Full Monte™ — The better approach to Schedule Risk Analysis

Full Monte™

Full Monte SRA User Guide

BARBECANA

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FOREWORD

Most project management software products implement a technique called Critical Path Methodology (CPM). This includes popular tools such as Microsoft Project™, Oracle Primavera™, and Deltek Open Plan™. The problem with the Critical Path Methodology is that it gives users a single-point estimate of when projects will be complete. This single, deterministic, estimate will not only most likely be wrong but in fact tends to be overly optimistic, often resulting in projects being delivered late and over budget compared to the 'plan'.

By including information related to estimate uncertainty and the potential impact of threats and opportunities, we can enhance the CPM model to provide insight into how these uncertainties interact and produce a range of completion estimates with associated levels of confidence.

These types of enhancements are called 'Quantitative Risk Assessment' or 'Schedule Risk Analysis'.

Barbecana's Full Monte™ addresses the issue of cost and schedule risk analysis by replacing single-point estimates with probability distributions and using Monte Carlo simulation to provide a much more realistic assessment of likely project outcomes.

We have strived to make the product powerful and flexible while retaining ease of use for all levels of schedule maturity. We hope you enjoy using the software as much as we have enjoyed creating it.

Comments, suggestions, and feedback are always welcome, so please feel free to contact us.

Thank you for choosing Full Monte to help improve your chance of delivering a successful project.

Tony Welsh, Founder

Chapter 1: Getting Started

1.1 User Guide Introduction

This user guide is for Full Monte SRA version 3.7 (3.724128.x or later). Where functionality varies between Full Monte for Microsoft Project and Full Monte for Oracle Primavera P6, it is noted in each section. Please see the Release Note for details of changes/updates between versions.

IMPORTANT: Some information, that is only pertinent to a specific edition of Full Monte (Microsoft Project or Primavera P6), can also be found in the relevant product **Installation Guide**. For example, instructions for saving Full Monte results to Microsoft Project Custom Fields or P6 User-Defined Fields will be found in the appropriate **installation** guide.

1.2 Supported Environments

Please see the relevant Full Monte installation guide or visit our web site support pages for details of supported environments.

1.3 Installation and Configuration

Please refer to the specific installation and configuration guide for the version of Full Monte appropriate to your scheduling tool. **Microsoft Project** users are recommended to read the **Field Mapping** and **Import/Export** sections of the **Full Monte for Microsoft Project Installation Guide**.

1.4 Data Migration from Earlier Versions of Full Monte

Please see the data migration appendix in the installation guide for the version of Full Monte appropriate to your scheduling tool.

1.5 Terminology

Different scheduling tools use different terminology to describe components of a Project. For example, the basic element used to describe work needing to be performed in Microsoft Project is a 'Task' while in Oracle Primavera P6 the same basic element is called an 'Activity'.

Microsoft Project	Oracle Primavera P6
Task	Activity
Slack	Float
Free Slack	Free Float

While the Full Monte application and the Full Monte on-line help adapt to the terminology of your scheduling tool and the installation guides use product specific terminology, the Full Monte User Guide itself (this document) cannot adapt to your specific scheduling solution.

NOTE: There may be some variation in the guide regarding the use of task vs activity depending on the product version used to capture specific screenshots.

Chapter 2: Opening a Project

The exact mechanism to open a project in Full Monte depends on the underlying scheduling tool.

2.1 Full Monte for Microsoft Project

Full Monte for Microsoft Project integrates into the Microsoft Project menu structure and Full Monte itself operates against data opened in Microsoft Project. Therefore, to work on a specific project, just open the project as normal with Microsoft Project either from local files or from Microsoft Project Server (if available).

The data used by Full Monte for Microsoft Project is stored in Microsoft Project custom fields. The user can control which custom fields are utilized using the Field Mapping dialog. For complete information on **Field Mapping** please see the **Full Monte for Microsoft Project installation guide.**

With Microsoft Project, menu items for Full Monte SRA and for the Full Monte Administration options will be added to the ADD-INS menu ribbon as shown in figure 2.2.

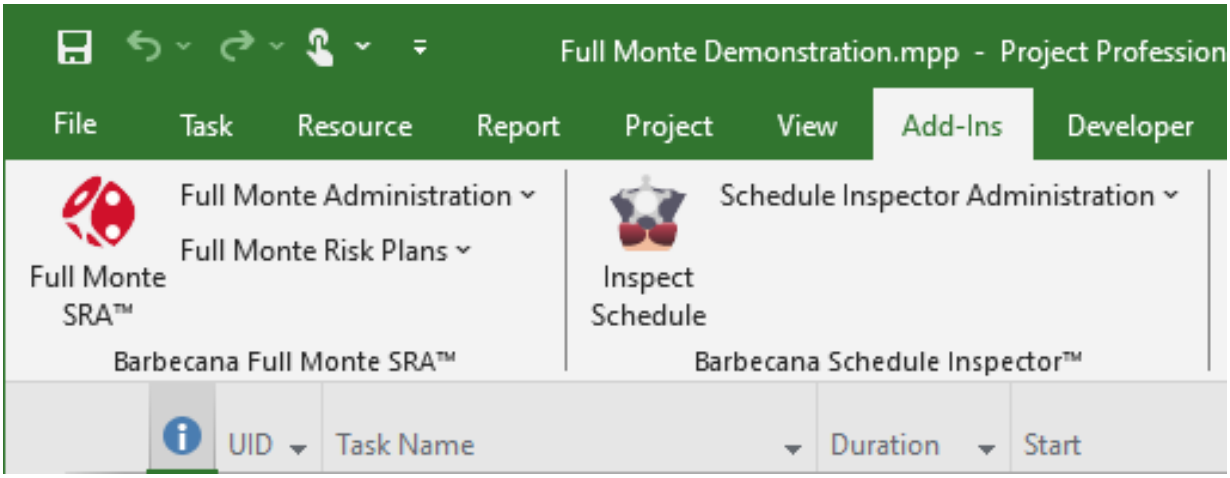


Figure 2.2

Clicking the Full Monte SRA dice icon will launch Full Monte and display the project currently opened in Microsoft Project in the Full Monte Activity Task Edit view, described in Chapter 4.

2.1.1 Full Monte for Microsoft Project Log Messages

When a project is opened in Full Monte, any potential issues found by Full Monte will be written to a log file. If issues are encountered, the user will be prompted to review the log as shown in Figure 2.3.

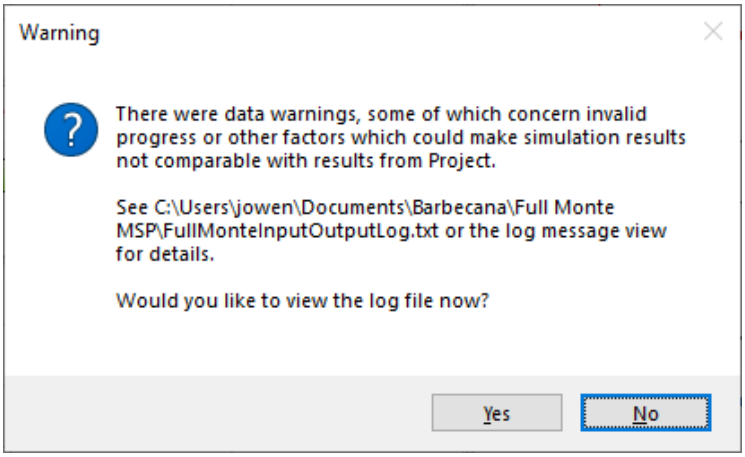


Figure 2.3

Selecting **Yes** will display the log as shown in Figure 2.4.

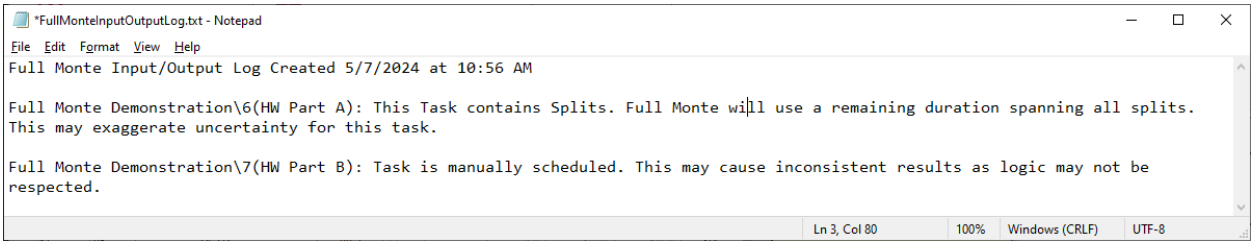


Figure 2.4

As noted in the message in Figure 2.3, the log messages are saved to a file called FullMonteInputOutputLog.txt in the folder <Documents>\Barbecana\Full Monte MSP.

Log Messages can include:

Task is manually scheduled. This may cause inconsistent results as logic may not be respected.

The task Scheduling Mode is set to 'Manually Scheduled'. This is a poor practice and can prevent schedules from being properly logic driven and would invalidate schedule risk analysis results. Full Monte will try to replicate the manually schedule results using a Fixed constraint date.

Task contains Splits that are not supported by Full Monte and will be ignored, resulting in an earlier finish.

A task contains manually entered 'Splits'. These introduce a manual delay or split in the task duration. Full Monte will ignore the splits which will cause the task to finish earlier in Full Monte.

Task Inactive flag is inconsistent with Probability of Existence

If the task is marked as Inactive in Microsoft Project, the Probability of Existence is not 0 (zero) or if the task is marked as Active in Microsoft Project the Probability of Existence is set to 0 (zero). This may be intentional and if so, the warning can be ignored.

Task started but <Constraint Type> predecessor <Task Name> has not finished

A successor task has been started before a logical predecessor is completed. This may be intentional and if so, the warning can be ignored.

Task finished but <Constraint Type> predecessor <Task Name> has not finished

A successor task has finished before a logical Finish-Finish or Start-Finish predecessor has finished. This may be intentional and if so, the warning can be ignored.

Actual start is set but % complete is 0

The task has an Actual Start date but the task Percent Complete is 0 (zero). This is a warning.

% complete is greater than 0 but actual start is not set

The task Percent Complete is greater than 0 (zero) but the task Actual Start date is not set. This is a warning.

Actual finish is set but % complete is less than 100

The task Actual Finish date is set but the task Percent Complete is not 100. Full Monte will treat the task as complete. This is a warning.

% complete is 100 but actual finish is not set

The task Percent Complete is set to 100 but the task Actual Finish date is not set. Full Monte will treat the task as complete. This is a warning.

2.2 Full Monte for Oracle Primavera

After logging in, the first view you will see is the Project view, shown in figure 2.5. For more information regarding configuring data sources and logging in please see the Full Monte for Primavera P6 Installation guide.

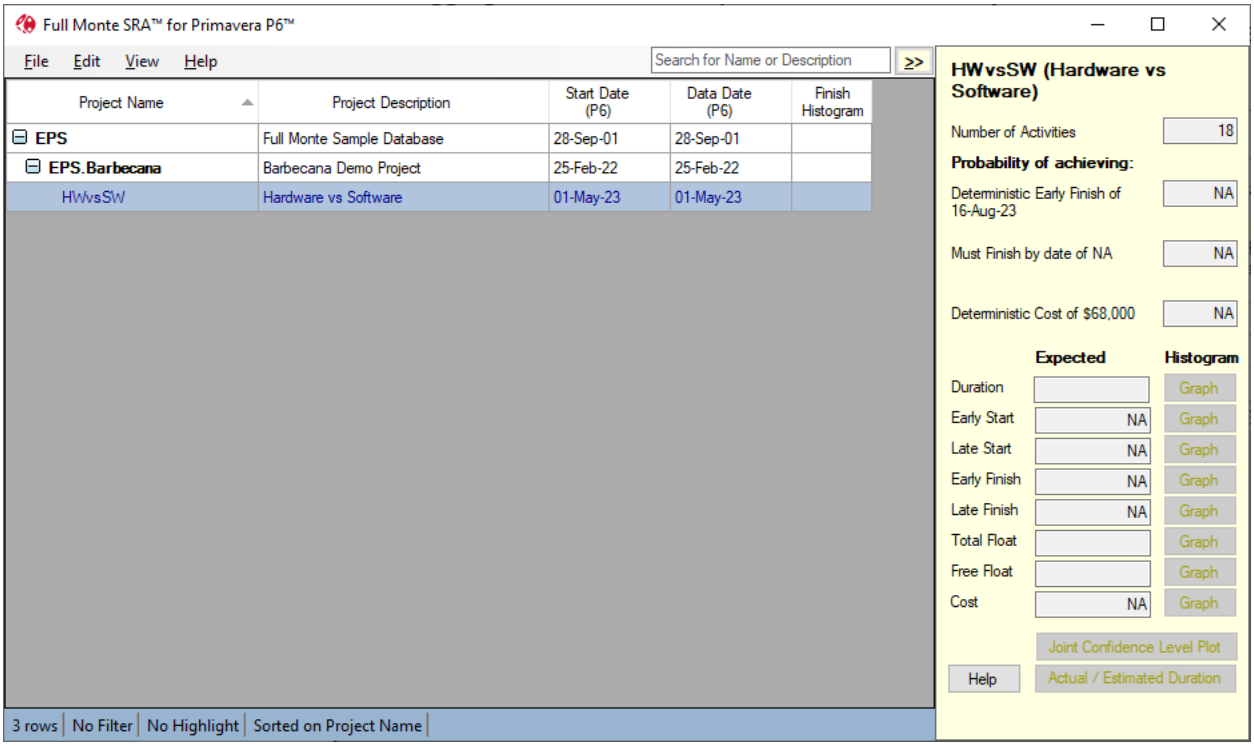


Figure 2.5

By default, projects are shown in a hierarchy. The view remembers the last project accessed by the user and highlights it, expanding the hierarchy just enough to show this project.

NOTE: There are many options to customize the view. Since these are common to all views, they are discussed in the next chapter.

You can highlight a different project by expanding the hierarchy, scrolling up and down, etc. Or you can start typing its name in the Find box at the top right. This will look for matches on either the name or description, highlighting the first match after expanding and scrolling as necessary to make it visible.

NOTE: You will not see projects to which you do not have rights in P6 unless they are necessary to indicate the hierarchical position of projects to which you do have rights, and then only the project ID will be displayed.

The panel to the right gives more information about the highlighted project. Most of these are Full Monte results that will be blank unless you have performed risk analysis on the project in question. The **Graph** buttons give access to histograms and S-curves of key dates etc., discussed further in Chapter 9.

NOTE: The panel can be shown (**<<**) or hidden (**>>**) by clicking on the chevron button located at the top right of the display.

The **Joint Confidence Level** and **Actual/Estimated Duration** buttons give access to special graphics discussed in Chapters 11 and 12, respectively.

Once the project you want to open is highlighted, you can open it by pressing **Enter**. If it is visible but not highlighted, you can double-click on it.

This will take you to the Full Monte Activity Edit view, described in Chapter 4.

Chapter 3: Tabular Views

3.1 Common View Components

The main component of the Full Monte interface is a series of spreadsheet-style views accessible from the primary Task/Activity Edit view which is displayed when a project is first opened.

From the Edit menu on the Task/Activity Edit view, you can open either the Calendar Edit view [P6 version only] or the Resource Edit view, but not both at the same time.

From the View menu on any tabular view, you can open other user-definable read-only views (reports) known as "named views". You can also control aspects of the current view (Filters, Highlights, Sorts etc.) from the View menu.)

There are several customization capabilities common to all views, including the following.

Right-click on a column heading to:

- **Find in Column** – Search for a row containing the specified number or text.
- **Find Again (F3)** - Only available if a Find in Column has been performed. Find the next occurrence of the specified number or text.
- **Delete Column** – Remove the column from the current view
- **Insert Column (before)** – Add a new column before (to the left of) the current column
- **Add Column (after**) – Add a new column after (to the right of) the current column
- **Freeze Column** - (and those columns to its left) so that they do not scroll horizontally
- **Resize Column to Fit Data** – Adjust the column width to show all data in the column
- **Resize Column to Fit Window** – Adjust the column width to either expand it to use any available remaining free space in the current Window or contract the column width in an attempt to show more columns in the available Window.
- **Edit Bar Chart Column…** - Only available if the column contains a Bar Chart. This is described in Chapter 13.
- **Do Full Analysis for All Bars** – Only available for Bar Chart columns in a Tornado view. This is described in Chapter 10.

You can also change the order of the columns by dragging the column heading. Note that you cannot drag a frozen column into the unfrozen area or vice versa.

The **File** menu varies slightly between views, but in all cases it includes the ability to:

- **Copy to clipboard**, copies the visible portion of the view (including text and graphics) to the Windows clipboard for pasting as graphics into applications like Microsoft Word or PowerPoint.
- **Copy to CSV file**, copies the tabular portion of a view to a Comma Separated Values (CSV) text file that can be opened in spreadsheet or database applications.
- **Print,** prints the current view

- **Print Preview,** generates a print ready preview including headers and footers.
- **Edit Header/Footer for Printed Reports,** specifies Headers and Footers for printed reports. Note that each view has its own Header/Footer settings.

The main Edit View (displayed when a project is opened) has the following **Edit** menu options:

- **Select All**, select all activities (taking into account any filter currently applied)
- **Apply Template**, Apply uncertainty/correlation information from the specified template to the selected activities.
- **Inherit Distribution**, reset the selected activities to inherit duration distribution information from higher level summary rows.
- **Inherit Correlations**, reset the selected activities to inherit correlation information from higher level summary rows.
- **Edit Resources,** open a view to edit resource rate uncertainty information.
- **Edit Calendars (P6 Only),** open a view to edit working calendar uncertainty information.
- **Manage Field Mappings (MS Project Only),** open a dialog to define which Microsoft Project custom fields are used to store Full Monte data. See the Full Monte for Microsoft Project Installation Guide for complete details of this function.
- **Manage Filters,** define, edit, and delete custom view filters. Filters are used to both define what activities are included in views and to control highlighting.
- **Manage Percentiles,** while Full Monte automatically calculates common percentile confidence values/dates, additional percentile values can be added/removed as necessary.
- **Manage Risks,** A list of specific risks/threats can be maintained together with their probability of occurrence. These can be applied to one or more activities to control the probability of existence for the relevant activities.
- **Manage Templates,** Uncertainty templates for both duration and correlation can be defined and managed.
- **Manage Views,** delete or rename modified system views or user defined custom views.

The following additional options are accessible from the **View** menu:

- For pre-defined system views, **Reset** the current view to the system default.
- Switch the **Observe Hierarchy** option on and off (when it is on you can expand and collapse individual rows by clicking on the + or - symbol in the ID column).
- If the hierarchy is on, **Expand** or **Collapse** all.
- Apply a **Natural ID Sort** (P6 only) for the numeric component of Activity ID's.
- Control **Filters**, **Highlighting**, and **Sorting.**
- Change the **Date Format.**
- Change the units used to display **Durations.**
- Resize all columns to fit the displayed data.

All views have a **Find** capability accessed from the text box at the top right, which finds matches of the entered text either in the ID or Name columns.

Note: The Find capability searches left to right in the ID or Name columns. It will not find partial matches **within** a column. For partial matches within a column use the column right-click context menu to find within a column.

All views also have a docked pane to the right. This can be displayed or hidden using the chevron control (<< or >>) at the top right. When displayed, it shows additional information about the highlighted row in the grid.

The editing views allow editing of Full Monte data in the docked pane. Most of this data can also be edited in the spreadsheet itself. Details of the editing operation depend on the view and are dealt with in the following chapters.

NOTE: Full Monte allows editing only of its own risk analysis data. No underlying schedule data is ever changed by Full Monte.

A **Status Bar** is displayed at the bottom of all views and provides information regarding:

- The number of rows currently displayed in the view.
- The name of any applied **Filter** (and the number of rows included by the filter)
- The name of any filter being used to define row **Highlighting** (and the number of rows currently highlighted).
- Any applied **Sort**.
- The status of simulation data and selected sensitivity targets (Only if space is available. If necessary, make the Window wider or close the edit pane to see all the status bar text).

NOTE: If the 'sorted on' information in the Status Bar end with 'etc.', hover the mouse over the text to see the full sort information. If the 'Simulations' status says 'Risk Analysis Required' then some input data has been changed since the last analysis was performed.

3.2 Filters

Filters are used to select which tasks are displayed in a view. Different views can have different filters applied.

Filters can be managed (created, edited, deleted) by selecting Manage Filters from the Edit Menu on the main Task/Activity Edit view. Filters can be applied (and created) from the View menu available on all views.

To create a new filter definition either choose Edit, Manage Filters (on the Task/Activity Edit view) or choose View, Filter, New Filter on any tabular view.

If you selected Edit, Manage Filters the dialog shown in Figure 3.1 is displayed.

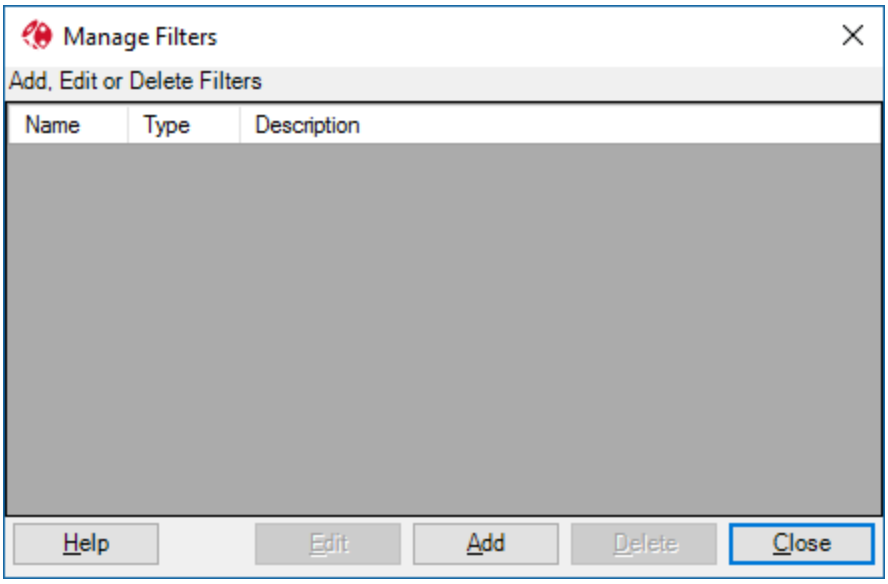


Figure 3.1

Click 'Add' to define a new filter using the Filter Definition dialog. If you selected View, Filter, New Filter then the Filter Definition dialog is displayed directly as shown in Figure 3.2.

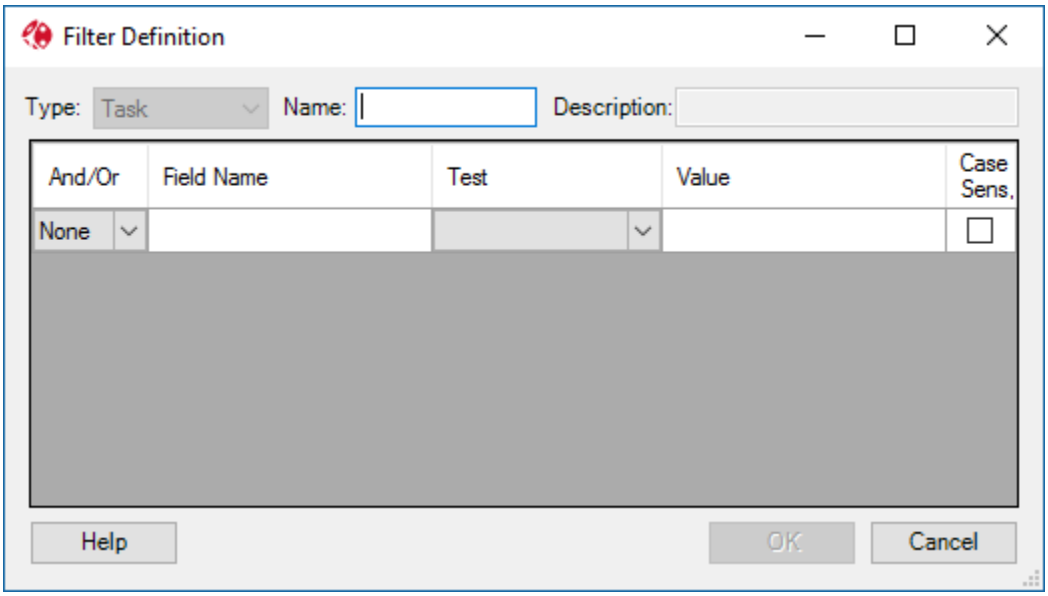


Figure 3.2

Enter a name and description for the new filter.

> *Note: A filter is effectively a user defined Boolean field. As such its name cannot conflict with an existing field name used by Full Monte.*

The filter is defined using one or more logical conditions. Conditions can be combined using AND/OR to create more complex criteria.

As an example, we will create a new filter to only show tasks that have a Risk Path number as shown in Figure 3.3. Risk Path is a Full Monte field that numbers tasks to show the various potential critical paths to project completion (or an interim milestone). For tasks that are never on the critical path it will be 0

(zero). For all other tasks, it will be an integer number representing a numbered path. A simple condition we can use will be 'Risk Path is more than 0'. Full Monte would also allow us to use 'Risk Path is valid'.

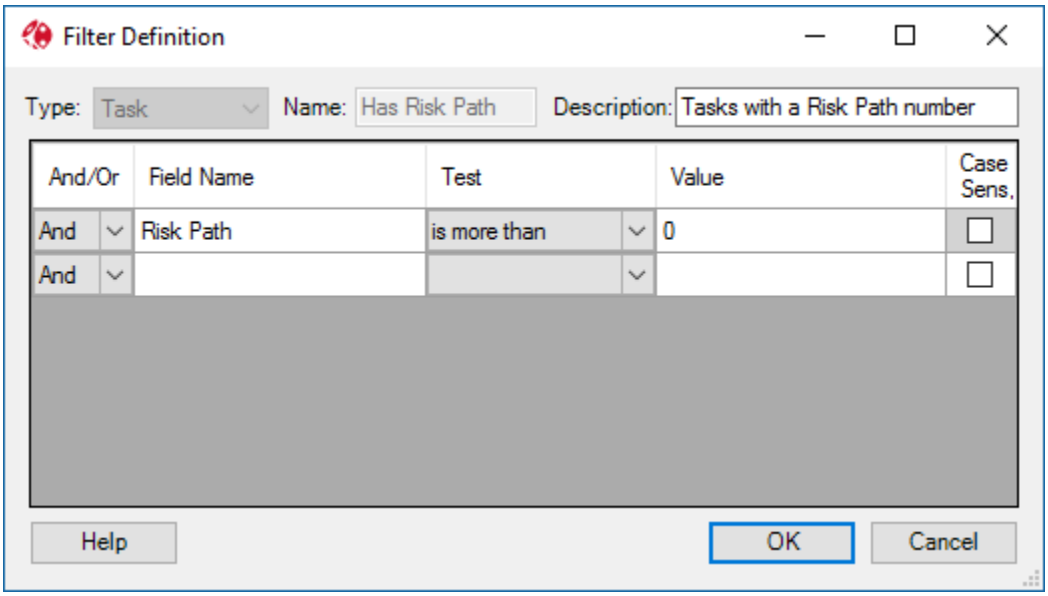


Figure 3.3

Note: We named the filter 'Has Risk Path' partly because it describes what the filter does but also because 'Risk Path' by itself would not have been a valid filter name because it conflicts with the Risk Path field itself.

The 'Value' column can be either a literal value (typed in by the user as in our example) or another Full Monte field. If you click in the cell, Full Monte will display the standard field chooser as shown in Figure 3.4. This can be dismissed by clicking in the cell a second time to enter a literal value.

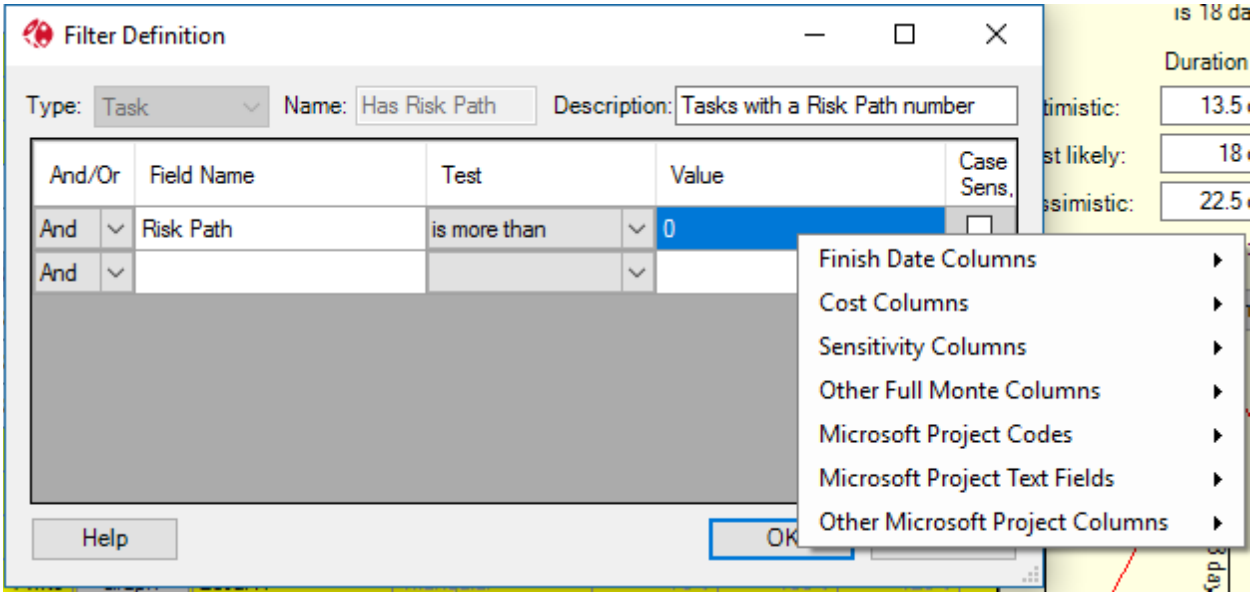


Figure 3.4

A more complex filter is shown in Figure 3.5.

