number in A1, then the formula =5 * DIV(A1, 5) + MODULO(A1, 5) gives the same number as in A1.
E	Returns the mathematical constant e. E() The E function returns a number.	The formula =LN(E^2) gives the number 2.

EURO	Converts some non-Euro data into Euro. The way the data is converted depends on the type of the data, described below. EURO(non-Euro [, Exchange Rate]) Non-Euro can be any of the following: Text is converted to Euros provided the text represents a number. If the text cannot be converted, the EURO function returns an Argument error. Sterling and US Dollars are converted directly to Euro on a one-to-one basis, unless the exchange rate is specified, in which case non-Euro is divided by exchange rate. Number is converted to Euro by using the number directly as an amount of Euro. Note: For numbers, the same effect can be achieved using the Euro operator (€) to prefix the number. Logical is converted to Euro: FALSE becomes €0, and TRUE €1.00. Exchange Rate is optional and can be any number. The EURO function returns a Euro figure.	The formulas =EURO("€35.99") =EURO(35.99) both give €35.99. The formula =EURO(£266) gives €266. =EURO(£100,0.85) gives €117.65. =EURO(£120, A1) gives €100.00 if A1 contains 1.2. =EURO(£120, rate) gives €100.00 if A1 contains 1.2 and is named 'rate'.
EXP	Returns the natural exponent of a given number. The natural exponent of a number is the mathematical constant e raised to that number EXP(number) Number can be any number. The EXP function returns a positive number.	The formula =EXP(3) gives e cubed, which is 20.0855. Because EXP is the inverse function of LN, the formula =EXP(LN(7)) gives 7.
FACTORIAL	Returns the factorial of a given number. This is equal to 1 multiplied by 2, multiplied by 3, multiplied by ... all the way up to n. Factorial n is sometimes written as n! FACTORIAL(number) Number must be a number. If it is negative, the FACTORIAL function returns an Argument error. The FACTORIAL function returns a number.	The formula =FACTORIAL(3) gives the number 6, which is 1 multiplied by 2 multiplied by 3.

FALSE	Returns the logical FALSE. FALSE The FALSE function requires no arguments. It returns the logical value FALSE.	The formula =IF(FALSE, "Never", "Always") gives the text "Always". The formula =!FALSE gives the logical TRUE.
FIND	Looks in some given text for a smaller piece of text, and returns the position of the piece. You can also specify to start the search some characters into the text, to exclude the prefix. FIND(piece, text[, start at]) Piece and text must be text. If Start at is given, it must be a number, specifying the position in the text to start looking for the piece. If start at is less than 1 or more than the number of characters in the text, the FIND function returns an Argument error. If start at is not a whole number, it will be rounded using the INT function. If Start at is omitted, it is assumed to be 1.	The formula =FIND("man", "Rich man poor man") gives the number 6, because the text "man" first occurs at the sixth character of the text "Rich man poor man". =FIND("man", "Rich man poor man", FIND("man", "Rich man poor man") + 1). gives 15, the position of the second "man" in the text.
FLOOR	Returns the first whole number below a given number. FLOOR(number) Number can be any number, currency figure or percentage. If number is a percentage, it is rounded down to 0%.	If cell B16 contains the number 4.23, then =FLOOR(B16) gives the number 4. =FLOOR(-€35.40) gives the currency -€36.00.

IF	Choose between one of two things, depending on a given condition. For example, suppose a model calculates the costs and chance of losses of a number of different proposed ventures. If your company policy is to always reject proposals that have more than a 5% chance of loss, then a proposal must not contribute any costs or profits to the company if it has more than a 5% chance of loss. IF(test, if true, if false) Test is a logical value, either TRUE or FALSE. If true is the data that IF will return if the test is TRUE. It can be any data class. If false is the data it will return if the test is FALSE. It can be any data class. The IF function returns either if true or if false depending on the test.	If the Bernoulli distribution for a risk's chance of happening is stored in C3 and the Triangular distribution of its impact is in G3, then the risk would be modelled as =IF(C3, G3, 0). Looking at the example to the left, suppose a cell called Chance New Product calculates the chance of loss of the launch of a particular new product. Suppose also that another cell, called Cost New Product, calculates the expected cost of the venture. Then the formula =IF(Chance New Product > 5%, £0, Cost New Product) calculates the expected cost of the venture to the company. The formula gives zero cost if the proposal is rejected, otherwise it gives the expected cost of the proposal. =IF(A1 = "Yellow", 1, 0) gives 1 if A1 contains the text "Yellow" or zero if not. Note that text must be included in double quotes.
INT	Returns the whole part of a given number. The whole part of a number x is the number with the fractional part removed. INT(number) Number can be any number, currency figure or percentage. If number is a percentage, it is treated as a fraction, for example 50% is equal to 0.5. INT therefore returns 0% for percentages between 0 - 99%, and 100% if number is 100%.	If cell B16 contains the number 4.23, then =INT(B16) gives the number 4. =INT(-\$35.40) gives the currency -\$35.00.