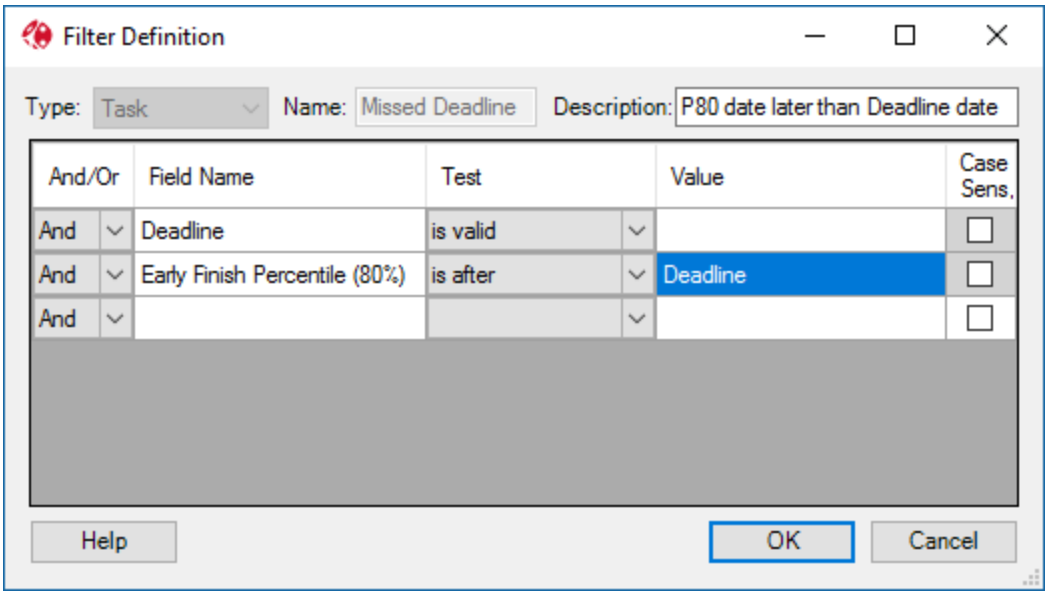


Figure 3.5

The Missed Deadline filter has two conditions. The first 'Deadline is valid' is used to determine if a task has a deadline date set. The second condition then tests if the Early Finish Percentile (80%) date calculated by Full Monte is after (greater than) the Deadline date. Technically the first condition is not required as Full Monte would not treat 'Early Finish Percentile (80%) as after the Deadline date if the Deadline date was not set at all however it does aid clarity.

Click OK to close the Filter Definition dialog. If you defined the new filter using View, Filter, New Filter then the filter is immediately saved and applied to the open view.

If you defined the filter using Edit, Manage Filters, Add then you will be returned to the Manage Filters dialog with your new filter added to those displayed in the list as shown in Figure 3.6.

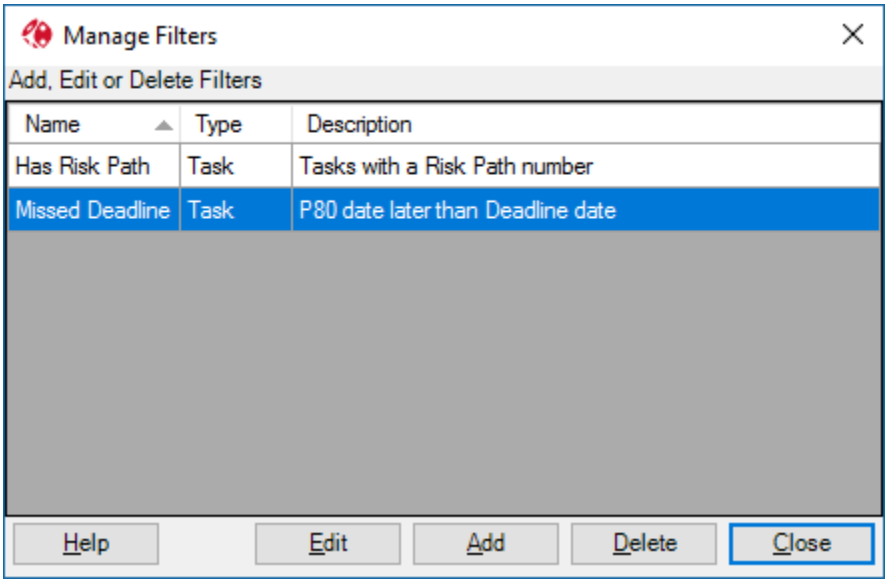


Figure 3.6

Click Close to close the Manage Filters dialog. If you made any changes (added a new filter or modified/deleted an existing filter) then the dialog shown in Figure 3.7 is displayed.

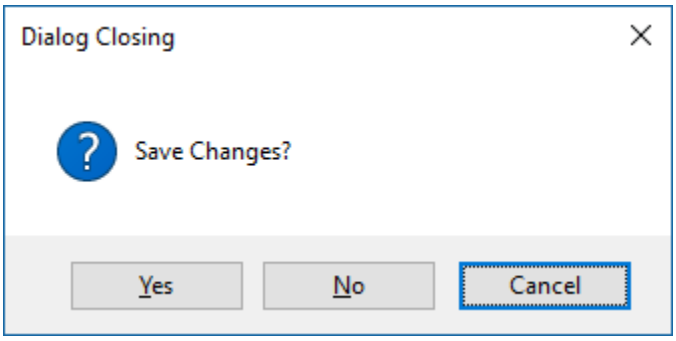


Figure 3.7

Click Yes to save the filter changes. If you click No, then all changes made via the Manage Filters dialog since you opened it will be lost.

You can apply any filter from the View menu using View, Filter as shown in Figure 3.8.

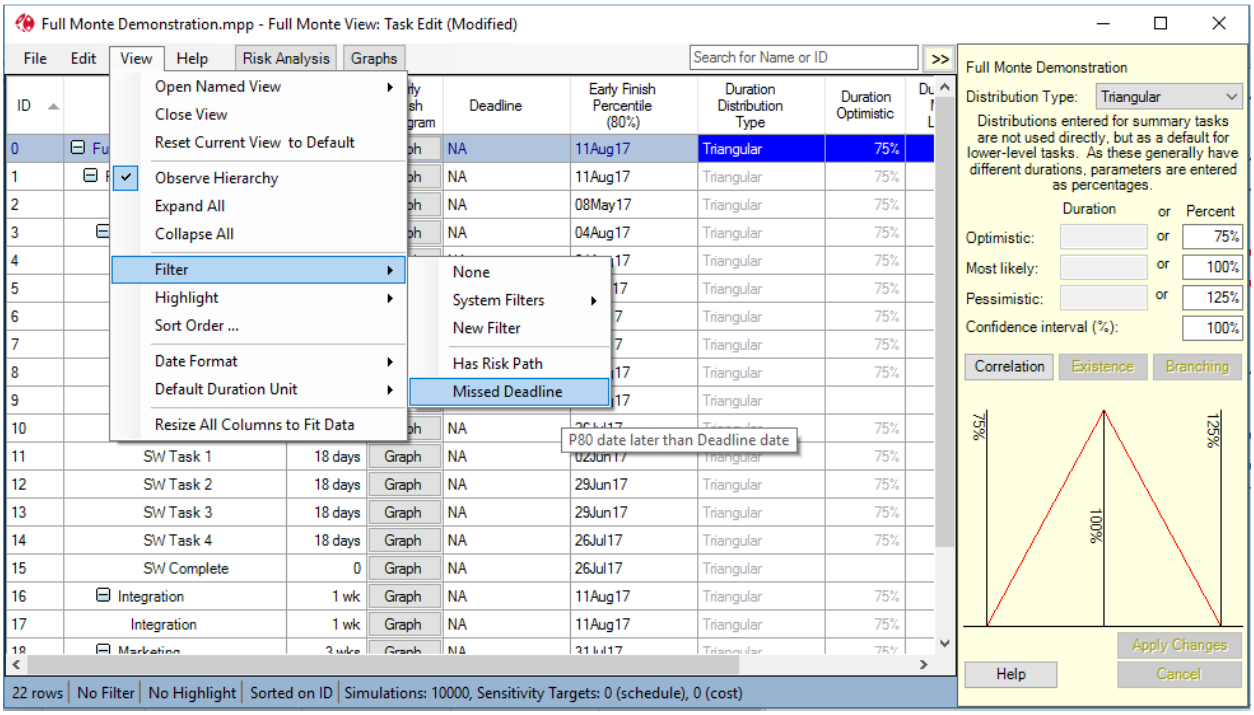


Figure 3.8

The options include:

- None – Clear any existing filter from the view
- System Filters – Predefined Filters used on some views shipped with Full Monte
- New Filter – Define a new filter
- <Named Filters> - Filters defined by the user

If we select 'Missed Deadline' the filter will be applied to the current view as shown in Figure 3.9.

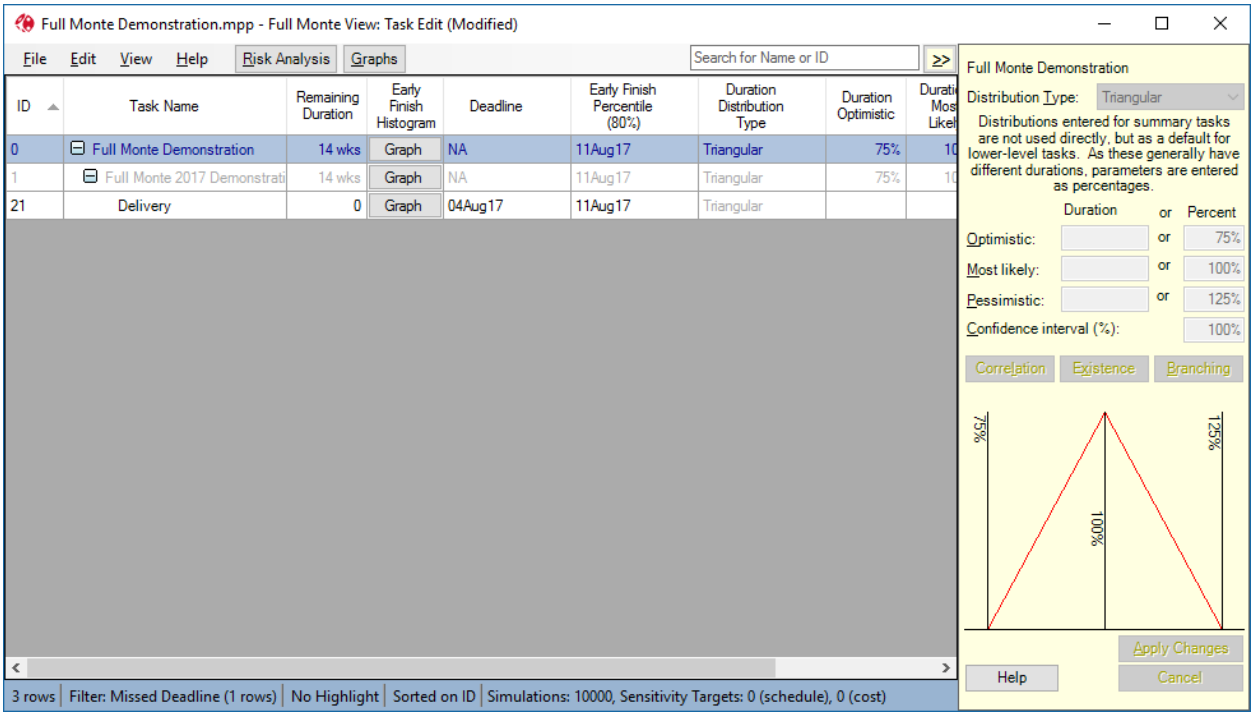


Figure 3.9

Note: Because the View has 'Observe Hierarchy' enabled, the view will also include any parent Summary Tasks for the selected tasks. If 'Observe Hierarchy' was disabled, then the view would strictly only show tasks that met the filter conditions. In this example, we can see this reflected in the Status Bar which shows 3 rows displayed but only 1 row selected by the filter.

Clear the filter by selecting View, Filter, None.

3.3 Highlights

Full Monte allows rows in a view to be highlighted based on Filter conditions. To define a filter, see section 3.2.

To apply a highlight, select View, Highlight. The options are:

- None – Remove any existing highlight from the view
- System Filters – Use a system defined filter to control highlighting
- New Filter – Define a new filter to control highlighting
- <Named Filters> - Use an existing named filter to control highlighting

In the example shown in Figure 3.10, the filter 'Missed Deadline' has been used to control highlighting.

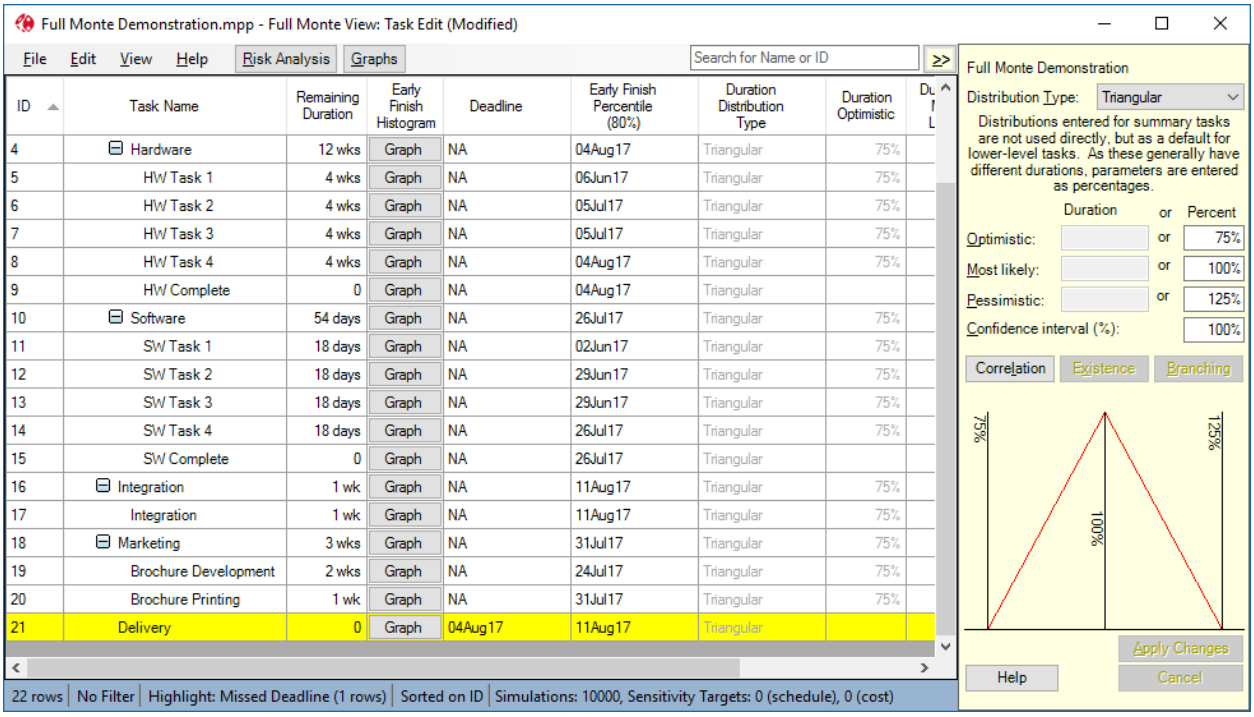


Figure 3.10

3.4 Sort Order

The sort order for each Full Monte View can be specified under View, Sort Order… as shown in figure 3.11.

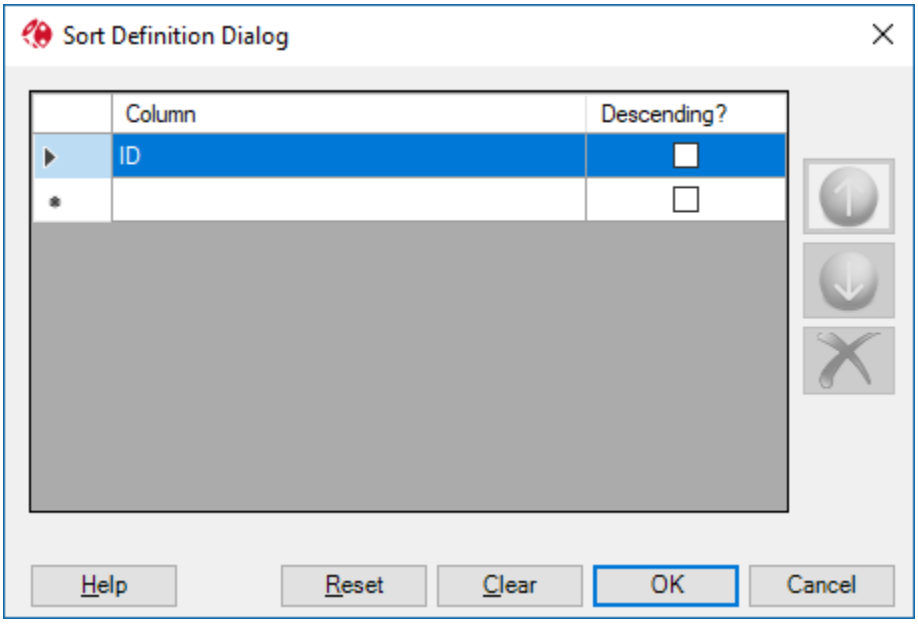


Figure 3.11

Additional columns can be added to sort within higher level columns.

If the View ‘Observe Hierarchy’ (Full Monte for Microsoft Project) or ‘Group by WBS’ (Full Monte for Primavera P6) option is enabled, then tasks/activities will be group by summary row/WBS first and then sorted within each group.

To sort all tasks/activities into a specific order regardless of their parent summary row/WBS, disable the ‘Observe Hierarchy’/’Group by WBS’ option.

Chapter 4: Editing Full Monte Data

4.1 Task/Activity Duration Uncertainty Information

When you open a project as described in Chapter 2, you will be presented with the **Task Edit** view, which is one of the tabular views described in Chapter 3 and shown in Figure 4.1.

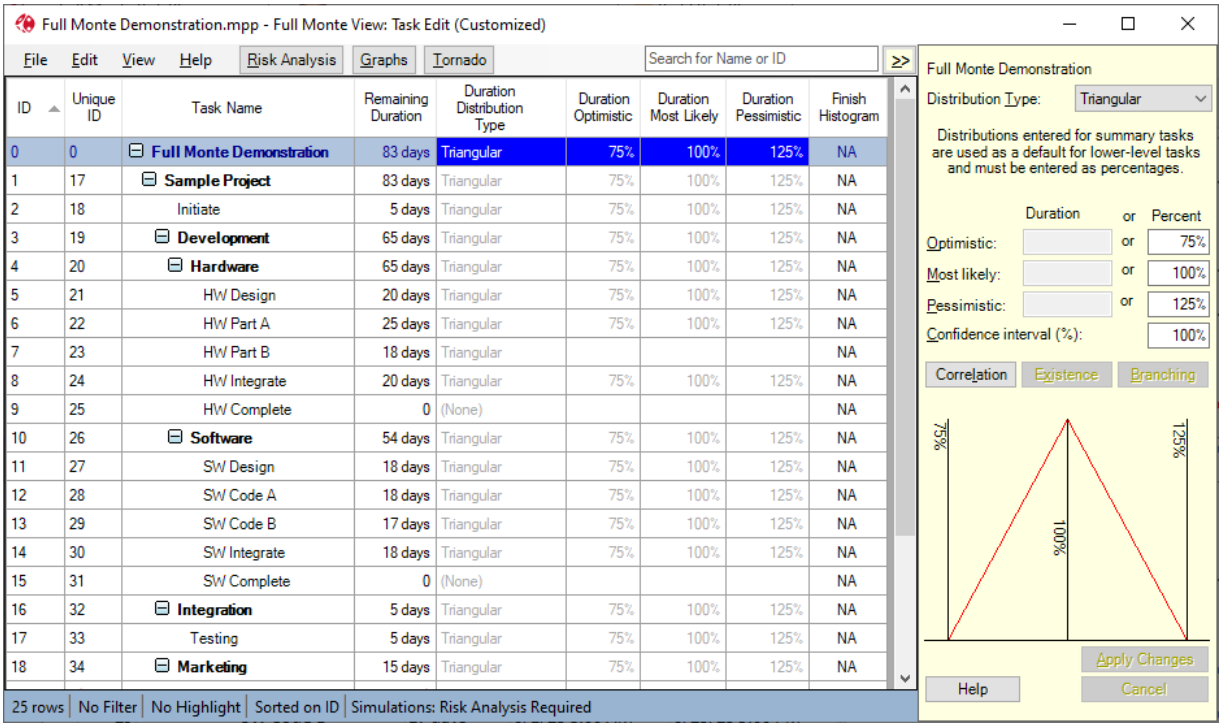


Figure 4.1

NOTE: The layout can be customized as discussed in Chapter 13. Any changes are saved on a per-user basis and will be used the next time you access this view. There is an option to **Reset Current View to Default** on the View menu.

The example shown in Figure 4.1 is from Full Monte for Microsoft Project. As with Microsoft Project itself, the hierarchy can be expanded/collapsed by clicking the +/- symbols against the summary task name.

For Full Monte for P6, the hierarchy can be expanded/collapsed using the +/- symbols against the Activity ID.

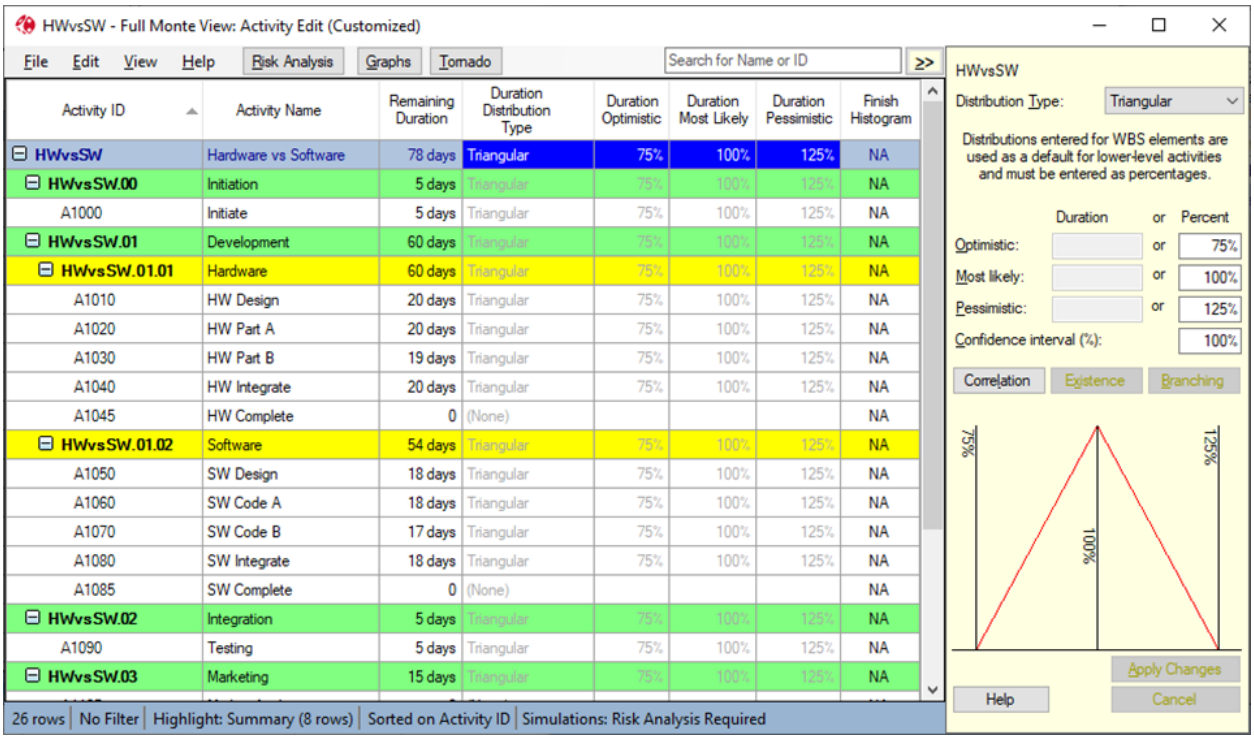


Figure 4.2

The Activity Edit view menu bar contains three shortcut buttons to launch Risk Analysis, open the Graphs view, and open the Tornado sensitivity chart view (also accessible from the View/Open named View menu). A fourth shortcut button can optionally be configured to show another view.

Distribution data are inherited by default, so, for example, you can set a default for the whole project, override this for a section of the project, and then override it again for individual activities. In the grid, inherited values are shown in grey. In Figure 4.1, everything is inherited from the top level (highlighted in blue). In Figure 4.2 additional Summary Row highlighting has been applied. The Early Finish Histogram column initially displays NA until a Risk Analysis has been performed.

Distribution values can be edited in the grid or in the docked panel to the right.

NOTE: Editing in the grid is explained at the end of this chapter.

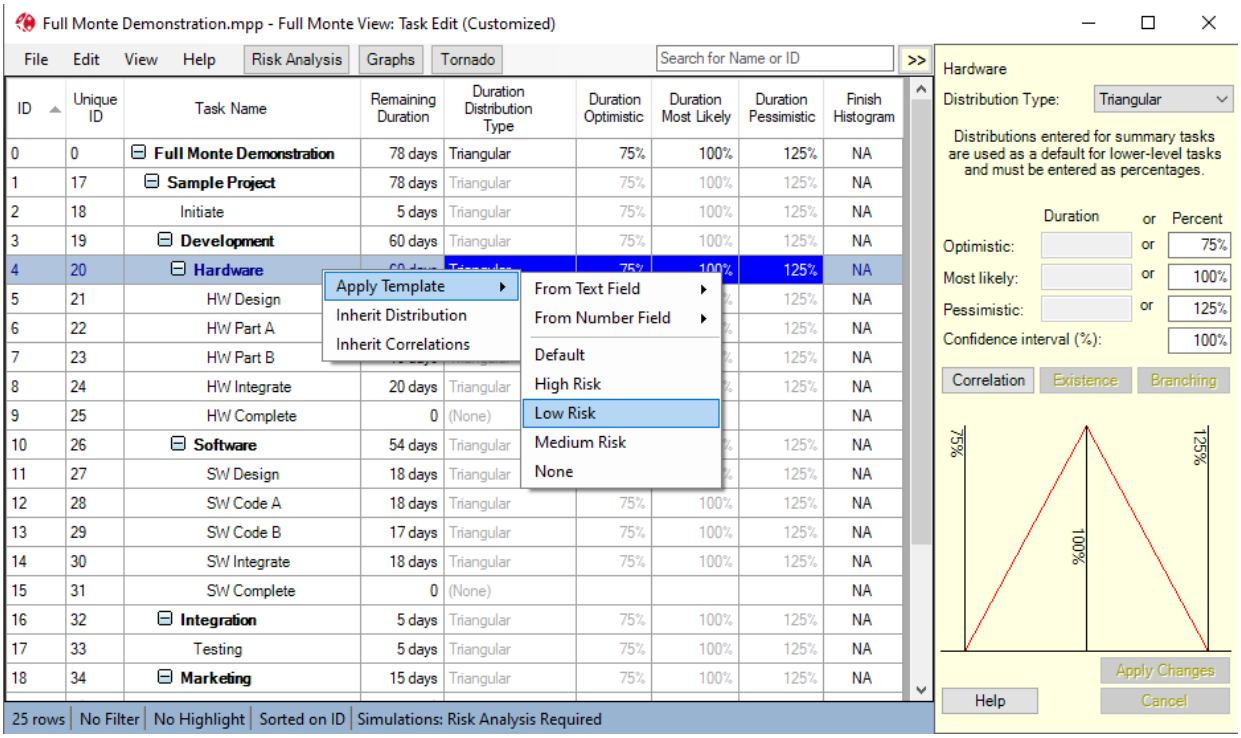
4.2 Templates

There is an ability to define and apply templates to quickly enter data on activities with similar profiles. Four templates are supplied with the product, but you can modify these and add your own. See Chapter 14 for further information on creating/editing templates.

NOTE: There must always be a template called “Default.” It is used as the default top level and is initially inherited by all activities in a new project. You can modify the Default template to apply values of your choice to new projects.

Templates can be assigned to one or more activities as follows:

To apply a template to a single summary element/activity, simply right-click on the summary/activity in the grid and choose Apply Template from the context menu as shown in figure 4.3.



ID	Unique ID	Task Name	Remaining Duration	Duration Distribution Type	Duration Optimistic	Duration Most Likely	Duration Pessimistic	Finish Histogram
0	0	**Full Monte Demonstration**	78 days	Triangular	75%	100%	125%	NA
1	17	**Sample Project**	78 days	Triangular	75%	100%	125%	NA
2	18	Initiate	5 days	Triangular	75%	100%	125%	NA
3	19	**Development**	60 days	Triangular	75%	100%	125%	NA
4	20	**Hardware**					125%	NA
5	21	HW Design					125%	NA
6	22	HW Part A					125%	NA
7	23	HW Part B					125%	NA
8	24	HW Integrate	20 days	Triangular			125%	NA
9	25	HW Complete	0	(None)				NA
10	26	**Software**	54 days	Triangular			125%	NA
11	27	SW Design	18 days	Triangular			125%	NA
12	28	SW Code A	18 days	Triangular	75%	100%	125%	NA
13	29	SW Code B	17 days	Triangular	75%	100%	125%	NA
14	30	SW Integrate	18 days	Triangular	75%	100%	125%	NA
15	31	SW Complete	0	(None)				NA
16	32	**Integration**	5 days	Triangular	75%	100%	125%	NA
17	33	Testing	5 days	Triangular	75%	100%	125%	NA
18	34	**Marketing**	15 days	Triangular	75%	100%	125%	NA

Figure 4.3

To apply a template to multiple summary elements/activities, select all the required rows using standard keystrokes such as CTRL+Click, Shift+Click, or Click+drag. To select all rows, choose Select All from the Edit menu or type CTRL+A.

NOTE: Activities in summary rows that are not expanded will not be selected by the above selection operations and will not be directly updated by template application. However, if such activities are set to inherit uncertainty information, they may be affected by changes applied to higher level summary elements.

After selecting the required template, the confirmation dialog shown in figure 4.4 is displayed.

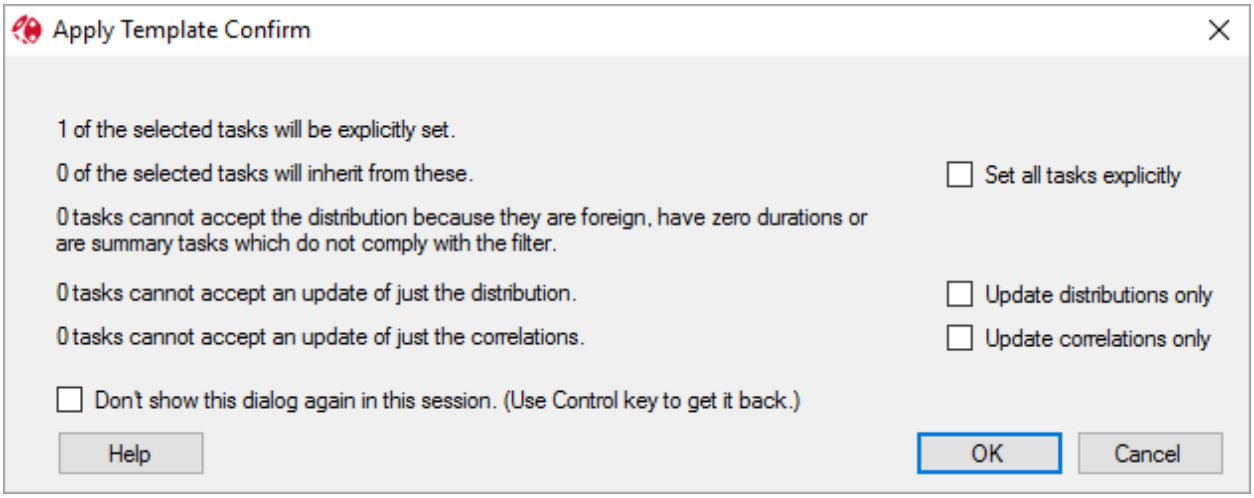


Figure 4.4

The template confirmation dialog displays summary information regarding the number of activities that will be affected by the template application.

Note: The summary information is only in respect of activities that are currently selected in the Activity Edit view.

Note: The Template Confirmation dialog can be suppressed by choosing 'Don't show this dialog again in this session'. If you subsequently wish to have the dialog displayed, hold the Control (CTRL) key while choosing 'Apply Template' from the right-click context menu.

The confirmation dialog can also control how the information from the template is applied:

- **Set all tasks explicitly:** If you are applying the template to multiple levels of summary and activity elements, then choosing this option will explicitly set the template uncertainty information to all selected elements rather than just setting the higher level WBS elements and allowing lower level summary/activity elements to inherit the relevant uncertainty information.
- **Update distributions/correlations only:** These options allow you to control what template data is applied to the selected summary/activity elements.

Note: Templates can be configured to either update duration distribution, correlation or both type of data. Template configuration takes precedence over Apply Template confirmation.

Note: The Activity Edit right click context menu also contains options to reset selected activities to inherit Distribution or Correlation data.

4.3 Apply Templates based on User Defined Fields or Lookup Tables

It is also possible to apply templates based on template names entered into custom lookup fields in the schedule.

For **Microsoft Project**, choose a Custom Text field to contain the template names. To avoid data entry errors, we suggest defining an associated 'Lookup' table with a list of valid template names. See figure 4.5 for an example. In the example, Text20 has been renamed 'Assessment 1' but this is optional.

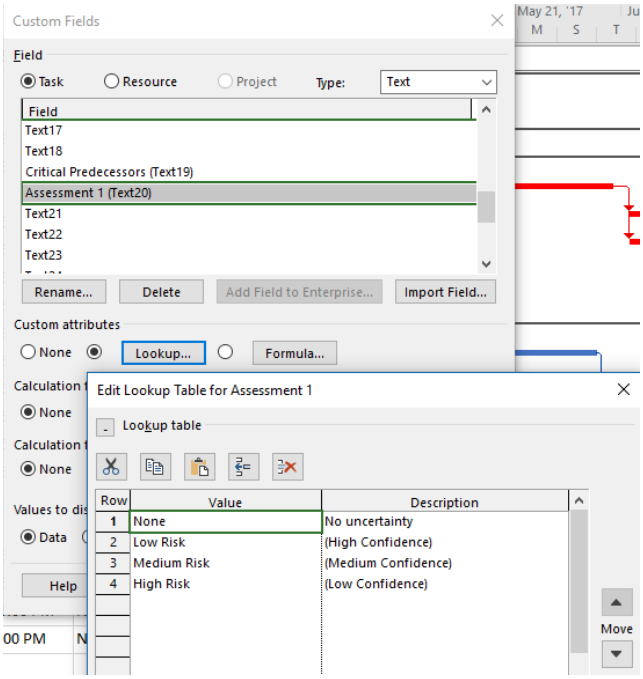


Figure 4.5

To apply the templates defined in the custom text field, select the required activities in Full Monte, right click and choose Apply Template, From Text Field and select the required Microsoft Project custom field as shown in figure 4.6

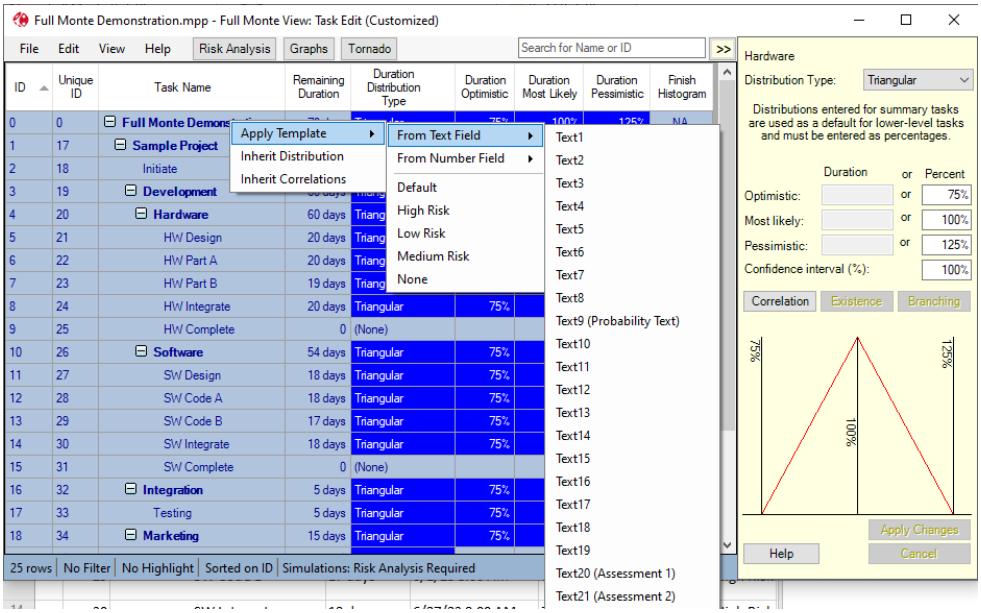
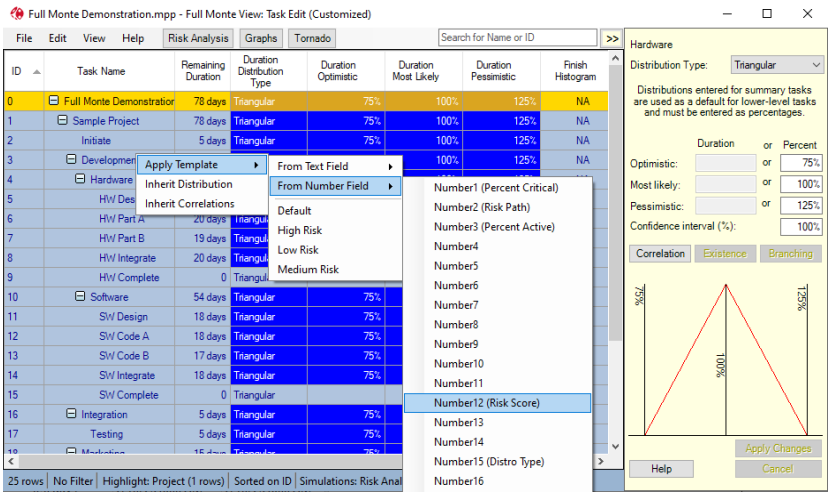


Figure 4.6

4.4 Apply Templates based on User Number Custom Fields

With Microsoft Project, template uncertainty can also be applied from Custom Number fields. The associated template names in Full Monte must be numeric (1,2,3 etc.).

There is special handling for the number 0 in the selected custom field. When the templates are being applied, if there is no template called “0”, then 0 will be interpreted as ‘do nothing’ (the same as a blank entry when applying templates from a text field) so any existing uncertainty will not be changed. However, if a template called “0” has been defined then that will be applied. A typical use case would be to define a template called “0” that sets the distribution type to (None) to remove an uncertainty from tasks where a numeric risk score was not specified.



For **Primavera P6**, define a custom Activity Code 'Lookup Table' as shown in figure 4.7

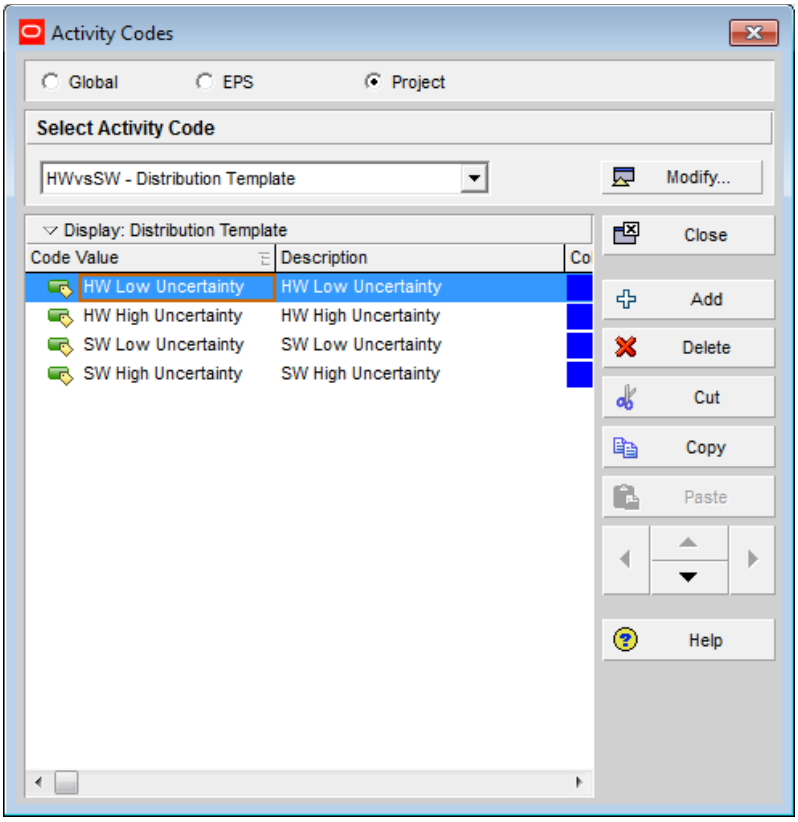


Figure 4.7

To apply the templates defined in the lookup table, select the required activities, right click, and choose Apply Template, From Lookup Table and select the required Table as shown in figure 4.8

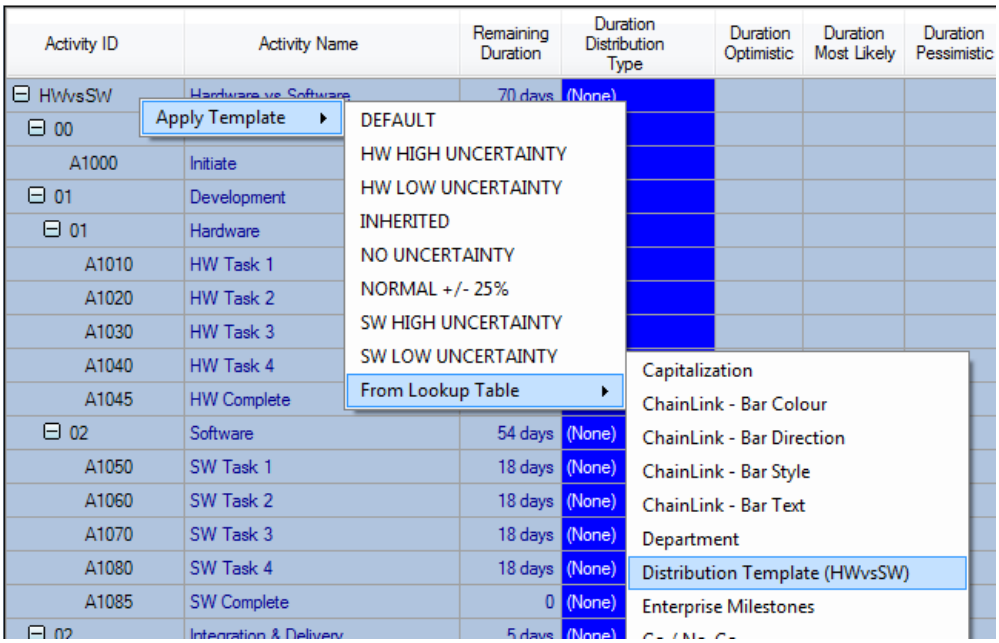


Figure 4.8

NOTE: The template name entered in the custom text/code field **must match exactly** with a template name defined in Full Monte.

4.5 Manually Entering Uncertainty Information

If you do not want to use a template, you can enter the parameters individually. To assign a probability distribution to the duration of this activity, first choose the general shape from the drop-down menu. Five different shapes are available: beta, lognormal, normal, triangular, and uniform. To determine which to choose for your application, see Appendix A, Probability Distributions.

Depending upon which probability distribution shape you choose, the controls will be enabled to allow entry of either a 2- or 3-point estimate of the duration. The uniform, normal, and lognormal distributions are each defined completely by two parameters, so Full Monte calculates the most likely value for you. In either case, you can enter the information either as an *absolute duration* or a *percentage of the deterministic duration*. (You are reminded of the current value of the deterministic duration above the data entry fields.) Whichever entry method you use, Full Monte will prorate the values when the activity is progressed or its duration has changed, so you will not have to update these as the project progresses unless you want to.

You can also enter a confidence interval for the optimistic and pessimistic values you enter. By default, it is set to 100%, meaning you are 100% sure that the actual value will fall between the values entered.

NOTE: In the case of the triangular distribution, this is similar to what other systems call the Trigen distribution. In Full Monte, this concept is extended to apply to all distribution types.

NOTE: 100% confidence cannot be strictly true for those distribution types that have infinitely long tails, namely the normal and lognormal. In these cases, Full Monte interprets 100% as a 6-standard-deviation range, or about 99.73%.

As you enter the data described above, the picture will change to indicate what the distribution function actually looks like, with the optimistic, most likely, and pessimistic values marked, along with the absolute limits if these are different.

NOTE: If the picture disappears, you have broken one of the rules defined in section 4.3.

4.6 Correlation

You can optionally enter correlation information. Full Monte implements correlations differently than other systems, allowing you to correlate each activity not directly with other activities but with shared influencing factors, which are called “correlation sources”. (For more information about correlation sources, please see Appendix B: Correlations.) Click on **Correlation** (around the middle of the edit panel) to bring up the correlation grid as shown in figure 4.9.

NOTE: Once you have clicked on **Set Correlations** to display the current correlations, if these are not inherited, then the button’s function changes as illustrated in figure 4.9 to **Inherit Correlations**. Clicking on it will delete the specific correlation for this activity and revert to the values inherited from above.

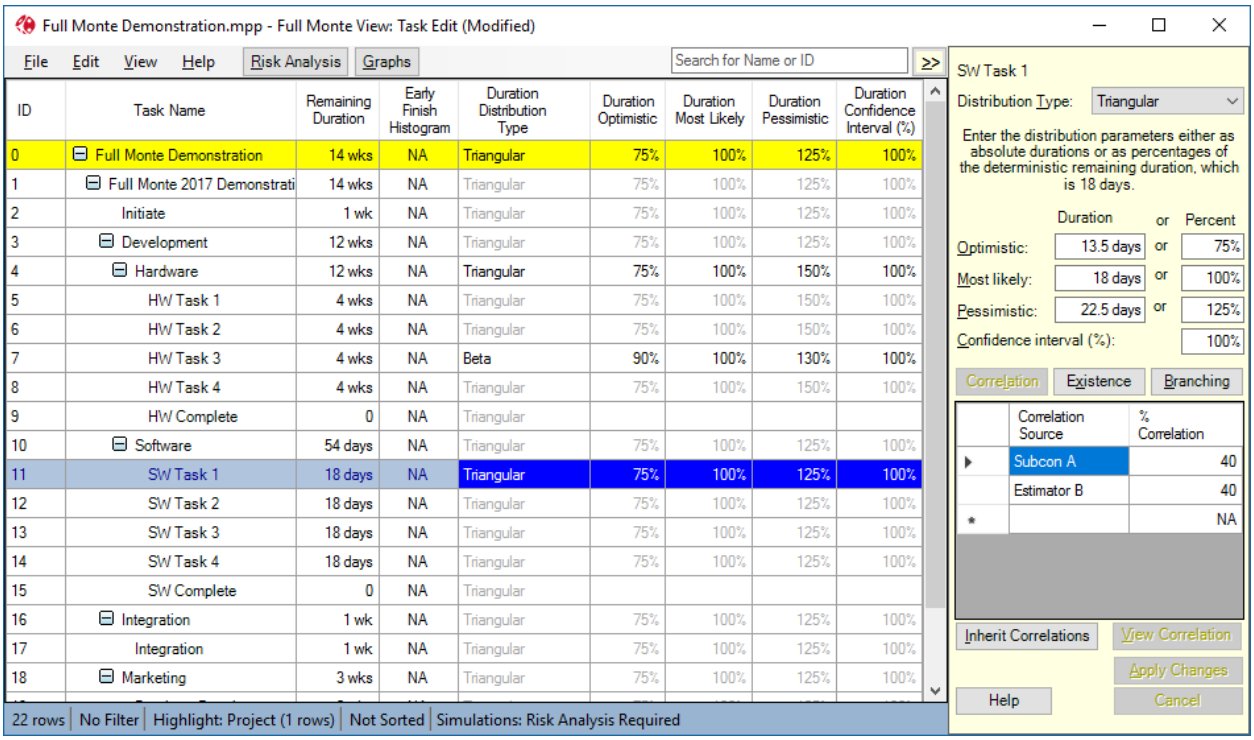


Figure 4.9

Position the cursor in the first cell under the heading **Correlation Source** (on the right side of the screen). From the drop-down menu, choose the correlation source or type in a new one. (Once you type in a correlation source, it will appear in the drop-down menu next time.) In the second column, enter a percentage for the correlation coefficient. This should be between -100% and +100%, and the sum of the squares of the values entered must not exceed 10,000 (i.e., if expressed as fractions rather than percentages, the sum of squares cannot exceed 1).

Note that this correlation coefficient is between the duration of the current activity and the specified correlation source. The correlation coefficient between any pair of activities correlated with this same factor will be the product of the two entered correlation coefficients, interpreting them as fractions. For example, if the two activities have coefficients of 50% and 70%, the correlation between the two activity durations will be 35%.

NOTE: This also means that if you enter negative correlations for two activities, they will be positively correlated with one another. If you want a negative correlation between two activities, one should be negatively and one positively correlated with the source.

This novel way of specifying correlations allows Full Monte to properly model correlations between any number of activities without the user having to resort to programming. (For more information on how this works, see Appendix B: Correlations.) After you have applied the changes, you can see the implied correlations with other activities by clicking **View Correlations** to display the grid illustrated in figure 4.10. (This button is enabled only if there is at least one other activity correlated with the current activity.)

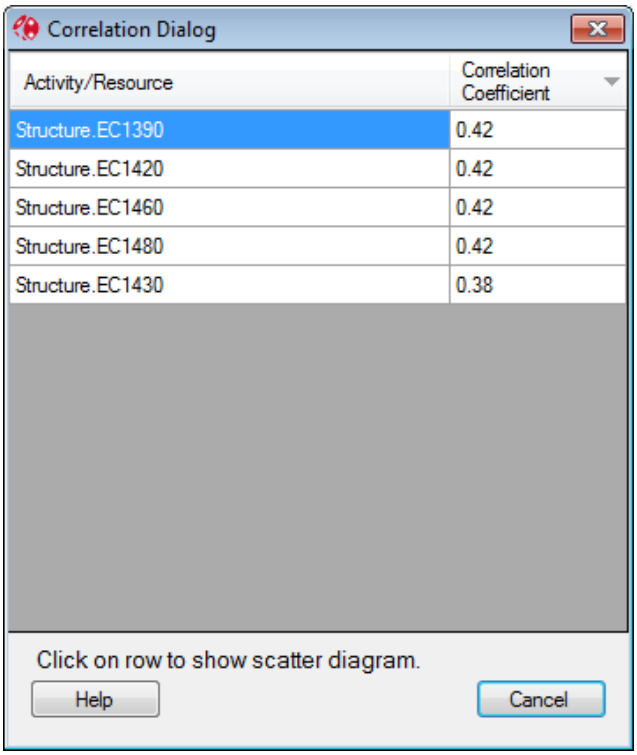


Figure 4.10

The grid shown in figure 4.9 lists all the activities correlated with the current activity, in descending order of the theoretical correlation coefficient between each activity and the current activity. Clicking on one of the rows produces a scatter diagram of the relationship between the two activities, as illustrated in figure 4.11.

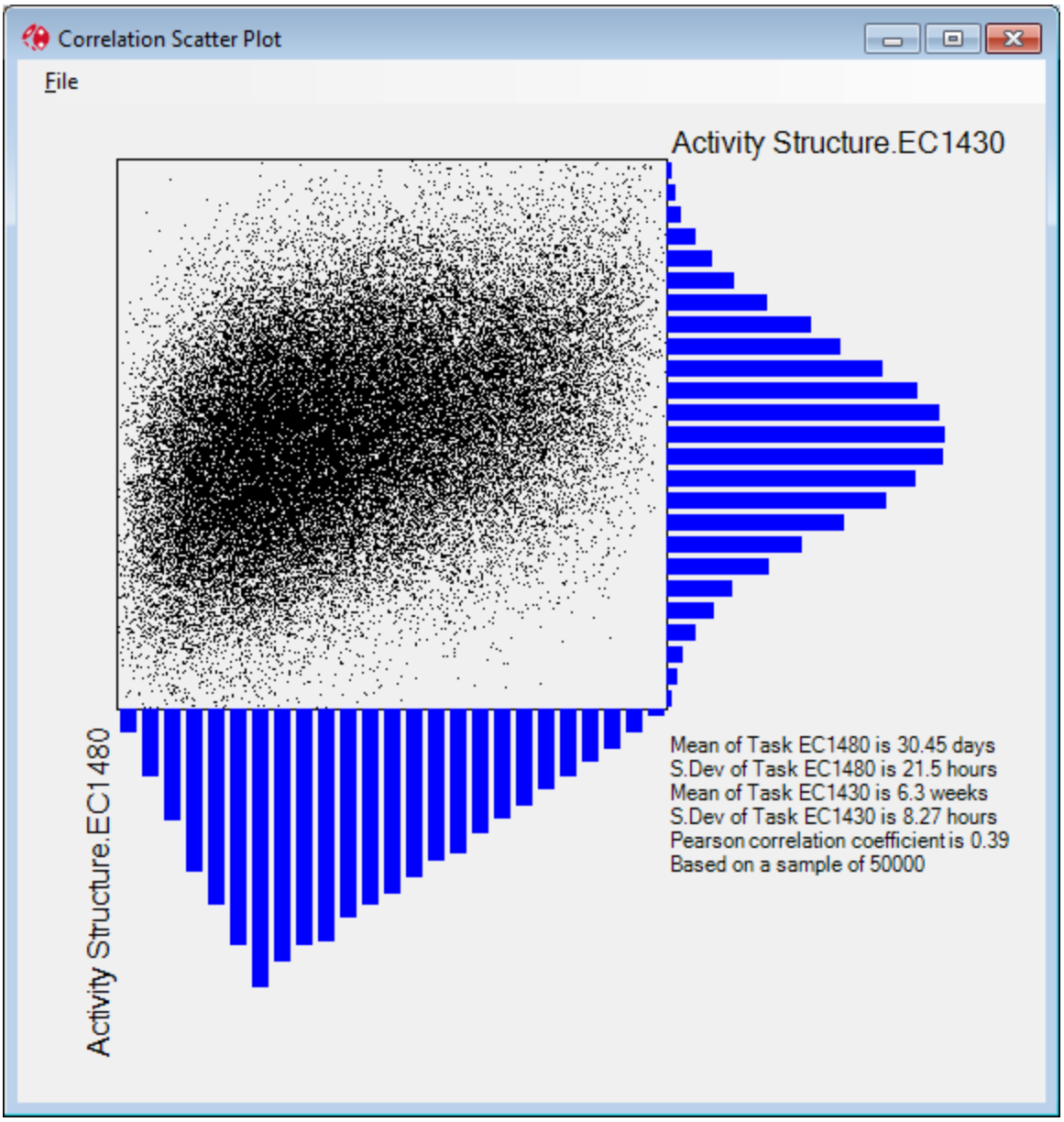


Figure 4.11

Each point on the scatter diagram represents a pair of duration values sampled from the joint distribution of the durations of the two activities. The blue bars indicate the sampled frequency functions. The text indicates the values of their means and standard deviations and the actually sampled correlation coefficient.

NOTE: Correlations can be inherited, so if you wanted to correlate every activity duration in the entire project, you could enter the name of the source and the coefficient at the top level with just a few keystrokes.

4.7 Branching and Task Existence

Threats (Risks) and Opportunities are events that may, or may not, occur. For example, having completed testing on a module it may, or may not, pass. This is a 'risk' where the sequence of work that follows testing may change depending on the outcome. Likewise, the duration of future work may be

shortened if a new fabrication process becomes available. We can create alternate logic to model this opportunity. It is also possible to model alternate logic to simply consider the impact of schedule delays. The two forms of 'branching' and task existence modelling in this section allow us to model these scenarios.

Note: Branching and Task existence modelling can be automated based on a Risk Register as described in Section 4.13.

4.7.1 Task Existence

The simplest form of conditional logic in Full Monte is Task Existence. This allows us to specify the probability that a specific task will need to be performed.

In Figure 4.12 the 'Repair' task may not always be required. In fact, based on historical analysis, we might know that units fail testing, requiring repair, only 20% of the time.

Figure 4.12

Note: In versions of Full Monte prior to 3.1, this scenario was modelled using Probabilistic Branching described in section 4.6.2. Task Existence is a simpler alternative.

Knowing that 'Repair' only has a 20% chance of being required, we can specify this using Task Existence. When performing the risk analysis (simulation), Full Monte will only consider the duration and cost of task 'Repair' 20% of the time. For the other 80% of the simulations the task will be treated as having zero duration and cost. The logic will remain intact so Deliver will still follow Test (and Repair 20% of the time).

Task Existence is specified by selecting the task that has less than 100% chance of existing (100% is always the default). Then, in the edit pane, click Existence. The edit pane will display controls for Discrete Risk ID and Existence Probability as shown in Figure 4.13.

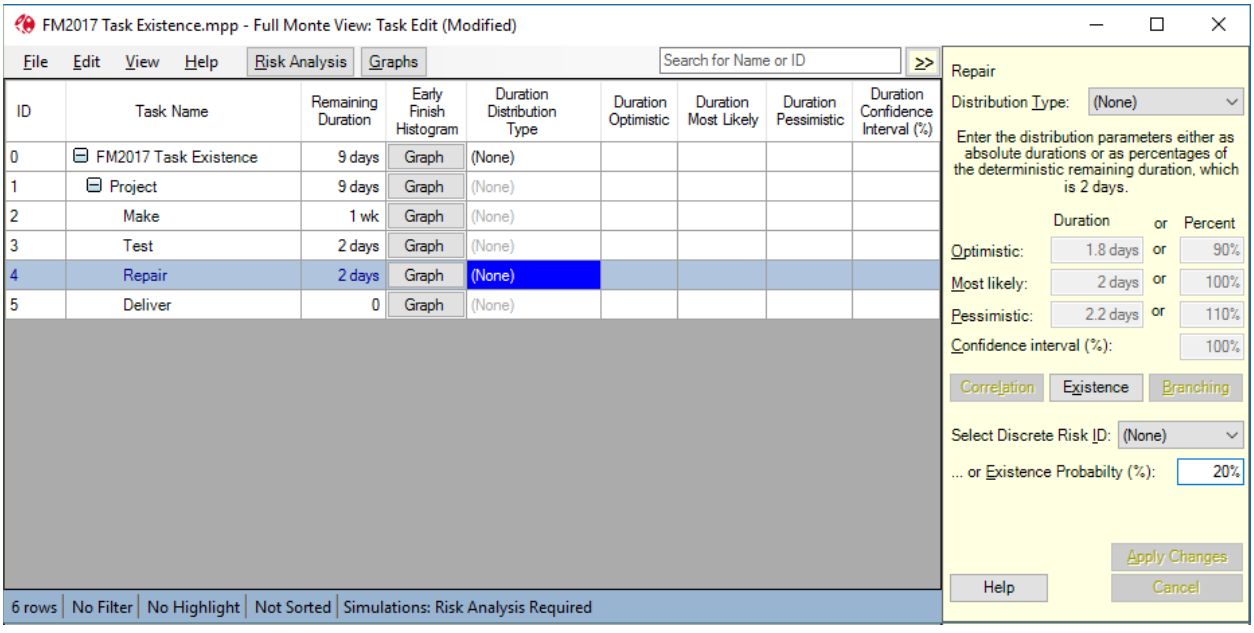


Figure 4.13

The controls for Discrete Risk ID and Task Existence are mutually exclusive. The Discrete Risk ID allows you to select a risk defined in the Edit, Manage Risk dialog. This allows a risk that affects multiple tasks to be defined once and the probability of occurrence managed in one place. Alternatively, as in our example, you can simply enter the probability that this task will exist.

In Figure 4.13 we can see that no task duration uncertainty has been specified. Normally Full Monte would not perform a simulation on a project with no task uncertainty information but in this case the Task Existence will count as 'uncertainty' and the simulation can be performed. The result will be a simple bi-modal distribution showing how the Delivery date is affected by the probability of 'Repair' having to be performed as shown in Figure 4.14.

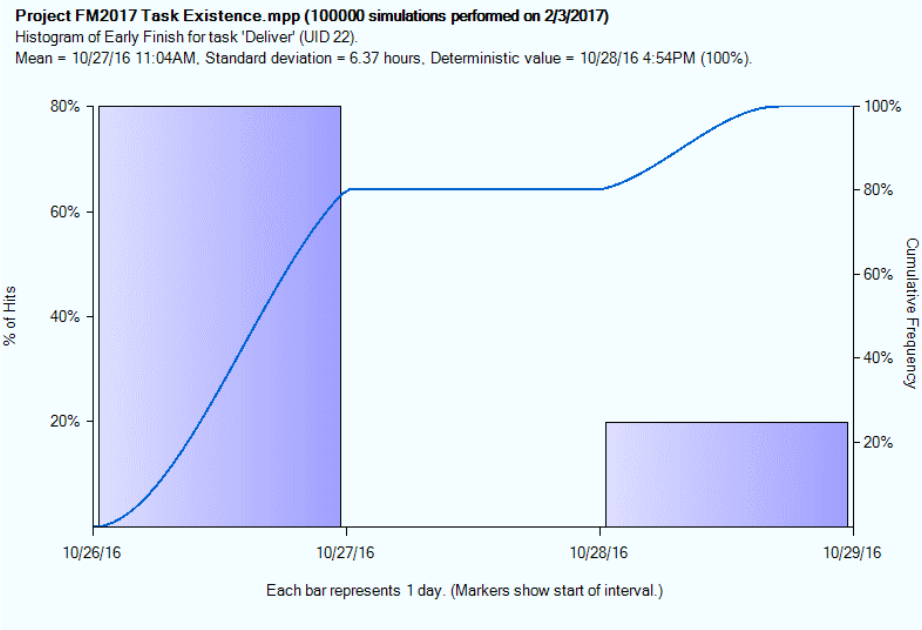


Figure 4.14

Note: Full Monte is showing we have a 100% chance of finishing by the deterministic date calculated by Microsoft Project because Project is always including the repair work in its analysis. If you have Microsoft Project Professional (as opposed to the Standard edition), you can set the Repair task Inactive (on the General tab of the Task Information dialog) so Microsoft Project does not include it when performing the critical path calculation. In this case the results shown by Full Monte will be the same except the chance of achieving the deterministic finish date in our example will change to 80%.

4.7.2 Probabilistic Branching

Where a task has more than one successor, **Probabilistic branching** allows you to specify the probability of each successor being executed. This type of branching can be used model both threats and opportunities although Task Existence probability described in section 4.6.1 may be a simpler way to model threats in your schedule.

Only one successor will be included in each individual simulation. A good practice is for the individual percentages assigned to the successors to total 100% although this is not mandatory. The software will scale the assigned values to a total of 100% automatically.

Note: If any successor is assigned a probability of 0% then it will never be executed.