INTERPOLATE	Performs linear interpolation between two points. Linear interpolation draws a line between two points, and reads off a third point on the line. For example, suppose you think a project activity will take 9 days and cost £100k, whereas if you spend £300k it will be completed in 5 days. You can use linear interpolation to calculate how long the activity will take if you spend £200k. INTERPOLATE(x, x1, y1, x2, y2) X is the point you want to read off from the line. x1 and y1 give the coordinates of one of the points on the line. x2 and y2 represent the other point.	Using the example above, the formula =INTERPOLATE(£200,£100,9,£300,4) gives the number 6.5. This is how long the activity will take if you spend £200 on it. =INTERPOLATE(150, 100, 9, 300, 5) gives the number 8.
IS_ERROR	Tests whether a function or data is an error. This function is the only function which absorbs error values. All other functions immediately return an error. IS_ERROR(data) Data can be any type of data. The IS_ERROR function returns a logical value TRUE or FALSE.	The formula =IS_ERROR(ERROR(5)) gives TRUE. the formula =IS_ERROR(B16) gives TRUE if the surface slice of cell B16 gives an error, otherwise it gives FALSE.

IS_EURO	Tests whether some data is of Euro currency type. IS_EURO(data) Data can be any data except a range of cells. The IS_EURO function returns a logical value TRUE or FALSE.	The formula =IS_EURO(€46.23) gives TRUE. Whereas the formula =IS_EURO(46.23) gives FALSE because 46.23 is a number. The formula =IS_EURO(B16) gives TRUE if the surface slice of cell B16 gives a Euro value, otherwise it gives FALSE.
IS_LOGICAL	Tests whether some data is of type TRUE or FALSE. IS_LOGICAL(data) Data can be any data except a reference. The IS_LOGICAL function returns a logical value TRUE or FALSE.	The formula =IS_LOGICAL(A1 = B6) gives TRUE, no matter what the cells A1 and B6 contain. The formula =IS_LOGICAL(B16) gives TRUE if the surface slice of cell B16 gives a logical value, otherwise it gives FALSE.
IS_NUMBER	Tests whether some data is a number. IS_NUMBER(data) Data can be any data except a range of cells. The IS_NUMBER function returns a logical value TRUE or FALSE.	The formula =IS_NUMBER(5) gives TRUE. Whereas the formula =IS_NUMBER(£5) gives false because £5 is Sterling data type. =IS_NUMBER(B16) gives TRUE if the surface slice of cell B16 contains a number, otherwise it gives FALSE.

IS_PERCENTAGE	Tests whether some data is a percentage. IS_PERCENTAGE(data) Data can be any data except a reference. The IS_PERCENTAGE function returns a logical value TRUE or FALSE.	The formula =IS_PERCENTAGE(15%) gives TRUE. Whereas the formula =IS_PERCENTAGE(0.15) gives false because 0.15 is a number. The formula =IS_PERCENTAGE(B16) gives TRUE if the surface slice of cell B16 contains a percentage, otherwise it gives FALSE.
IS_STERLING	Tests whether some data is of Sterling currency type. IS_STERLING(data) Data can be any data except a range of cells. The IS_STERLING function returns a logical value TRUE or FALSE.	The formula =IS_STERLING(£5) gives TRUE. Whereas the formula =IS_STERLING(5) gives FALSE because 5 is a number. =IS_STERLING(B16) gives TRUE if the surface slice of cell B16 contains a Sterling value, otherwise it gives FALSE.
IS_TEXT	Tests whether some data is text. IS_TEXT(data) Data can be any data except a range of cells. The IS_TEXT function returns a logical value TRUE or FALSE.	The formula =IS_TEXT("This is text") gives TRUE. Whereas the formula =IS_TEXT(90%) gives FALSE because 90% is a percentage. the formula =IS_TEXT(B16) gives TRUE if the surface slice of cell B16 contains text, otherwise it gives FALSE.

IS_TIME	Tests whether some data is a time. IS_TIME(data) Data can be any data except a range of cells. The IS_TIME function returns a logical value TRUE or FALSE.	The formula =IS_TIME(23/2/94) gives TRUE. Whereas the formula =IS_TIME("23/2/94") gives FALSE because the argument is text. the formula =IS_TIME(B16) gives TRUE if the surface slice of cell B16 gives a time or date, otherwise it gives FALSE.
IS_USDOLLARS	Tests whether some data is of US dollars currency type. IS_USDOLLARS(data) Data can be any data except a range of cells. The IS_USDOLLARS function returns a logical value TRUE or FALSE.	The formula =IS_USDOLLARS(\$46.23) gives TRUE. Whereas the formula =IS_USDOLLARS(46.23) gives FALSE because 46.23 is a number. The formula =IS_USDOLLARS(B16) gives TRUE if the surface slice of cell B16 gives a US dollars value, otherwise it gives FALSE.
LARGE	Returns the kth largest element of a list. LARGE(list, k) List can be any list. Each of its elements must be one of the following: number, date, time, percentage, Euro, Sterling or US dollars. K must be a positive number. If it is not a whole number, it is rounded using the INT function. If k is less than 1 or greater than the number of elements in the list, the LARGE function returns an Argument error. The LARGE function returns an element from the list.	If A1 to A7 contain the numbers 3, 7, 9, 2, 12, 5, 6 Then the formula =LARGE(A1~A7, 1) gives the number 12. And =LARGE(A1~A7, 7) gives the number 2. =LARGE(A1, A2, A3, A4, 3) gives the number 3.

LAST	Returns the last element of a list. LAST(list) List can be any list. Each of its elements must be one of the following: number, date, time, text, percentage, Euro, Sterling or US dollars.	If A1 to A7 contain the numbers 3, 7, 9, 2, 12, 5, 6 Then the formula =LAST(A1~A7) gives the number 6. =LAST(A1, A2, A4, A6) gives the number 5. If cells B2 to B5 contain 99, 22/1/2014, FALSE, "Hello" =LAST(B2~B5) gives the text "Hello".
LEFT	Returns the prefix of some given text. A prefix of text is the front few characters, of a specified length. LEFT(text [, length]) Text is the text you want the prefix of. Length is the length of the prefix you want, and must be a number. If length is negative or zero or more than the length of the text, the LEFT function returns an Argument error. If length is omitted, it is assumed to be 1. The LEFT function returns text.	The formula =LEFT("Prefixes first ...", 6) gives the text "Prefix".
LENGTH	Returns the number of characters in some given text LENGTH(text) Text is the text you want the length of. The LENGTH function returns the number of characters in the text.	The formula =LENGTH("Fore") gives the number 4.
LIMIT	Limits a number between two end-points. LIMIT(x, Low, High) X is the number you want to limit. It can be one of the following: number, currency or percentage. Low and high are the end-points. They must both be the same type of data as x. The LIMIT function returns x if it is between low and high. Otherwise it returns low if x is smaller than low, or high if x is larger than high.	The formula =LIMIT(5, 3, 9) gives the number 5, whereas the formula =LIMIT(1, 3, 9) gives the number 3.

LN	Returns the natural logarithm of a given number. LN(number) Number must be a positive number. If it is zero or negative, the LN function returns an Argument error. The LN function returns a number.	The formula =LN(20.0855) gives the number 3, because e^3 is 20.0855, LN is the inverse function of EXP. The formula =LN(EXP(7)) gives the number 7.
LOG	Returns the logarithm to a given base of a given number. The logarithm is the opposite of the exponent, for which you use the exponentiation operator (^). The exponent of a number's logarithm is equal to the number itself. LOG(number[, base]) Base is the base of the logarithm. If base is omitted, it is assumed to be e, the natural base. Number and base must be positive numbers. If either number or base is zero or negative, the LOG function returns an Argument error. The LOG function returns a number.	The formula =LOG(8, 2) gives the number 3, because 2^3 is 8, because LOG is the inverse function of exponentiation operator (^). The formula =LOG(11^3,11) gives the number 3.
LOG10	Returns the logarithm to base 10 of a given number. LOG10(number) Number must be a positive number. If it is zero or negative, the LOG10 function returns an Argument error. The LOG10 function returns a number.	The formula =LOG10(1000) gives the number 3, because 10^3 is 1000. LOG10 is the inverse of the exponentiation operator (^). The formula =10^LOG10(3) gives the number 3.

LOGICAL	Converts some non-logical data into TRUE or FALSE. TRUE and FALSE are logical values. =LOGICAL(non-logical) Non-logical can be any of the following: Text is converted to a logical value in the same way as Risk Analyser converts logical values entered in the edit bar. If the text cannot be converted, the LOGICAL function returns an Argument error. For currency, percentage, number, zero becomes FALSE and any other figure becomes TRUE. The LOGICAL function returns a logical value.	The formula =LOGICAL("true") gives the logical value TRUE
LOOKUP	Looks for something in a lookup list, and returns the data in the corresponding position in a result list. For example, you may have a column of salespersons' names entered on a sheet, together with another column of each salespersons' sales performance figure last month. You can use the LOOKUP function to look up a salesperson in the list of names, and get that person's performance figure. LOOKUP(look for, lookup list, result list) Look for is the data that is to be found in the lookup list. Lookup list is the list to be searched. Result list is the list to be returned. Lookup list and result list must have the same number of elements, otherwise the LOOKUP function returns an Argument error.	Using the sales example, if the salespersons' names are in cells C1~C25, and the performance figures are in E1~E25, then the formula =LOOKUP("Fred", C1~C25, E1~E25) gives the performance figure corresponding to Fred, as long as his name is in cells C1 to C25.
LOWER	Converts some given text to lower case. LOWER(text) Text can be any text. The LOWER function returns the same text, but with all upper case characters replaced by lower case ones.	The formula =LOWER("MadamImAdam") gives the text "madamimadam".
MAXIMUM	Returns the maximum outcome of a given list of distributions and values. MAXIMUM(list) List is the list of distributions and/or values to be measured. It must be a list of elements of one of the following: currency, percentage, number or time. The MAXIMUM function returns the same data class as the distribution.	=MAXIMUM(2, 6, 4, 2) gives 6. If a cell called Finish Date calculates the finish date of a project, then =MAXIMUM(Finish Date\$) gives the latest possible finishing date of the project.