In Figure 4.15, an example is shown where we have three, mutually exclusive, options for manufacturing. Option 1 has a 50% chance of being selected, Option 30%, and Option 3 just 20%. The final selection will depend on availability of the option but we are modelling the likely chance of each being available once design is complete. As mentioned above the percentages add up to 100% but we could have equally used values of 5, 3, and 2 if this was more convenient.

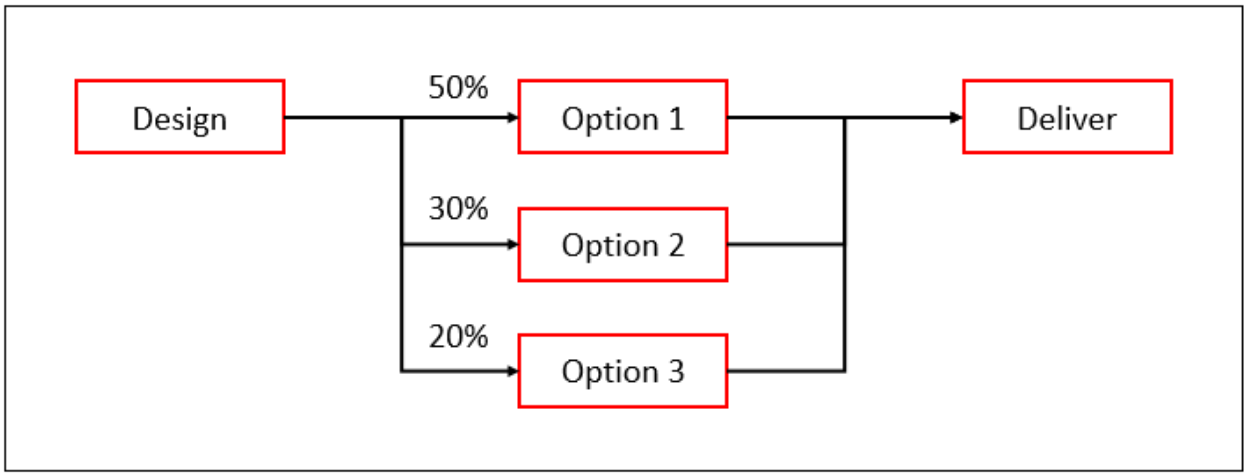


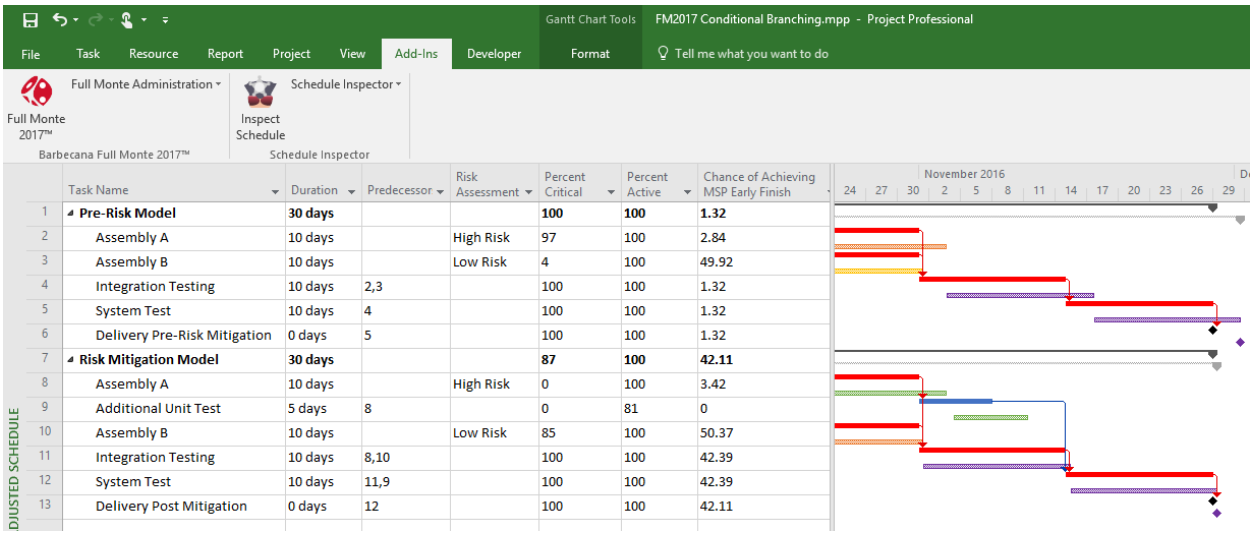
Figure 4.15

During each simulation, the software will randomly choose one of the Design successors, considering their relative probability, and include that task (or tasks). The tasks that were not selected will not be included and have no effect on time or cost. In the example, the tasks labelled Option 1-3 could comprise many discrete tasks.

4.7.3 Conditional Branching

Conditional Branching can be used to model risk mitigation for late delivery. For example, if the original schedule calls for all subcomponents to be delivered before integration testing can take place, but one subcomponent has very high risk, alternate logic can be included to allow that subcomponent to undergo further unit testing and subsequently integrated later in the system testing phase if it arrives late.

Consider the schedule shown in Figure 4.16. The two summary tasks represent two different schedules for the same project. The second summary task 'Risk Mitigation Model' shows additional logic via 'Additional Unit testing' that will be included by Full Monte if 'Assembly A' is delivered later than 11/1/2016.

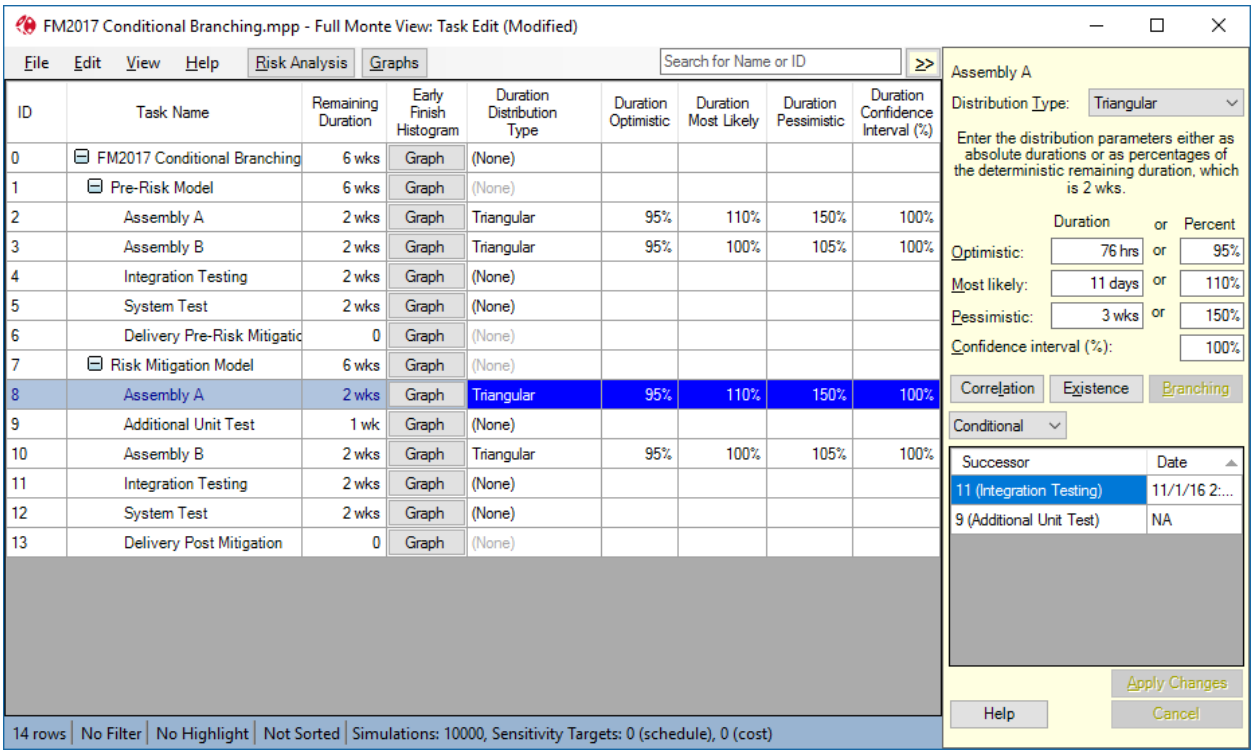


	Task Name	Duration	Predecessor	Risk Assessment	Percent Critical	Percent Active	Chance of Achieving MSP Early Finish
1	**Pre-Risk Model**	**30 days**			**100**	**100**	**1.32**
2	Assembly A	10 days		High Risk	97	100	2.84
3	Assembly B	10 days		Low Risk	4	100	49.92
4	Integration Testing	10 days	2,3		100	100	1.32
5	System Test	10 days	4		100	100	1.32
6	Delivery Pre-Risk Mitigation	0 days	5		100	100	1.32
7	**Risk Mitigation Model**	**30 days**			**87**	**100**	**42.11**
8	Assembly A	10 days		High Risk	0	100	3.42
9	Additional Unit Test	5 days	8		0	81	0
10	Assembly B	10 days		Low Risk	85	100	50.37
11	Integration Testing	10 days	8,10		100	100	42.39
12	System Test	10 days	11,9		100	100	42.39
13	Delivery Post Mitigation	0 days	12		100	100	42.11

Figure 4.16

We can see that by mitigating the delay to Assembly A we have improved our chance of on-time delivery to 42% compared to just 1% pre-mitigation. More work will be required to bring the chance of delivery up to an even more acceptable 80%.

To enter the Conditional Branching information, select the predecessor task that may be delayed and then click the 'Branching' button on the edit pane. Select 'Conditional' in the drop-down as shown in Figure 4.17.



ID	Task Name	Remaining Duration	Early Finish Histogram	Duration Distribution Type	Duration Optimistic	Duration Most Likely	Duration Pessimistic	Duration Confidence Interval (%)
0	FM2017 Conditional Branching	6 wks	Graph	(None)				
1	Pre-Risk Model	6 wks	Graph	(None)				
2	Assembly A	2 wks	Graph	Triangular	95%	110%	150%	100%
3	Assembly B	2 wks	Graph	Triangular	95%	100%	105%	100%
4	Integration Testing	2 wks	Graph	(None)				
5	System Test	2 wks	Graph	(None)				
6	Delivery Pre-Risk Mitigatic	0	Graph	(None)				
7	Risk Mitigation Model	6 wks	Graph	(None)				
8	Assembly A	2 wks	Graph	Triangular	95%	110%	150%	100%
9	Additional Unit Test	1 wk	Graph	(None)				
10	Assembly B	2 wks	Graph	Triangular	95%	100%	105%	100%
11	Integration Testing	2 wks	Graph	(None)				
12	System Test	2 wks	Graph	(None)				
13	Delivery Post Mitigation	0	Graph	(None)				

Figure 4.17

The two alternate successors for task ‘Assembly A’ are shown in the grid. The logic to task ‘Integration Testing’ will be included during the simulation if the current task ‘Assembly A’ finishes on or before 11/1/16. If ‘Assembly A’ finishes after 11/1/16 then the logic to task ‘Additional Unit test’ will be followed.

NOTE: You do not have to enter the dates in order, and the missing date can be anywhere. When you click on **Apply Changes**, Full Monte will display them in order. If you enter dates in every row, the latest date will be replaced with “NA.”

4.8 Delivery Milestone Date Uncertainty / Input Milestones

Many projects rely on deliverables from external sources including design approval and material delivery. These are typically represented as an input Milestone. These deliverables are also often subject to some uncertainty which Full Monte can model as a range of dates. Full Monte defines an input Milestone as a zero-duration milestone with one of the following constraint types; ‘Start No Earlier Than’, ‘Start On’, ‘Finish No Earlier Than’, ‘Finish On’ and at least one successor task. Barbecana recommends using a ‘Start No Earlier Than’ constraint.

The example in Figure 4.18 shows a small project where Assembly A is being developed in-house and Assembly B is being supplied by an external subcontractor. The contractor has committed to deliver on 5/8/17. Integration cannot start until both assemblies are completed/delivered.

Task Name	Duration	Predecessor	Constraint	Start	Finish
Project	**13 days**			**5/1/17 8:00 AM**	**5/17/17 5:00 PM**
Assembly A	6 days			5/1/17 8:00 AM	5/8/17 5:00 PM
Assembly B Delivery	0 days		SNE 5/8/2017	5/8/17 8:00 AM	5/8/17 8:00 AM
Integration	2 days	2,3		5/9/17 8:00 AM	5/10/17 5:00 PM
Testing	5 days	4		5/11/17 8:00 AM	5/17/17 5:00 PM
Delivery	0 days	5		5/17/17 5:00 PM	5/17/17 5:00 PM

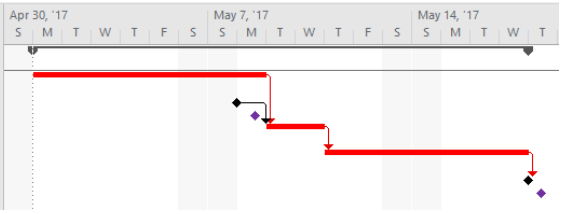


Figure 4.18

For our example, we will model both duration uncertainty on our in-house work and a range of dates that the external Assembly B may be delivered.

To enter this data into Full Monte first select the input Milestone. Provided it meets the criteria described above, the edit pane will change to allow the entry of a range of dates as shown in Figure 4.19.

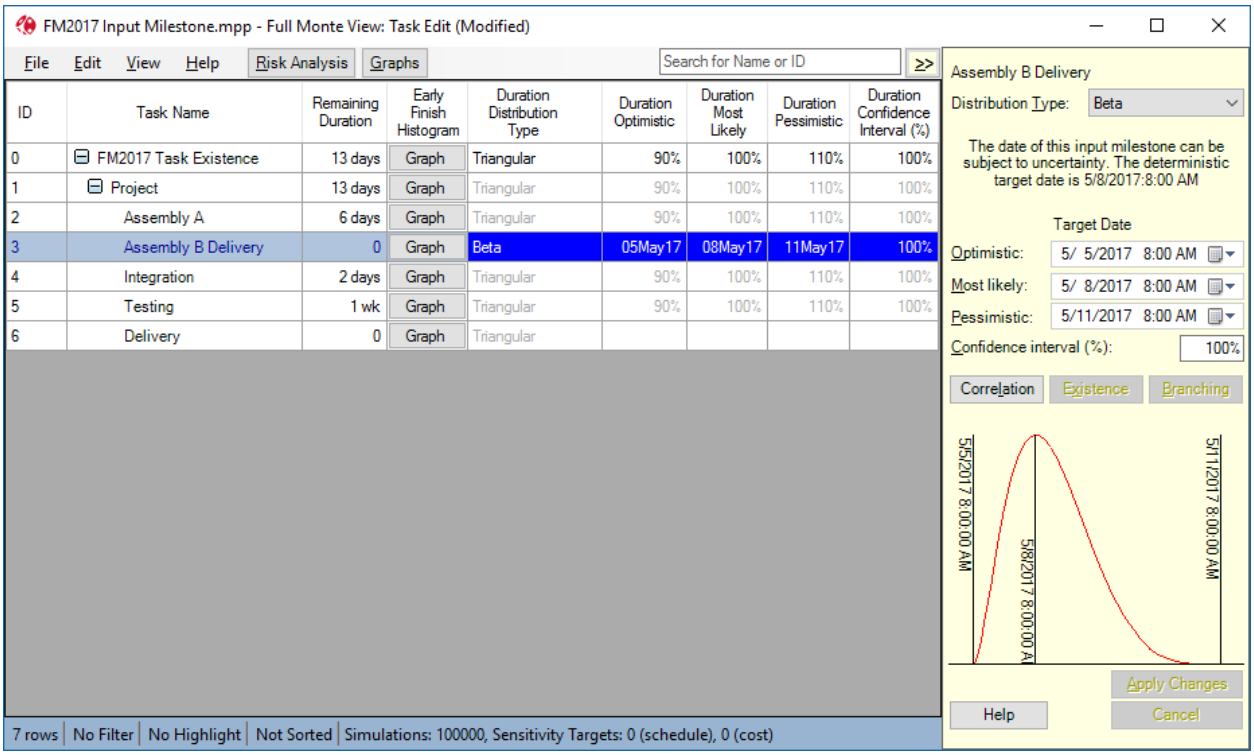


Figure 4.19

In the example, we have specified a Beta distribution based on an Optimistic delivery of 5/5, Most Likely delivery of 5/8, and a Pessimistic delivery of 5/11.

Figure 4.20 shows the results of the simulation and we can see that, based on our input assumptions, the subcontractor will be on the critical path 14% of the time despite originally having float/slack.

Task Name	Duration	Predecessor	Constraint	Percent Critical	Early Start Percentile (80%)	Early Finish Percentile (80%)
Project	**13 days**			**100**	**5/1/17 8:00 AM**	**5/18/17 10:45 AM**
Assembly A	6 days			86	5/1/17 8:00 AM	5/9/17 9:46 AM
Assembly B Delivery	0 days		SNE 5/8/2017	14	5/8/17 3:13 PM	5/8/17 3:13 PM
Integration	2 days	2,3		100	5/9/17 10:14 AM	5/11/17 10:17 AM
Testing	5 days	4		100	5/11/17 10:18 AM	5/18/17 10:44 AM
Delivery	0 days	5		100	5/18/17 10:45 AM	5/18/17 10:45 AM

Figure 4.20

4.9 Validating and Committing Changes

When you have made changes in the edit panel, both the **Apply Changes** and **Cancel** buttons will be enabled. You cannot move to a different activity in the grid until you either apply or cancel the changes. Click on **Apply Changes** to commit the changes to the grid, or **Cancel** to discard them. In either case, both buttons will then be disabled.

NOTE: Full Monte operates a two-stage commit process. Committing the changes as described here commits them only to the memory image of the project. They are not committed to the database until you close the view, at which point you will be asked whether to save or not.

Apply Changes also performs a number of validity checks and may display an error message as a result. Until you try to apply the changes, the panel deliberately allows you to have inconsistent data because this is sometimes necessary temporarily while making a number of related changes. An indication that a rule has been broken is that the pictorial representation of the distribution will not appear. Clicking on **Apply Changes** in such a case will tell you what the problem is. Here are the rules:

1. The pessimistic value must be strictly greater than the optimistic value.
2. The most likely value (where applicable) must be between the two, inclusive.
3. Confidence must be between 50% and 100% inclusive.
4. The optimistic value must be no less than zero after adjusting for the confidence value.
5. For lognormal only, optimistic must be strictly greater than zero.

NOTE: The absolute minimum of a lognormal is always zero, but Full Monte interprets the optimistic value so that about 1 in 750 samples fall between 0 and the optimistic value.

4.10 Editing in the Tabular Grid

Appropriate data may be directly entered into the tabular grid.

Editable columns are shown in blue when the row is selected, as shown in figure 4.6. You can enter percentages, durations and, for Input Milestones, dates.

NOTE: One disadvantage of editing in the grid is that each change is validated as soon as you leave the cell, so you may sometimes have to be careful in what order you make the changes. For example, if you had a triangular distribution and wanted to change the optimistic value from 50 to 65 days and the most likely value from 60 to 75 days, you would have to make the second change first to avoid breaking the rules even temporarily.

4.11 Data Import

4.11.1 Import for Microsoft Project

Full Monte for Microsoft Project supports loading duration uncertainty and other task information from Microsoft Project custom fields using File, Import. From Full Monte version 3.6, multiple import/export definitions can be saved.

File, Import allows the loading of the following data from Project fields.

On first use, the Import/Export dialog will be empty, as shown in figure 4.21.

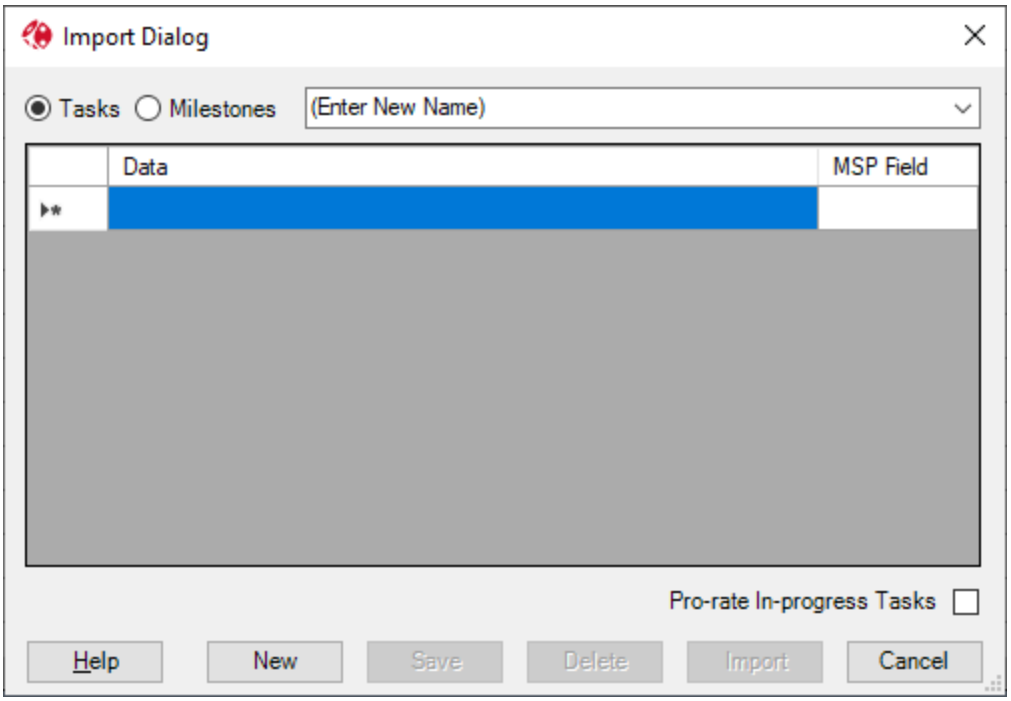


Figure 4.21

The radio buttons specify if the import definition is to be used to import task or milestone data. This is disabled for export as only task data can be exported.

Imports allow the loading of the following information:

- Duration Distribution Type
- Duration Optimistic
- Duration Most Likely
- Duration Pessimistic
- Duration Confidence Interval
- Probability of Existence (%)
- Discrete Risk

If the import is for Milestone data, then date fields must be used for the Duration Uncertainty fields.

To create a new import/export definition, first enter a name for the definition. Then click in the first empty row of the grid and it will be pre-populated with the basic fields.

The initial Project import fields can be modified by clicking on the field and choosing a new value.

After creating the definition, click Save to save the changes. New definitions can be created by clicking **New** and definitions no longer required can be removed by clicking **Delete**.

An existing definition can be copied by modifying the displayed definition name.

After any changes, click Save to commit the changes before executing the import/export.

An example import definition is shown in figure 4.22.

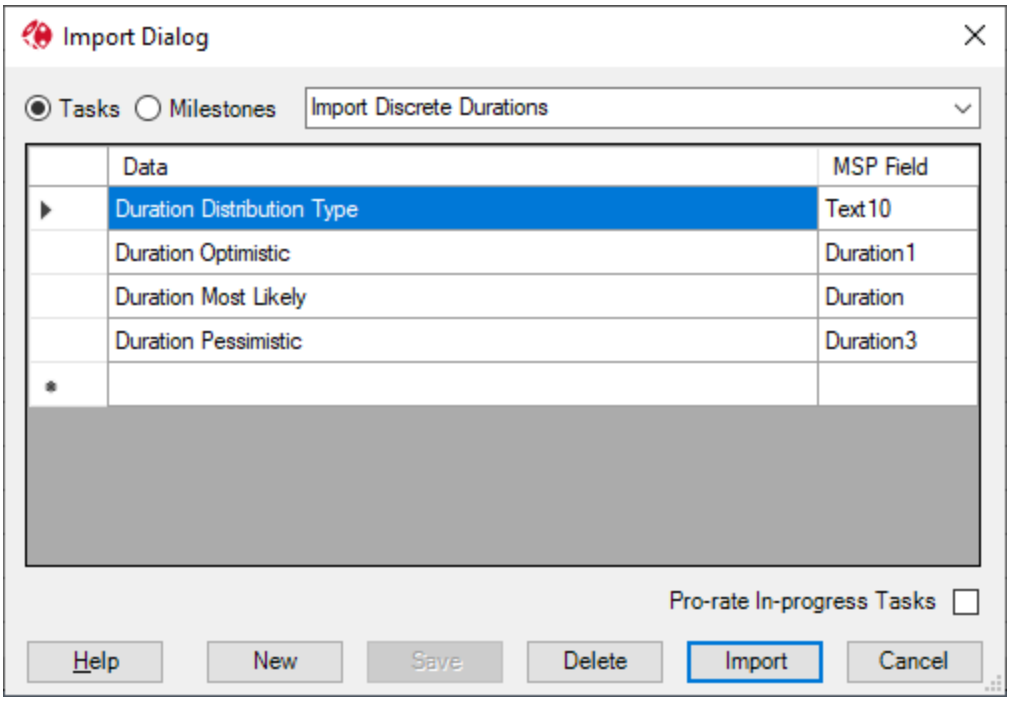


Figure 4.22

In Figure 4.22 the import has been configured to load task duration uncertainty data from Text10 and duration fields Duration1 (Optimistic), Duration (Most Likely), and Duration3 (Pessimistic).

The Duration Distribution Type field can be imported from either Text or Numeric custom fields. Only valid data will be loaded as defined in the following table:

Distribution Type	Text Field	Numeric Field
<No Change>	<blank>	Not Applicable
None	(None)	0
Beta	Beta	4
LogNormal	LogNormal	5
Normal	Normal	3
Triangular	Triangular	2
Uniform	Uniform	1

Note: If the custom text column containing the distribution type is empty (blank), then no changes will be made to existing uncertainty data in Full Monte for that task. If you wish to remove uncertainty information for a task, then the input custom column should contain '(None)' (or 0 if using a custom numeric column).

The duration optimistic, most likely, and pessimistic values can be imported from either custom Duration or Text fields (or Date fields for Milestones). As Microsoft Project Duration custom fields cannot contain percentages you must use a custom Text field if you wish to import percentages. If you are importing discrete durations, then we recommend using Duration custom fields because Microsoft Project can then validate the values are valid durations.

The import will replace any existing uncertainty data for the task (unless the distribution type is loaded from a custom Text field and that field is blank).

For **in-progress tasks** this can create an issue if the imported data has not been updated to reflect progress on the task.

When a project with existing uncertainty data is opened in Full Monte, Full Monte automatically pro-rates the uncertainty information on each task considering progress. However, if you then re-import the original data from custom columns then the pro-rated data will be replaced with the original uncertainty and can lead to remaining uncertainty being larger than expected. If you are re-importing uncertainty data, perhaps to include new scope, then you must either set the duration distribution type custom text field for existing tasks to blank (Empty) or enable the check box 'Pro-rate In-progress tasks' so that Full Monte will adjust the imported data to consider progress.

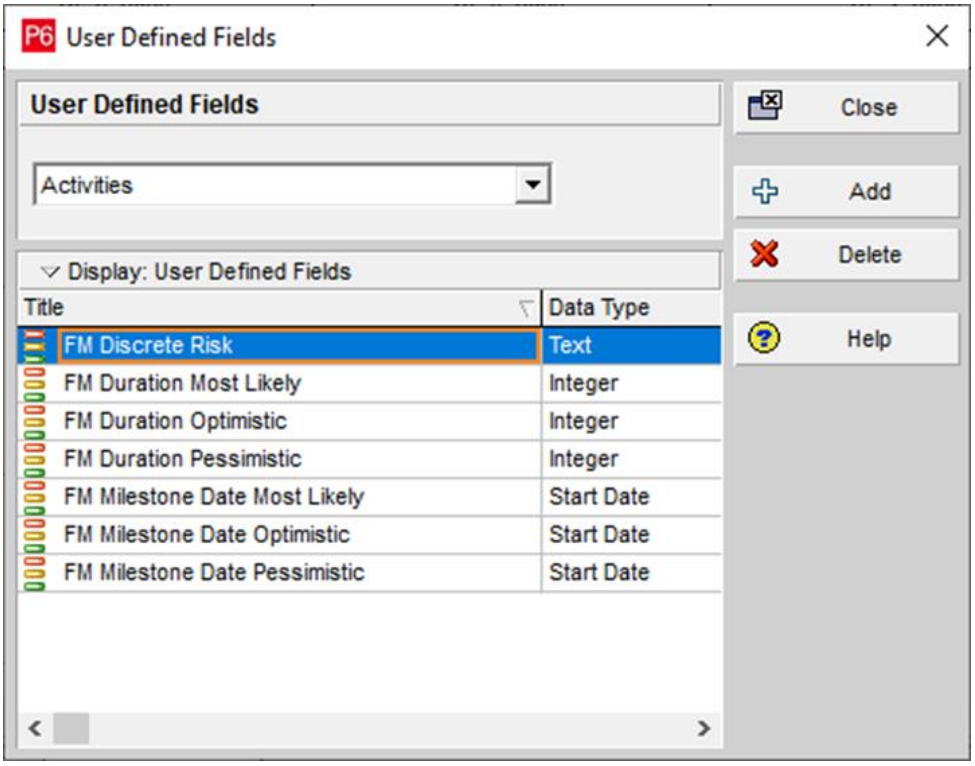
4.11.2 Import for Primavera P6

Full Monte for Primavera P6 supports loading duration uncertainty and other task information from Primavera P6 User Defined activity fields using File, Import.

There are three configurations for the import.

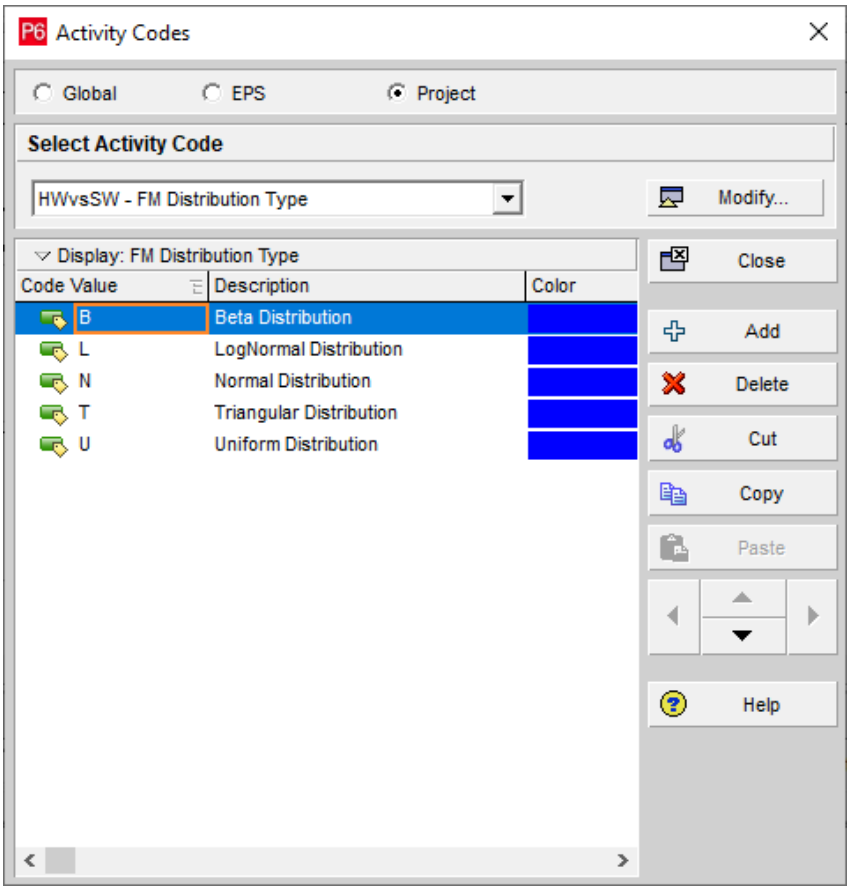
Only the specific Primavera User Defined Fields for the required import need to be defined. In total there are 8 User Defined Fields or Activity Codes that can be imported.