MEAN	Returns the average value, the mean, of a given distribution. MEAN(distribution) Distribution is the distribution to be measured. It must be a list of elements of one of the following data classes: currency, percentage, number or time. If any of the items in the distribution list are blank or text cells, then these items are skipped and do not contribute to the count of items used in the MEAN calculation. If all of the items in the distribution are blank or text cells, an Argument error is returned.	If cell B16 calculates the profit of a proposed venture, then =MEAN(B16\$) gives the mean profit. =MEAN(1, 2, 3, 4, 5, 6) gives 3.5, the average outcome of rolling a fair dice. =MEAN(1, 2, 3, "hello", 4, 5, 6) also gives 3.5, as the text "hello" is ignored.
MEDIAN	Returns the median outcome (50% point) of a given distribution. MEDIAN(distribution) Distribution is the distribution to be measured. It must be a list of elements of one of the following: currency, percentage, number or time. If the list contains an even number of arguments, the median returns the midpoint between the two numbers in the middle. The MEDIAN function returns the same type of data as the elements of the distribution.	If cell G6 calculates profit, then =MEDIAN(G6\$) gives the profit that you are equally likely to achieve and not achieve. =MEDIAN(11, 13, 2, 17, 5, 7, 3) gives 7, the midpoint. =MEDIAN(A1~A4) where A1 to A4 contain 1, 2, 3, 4 gives 2.5, the midpoint between 2 & 3.
MID	Returns the middle piece of some given text. The middle of text is the middle few characters, of a specified length. MID(text, start at, length) Text is the text you want the middle of. Start at is the position of the first character of the middle piece you want. Length is the length of the middle piece you want, and must be a number. If length is negative or zero, or if (length + start at - 1) is more than the length of the text, the MID function returns an Argument error. The MID function returns text.	The formula =MID("small middle piece", 7, 6) gives the text "middle".

MINIMUM	Returns the minimum outcome of a given distribution. MINIMUM(distribution) Distribution is the distribution to be measured. It must be a list of elements of one of the following: currency, percentage, number or time. The MINIMUM function returns the same type of data as the elements of the distribution.	If a cell called Finish Date calculates the finish date of a project, then =MINIMUM(Finish Date\$) gives the earliest possible finishing date of the project.
MODE	Returns the most likely outcome of a given distribution. MODE(distribution) Distribution is the distribution to be measured. It can be any list, although String values and blank cells are ignored. The MODE function returns the same type of data as the most common element of the distribution. If the distribution is continuous, then the MODE function calculates the mode of the distribution by dividing the range of outcomes of the distribution into equal strips, and finding the strip with the most number of outcomes. It then returns the mid-point of this strip. This is a similar method to that used to draw continuous distribution graphs. A distribution can be continuous only if its outcomes are one of the following: currency, percentage, number or time.	The formula =MODE(3, 5, 4, 2, 6, 5, 1, 2, 6, 2) gives the number 2, because it occurs more times than any of the others.
MODULO	Returns the remainder from dividing a given number by a given divisor. MODULO(number, divisor) Number can be any number. Divisor can be any non-zero number. If divisor is zero, the MODULO function returns an Argument error. The MODULO function returns the remainder after dividing Number by Divisor.	The formula =MODULO(16, 3) gives the number 1 =MODULO(4, -3) gives the number -2.
MSE	Returns the mean standard error of a given distribution. MSE(distribution) Distribution is the distribution to be measured. It must be a list of elements of one of the following: currency, percentage, number or time. The MSE function returns the same type of data as the elements of the distribution, unless they are times, in which case it returns a number of days. If all the elements of the distribution list are exactly the same, the MSE function returns zero.	If cell G6 calculates the profit of a proposed venture, the formula =MSE(G6\$) gives the mean standard error of the profit. As cell G6 calculates more slices, this statistic should get closer and closer to zero.

NEXTWD	Returns the next working day after a given date. NEXTWD(start date, calendar) start date can be any date, possibly including a time portion. Calendar is normally imported from a project planning tool such as Microsoft Project and is defined by a range name. If start date is a working day in the given calendar then start date is returned unaltered, otherwise the next working day in the given calendar is returned. Also, NEXTWD(date, working days per week, first day of weekend) NEXTWD(date) just uses the default simple calendar, i.e. 5 working days per week, weekend sat/sun.	If Standard is a normal 5 day working week, then =NEXTWD(2/11/2008, Standard) gives 03 Nov 08. If your calendar includes holiday exceptions between Christmas Day and New Year's day inclusive then =NEXTWD(24/12/2008, Standard) gives 2 Jan 09. =NEXTWD(3/12/2008 8:30:00, Standard) gives 3 Dec 08 8:30:00.
NOT	Returns TRUE if a given logical argument is FALSE, and vice versa. This is called the logical "not". The same effect can be achieved using the logical "not" operator (!). NOT(data) Data is a logical value. The =NOT function returns a logical value.	The formula =NOT(TRUE) gives the value FALSE.
NUMBER	Converts given data into a number. The way the data is converted depends on the type of data, described below. NUMBER(non-number) Non-number can be any of the following: Text: If the text cannot be converted, the NUMBER function returns zero. Currency: Removes the Pound, Dollar or Euro sign. Percentage: Divides the percentage by 100, so that 55% becomes the number 0.55. Date/time: The date becomes a whole number, which is the number of days since 31st December 1899. The time becomes a fractional number between zero and 1 inclusive, where zero is midnight and 1 is midnight the next day. The whole date number and fractional time number are then added together to give a single number which represents both the date and the time. The NUMBER function only applies to dates from 1/1/1900.	The formulas =NUMBER("2,499.99") =NUMBER(\$2499.99) both give the number 2,499.99. If today's date is 11 Jun 2012 and the time is 1:49pm, then the formula =NUMBER(NOW) gives 41071.5757

	Logical: FALSE becomes 0, and TRUE becomes 1 The NUMBER function returns a number.	
OFFSET	Returns a reference to a cell range of specified position, width and height. OFFSET(array, column offset, row offset [, width][, height]) Array is the reference to use as a starting point. It must be a reference i.e. a cell reference, range reference or a defined name. Column offset specifies the number of columns you want to offset the array by. It can be any number. A positive column offset means to the right, and a negative one means to the left. Row offset specifies the number of rows you want to offset the array by. It can be any number. A positive row offset means down, and a negative one means up. Width specifies how many columns you want the reference to have. It must be a positive number, otherwise the OFFSET function returns an Argument error. If it is omitted, it is assumed to be the width of the array. Height specifies how many rows you want the reference to have. It must be a positive number, otherwise the OFFSET function returns an Argument error. If it is omitted, it is assumed to be the height of the array. If any of column offset, row offset, width or height are not whole numbers, they are rounded using the INT function. The OFFSET function returns a reference.	The formula =OFFSET(C5~E7, 0, 1) gives the reference C6~E8. The formula =SUM(OFFSET(B9, 3, 4, 2, 2)) gives the sum of values contained in cells E13~F14.

OR	Returns TRUE if one or more given logical values are TRUE. This is called the logical "or". For example, if you have seven cells which calculate whether it rained on respective days of a week, then the logical "or" of the seven cells calculates whether it rained at all. The same effect can be achieved using the logical "or" operator (). OR(logical 1, logical 2, ...) Each logical is a list of logical values. The OR function returns a logical value.	The formula =OR(FALSE, TRUE, FALSE, TRUE) gives TRUE, whereas the formula =OR(FALSE, FALSE, FALSE, FALSE) gives FALSE. If the seven cells D1 to D7 calculate whether it rained on each respective day of the week, then the formula =OR(D1~D7) gives TRUE if it rained at all, otherwise it gives FALSE. The formula =OR(B17\$) gives TRUE if any of B17's slices are TRUE, otherwise it gives FALSE.
ORDINAL	Chooses a given element from a list. ORDINAL(ordinal, list) Ordinal must be a positive number indicating which element of the list is to be chosen. If ordinal is not a whole number, it is rounded using the INT function. List can be any list. The ORDINAL function returns one of the elements of the list.	The formula =ORDINAL(50,B5\$) gives the 50th slice of cell B5.

PERCENTAGE	Converts some non-percentage data into a percentage. The way the data is converted depends on the class of the data, described below. PERCENTAGE(non-percentage) Non-percentage can be any of the following: Text is converted to a percentage in the same way as Risk Analyser converts percentages entered in the edit bar. If the text cannot be converted, the PERCENTAGE function returns an Argument error. Number is converted to a percentage by multiplying the number by 100, so that 0.53 becomes 53%. For logical values, FALSE becomes 0% and TRUE becomes 100%. The PERCENTAGE function returns a percentage.	The formulas =PERCENTAGE("56%") =PERCENTAGE(0.56) each give 56%.
The percentage operator (%)	Converts a number into a percentage. number% Number must be a number. The percentage operator returns a percentage. It does not convert numbers in the same way as the PERCENTAGE function. Note. When adding or subtracting percentages from a number other than a percentage, the result is that given by the percentage key on a calculator. For example, =£200 - 50% gives £100, =\$500 + 10% gives \$550 and =666 - 100% gives 0. But note that 20% + 50% gives 70% (simple addition) not 30%.	The formula =55% gives 55%. If cell C6 contains the number 25, then the formula =C6% gives 25%. =PERCENTAGE(0.56) gives 56% while =0.56% is simply 0.56%
PI	Returns the mathematical constant PI. PI() The PI function returns a number.	The formula =PI() gives the number 3.142.

PREVWD	Returns the previous working day before a given date. PREVWD(start date [, calendar]) Start date can be any date, possibly including a time portion. Calendar is normally imported from a project planning tool such as Microsoft Project and is defined by a range name. If calendar is omitted, a working week of Monday to Friday with working times of 9am to 5pm is assumed. If the start date is a working day in the given calendar then it is returned unaltered, otherwise the previous working day in the given calendar is returned. Alternatively: PREVWD(date, working days per week, first day of weekend)	If Standard is a normal 5 day working week Then =PREVWD(2/11/2008, Standard) gives 31 Oct 08. If your calendar includes holiday exceptions between Christmas Day and New Year's day inclusive: =PREVWD(2/1/2009) gives 24 Dec 2008. =PREVWD(3/1/2009 18:30:00, Standard) gives 3 Jan 09 8:30:00, since 18:30 is after the end of the working day.
PRODUCT	Returns the product of many given numbers. PRODUCT(number [, number]) Number can be any number. If any of the numbers are blank cells, the PRODUCT function skips over these cells; It only treats them as zero if all of the numbers are blank cells.	The formula =PRODUCT(1, 2, 3) gives 6 If B6 contains the number 10 =PRODUCT(1, 2, 3, B6) gives 60.
PROPER	Converts some given text to proper case, (lower case except first letters). PROPER(text) Text can be any text. The PROPER function returns the same text, but with first letters of words changed to upper case.	The formula =PROPER("madam i'm adam") gives the text "Madam I'm Adam".
RANGE	Returns the range of a given distribution. RANGE(distribution) Distribution is the distribution to be measured. It can be a list of elements of one of the following: currency, percentage, number or time. The RANGE function returns the same type of data as the elements of the distribution, unless they are times, in which case it returns a number of days.	If a cell called Finish Date calculates the finish date of a project, then =RANGE(Finish Date\$) gives the difference between the earliest and the latest possible finishing date of the project.