The user is responsible for creating the fields in Primavera P6. Take care to set the correct Data Type.



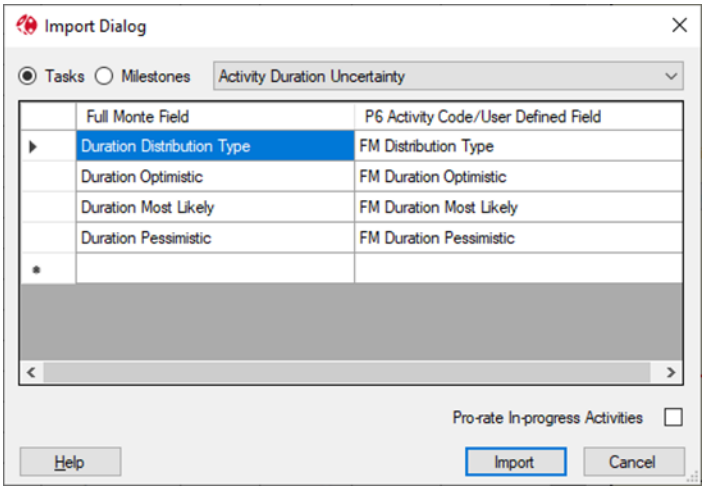
The 8th field is 'FM Distribution Type'. This can either be defined as a text User Defined Field or as an Activity Code. This field is used to define the relevant distribution for both Duration and Milestone uncertainty values.

Here is an example for defining FM Distribution Type as an Activity Code.



The 'values' can be either Beta, LogNormal, Normal, Triangular, Uniform or abbreviated to B, L, N, T, U. The value 'Constant' or 'C' can be used instead of Uniform or U.

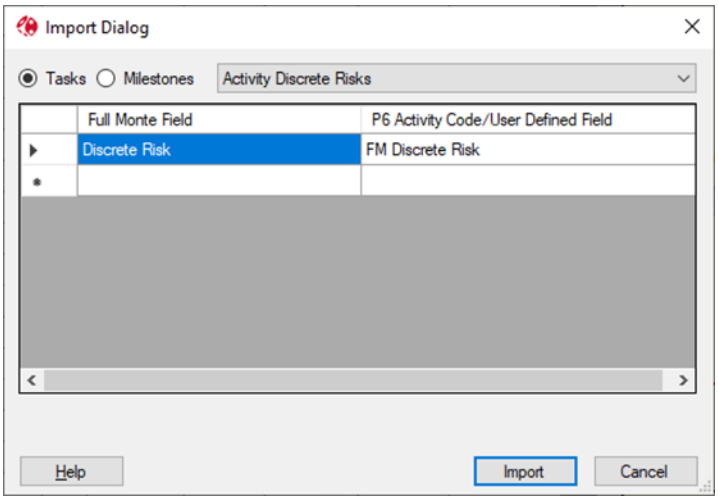
The first configuration imports Duration Uncertainty data.



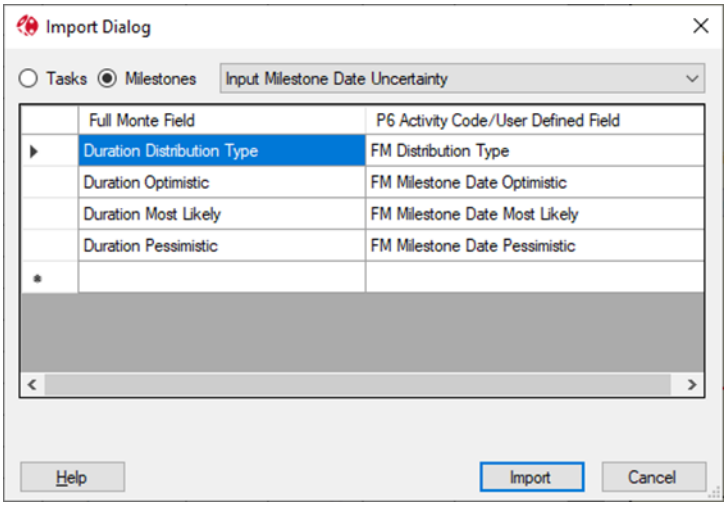
The FM Duration Distribution Type user defined field must contain a type supported by Full Monte (Triangular, Beta, Normal, LogNormal, or Uniform). If the FM Duration Distribution Type is empty (blank) then no data will be loaded for that activity.

If you have in-progress activities and do not wish to manually adjust the specified durations values to match the current progress, you can check the 'Pro-rate In-Progress Activities' option to have Full Monte automatically adjust the Uncertainty values to reflect progress.

The second configuration can be used to import Discrete Risk Assignments. The imported Risk ID must match an existing Discrete Risk defined in Full Monte (Edit, Manage Risks).



The third configuration can be used to import Input Milestone Date Uncertainty.



The FM Milestone Date Distribution Type user defined field must contain a type supported by Full Monte (Triangular, Beta, Normal, or Uniform). If the FM Milestone Date Distribution Type user defined field is empty (blank) then no data will be loaded for that milestone.

4.12 Data Export

Note: Currently only supported by Full Monte for Microsoft Project. For Primavera P6 please see the related feature Edit, P6 User Defined Fields.

Full Monte data and results can be saved to Microsoft Project custom fields on a one-off basis using the File; Export… menu option.

> *Note: Full Monte does not check for any existing data in the custom fields specified for the export. Any existing data in those fields will be **overwritten without warning** by the export.*

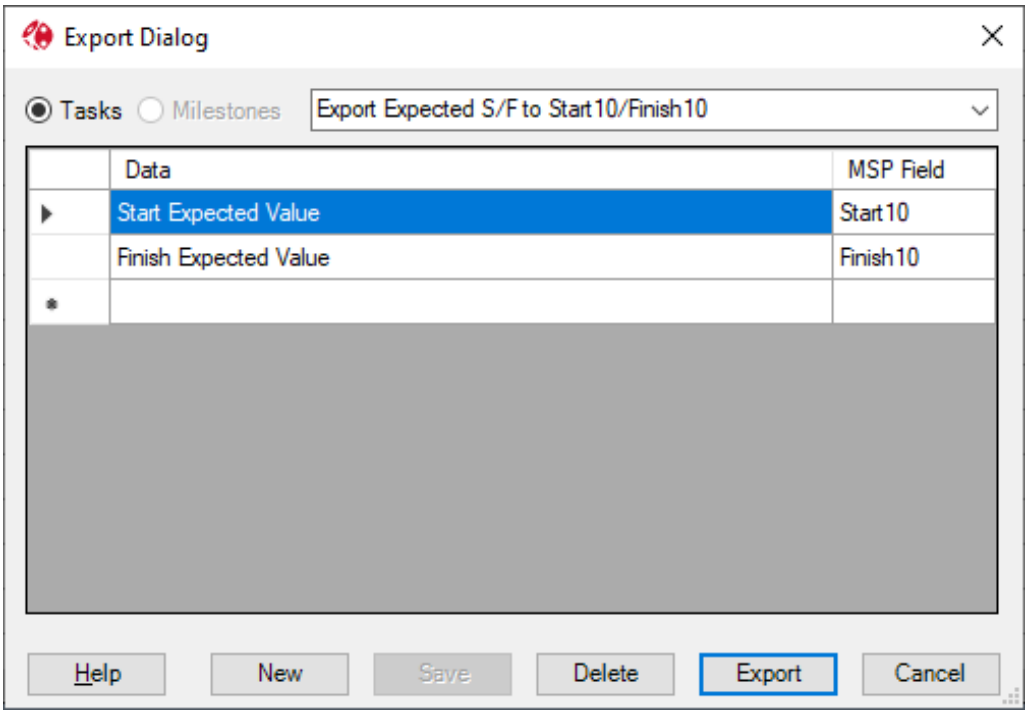


Figure 4.23

While most Full Monte fields can only be exported to Microsoft Project custom fields of the same data type, some fields can be exported to multiple data types.

Duration Distribution Type – This can be exported to either a Numeric or Text custom field.

Export values will be:

Distribution Type	Numeric Field	Text Field
None	0	(None)
Beta	4	Beta
LogNormal	5	LogNormal

Normal	3	Normal
Triangular	2	Triangular
Uniform	1	Uniform

Duration Optimistic/Most Likely/Pessimistic – These fields can be exported to either Duration or Text custom fields.

> *Note: if you choose to export optimistic/most likely/pessimistic duration values represented in Full Monte as percentages to a Duration custom field, the percentage will be converted to duration values.*

Chapter 5: Risk (Threat and Opportunity) Management

Threats and Opportunities are random events that may or may not occur. If they occur there will be some impact on the schedule. Collectively these are often called Risks.

Risks (Threats and Opportunities) can be modelled in several different ways in Full Monte.

- Using **Manage Risks** (available from the Full Monte Edit Menu).
- Using **Full Monte Risk Plans** (available from the main Full Monte Add-Ins menu).
- Using **Probabilistic Branching** and **Probability of Existence** (available from the Full Monte Edit view).

Threats typically delay the schedule by adding more work to be performed while Opportunities may present an alternative approach that can reduce the time and work for the schedule.

> *Note: Not all Opportunities can be considered random events. In fact, many opportunities can be considered decision points: - A **decision** will be made regarding whether to adopt an available opportunity. Such tasks are not 'random' and the underlying schedule can simply be updated when the decision has been made to implement such an opportunity.*

5.1 Manage Risks

The Edit, Manage Risks dialog shown in Figure 4.1 is a simple way to define Threats that may impact the schedule.

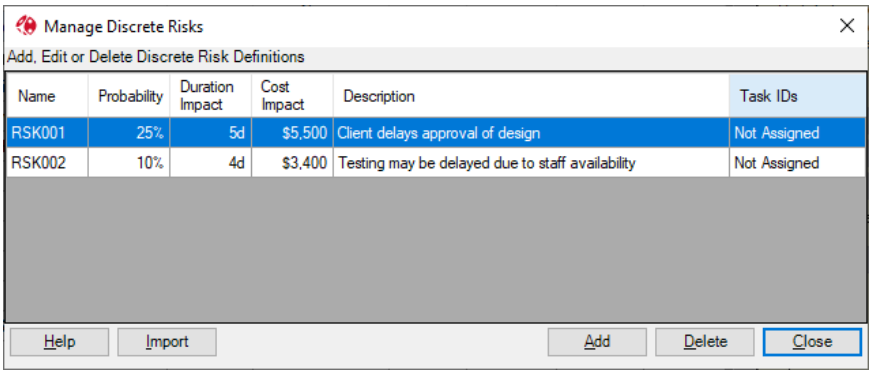


Figure 5.1

This dialog allows the user to create and manage risks that can be applied to the schedule.

The Manage Risks dialog can define risks in two different ways:

1) By assigning a risk that has a Probability of occurrence but no Duration Impact (Impact is 0d), the probability will be assigned to the Task Existence and will govern whether the entire task exists or not. This mechanism was supported in earlier versions of Full Monte.
2) By assigning a risk that has both a Probability and a Duration Impact to a task, the Probability will govern the chance of the Duration Impact being added to the existing assigned task duration during the simulation. This option was introduced in Full Monte 3.6.

Assignments of Tasks/Activities to defined Risks is achieved through the main Edit View in one of three ways:

- Selecting a Risk in the Existence tab of the edit pane.
- Importing a Risk Assignment from a schedule user column.
- Adding relevant columns to the main edit spreadsheet.

See section 4.7.1 for further information regarding the Existence tab.

The File, Import can be configured to load risk assignments as shown in Figure 5.2.

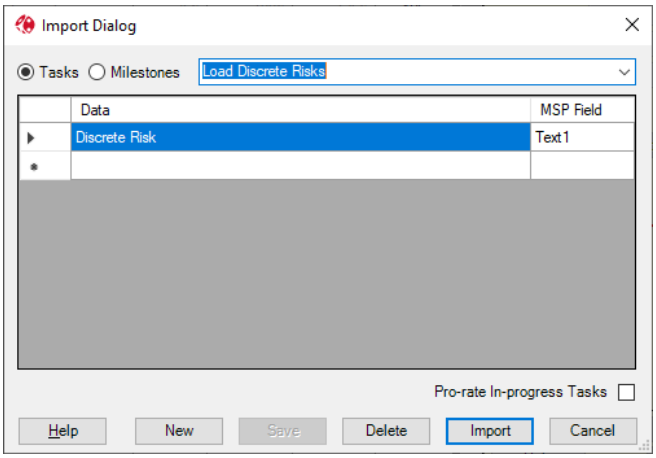
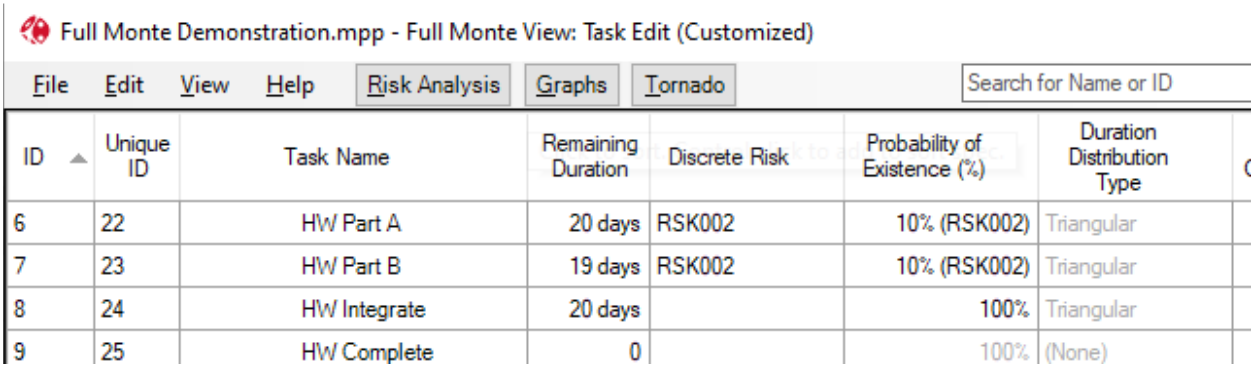


Figure 5.2

In this example, the custom field Text1 should contain Risk IDs that match those defined in Edit, Manage Risks.

Figure 5.3 shows an example where the Discrete Risk and Probability of Existence have been added as columns to the Edit view.



ID	Unique ID	Task Name	Remaining Duration	Discrete Risk	Probability of Existence (%)	Duration Distribution Type
6	22	HW Part A	20 days	RSK002	10% (RSK002)	Triangular
7	23	HW Part B	19 days	RSK002	10% (RSK002)	Triangular
8	24	HW Integrate	20 days		100%	Triangular
9	25	HW Complete	0		100%	(None)

Figure 5.3

This can be used both to enter data and validate information loaded in other ways.

Duration and Cost Impact values can be both positive (threats) and negative (opportunities).

5.2 Full Monte Risk Plans

This is a new feature added in version 3.7. Risk Plans comprise a more extensive risk register that allows the definition of both Pre and Post Response impacts including both schedule and cost and automated generation of schedules that include tasks representing both threats and opportunities.

Risk Plans are maintained from the Full Monte Risk Plans menu in the main Full Monte Add-Ins menu block as shown in Figure 5.4

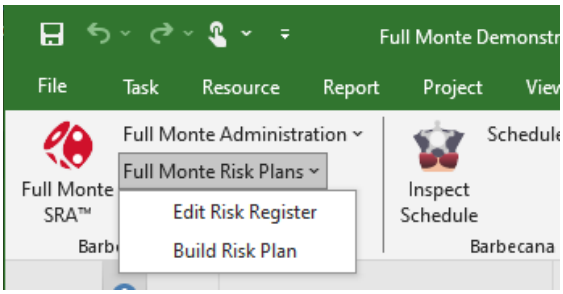


Figure 5.4

5.2.1 Edit Risk Register

Selecting Edit Risk Register will open a dialog to maintain risks for the current schedule as shown in Figure 5.5

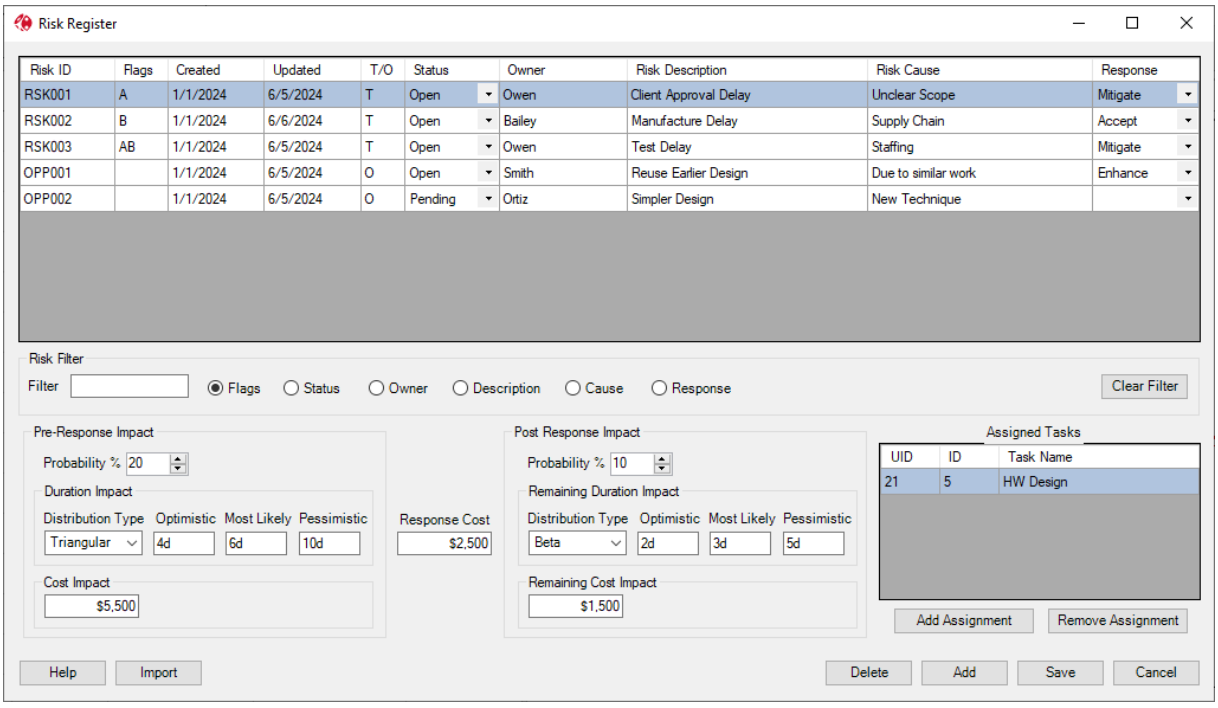


Figure 5.5

Risk information includes:

Risk ID A unique identifier.

Flags The flag field allows you to create groups of risks that comprise various scenarios. The scenarios to include can be selected when creating the Rik Plan.

Created Date	The date a risk was added to the register.
Updated Date	The date a risk was last updated in the register.
T/O	Threat or Opportunity.
Status	Pending – Risk is newly added to the register and no response identified. Open – Risk actively being worked and a response being identified. Closed – Risk is fully defined. Realized – The risk occurred and has become an active issue.
Owner	The person or group responsible for working the risk.
Risk Description	A description of the risk.
Risk Cause	An explanation of why the risk may occur.
Response	Accept – Accept the risk may occur. Avoid – Modify the plan to avoid the circumstances that lead to the risk. Enhance – The Opportunity can improve the schedule. Mitigate – Reduce the impact of the risk should it occur. Transfer – Make someone else responsible for the risk and its impact.
Pre-Response Impact	A definition of the chance the risk will occur, and the time and cost impacts should it occur.
Response Cost	The cost of the work required to respond (typically mitigate) to the risk.
Post-Response Impact	A definition of the chance the risk will occur after the response steps have been completed and the revised time and cost impacts.

Note: Cost Impacts (both Pre and Post response) are applied as Fixed Costs to the tasks used to model the risk impact in the schedule. The Response Cost is applied as an additional Fixed Cost to the original task(s) that are assigned to the risk.

Assigned Tasks	A list of tasks that the risk has been assigned to.

Threats will be modelled using new tasks added to the schedule as successors of the assigned task to represent the risk. The risk probability (either Pre or Post mitigation) will be used to set the task existence for the task.

Opportunities will be modelled using new tasks added to the schedule as alternatives to the assigned task using Probabilistic Branching.

Risk Filter options include filter by Flag, Status, owner, Description, Cause or response.

Adding Task Assignments

To associate a risk with a task in the schedule, click Add Assignment. This will open the dialog shown in Figure 5.6.

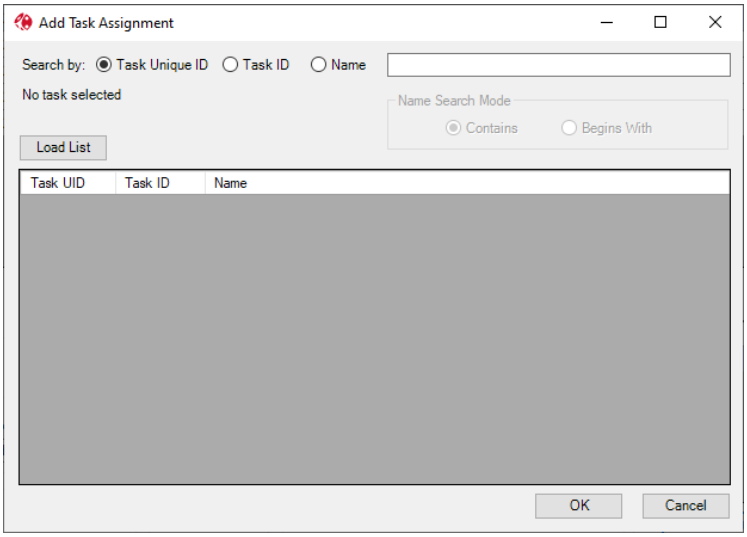


Figure 5.6

The Add Task Assignment allows you to add/search for tasks using three different keys: Task Unique ID, Task ID, or Task Name.

The dialog can display all tasks in the schedule. The list is populated if you either choose to search by Task Name or click the Load List button.

If you choose to search by Task name, then you have the option to search for Names containing the search text or for Names beginning with the search text as shown in Figure 5.7.

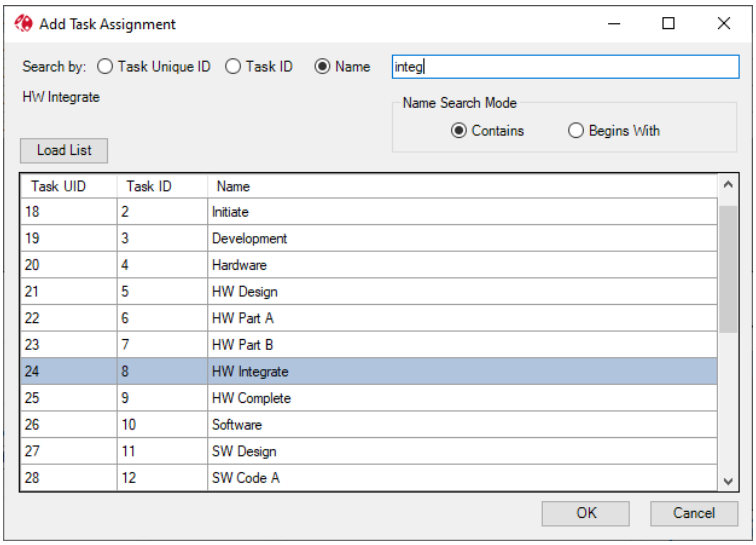


Figure 5.7

The grid can be sorted by clicking the column headings.

5.2.2 Build Risk Plan

The Build Risk Plan option will create a copy of the original schedule (the Risk Plan) that includes tasks to model Threats and Opportunities.

The new project will be named as follows (using the demonstration project as an example):

Original Project Name: **Full Monte Demonstration.mpp**
Copy Project name if based on Pre-Response data: **Full Monte Demonstration-Pre-Response.mpp**
Copy Project name if based on Post-Response data: **Full Monte Demonstration-Post-Response.mpp**

When first selected, the Build Risk Plan option will display the dialog shown in Figure 5.8

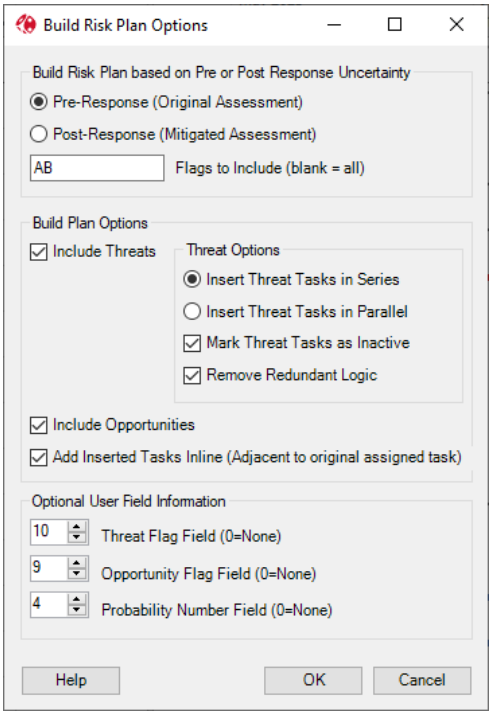


Figure 5.8

The user can choose whether to use Pre or Post Response impact values for tasks added to the schedule.

> *Note: For Opportunities, only Pre-Response impact values will be used as no Response is required or allowed for Opportunities.*

If the Flag field is blank then all defined active risks (Pending, Open, Closed) will be included in the Risk Plan. If the Flag field contains characters, then only Risks that include the same Flag will be included in the Risk Plan. In the example, in Figure 5.8, only Risks flagged with either an A, B or both A and B will be included.

> *Note: Risks with a status of Realized are never included in a Risk Plan as they are deemed to have occurred and are no longer Risks. They have become issues.*

The user can choose to include either **Threats** or **Opportunities** (or both) in the risk plan schedule.

Other options are:

Insert Threat Tasks in Series

This option controls how multiple risks assigned to the same task are modelled.

If the option is selected, then each new risk will be added in series between the original task and its successor. In the worst case, if both risks deemed 'active' in a particular iteration then the successor will be delayed by the sum of the impact duration. An example is shown in Figure 5.9.

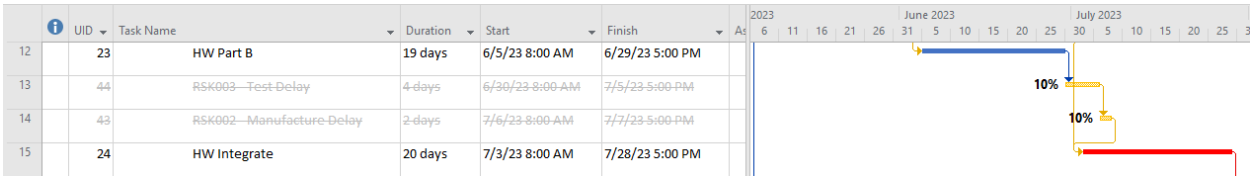


Figure 5.9

Insert Threat Tasks in Parallel

If this option is selected, then each new risk will be added in parallel with any other assigned risks. This will reduce the overall schedule delay although the cost impact will remain the same. An example is shown in Figure 5.10.

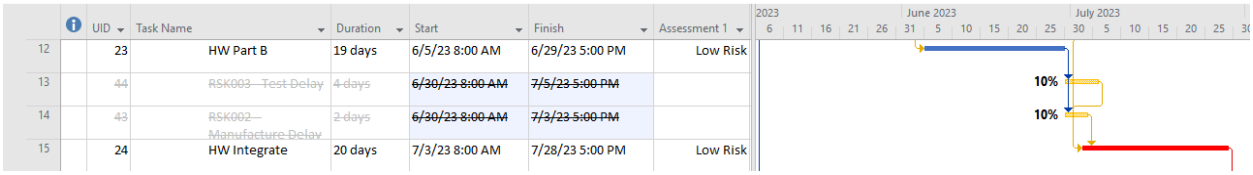


Figure 5.10

Mark Threat Tasks as Inactive

This option is only available when you are using Microsoft Project Professional Edition. As shown in the examples above, the tasks representing risks have been marked as inactive, so Microsoft Project treats them as zero duration for the purposes of the regular critical path calculation. Full Monte will use the Probability of Existence to determine how frequently the risk is active during the simulation.

Remove Redundant Logic

When a risk task is inserted between the original assigned task and its successors, Full Monte adds the necessary logic to link the original assigned task to the risk and then the successor. Any original logic linking the original assigned task to the successor will be removed if this option is selected. If the option is not selected, then the original logic will remain. It does no harm.

> *Note: There appears to be a bug in Microsoft Project related to the slack (float) calculated for a task that has an Inactive task as a Successor. If this is an issue, two workarounds exist: Either disable the Full Monte option to mark Threat tasks as inactive or disable the Full Monte option to Remove Redundant Logic. Slack will then be calculated correctly. Full Monte calculates the correct slack values regardless of the setting of this option.*
>
> *Consider the following example (Figure 5.11)*

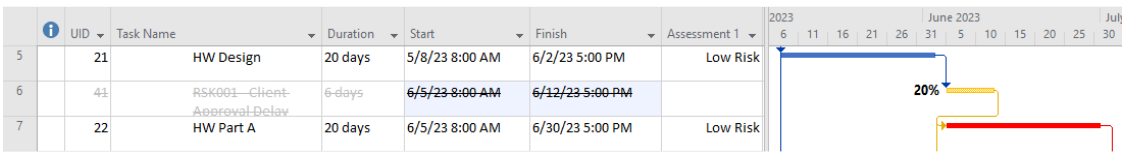


Figure 5.11

Task UID 21 finishes on 2Jun23 5:00pm (A Friday). Its successor (UID 22) starts on 5Jun23 8:00am (a Monday). UID 22 is critical (red bar) as should UID 21, but it is not (blue bar).

If we either disable the option to Mark Threat Tasks as Inactive (Figure 5.12) or disable the option to remove redundant logic (Figure 5.13) the original task is correctly marked as Critical by Project.

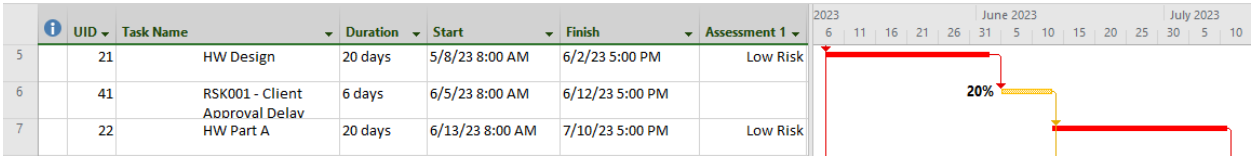


Figure 5.12 Threat tasks not marked as Inactive.

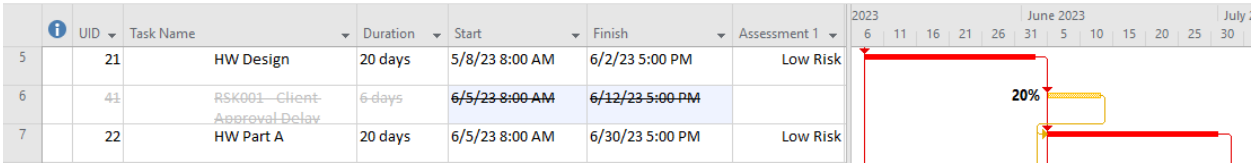


Figure 5.13 Redundant Logic not removed.

As stated above, Full Monte will always calculate the correct values, regardless of the options selected.

Add Inserted tasks Inline (Adjacent to original assigned task)

This option controls have the tasks representing Threats and Opportunities are added to the schedule.

If selected, the risk tasks will be inserted into the schedule adjacent to the assigned task as shown in Figure 5.14.

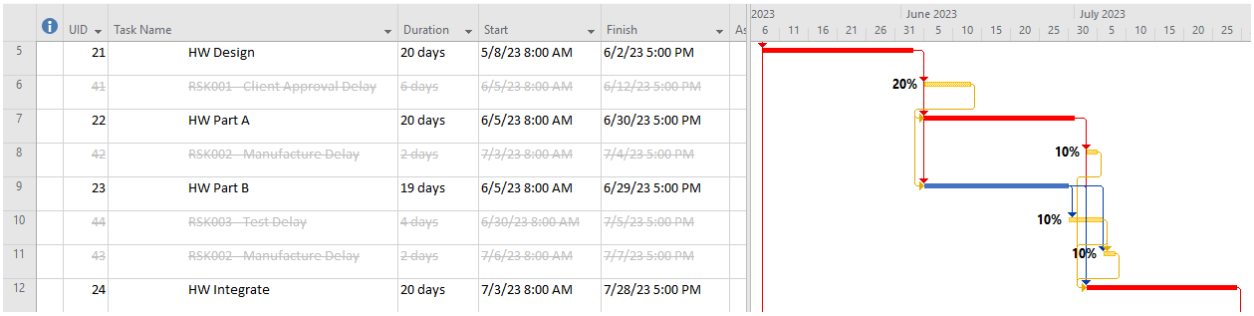


Figure 5.14

If the option is not selected, then the risk tasks will be added after the last task in the schedule as shown in Figure 5.15. Note: Some intermediate tasks have been hidden for clarity.

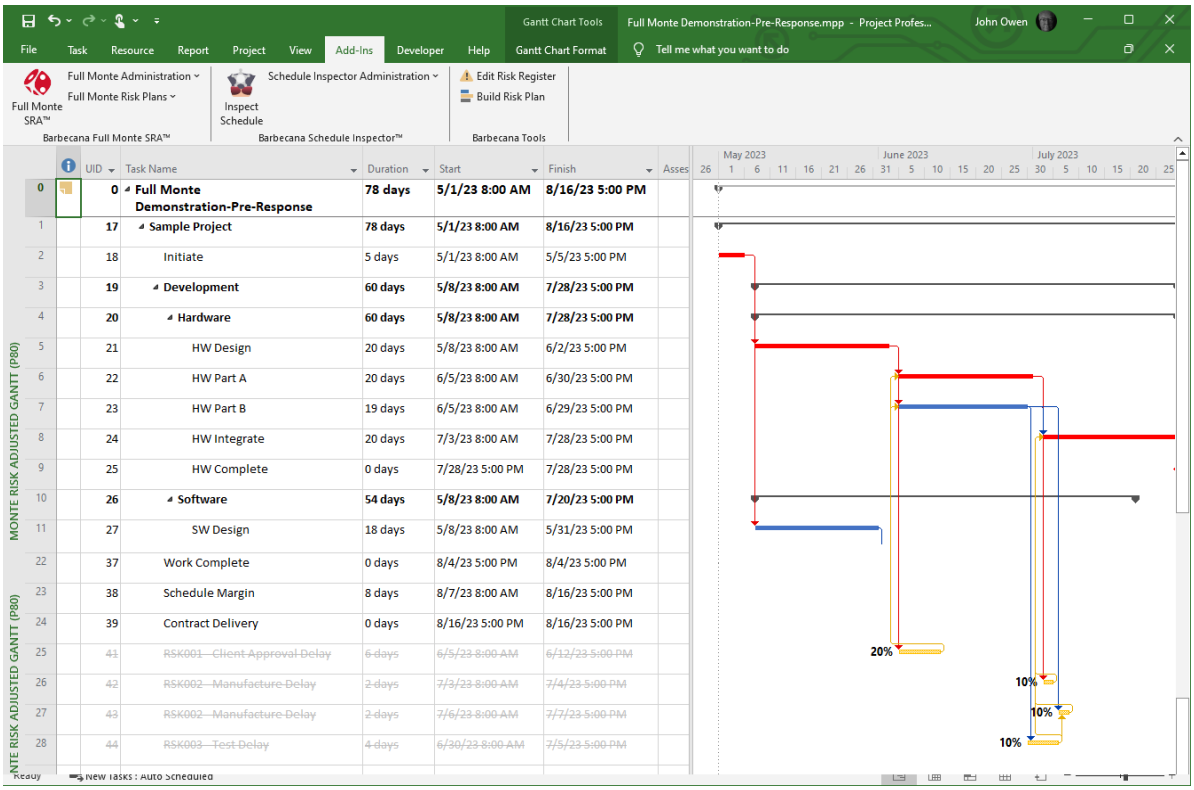


Figure 5.15

All the appropriate Full Monte data for Duration Uncertainty, Task Existence and Branching is automatically generated and can be viewed in Full Monte as shown in Figure 5.16.

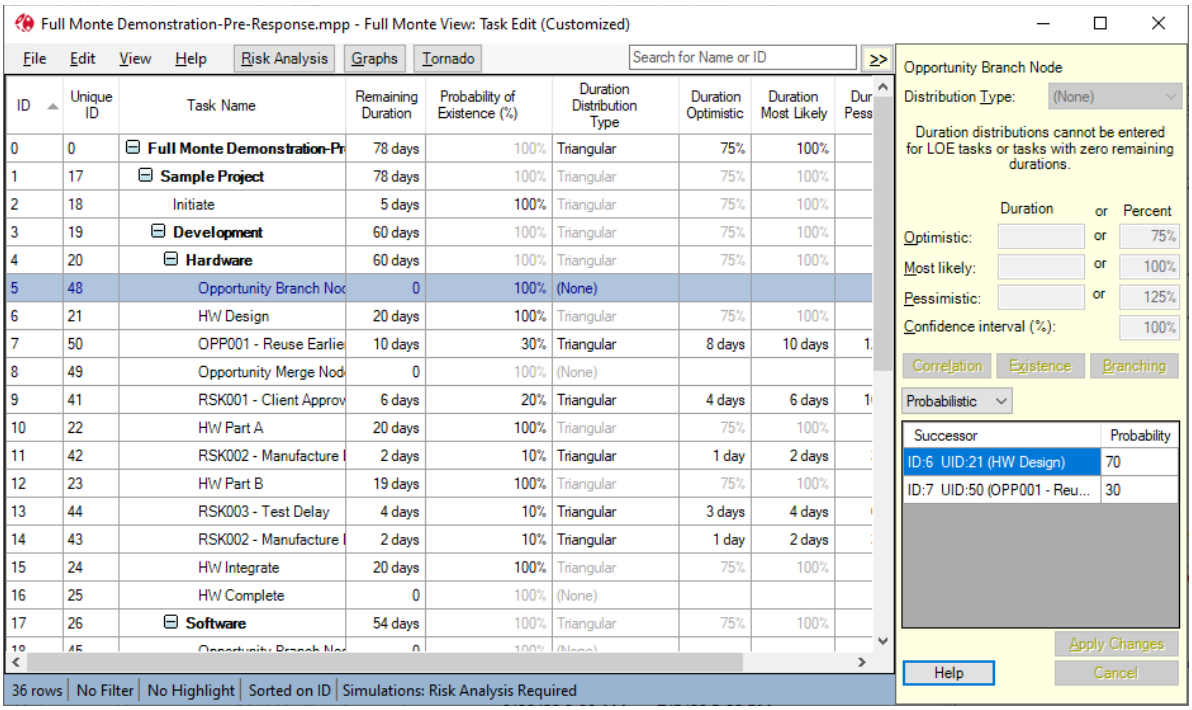


Figure 5.16

The user can then add any required additional duration uncertainty information and perform the Risk Analysis.

There are three Optional User Field Information controls.

Threat Flag Field – An optional flag field that will be set to Yes/True for newly created Threat tasks.

Opportunity Flag Field - An optional flag field that will be set to Yes/True for newly created Opportunity tasks.

Probability Number Field – An option number field to store the probability of existence for Threats and Opportunity tasks.

These values can be used to highlight Threats and Opportunities in Microsoft Project Gantt charts as shown in Figure 5.17.

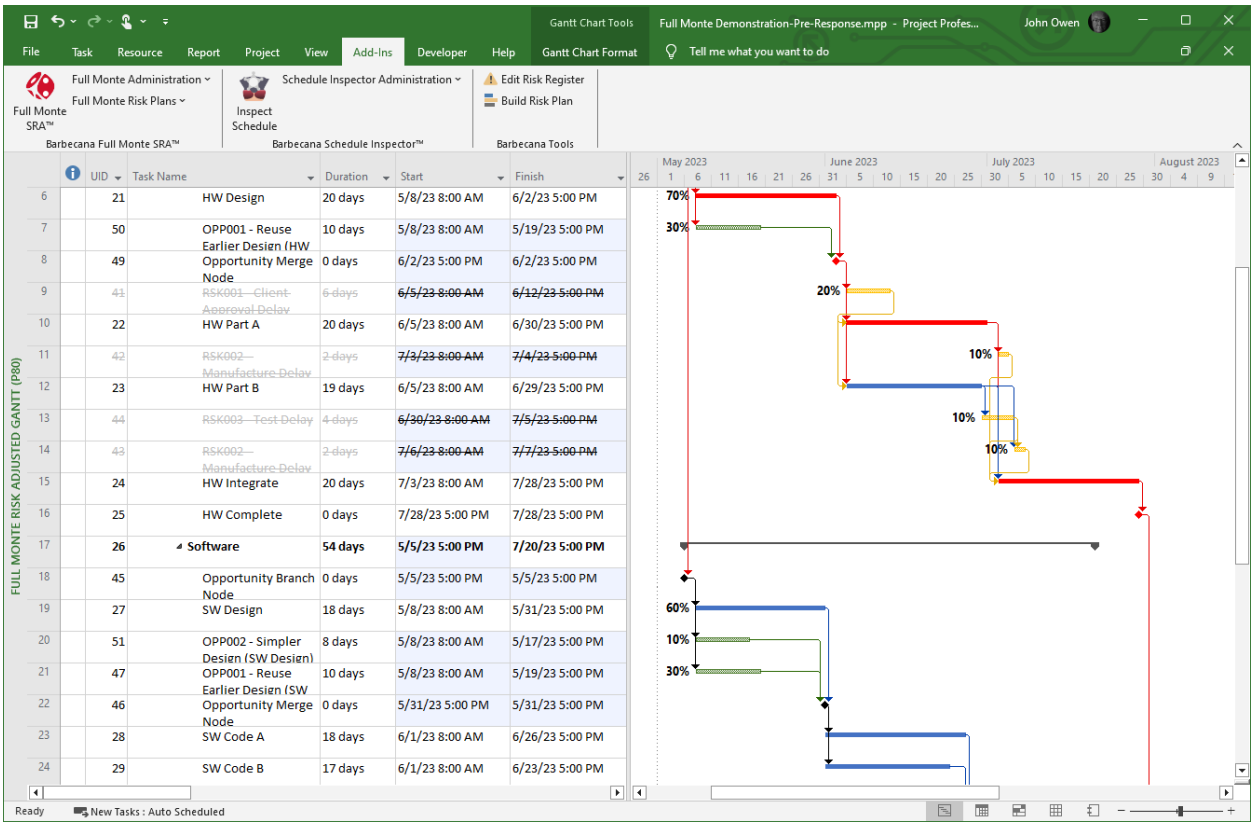


Figure 5.17

Yellow Bars represent Threats (with Probability of Existence)

Green Bars represent Opportunities (with Probabilistic Branching)

Red and Blue bars are the original Microsoft Project schedule.

Chapter 6: Editing Full Monte Data for Resources / Costs

Costs are calculated by Full Monte based on Resources and Costs assigned to tasks/activities in the schedule.

6.1 Microsoft Project

Costs in Microsoft Project are derived from resources assigned to tasks and fixed costs.

Microsoft Project supports three types of resources:

- Work (Labor)
- Material
- Cost

For Work and Material resources, cost is calculated by multiplying the assigned units by the rate specified for the resource. Cost resources are assigned using the cost value. For example, if a 10d task on an 8hr/day calendar has a Work resource assigned at a level of 100% and the standard rate for that resource is $50/hr, then the total cost for the task will be $4,000 (10d * 8hrs * $50/hr).

Any Fixed Costs assigned to the task are added to the resource cost to derive a total task cost.

When Duration Uncertainty data has been specified for a task in Full Monte, Work and Cost resource costs are prorated based on the sampled duration in each simulation.

Using the example above, assume the task has +/- 1 Day of uncertainty. If the sampled duration in a simulation is 9d then the resource cost will become 9d/10d*$4000 = $3,600 for that iteration of the simulation. In practice the calculation is more complex because it takes into account any rates change from time-based rate escalation in Microsoft Project and/or resource rate uncertainty defined in Full Monte.

Material and Fixed Costs are not modified during the simulation.

> ***Note**: While technically Microsoft project allows the manual editing of the 'Cost' column, this is not recommended because costs derived from resources may not match the manually entered value. Full Monte always bases costs on assigned resources and fixed costs. It will not be aware of any manually modified 'Cost' values.*

6.2 Oracle Primavera

Costs in Primavera are derived from Resource Costs and Expense Costs.

Primavera supports three types of resources:

- Labor (People)
- Material (Supplies)
- Non-Labor (Machinery, Equipment, etc.)

6.3 Resource rate Uncertainty

Selecting the menu item **Edit/Edit Resources** takes you to a similar view for editing distributions on resource cost rates.

> *NOTE: This menu item will be disabled if there are no cost rates associated with any resources used by the project or the resource fields are not mapped in Full Monte for Microsoft Project (see the Full Monte for Microsoft Project Installation Guide).*

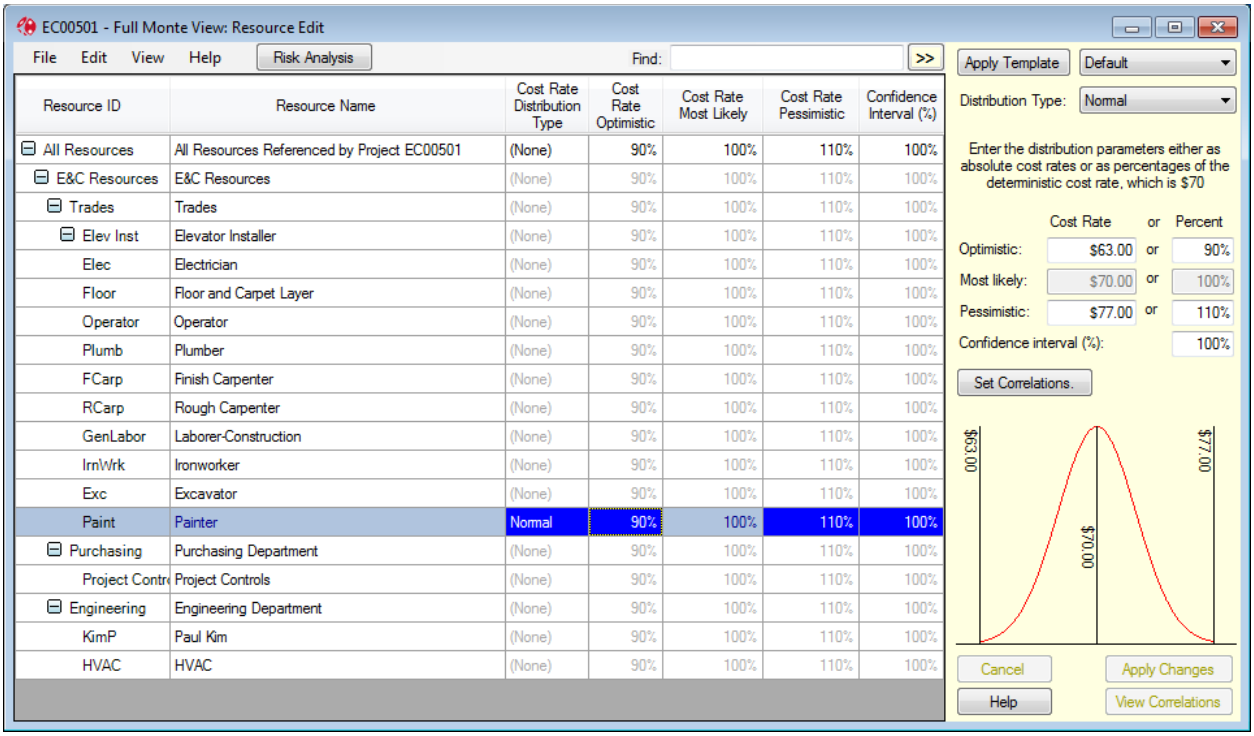


Figure 6.1

The view shows only those resources assigned to activities in this project. It works in a similar way to the **Activity Edit** view.

For individual resources, you can enter data only if there is a cost rate defined. If there is only one rate for the resource, you can enter the values in currency units. If there is more than one rate, that is if there is cost escalation, all rates are assumed to move in unison and the distribution parameters must be entered as percentages.

For higher levels in the resource hierarchy, data must be entered in percentage terms, and it is used as defaults for the lower levels.

Correlations work in the same way as activity durations. Resource rates can be correlated with either other resource rates or with activity durations or both.

NOTE: During the simulation, the cost of each activity is calculated using its resource usage and the appropriate rate, having regard to any escalation.

When you have finished you can close the view, and you will be back in the **Activity Edit** view. You will be prompted whether you want to save any changes made to the resource rate distributions.

Chapter 7: Editing Full Monte Data for Calendars

[This capability is available only in **Full Monte for Primavera P6**.]

Selecting the menu item **Edit/Edit Calendars** takes you to a somewhat similar view for editing calendars. It looks like the example shown in figure 7.1.

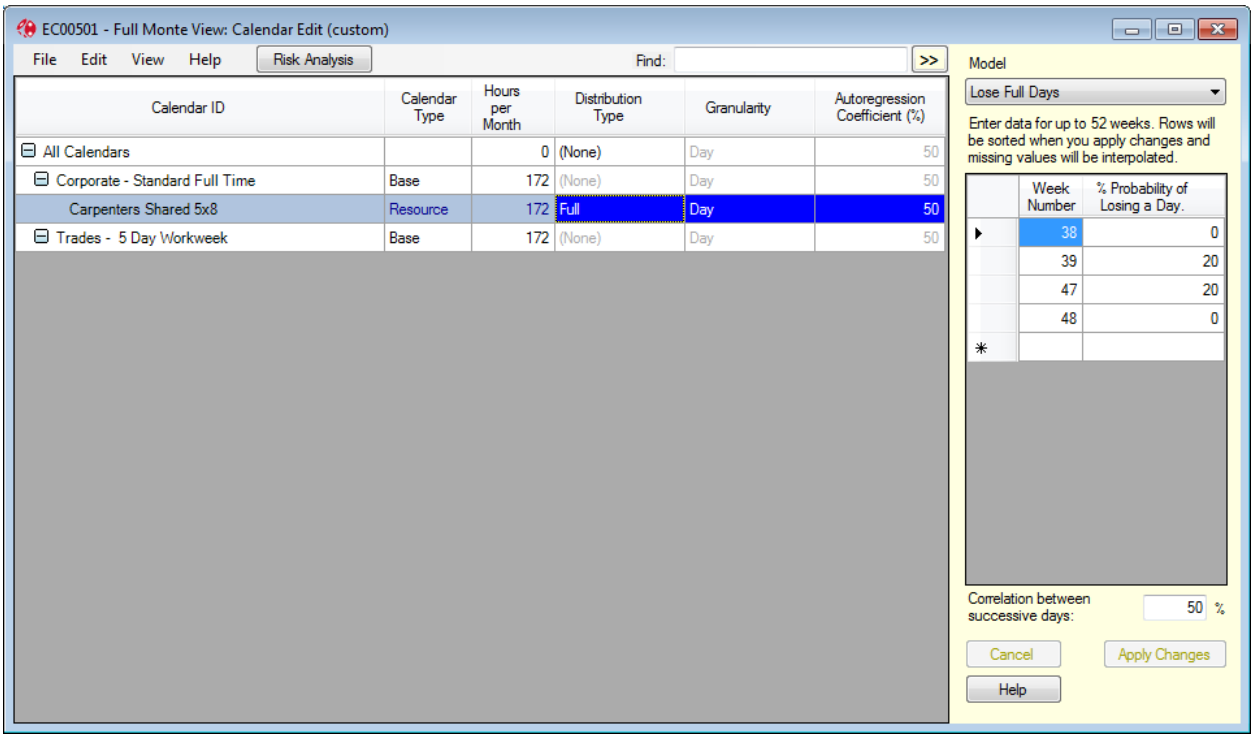


Figure 7.1

The view shows only those calendars assigned to activities in this project or to their resources. The way calendars are modeled requires some explanation. There are four basic models:

1. Full days may be lost or not on a seasonal and random basis.
2. A randomly generated proportion of a day may be lost; this proportion being generated from a lognormal distribution.
3. Full weeks may be lost or not on a seasonal and random basis.
4. A randomly generated proportion of a week may be lost; this proportion being generated from a lognormal distribution.

The model is used in conjunction with an expected value for the particular week number. In the above example, we expect to lose 20% of the working time between weeks 39 and 47 inclusive, and none at the other times. During the simulation, Full Monte will interpolate the probability between specified points, including wrapping around the year-end from the last week number to the first. (Any odd days in week 53 are treated as part of week 52 for this purpose.)

NOTE: If your data is not seasonal, maybe because it has nothing to do with the weather, you only need to add one row to the grid, and it does not matter what the week number is.

It is also possible to specify a correlation between consecutive days or weeks. This is meant to model the extent to which one period affects the next and allows modeling of the fact that the weather is more likely to be also bad on the day following an episode of bad weather. A default is provided of 50% for daily models and 0% for weekly models, which is appropriate for some measures of the weather. (The effect wears off rapidly with time. Raising 50% to the power of 7 — to get the weekly value — gives less than 1%, which would not be material.)

NOTE: Correlations of more than 70% for daily models (8% for weekly models) are rarely appropriate, especially when the probability of lost time is also high. With the discrete models (full days or weeks lost) in particular, even moderate correlations when used in conjunction with high probabilities of lost time for extended parts of the year can result in unintentionally long periods with no working time, with consequent effects on project duration.

When you see the results (see Chapters 8 and 9), you will notice that this does not change the reported duration, which is typically in *working* days, but it does change the *elapsed duration*. Two activities with the same duration (in working days) may take different times (or elapsed durations) if they occur in different periods. This is a much better way to model the weather than using correlations.

NOTE: Two activities that both depend on the weather in the same location are correlated only if they happen at the same time, which, in theory at least, is not known in advance. Modeling the connection with a correlation between the two durations is therefore not as realistic as modeling the calendar as described above.

Chapter 8: Risk Analysis (Monte Carlo Simulation)

8.1 Running Risk Analysis

This is performed by clicking on the **Risk Analysis** button on any tabular view. The Risk Analysis dialog is displayed.

8.1.1 Full Monte for Microsoft Project

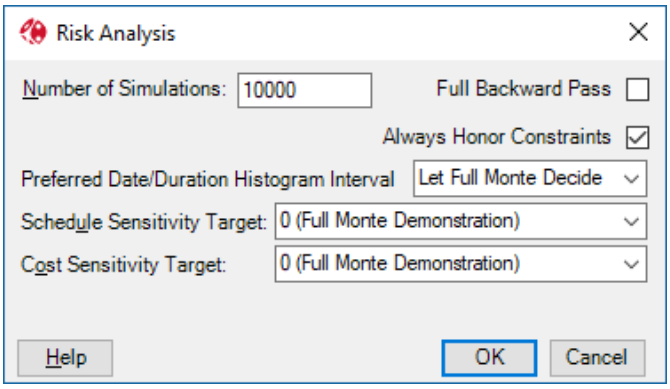


Figure 8.1

The edit controls are populated using the values last used for this project, or system defaults otherwise. You can choose several options, as described below.

Number of Simulations: The larger this number, the better your results will be. Not only will your results be more accurate, but the graphics will tend to be smoother and therefore more aesthetically pleasing. The only downside to doing more simulations is the additional processing time. However, Full Monte is fast, so you can afford to do more simulations than might be practical with slower products. We recommend a minimum of 10,000 for presentation reports.

Full Backward Pass: For each iteration of the simulation, Full Monte performs a complete Forward pass of the Critical Path Method (CPM) algorithm. This calculates the early dates and histograms, sensitivity (Tornado chart), criticality, and basis (diagnostic) information. This forward pass is performed regardless of the setting of the 'Full Backward Pass' option.

If Late Dates and Slacks/Floats (calculated by a CPM Backward pass) are required, then enable the option for a 'Full Backward Pass'. This will roughly double the amount of time required for each simulation. For most schedule risk analysis purposes this option is not required.

> *Note (Microsoft Project only): If the project contains tasks using the As Late as Possible (ALAP) constraint type, then the Full Backward Pass option will be enabled, and cannot be disabled, as the backward pass and an additional forward pass are required to correctly process ALAP constraints as interpreted by Microsoft Project.*

Always Honor Constraints (Full Monte for Microsoft Project only): Since we are trying to study the effect of uncertainty on the schedule, it is best to allow the analysis to show how delays to predecessors can affect successors. Constraint Dates such as 'Start No Later Than', 'Finish No Later Than, 'Finish On', etc. can prevent tasks moving into the future as driven by logic. Microsoft Project has a setting

called 'Tasks will always honor their constraint dates' (Options, Schedule). When set, this option allows constraint dates (Start/Finish No Later and Must Start/Finish On) to prevent early dates from moving into the future even if logic dictates that the dates are not achievable. This creates an unrealistic/unattainable goal. If the option is set in Microsoft Project, it will also be set in Full Monte as our first goal is to honor data from Microsoft Project. However, the option can also be temporarily disabled in Full Monte by clearing the 'Always Honor Constraints' check box. When disabled, Full Monte will modify the effect of certain constraint types as follows:

Constraint Type	Treated As
Must Start On	Start No Earlier Than
Must Finish On	Finish No Earlier Than
Start No Later Than	Ignored
Finish No Later Than	Ignored

This allows Full Monte to produce a more realistic forecast completion date based on logic rather than artificial, unrealistic, constraints.

8.1.2 Full Monte for Primavera P6

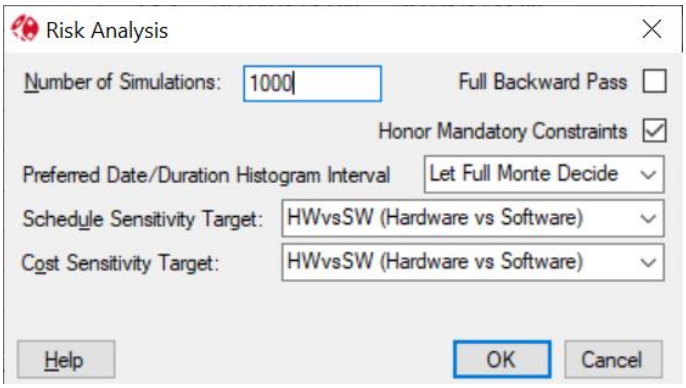


Figure 8.1

Number of Simulations: The larger this number, the better your results will be. Not only will your results be more accurate, but the graphics will tend to be smoother and therefore more aesthetically pleasing. The only downside to doing more simulations is the additional processing time. However, Full Monte is fast, so you can afford to do more simulations than might be practical with slower products. We recommend a minimum of 10,000 for presentation reports.

Full Backward Pass: For each iteration of the simulation, Full Monte performs a complete Forward pass of the Critical Path Method (CPM) algorithm. This calculates the early dates and histograms, sensitivity (Tornado chart), criticality, and basis (diagnostic) information. This forward pass is performed regardless of the setting of the 'Full Backward Pass' option.

If Late Dates and Slacks/Floats (calculated by a CPM Backward pass) are required, then enable the option for a 'Full Backward Pass'. This will roughly double the amount of time required for each simulation. For most schedule risk analysis purposes, this option is not required.

Honor Mandatory Constraints (Full Monte for Primavera P6 only): Since we are trying to study the effect of uncertainty on the schedule, it is best to allow the analysis to show how delays to predecessors can affect successors. P6 Mandatory Start/Finish Constraints can prevent tasks moving into the future as

driven by logic. By default, Full Monte for P6 will honor Mandatory Start/Finish Constraint dates the same as P6. However, if the user wishes to see more realistic future dates, the user can deselect this option in which case Full Monte will modify the treatment of Mandatory Constraints as follows:

Constraint Type	Treated As
Mandatory Start	Must Start On
Mandatory Finish	Must Finish On

This allows Full Monte to produce a more realistic forecast completion date based on logic rather than artificial, unrealistic, constraints.

8.1.3 Other Options common to all scheduling tools

Preferred Date/Duration Histogram Interval: By default, Full Monte decides from the data what interval to use for the histograms generated by the risk analysis process. This may result in histograms for different activities being in different units, say days or weeks, making comparisons difficult. You can specify a preferred interval here, from an hour to four weeks, as indicated in figure 8.2.

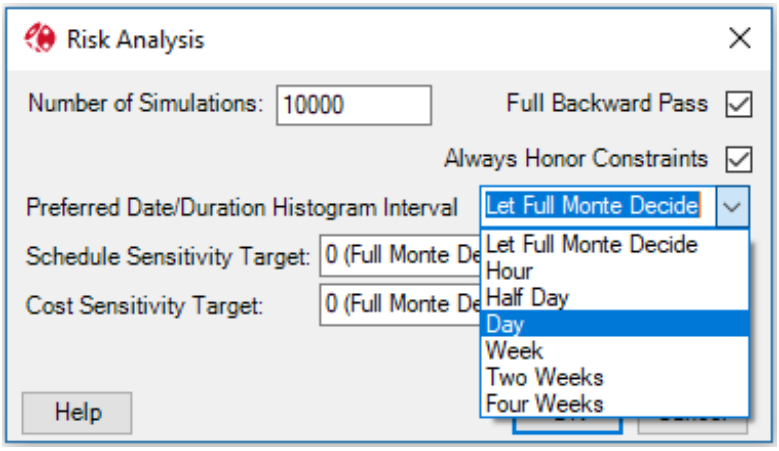


Figure 8.2

> *NOTE: It is not guaranteed that the preferred interval you specify will be used for all histograms. In particular, Full Monte will override your choice if it estimates, on the basis of the data, that your choice would result in just a single histogram bar or more than 350 histogram bars.*

Schedule Sensitivity Target: By default, this is the finish of the project summary row. It is also possible to measure sensitivity relative to any milestone. If you select a milestone, all schedule sensitivity results will relate to the sensitivity of the early date for this milestone to the activity in question. The Schedule Sensitivity drop list supports searching by ID, Unique ID, or Task Name contents by typing in the entry box.