REPEAT	Returns a number of repetitions of a piece of given data. REPEAT(data, repetitions) Data can be text or a number that you want repeated. Repetitions is the number of repetitions you want. It must be a positive number, otherwise the REPEAT function returns an Argument error. If repetitions is not a whole number, it is rounded using the INT function. The REPEAT function returns text.	The formula =REPEAT("I'm glad that you're glad that ", 3) + "I'm glad." gives the text "I'm glad that you're glad that I'm glad that you're glad that I'm glad that you're glad that I'm glad." =REPEAT(123, 2) gives the text "123123".
REPLACE	Removes the middle piece of some given text, and replaces it with a new piece. The middle of text is the middle few characters, of a specified length. REPLACE(text, start at, length, new piece) Text is the text whose middle you want to replace. Start at is the position of the first character of the middle piece you want to replace. Length is the length of the middle piece you want, and must be a number. If length is negative or zero, or if (length + start at - 1) is more than the length of the text, the REPLACE function returns an Argument error. The REPLACE function returns text.	The formula =REPLACE("small middle piece", 7, 6, "green") gives the text "small green piece".
RIGHT	Returns the suffix of some given text. A suffix of text is the last few characters, of a specified length. RIGHT(text [, length]) Text is the text you want the suffix of. Length is the length of the suffix you want, and must be a number. If length is negative or zero or more than the length of the text, the RIGHT function returns an Argument error. If length is omitted, it is assumed to be 1. The RIGHT function returns text.	The formula =RIGHT("...then the suffix", 6) gives the text "suffix".

ROUND	Returns a number rounded to a given number of decimal places. ROUND(number [, places]) Number can be one of the following data types: number, currency and percentage. If number is a percentage, it is rounded up/down to 100%/0%. Places must be a number. If places is positive, the number is rounded to that number of decimal places. If places is zero, the number is rounded to the nearest whole number. If places is negative, the number is rounded to multiples of 10. If places is omitted, it is assumed to be zero. If places is not a whole number, it is rounded using the INT function. If the number is a time, places must be zero or omitted, otherwise the ROUND function returns an error.	The formula =ROUND(4.23, 1) gives 4.2 =ROUND(£24634.78, -3) gives £25,000.
ROW	Returns the row number of a given cell. ROW(cell) Cell is a reference. It can be a name or cell reference. If cell refers to a range, only the top left cell of the range is considered. The ROW function returns a number between 1 and 9,999 inclusive.	=ROW(D6) gives the number 6, which is the row number of row 6.
ROWS	Returns the number of rows of a given reference. ROWS(array) Array is a list. The ROWS function returns a number between 1 and 65500 inclusive.	=ROWS(B7~G25) gives the number 19.
SIGN	Returns the sign of a given number. The sign is -1 if the number is less than zero, 1 if it is greater than zero, and 0 if the number is 0. SIGN(number) Number can be any number.	If B15 contains 17.5, then the formula =SIGN(B15) gives the number 1 =SIGN(-£35) gives the number -1.

SIN	Returns the sine of a given angle. SIN(angle) Angle can be any angle. The SIN function returns a number between -1 and 1 inclusive. Note: All angles in Predict! Risk Analyser are shown in radians, and must be entered as radians. To convert degrees to radians, multiply by pi / 180.	The formula =SIN(PI()) gives 0 =SIN(30 * PI() / 180) gives 0.5.
SINH	Returns the hyperbolic sine of the given number. SINH(number) Number can be any number. The SINH function returns a number.	The formula =SINH(5) gives approximately 74.203 =SINH(ASINH(2)) gives 2 because the SINH function is the inverse of the ASINH function.
SMALL	Returns the kth smallest element of a list. SMALL(list, k) List can be any list. Each of its elements must be one of the following: number, date, time, percentage, Euro, Sterling or US dollars. K must be a positive number. If it is not a whole number, it is rounded using the INT function. If k is less than 1 or greater than the number of elements in the list, the SMALL function returns an Argument error.	If A1 to A7 contain the numbers 3, 7, 9, 2, 12, 5, 6 then the formula =SMALL(A1~A7, 1) gives the number 2. And =SMALL(A1~A7, 7) gives the number 12.
SQRT	Returns the square root of any given number. SQRT(number) Number can be any non-negative number. If number is less than zero, the SQRT function returns an Argument error.	The formula =SQRT(9) gives 3.