Cost Sensitivity Target: By default, this is the total project cost. It is also possible to measure sensitivity relative to any WBS element. If you select a WBS (work breakdown structure) element, all cost sensitivity results will relate to the sensitivity of the cost of this WBS element to the activity in question.

NOTE: For more on sensitivity, see Chapter 10: Exploring Sensitivity.

When you have selected the required options:

Click on **OK** to start the analysis. The progress bar roughly indicates the proportion of the analysis that is complete.

Clicking on **Cancel** before clicking on OK will dismiss the dialog.

NOTE: Clicking on **Cancel** after clicking on OK but before the analysis is complete will stop the analysis, though on a large project you may have to wait a few seconds for this to take effect. Clicking on **Cancel** again will dismiss the dialog.

8.2 Viewing Risk Analysis Results

Basic results from Risk Analysis can be displayed in any tabular view by inserting appropriate columns such as:

- Early Finish Expected - the mean finish date during the simulation
- Early Finish Percentile (x%) – The early finish at a required level of confidence
- Early Start Expected – the mean start date during the simulation

Graphical charts showing the range of start/finish dates for tasks, milestones, summary tasks and the entire project can be displayed by clicking an available Graph button on the Graphs view (or a Histogram column inserted in any tabular view). See chapter 8 for more information on views.

Results can also be saved back to Microsoft Project custom fields for incorporation into standard Microsoft Project views by using Field Mappings as described in Chapter 3 of the Full Monte for Microsoft Project Installation guide.

8.2 Understanding and Explaining Results

While the views and graphical charts, mentioned in section 7.2 and described fully in chapters 8 and 9 of this guide, present the results of schedule risk analysis they do not necessarily help explain ***why*** the results are what they are.

Sensitivity Analysis (chapter 10) can help identify tasks creating uncertainty in the outcome but again does not necessarily explain how dates were calculated.

8.2.1 Diagnostic Fields

During the risk analysis, Full Monte records additional diagnostic information that can be used to help understand the basis for dates calculated during the simulations. These fields are:

- Early Start Basis – Lists the reason(s) driving the task Early Start date
- Early Finish basis – Lists the reason(s) driving the task Early Finish date
- Critical Predecessors – Lists any predecessor tasks on the critical path
- Critical Successors – Lists any successor tasks on the critical path
- Late Start Basis – Lists the reason(s) driving the Late Start date
- Late Finish Basis – Lists the reason(s) driving the Late Finish date

The diagnostic fields can be inserted in any Full Monte tabular view. Figure 7.3 shows an example diagnostic view with many useful columns.

ID	Task Name	Remaining Duration	Percent Complete (MSP)	Start (MSP)	Early Start Expected Value	Finish (MSP)	Early Finish Expected Value	Early Start Basis	Early Finish Basis	Predecessors	Critical Predecessors	Percent Critical	Percent Active
0	Full Monte Demonstration	70 days	0%	05/01/17 08:00	05/01/17 08:00	08/04/17 17:00	08/08/17 10:45	Project Start	Task 1			100%	100%
1	Full Monte 2017 Demon	70 days	0%	05/01/17 08:00	05/01/17 08:00	08/04/17 17:00	08/08/17 10:45	Task 0	Tasks 21, 16 (97%), 18 (3%)			100%	100%
2	Initiate	5 days	0%	05/01/17 08:00	05/01/17 08:00	05/05/17 17:00	05/08/17 08:02	Task 1	Early Start			97%	100%
3	Development	60 days	0%	05/08/17 08:00	05/08/17 08:02	07/28/17 17:00	08/01/17 10:30	Tasks 10, 4	Tasks 4 (91%), 10 (9%)			97%	100%
4	Hardware	60 days	0%	05/08/17 08:00	05/08/17 08:02	07/28/17 17:00	08/01/17 08:59	Task 5	Task 9			89%	100%
5	HW Task 1	20 days	0%	05/08/17 08:00	05/08/17 08:02	06/02/17 17:00	06/02/17 16:42	Task 2	Early Start	2	2 (97%)	89%	100%
6	HW Task 2	20 days	0%	06/05/17 08:00	06/02/17 16:42	06/30/17 17:00	06/30/17 16:46	Task 5	Early Start	5	5 (89%)	45%	100%
7	HW Task 3	20 days	0%	06/05/17 08:00	06/02/17 16:42	06/30/17 17:00	06/30/17 16:41	Task 5	Early Start	5	5 (89%)	44%	100%
8	HW Task 4	20 days	0%	07/03/17 08:00	07/04/17 09:04	07/28/17 17:00	08/01/17 08:59	Tasks 6 (51%), 7 (49%)	Early Start	6, 7	6 (45%), 7 (44%)	89%	100%
9	HW Complete	0	0%	07/28/17 17:00	08/01/17 08:59	07/28/17 17:00	08/01/17 08:59	Task 8	Early Start	8	8 (89%)	89%	100%
10	Software	54 days	0%	05/08/17 08:00	05/08/17 08:02	07/20/17 17:00	07/24/17 08:43	Task 11	Task 15			8%	100%
11	SW Task 1	18 days	0%	05/08/17 08:00	05/08/17 08:02	05/31/17 17:00	06/01/17 08:03	Task 2	Early Start	2	2 (97%)	8%	100%
12	SW Task 2	18 days	0%	06/01/17 08:00	06/01/17 08:03	06/26/17 17:00	06/27/17 08:18	Task 11	Early Start	11	11 (8%)	4%	100%
13	SW Task 3	18 days	0%	06/01/17 08:00	06/01/17 08:03	06/26/17 17:00	06/27/17 08:10	Task 11	Early Start	11	11 (8%)	4%	100%
14	SW Task 4	18 days	0%	06/27/17 08:00	06/28/17 08:41	07/20/17 17:00	07/24/17 08:43	Tasks 12 (50%), 13 (50%)	Early Start	12, 13	12 (4%), 13 (4%)	8%	100%
15	SW Complete	0	0%	07/20/17 17:00	07/24/17 08:43	07/20/17 17:00	07/24/17 08:43	Task 14	Early Start	14	14 (8%)	8%	100%
16	Integration	5 days	0%	07/31/17 08:00	08/01/17 10:30	08/04/17 17:00	08/08/17 10:30	Task 17	Task 17			97%	100%
17	Integration	5 days	0%	07/31/17 08:00	08/01/17 10:30	08/04/17 17:00	08/08/17 10:30	Tasks 9 (91%), 15 (9%)	Early Start	9, 15	9 (89%), 15 (8%)	97%	100%
18	Marketing	15 days	0%	07/10/17 08:00	07/10/17 08:00	07/28/17 17:00	07/31/17 08:08	Task 19	Task 20			3%	100%
19	Brochure Developm	10 days	0%	07/10/17 08:00	07/10/17 08:00	07/21/17 17:00	07/24/17 08:08	Target Date: 7/10/2017:8:00 AM	Early Start			3%	100%
20	Brochure Printing	5 days	0%	07/24/17 08:00	07/24/17 08:08	07/28/17 17:00	07/31/17 08:08	Task 19	Early Start	19	19 (3%)	3%	100%
21	Delivery	0	0%	08/04/17 17:00	08/08/17 10:45	08/04/17 17:00	08/08/17 10:45	Tasks 17 (97%), 20 (3%)	Early Start	17, 20	17 (97%), 20 (3%)	100%	100%

Figure 8.3

In the 'Early Start Basis' and 'Early Finish Basis' we can see the reasons for the probabilistic dates for each task the, where applicable, the percentage of time that predecessors drove the date. If no percentage is displayed, then the predecessor was 100% responsible for the date.

Possible 'explanations' in the basis fields include:

Project Start – The activity early start is defined by the Project Start.

Task <ID> - The activity early start is driven 100% by predecessor <ID>.

Tasks <IDx> (93%), <IDy>(7%) – The activity early start is driven by predecessor (IDx) 93% of the time and <IDy> 7% of the time during the simulations.

Target: <Date> - The Early Start of the activity is constrained by a Target Constraint Date.

For example, for Task ID 5 (HW Task 1), we can see that the early start was driven 100% by Task ID 2 (Initiate). We can also see that Task ID 2 was on the critical path in 97% of the simulations. Brochure Development (Tasks 19 and 20) drove the remaining 3% of the critical path to Delivery.

Other useful fields include:

- Percent Critical – Percentage of the simulations that the task was on the critical path to project completion
- Percent Critical (Sensitivity) – Percentage of the simulations that the task was on the critical path to the selected Sensitivity Target (see chapter 10)
- Percent Active – Percentage of the simulations that the task was included in the logic (always 100% unless Task Existence or Probabilistic/Conditional branching was used)

8.2.2 Risk Path Analysis

Although Sensitivity Analysis (chapter 10) shows the tasks creating the most uncertainty in the project/selected milestone delivery date it does not include all tasks responsible for the date.

Specifically, it will never include tasks that have no uncertainty even if they are on the critical path and are therefore at least partly responsible for the date.

Risk Path analysis can provide insight into the various potential critical paths that are driving the outcome of either the project or a selected milestone.

Risk Path analysis is like techniques used to view secondary, tertiary etc. critical paths in a standard critical path analysis (CPM) but is based on probability of being critical rather than slack/float.

To support this analysis, Full Monte includes a field called Risk Path. This is calculated during the risk analysis and numbers tasks per the probability of a certain path driving the outcome.

Risk Path can be added to any tabular view as shown in Figure 7.4.

ID	Task Name	Remaining Duration	Early Finish Histogram	Risk Path	Duration Distribution Type	Duration Optimistic	Duration Most Likely	Duration Pessimistic	Dura Confi Interv
0	⊟ Full Monte Demonstration	70 days	Graph		(None)				
1	⊟ Full Monte 2017 Demonstrati	70 days	Graph		(None)				
2	Initiate	5 days	05May17	1	(None)				
3	⊟ Development	60 days	Graph		(None)				
4	⊟ Hardware	60 days	Graph		(None)				
5	HW Task 1	20 days	Graph	3	Triangular	90%	100%	115%	
6	HW Task 2	20 days	Graph	3	Triangular	95%	100%	125%	
7	HW Task 3	20 days	Graph	4	Triangular	90%	100%	115%	
8	HW Task 4	20 days	Graph	3	Triangular	90%	100%	115%	
9	HW Complete	0	Graph	3	(None)				
10	⊟ Software	54 days	Graph		(None)				
11	SW Task 1	18 days	Graph	1	Triangular	95%	110%	150%	
12	SW Task 2	18 days	Graph	2	Triangular	95%	110%	150%	
13	SW Task 3	18 days	Graph	1	Triangular	95%	110%	150%	
14	SW Task 4	18 days	Graph	1	Triangular	95%	110%	150%	
15	SW Complete	0	Graph	1	(None)				
16	⊟ Integration	5 days	Graph		(None)				
17	Integration	5 days	Graph	1	(None)				
18	⊟ Marketing	15 days	28Jul17		(None)				
19	Brochure Development	10 days	21Jul17		(None)				
20	Brochure Printing	5 days	28Jul17		(None)				
21	Delivery	0	Graph	1	(None)				

Figure 8.4

In Figure 8.4 we can see that Tasks 2, 11, 13,14, 17, and 21 have been identified as the primary path driving Delivery. Task 12 has been identified as the second path and so on. But why?

Figure 8.5 shows an example of the standard view ‘Risk Path Gantt’.

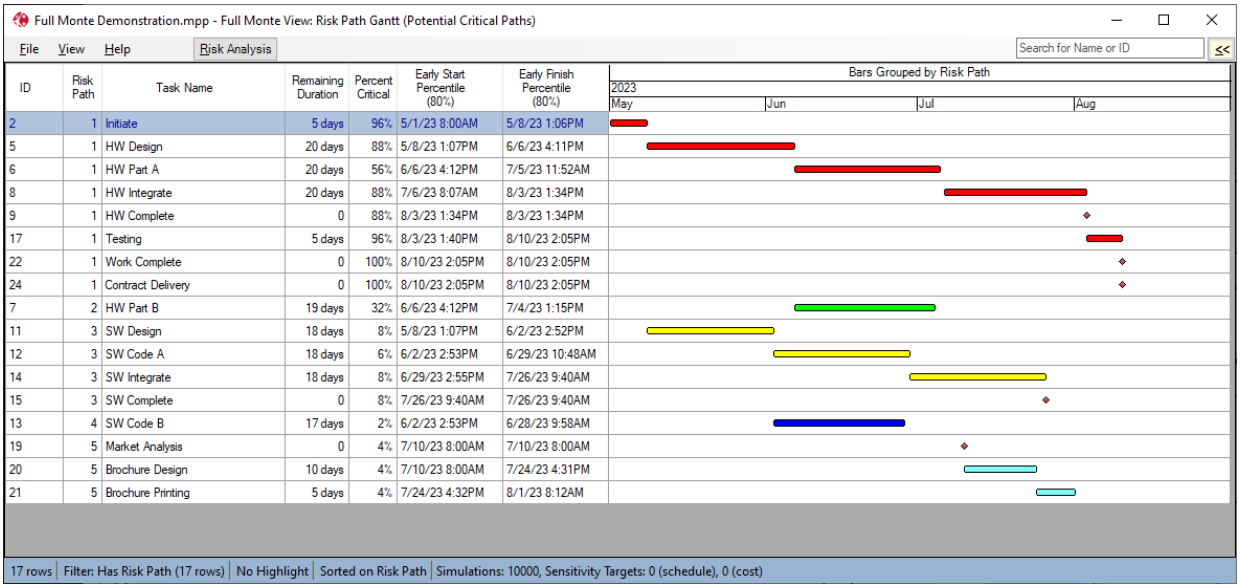


Figure 8.5

8.2.2.1 Full Monte for Microsoft Project

To create the Risk Path view in Microsoft Project we will use the Full Monte Field Mappings to save Risk Path, Percent Critical, and the Expected Early Start/Finish dates into custom fields in Microsoft Project as shown in Figure 8.6.

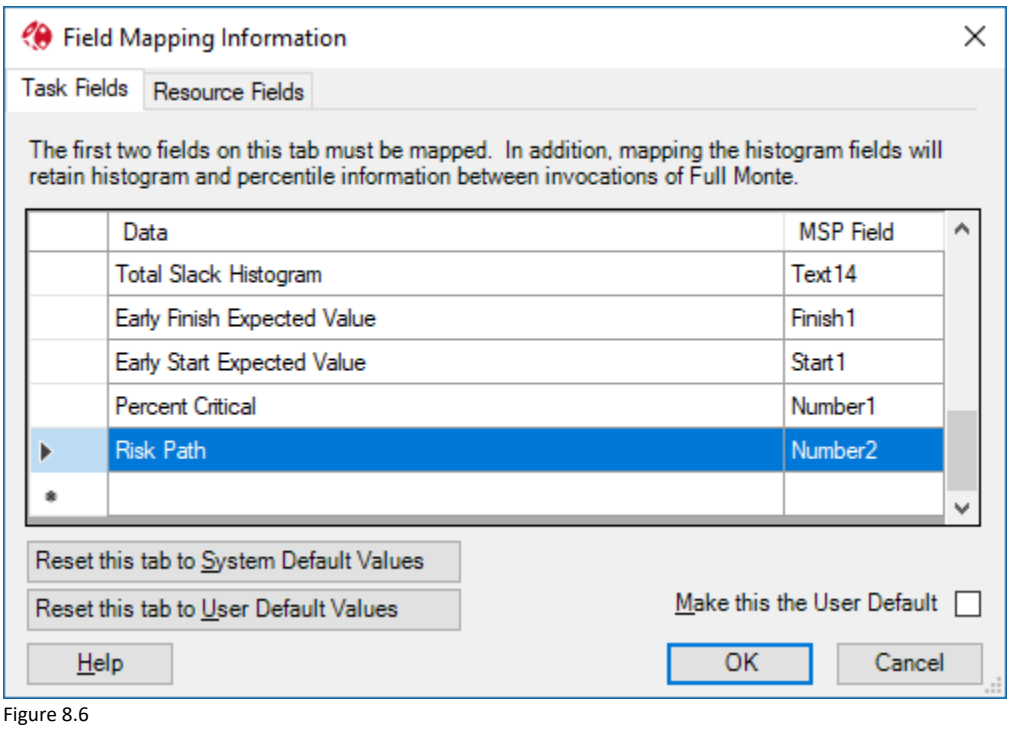


Figure 8.6

Run a Risk Analysis and save the results back to Microsoft Project.

We can add some formulas to Flag fields to control the color of the bars as shown in Figure 8.7.

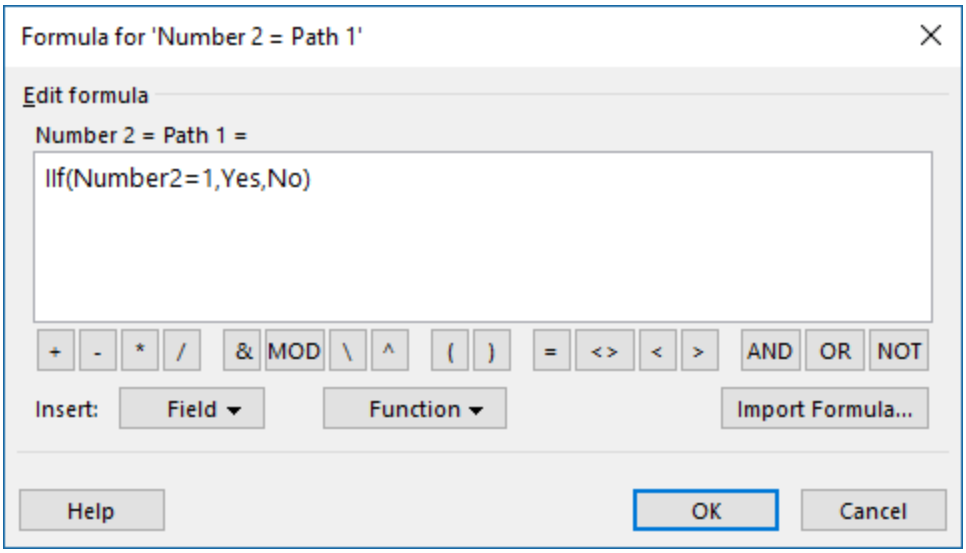


Figure 8.7

Then define the bar styles like those shown in Figure 8.8.

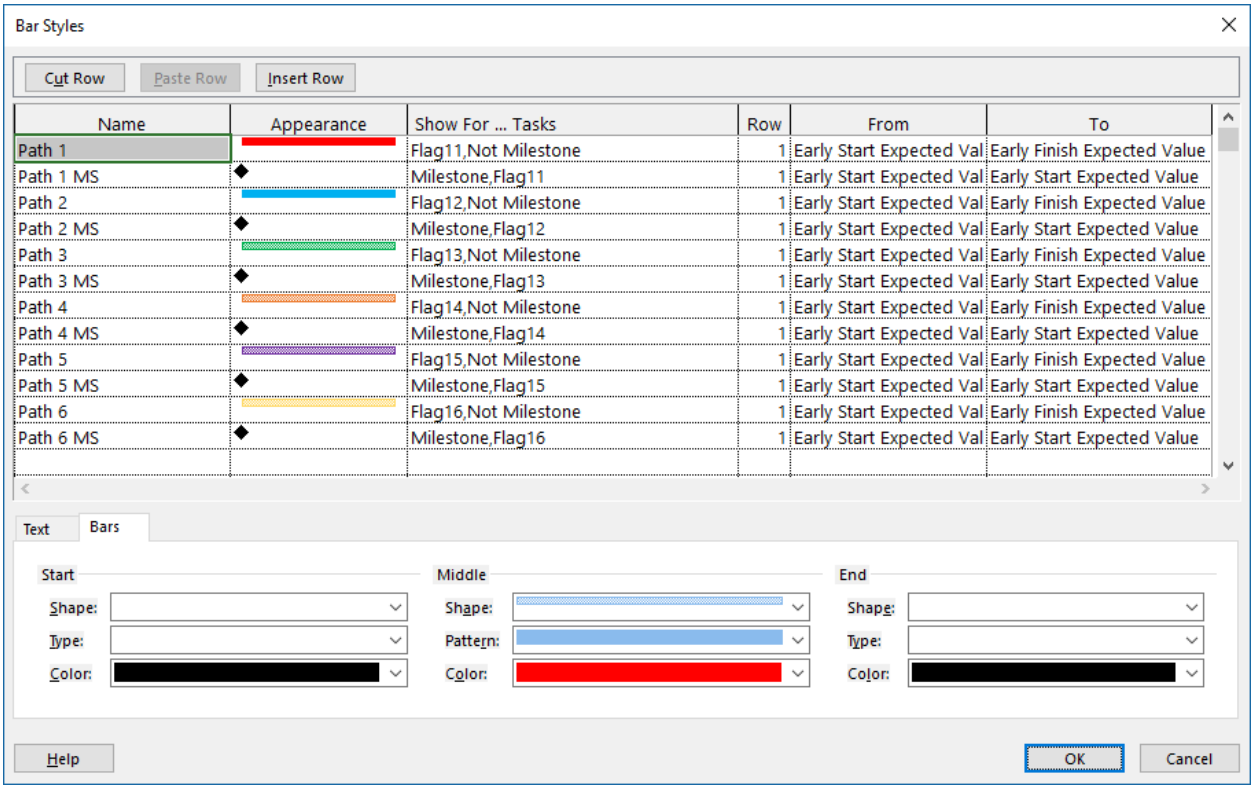


Figure 8.8

The result will look something like that shown in Figure 8.9.

Task Name	Duration	Assessment 1	Early Start Expected Value	Early Finish Expected Value	Percent Critical
Risk Path: 1	**70d**				
Initiate	5 days		5/1/17 8:00 AM	5/5/17 5:00 PM	100
SW Task 1	18 days	High Risk	5/8/17 8:00 AM	6/6/17 10:28 AM	76
SW Task 3	18 days	High Risk	6/6/17 10:28 AM	7/5/17 2:00 PM	39
SW Task 4	18 days	High Risk	7/6/17 3:14 PM	8/7/17 8:31 AM	76
SW Complete	0 days		8/7/17 8:31 AM	8/7/17 8:31 AM	76
Integration	5 days		8/7/17 1:48 PM	8/14/17 1:48 PM	100
Delivery	0 days		8/14/17 1:48 PM	8/14/17 1:48 PM	100
Risk Path: 2	**18d**				
SW Task 2	18 days	High Risk	6/6/17 10:28 AM	7/5/17 1:33 PM	37
Risk Path: 3	**60d**				
HW Task 1	20 days	Low Risk	5/8/17 8:00 AM	6/5/17 10:32 AM	24
HW Task 2	20 days	Medium Risk	6/5/17 10:32 AM	7/4/17 2:06 PM	19
HW Task 4	20 days	Low Risk	7/4/17 4:16 PM	8/2/17 9:54 AM	24
HW Complete	0 days		8/2/17 9:54 AM	8/2/17 9:54 AM	24
Risk Path: 4	**20d**				
HW Task 3	20 days	Low Risk	6/5/17 10:32 AM	7/3/17 2:18 PM	6

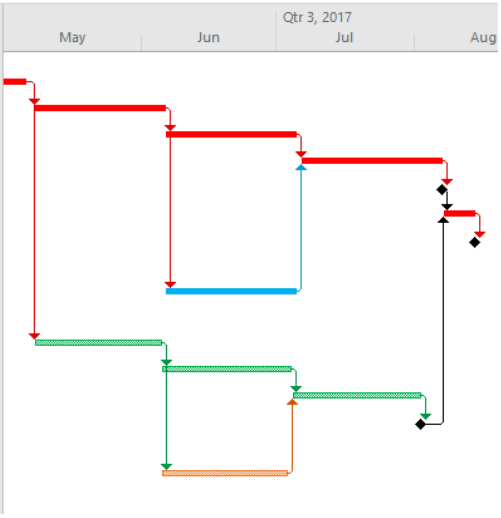


Figure 8.9

The primary critical path (based on the probabilities) is clearly shown as Path 1 in red. We can see that not all tasks on Path 1 were 100% critical. In fact, the criticality of Task SW Task 3 is just 39 percent. However, combine that with the criticality of task SW Task 2 (37%) from Path 2 and we can see that the overall criticality of those two tasks is in fact 76% which explains the 76% on task SW Task 4.

Path 3 shows another alternative that includes Initiate and Integration but shows a 24% chance that the critical path will run through HW Task 1, 2, and 4.

This graphically highlights the various potential critical paths and helps us focus management effort accordingly.

Compare this with the Sensitivity Tornado chart for the same data shown in Figure 8.10.

ID	Task Name	Remaining Duration	Percent Critical	Percent Critical (Sensitivity)	Sensitivity Index	Sensitivity Index 50.0	Optimistic Finish of Project	Pessimistic Finish of Project	2017 Aug 06 13 20
14	SW Task 4	18 days	76%	76%	53%		8/10/17 4:40PM	8/22/17 10:24...	
11	SW Task 1	18 days	76%	76%	53%		8/10/17 4:40PM	8/22/17 10:24...	
13	SW Task 3	18 days	39%	39%	27%		8/14/17 8:03AM	8/21/17 10:01...	
12	SW Task 2	18 days	37%	37%	26%		8/14/17 8:22AM	8/21/17 9:25AM	
6	HW Task 2	4 wks	19%	19%	8%		8/14/17 11:46AM	8/16/17 3:39PM	
5	HW Task 1	4 wks	24%	24%	8%		8/14/17 11:42AM	8/16/17 11:03...	
8	HW Task 4	4 wks	24%	24%	8%		8/14/17 11:42AM	8/16/17 11:03...	
7	HW Task 3	4 wks	6%	6%	2%		8/14/17 1:40PM	8/15/17 1:14PM	

Figure 8.10

While figure 8.10 clearly shows the tasks creating the most uncertainty in the outcome, and does identify opportunities for schedule compression, it does not show us ***how*** these tasks affect the outcome. Risk Path analysis fills that gap.

8.2.2.2 Full Monte for Primavera P6

With Full Monte for Primavera P6 the risk path data can be saved to a P6 User-Defined Field by adding Risk Path to the Task Fields on the P6 user-Defined Field Definition dialog.

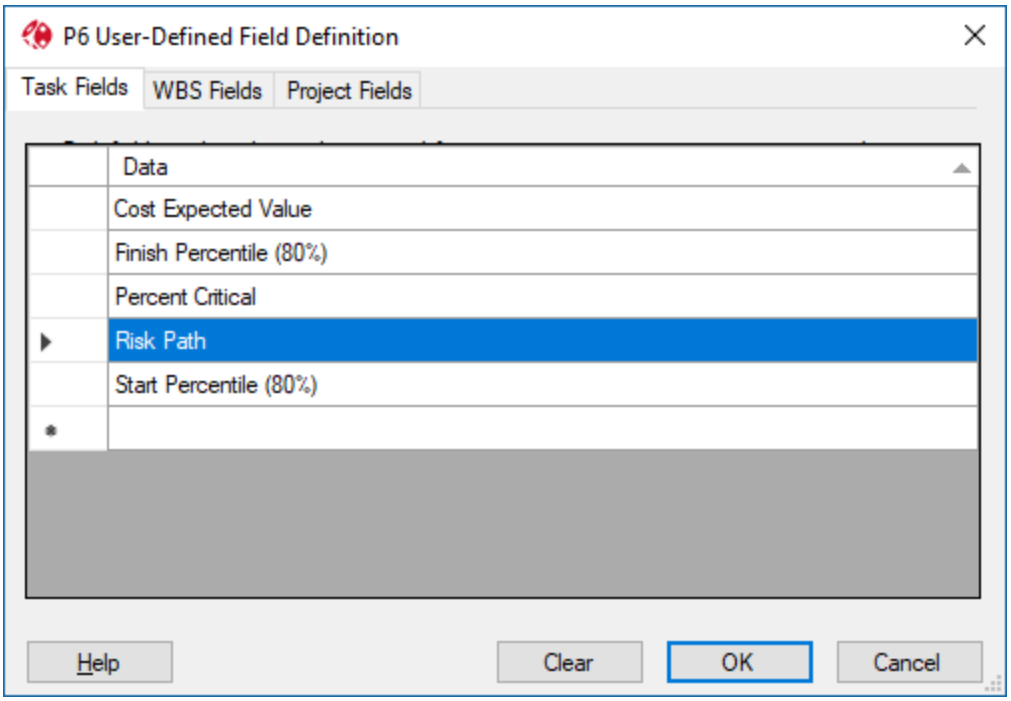


Figure 8.11

Fields added to the P6 User-Defined Field Definition dialog in Full Monte will automatically create appropriate User-Defined Field in P6 as shown in figure 8.12.

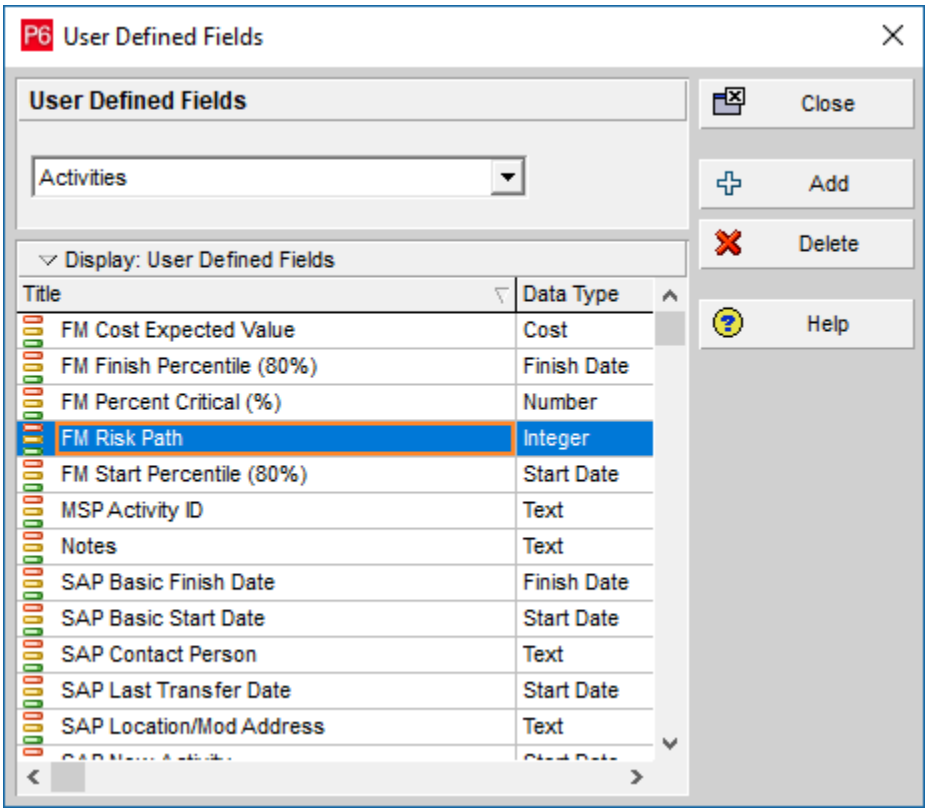


Figure 8.12

Note: The UDF field name in P6 will have a prefix of 'FM' to assist with management of UDFs. The name can be changed in P6 without affecting Full Monte integration.