STERLING	Converts some non-Sterling data into Sterling. The way the data is converted depends on the type of the data, described below. STERLING(non-Sterling [, exchange rate]) Non-Sterling can be any of the following: Text is converted to Sterling provided the text represents a number. If the text cannot be converted, the STERLING function returns an Argument error. Euro and US dollars are converted directly to Sterling on a one-to-one basis, unless the exchange rate is specified, in which case non-Sterling is divided by the exchange rate. Number is converted to Sterling by using the number directly as an amount of Sterling. Note: For numbers, the same effect can be achieved using the Sterling operator (£) to prefix the number. Logical is converted to Sterling: FALSE becomes £0, and TRUE £1.00. Exchange rate is optional and can be any number. The STERLING function returns a Sterling figure.	The formulas =STERLING("\$35.99") =STERLING(35.99) both give £35.99. The formula =STERLING(€266) gives £266. =STERLING(\$300, 1.5) gives £200. =STERLING(\$300, A1) gives £200 if A1 contains 1.5. =STERLING(\$300, rate) gives £200 if A1 contains 1.5 and is named 'rate'.
SUM	Returns the sum of many given numbers. SUM(number 1, number 2, ...) Each number is a list of one of the following data types: number, currency or percentage. If any elements of any of the number lists are text, they are treated as zeros.	=SUM(2, 4, 5, B7) gives 11 plus the figure in cell B7. =SUM(D10~D20, F10~F20) gives the sum of all the figures in cells D10~D20 and cells F10~F20.

TAN	Returns the tangent of a given angle. TAN(angle) Angle can be any angle. The TAN function returns a number. If the angle is 90 degrees (or $90 * \pi / 180$ radians), the TAN function returns the same as the INFINITY function. If the angle is 270 degrees, the TAN function returns the same as the -INFINITY function. Note: All angles in Predict! Risk Analyser are shown in radians, and must be entered as radians. To convert degrees to radians, multiply by $\pi / 180$.	The formula =TAN(30 * PI() / 180) gives 0.577.
TEXT	Converts some non-text data into text. The way the data is converted depends on the type of data, described below. TEXT(non-text) Non-text can be any type of data apart from an error value. The TEXT function returns text. The data is converted in the same way as Risk Analyser shows the data in a cell formatted with the Normal style.	The formula =TEXT(£3499.99) gives the text "£3,499.99" =TEXT(\$3499.99) gives the text "\$3,499.99" =TEXT(56%) gives the text "56%" =TEXT(FALSE) gives the text "FALSE" =TEXT(A1) gives the textual representation of the data in cell A1. The above assumes that the Normal style has not been changed since Risk Analyser was installed.
TRIM	Trims spaces from some given text. Trimming spaces involves removing spaces from the beginning and the end of the text, and replacing all multiple spaces in the text with single spaces. TRIM(text) Text can be any text. The TRIM function returns text.	The formula =TRIM(" many many spaces ") gives the text "many many spaces".

TRUE	Returns the logical value TRUE. TRUE The TRUE function requires no arguments. It returns the logical value TRUE.	The formula =IF(TRUE, "Always", "Never") gives the text "Always". The formula =!TRUE gives the logical FALSE.
UPPER	Converts some given text to upper case. UPPER(text) Text can be any text. The UPPER function returns the same text, but with lower case letters replaced by upper case ones.	The formula =UPPER("MadamImAdam") gives the text "MADAMIMADAM".
USDOLLARS	Converts some non-US dollars data into US dollars. The way the data is converted depends on the type of the data, described below. USDOLLARS(non-US dollars [, exchange rate]) Non-US dollars can be any of the following: Text is converted to US dollars provided the text represents a number. If the text cannot be converted, the USDOLLARS function returns an Argument error. Euro and Sterling are converted directly to US dollars on a one-to-one basis, unless the exchange rate is specified, in which case non-US dollars is divided by the exchange rate. Number is converted to US dollars by using the number directly as an amount of US dollars. Note: For numbers, the same effect can be achieved using the US Dollars operator (\$) to prefix the number. Logical is converted to US dollars: FALSE becomes \$0, and TRUE \$1.00. Exchange rate is optional and can be any number. The USDOLLARS function returns a US dollars figure.	The formulas =USDOLLARS("\$35.99") =USDOLLARS(35.99) both give \$35.99. The formula =USDOLLARS(£266) gives \$266. =USDOLLARS(£200,A1), where A1 contains =2/3. gives \$300. =USDOLLARS(£200,rate) gives \$300, where A1 contains =2/3 and is named 'rate'.

VARIANCE	Returns the variance of a given distribution. This function assumes that the samples in the distribution are merely samples, and that they do not include every possible outcome of the distribution. VARIANCE(distribution) Distribution is the distribution to be measured. It must be a list of elements of one of the following: currency, percentage, number or time. The VARIANCE function returns the same type of data as the elements of the distribution, unless they are times, in which case it returns a number of days. If all the elements of the distribution list are exactly the same, the VARIANCE function returns zero.	If cell G6 calculates the profit of a proposed venture, the formula =VARIANCE(G6\$) gives the variance of the profit.
WORKDATE	Returns the date which is a given number of working days after a given date. WORKDATE(start date, working days [, days per week [, start of weekend [, as late as possible]]]) or WORKDATE(start date, working days [, calendar [, as late as possible]]) Start date can be any date. If no time is given, midnight (00:00:00) is assumed. Working Days can be any number. This number can be negative to represent an activity that starts before the Start Date. Days per week is the number of working days per week. It can be any number between 1 and 7 inclusive, otherwise it returns an Argument error. If it is not a whole number, it is rounded using the INT function. If it is omitted, it is assumed to be 5. Start of weekend is a number representing the first day of the weekend (where Sunday is 0,	6th October 2014 is a Monday, and Standard is a 5 day, Monday to Friday working week calendar, so: =WORKING_DAYS(06/10/2014 09:00, 6) and =WORKING_DAYS(06/10/2014 09:00, 6, Standard) and =WORKING_DAYS(06/10/2014 09:00, 6, 5, 6) all return Monday, 13th October 2014 at 5PM. However, if FourDayWeek is a 4 working day, Monday to Thursday calendar: =WORKING_DAYS(06/10/2014 09:00, 6, FourDayWeek) and =WORKING_DAYS(06/10/2014 09:00, 6, 4, 6) both return Tuesday 14th October 2014 at 5PM.

	Monday 1, etc). It must be a number between 0 and 6 inclusive, otherwise the WORKDATE function returns an Argument error. If it is not a whole number, it is rounded using the INT function. If it is omitted, it is assumed to be Saturday (6). As late as possible can be TRUE or FALSE. If FALSE the workdate will be taken as early as possible, i.e. 5pm on end date; if TRUE the workdate will be taken as late as possible, i.e. 9am on the next working day after the end date. If omitted, this argument is assumed to be FALSE. Calendar is the calendar to be used. A calendar is used in cases when a standard working week is frequently affected by holidays or irregularities. If neither calendar nor days per week and start of weekend are provided, then a standard 5 day week (Monday to Friday, 9am-5pm) is used. The WORKDATE function returns a date.	
WORKING_DAYS	Returns the number of working days between two given dates. WORKING_DAYS(start date, end date[, calendar]) or WORKING_DAYS(start date, end date[, days per week, start of weekend]) Start date can be any date. If no time is given, midnight (00:00:00) is assumed. End date can be any date; if it is earlier than start date, the WORKING_DAYS function returns a negative number. If no time is given, midnight (00:00:00) is assumed. Calendar is the calendar to be used. A calendar is used in cases	30th May 2013 is a Thursday, and Standard is a Mon-Fri working week calendar, so =WORKING_DAYS(30/5/2013, 5/6/2013) and =WORKING_DAYS(30/5/2013, 5/6/2013, Standard) =WORKING_DAYS(30/5/2013, 5/6/2013, 5, 6) all give 4. Whereas =WORKING_DAYS(30/5/2013, 5/6/2013, FourDayWeek) where the working week is Monday to Thursday with the calendar named FourDayWeek gives 3.

	when a standard working week is frequently affected by holidays or irregularities. Days per week is the number of working days per week. It can be any number between 1 and 7 inclusive, otherwise it returns an Argument error. If it is not a whole number, it is rounded using the INT function. If it is omitted, it is assumed to be 5. Start of weekend is a number representing the first day of the weekend (where Sunday is 0, Monday 1, etc). It must be a number between 0 and 6 inclusive, otherwise the WORKDATE function returns an Argument error. If it is not a whole number, it is rounded using the INT function. If it is omitted, it is assumed to be Saturday (6). If neither calendar, or days per week and start of weekend are provided, then a standard 5 day week (Monday to Friday, 9am-5pm) is used. The WORKING_DAYS function returns the number of working days, including partial days, between start date and end date inclusive.	
XOR	Returns TRUE if one or more (but not all) given logical values are TRUE. This is called the logical "exclusive or". XOR(logical1, logical2, ...) Each logical is a list of logical values. The XOR function returns a logical value.	The formulas =XOR(TRUE, TRUE, TRUE, TRUE) =XOR(FALSE, FALSE, FALSE, FALSE) both give FALSE, whereas the formula =XOR(FALSE, TRUE, FALSE, TRUE) gives TRUE.

8. Appendix. User Defined Fields in Primavera

In order to transfer data such as 3-point estimates of duration and cost, risk probability, and correlations from Primavera to Risk Controller or Risk Analyser, you will need to define some User Defined Fields in your Primavera projects.

To create User Defined Fields, in Primavera, navigate to Enterprise -> User Defined Fields...

Click 'Add' to add a new column. Change the 'Title' and 'Data Type' according to the tables below:

Fields for writing data to Predict!

Risk Controller and Risk Analyser require eight fields to be defined within Primavera to receive 3-point estimates of cost and duration, risk probabilities and correlations from projects in the Primavera database:

Name Name	Type Type	Purpose Purpose
RDL_MinDuration	Numeric	Minimum expected duration of the task
RDL_MLDuration	Numeric	Most Likely duration of the task
RDL_MaxDuration	Numeric	Maximum expected duration of the task
RDL_MinFixedCost	Numeric	Minimum expected cost of the task
RDL_MLFixedCost	Numeric	Most Likely cost of the task
RDL_MaxFixedCost	Numeric	Maximum expected cost of the task
RDL_Correlation	Text	Activity Id of a task to be correlated with, and the correlation coefficient, in the format: ActivityID[coefficient]
RDL_RiskProbability	Text	If the activity is a risk, the probability of occurrence, otherwise blank

WARNING: If the above fields for 3-point estimates of duration are not defined then the Primavera Activity remaining duration will be used instead. If the fields for 3-point estimates of fixed cost are not defined then a fixed cost of zero will be assumed.