Create a new View Layout in P6 and select to Group on FM Risk Path as shown in Figure 8.13.

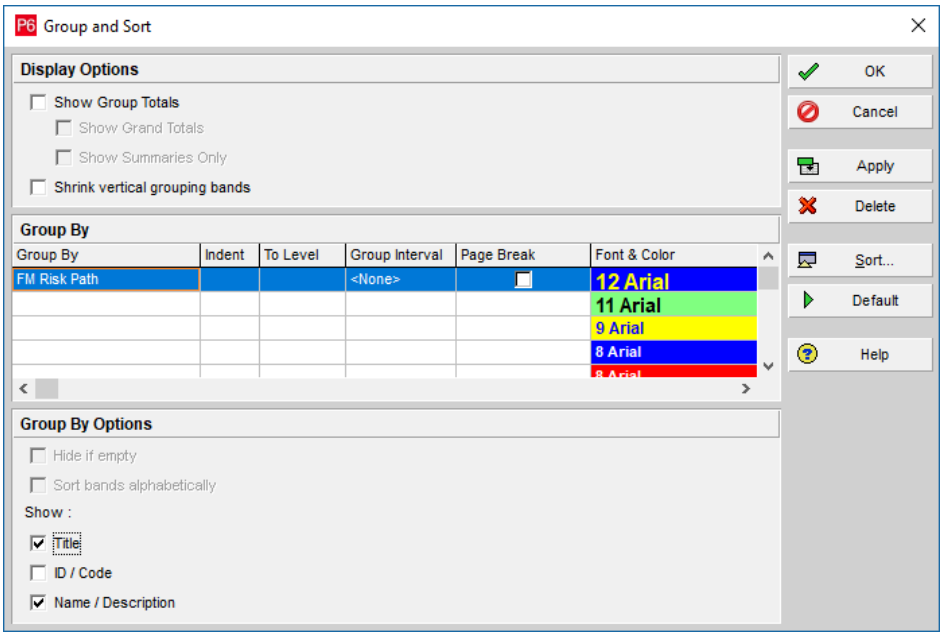


Figure 8.13

Sort the Layout on Early Start and Activity ID as shown in Figure 8.14.

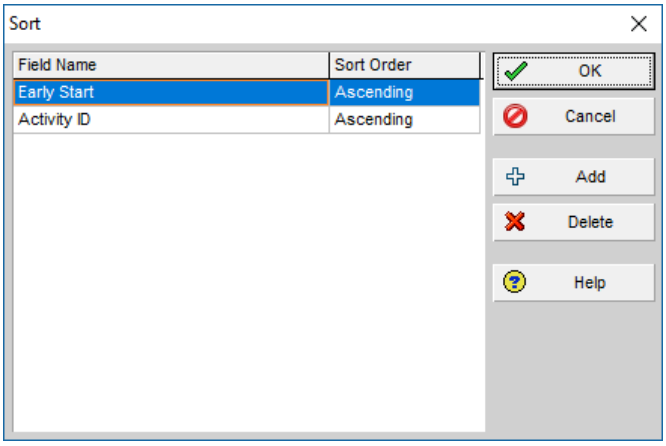


Figure 8.14

Filter the view to only show tasks that have been allocated a path number as shown in Figure 8.15.

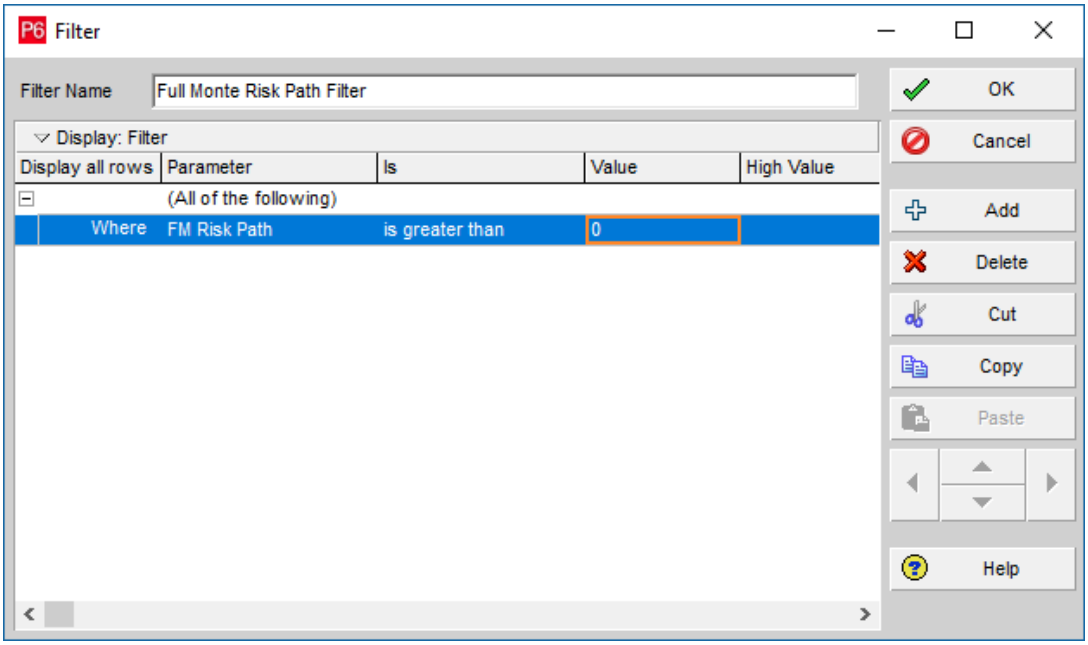


Figure 8.15

Finally create some filters to use to color code the bars based on the risk path.

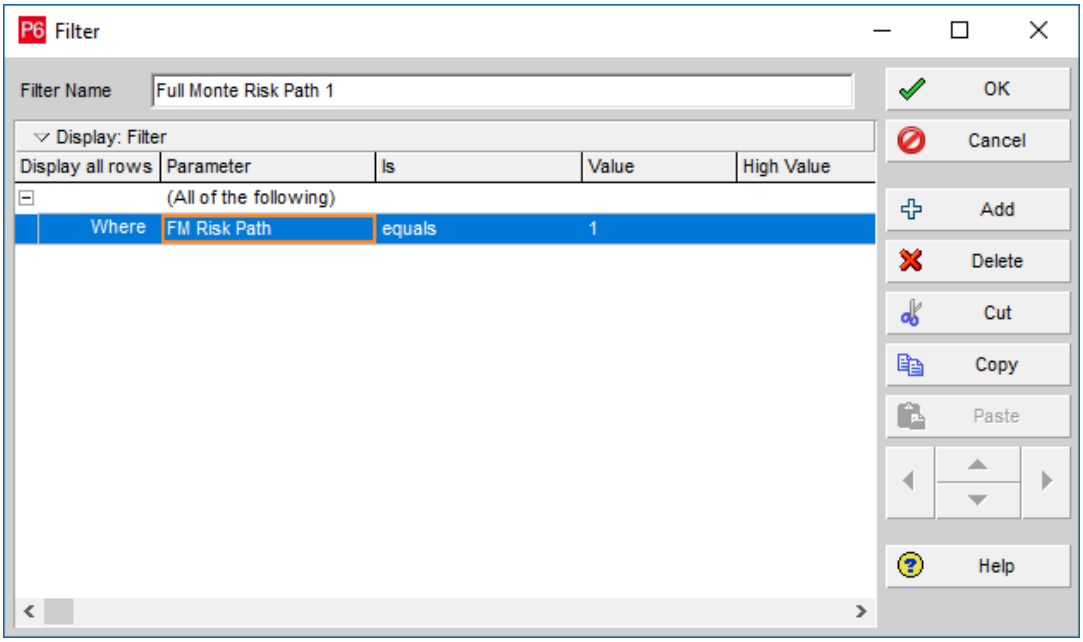


Figure 8.16

Then define the bars for the layout.

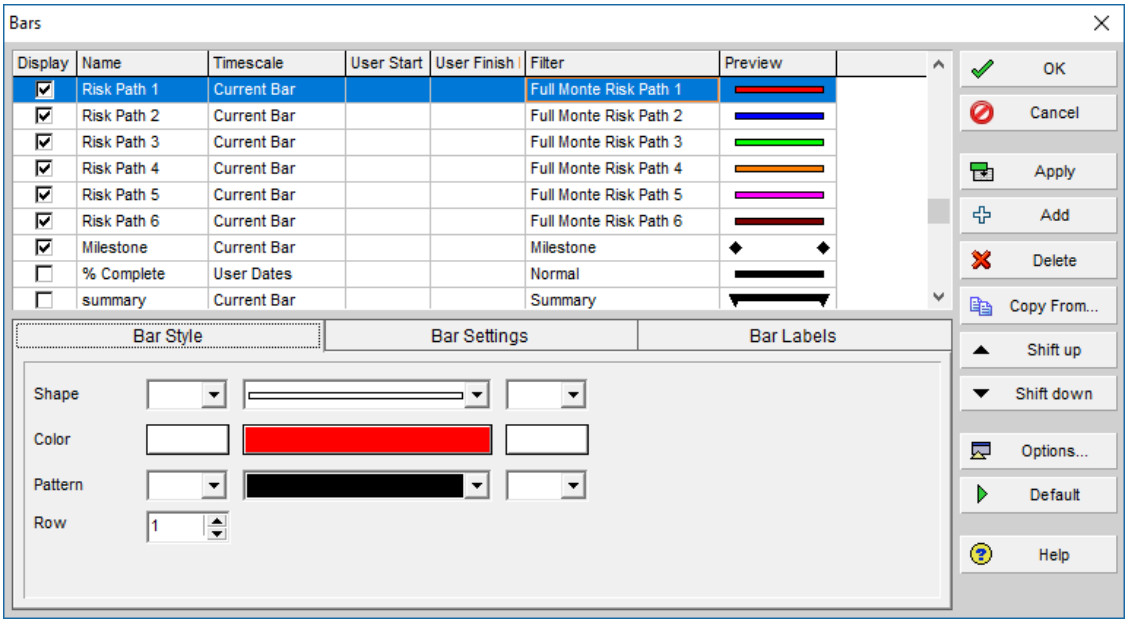


Figure 8.17

The resulting Layout will look something like figure 8.18.

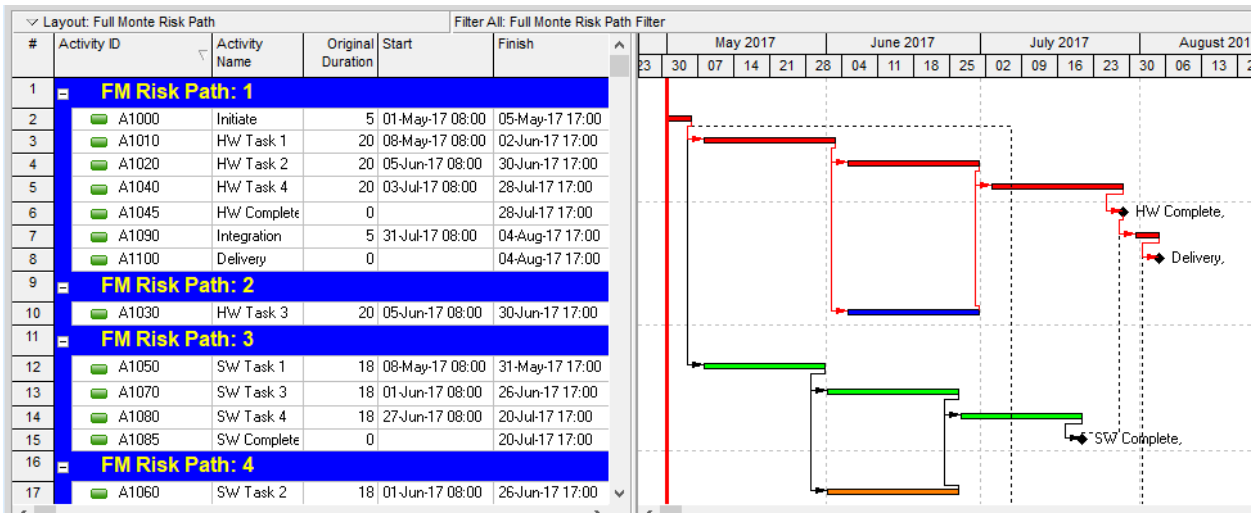


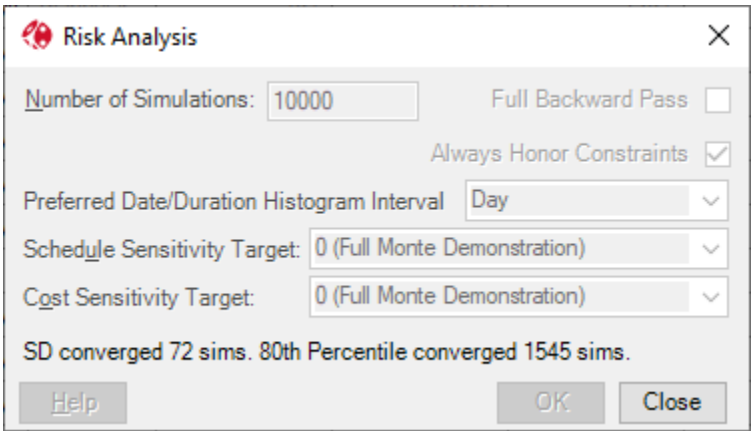
Figure 8.18

8.3 Risk Analysis Convergence

A user option is available to display Convergence information after a Risk Analysis has been performed. Convergence can be used as an indicator that sufficient simulations have been performed to produce reliable results.

See Chapter 17 for information on configuration options.

With the option enabled, after a Risk Analysis is complete, the Risk Analysis dialog will display additional information as shown here:

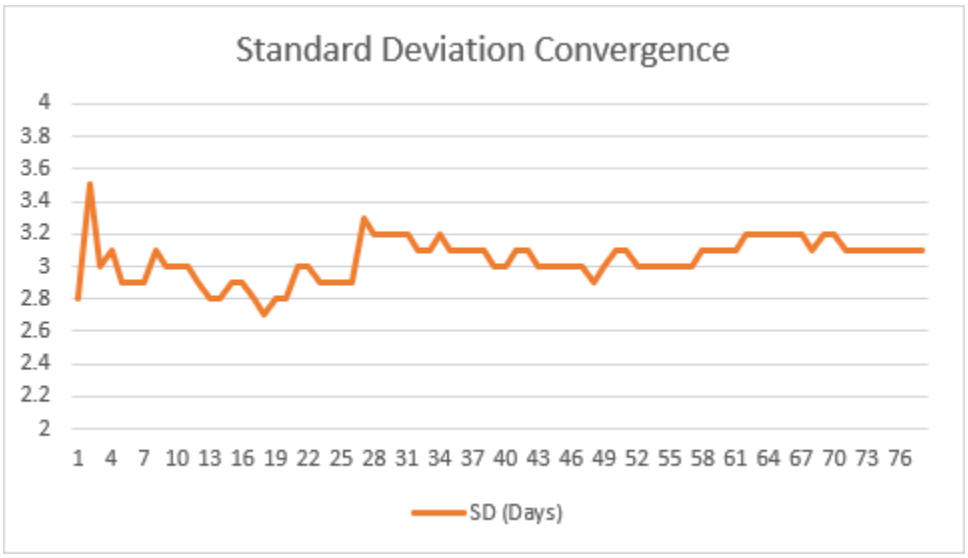


In the example, the Standard Deviation (SD) converged after 72 simulations and the 80th Percentile Finish date converged after 1,545 simulations.

Note: The 80th Percentile Finish date is more volatile than the Standard Deviation so generally requires more simulations to converge. The 80th Percentile convergence is therefore a more useful indication that sufficient simulations have been performed.

Four optional settings are available:

SAVE CONVERGENCE DATA – Setting this option causes Full Monte to save the individual simulation convergence results to a file (RiskAnalysisLog.txt). This data can be used to plot convergence charts as shown here:



CONVERGENCE COUNT – The number of sequential simulations where the percentage chance between subsequent results must be with the specified tolerance. The default is 20.

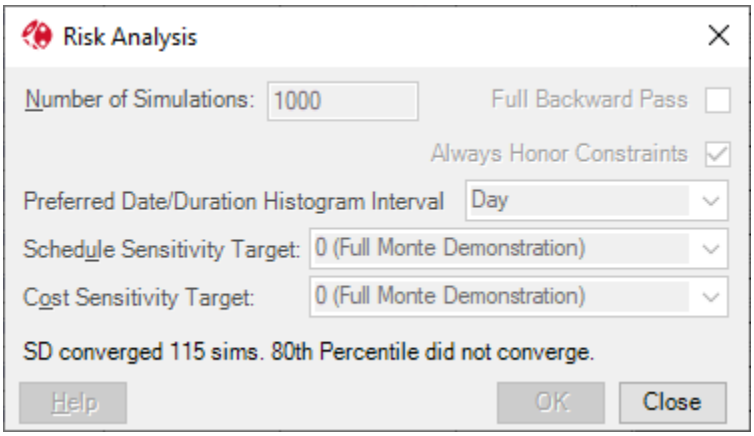
SD CONVERGENCE PERCENTAGE – The tolerance for change in Standard Deviation results between subsequent simulations before convergence is claimed. The default is 0.01.

80TH CONVERGENCE PERCENTAGE – The tolerance for change in the 80th Percentile Finish date between subsequent simulations before convergence is claimed. The default is 0.00001.

Note: The percentage change value for 80th Percentile Finish date is much smaller than Standard Deviation because the range of possible values is much larger.

If the DISPLAY CONVEREGNCE option is enabled, then the Close button must be clicked to close the Risk Analysis dialog after the simulation is complete. The results are also displayed in the Status bar at the bottom of the Full Monte Window.

If Convergence is not achieved within the number of simulations performed, this will be noted in the dialog.



This indicates a larger number of simulations should be performed to achieve reliable results.

Note: Barbecana always recommends a large number of simulations be performed, especially when producing final reports. Convergence values are a minimum, more is better.

Chapter 9: Named Tabular Views

9.1 Overview

Named views are read-only views that you can use to view various aspects of the project data, including the results of Full Monte's risk analysis, as well as the data used to generate it and a variety of source scheduling system data (though by no means all). You can select the views by name from the **View/Open Named View** menu available whenever a project is open.

Some named views are standard views that are hard-coded in the software and cannot be changed by the user. Others are user-defined, in other words, created by the user.

NOTE: You can make changes to standard view and save the modified view under different names using **View/Save View Specification As**, but you cannot overwrite the standard reports. There are also a small number of features in the standard reports that cannot be added directly by the user, so starting with a standard report is the only way to duplicate these. These are described in section 9.3.

All views can be printed or copied to the clipboard.

9.2 Standard Views

When you select **View/Open Named View**, the standard reports are those listed above the line in the drop-down menu shown in figure 9.1.

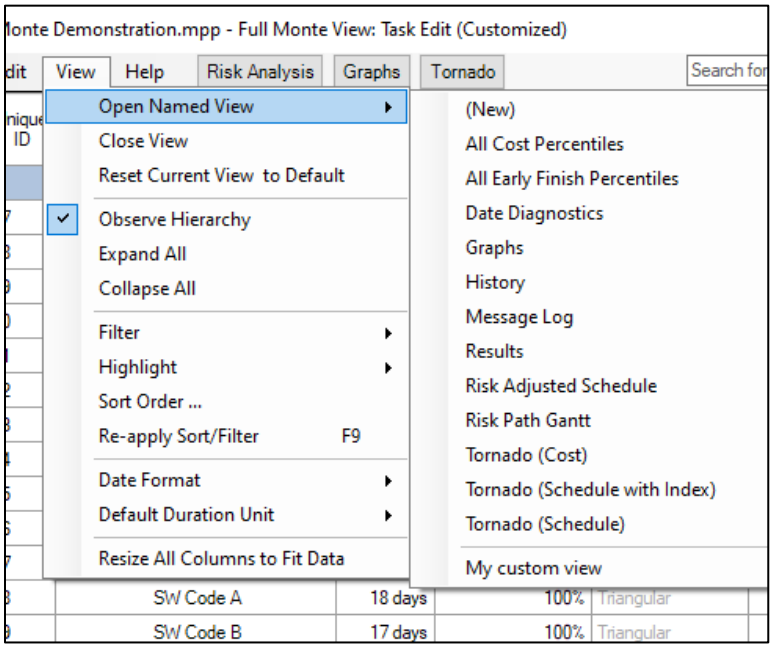


Figure 9.1

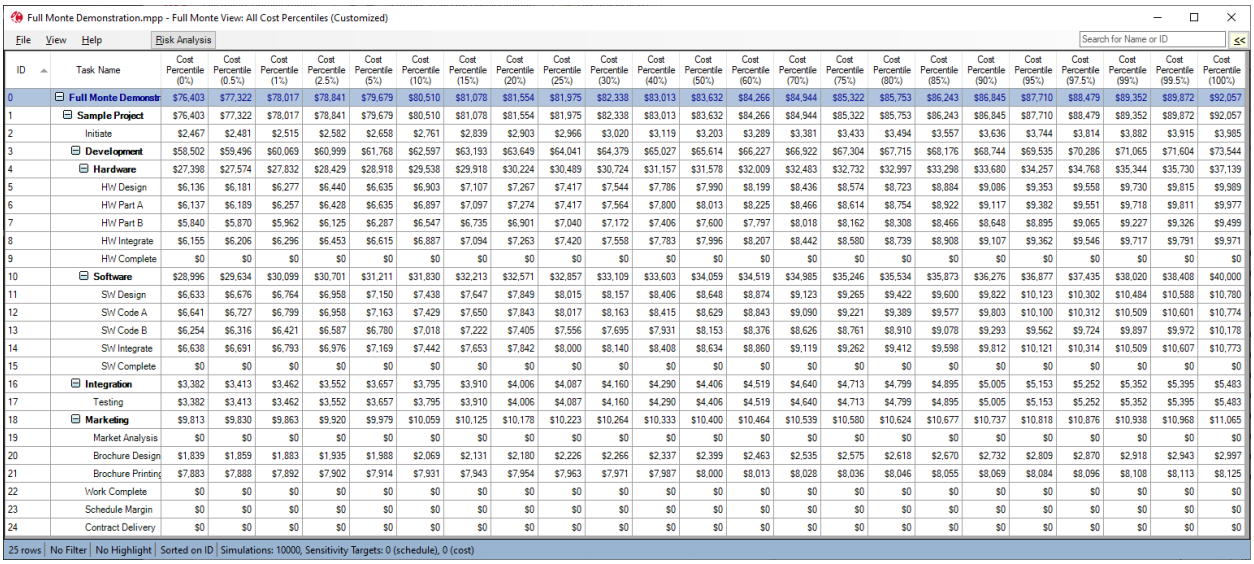
The top item, "(New)," is not so much a view as a starting point for developing your own new views.

The other standard views are listed in alphabetical order and described below in the same order.

9.2.1 All Cost Percentiles

The **All Cost Percentiles** view displays costs for every level of the schedule. For each task the costs are shown at various percentiles (levels of confidence). The percentiles displayed are based on the standard

percentiles defined in Full Monte. If you have added/removed percentiles (as described in Chapter 15 Manage Percentiles) then you will need to manually add any newly defined percentiles to the view.



Full Monte Demonstration.mpp - Full Monte View: All Cost Percentiles (Customized)

File View Help | Risk Analysis | Search for Name or ID

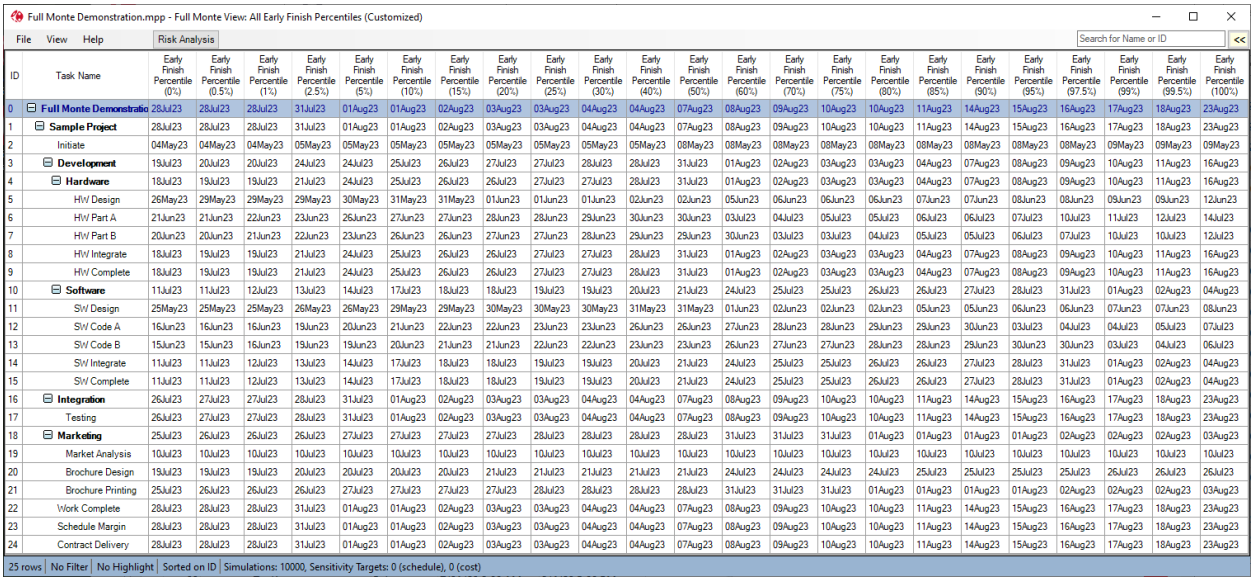
ID	Task Name	Cost Percentile (0%)	Cost Percentile (0.5%)	Cost Percentile (1%)	Cost Percentile (2.5%)	Cost Percentile (5%)	Cost Percentile (10%)	Cost Percentile (15%)	Cost Percentile (20%)	Cost Percentile (25%)	Cost Percentile (30%)	Cost Percentile (40%)	Cost Percentile (50%)	Cost Percentile (60%)	Cost Percentile (70%)	Cost Percentile (75%)	Cost Percentile (80%)	Cost Percentile (85%)	Cost Percentile (90%)	Cost Percentile (95%)	Cost Percentile (97.5%)	Cost Percentile (99%)	Cost Percentile (99.5%)	Cost Percentile (100%)
0	**Full Monte Demonstr**	$76,403	$77,322	$78,017	$78,841	$79,679	$80,510	$81,078	$81,554	$81,975	$82,338	$83,013	$83,632	$84,266	$84,944	$85,322	$85,753	$86,243	$86,845	$87,710	$88,479	$89,352	$89,872	$92,057
1	**Sample Project**	$76,403	$77,322	$78,017	$78,841	$79,679	$80,510	$81,078	$81,554	$81,975	$82,338	$83,013	$83,632	$84,266	$84,944	$85,322	$85,753	$86,243	$86,845	$87,710	$88,479	$89,352	$89,872	$92,057
2	Initiate	$2,467	$2,481	$2,515	$2,582	$2,658	$2,761	$2,839	$2,903	$2,966	$3,020	$3,119	$3,203	$3,289	$3,381	$3,433	$3,494	$3,557	$3,636	$3,744	$3,814	$3,882	$3,915	$3,985
3	**Development**	$58,502	$59,496	$60,069	$60,999	$61,768	$62,597	$63,193	$63,649	$64,041	$64,379	$65,027	$65,614	$66,227	$66,922	$67,304	$67,715	$68,176	$68,744	$69,535	$70,286	$71,065	$71,604	$73,544
4	**Hardware**	$27,398	$27,574	$27,832	$28,429	$28,918	$29,538	$29,918	$30,224	$30,489	$30,724	$31,157	$31,578	$32,009	$32,483	$32,732	$32,997	$33,298	$33,680	$34,257	$34,768	$35,344	$35,730	$37,139
5	HW Design	$6,136	$6,181	$6,277	$6,440	$6,635	$6,903	$7,107	$7,267	$7,417	$7,544	$7,786	$7,990	$8,199	$8,436	$8,574	$8,723	$8,884	$9,086	$9,353	$9,558	$9,730	$9,815	$9,989
6	HW Part A	$6,137	$6,189	$6,257	$6,428	$6,635	$6,897	$7,097	$7,274	$7,417	$7,564	$7,800	$8,013	$8,225	$8,466	$8,614	$8,754	$8,922	$9,117	$9,382	$9,551	$9,718	$9,811	$9,977
7	HW Part B	$5,840	$5,870	$5,962	$6,125	$6,287	$6,547	$6,735	$6,901	$7,040	$7,172	$7,406	$7,600	$7,797	$8,018	$8,162	$8,308	$8,466	$8,648	$8,895	$9,065	$9,227	$9,326	$9,499
8	HW Integrate	$6,155	$6,206	$6,296	$6,453	$6,615	$6,887	$7,094	$7,263	$7,420	$7,558	$7,783	$7,996	$8,207	$8,442	$8,580	$8,739	$8,908	$9,107	$9,362	$9,546	$9,717	$9,791	$9,971
9	HW Complete	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10	**Software**	$28,996	$29,634	$30,099	$30,701	$31,211	$31,830	$32,213	$32,571	$32,857	$33,109	$33,603	$34,059	$34,519	$34,985	$35,246	$35,534	$35,873	$36,276	$36,877	$37,435	$38,020	$38,408	$40,000
11	SW Design	$6,633	$6,676	$6,764	$6,958	$7,150	$7,438	$7,647	$7,849	$8,015	$8,157	$8,406	$8,648	$8,874	$9,123	$9,265	$9,422	$9,600	$9,822	$10,123	$10,302	$10,484	$10,588	$10,780
12	SW Code A	$6,641	$6,727	$6,799	$6,958	$7,163	$7,429	$7,650	$7,843	$8,017	$8,163	$8,415	$8,629	$8,843	$9,090	$9,221	$9,389	$9,577	$9,803	$10,100	$10,312	$10,509	$10,601	$10,774
13	SW Code B	$6,254	$6,316	$6,421	$6,587	$6,780	$7,018	$7,222	$7,405	$7,556	$7,695	$7,931	$8,153	$8,376	$8,626	$8,761	$8,910	$9,078	$9,293	$9,562	$9,724	$9,897	$9,972	$10,178
14	SW Integrate	$6,638	$6,691	$6,793	$6,976	$7,169	$7,442	$7,653	$7,842	$8,000	$8,140	$8,408	$8,634	$8,860	$9,119	$9,262	$9,412	$9,598	$9,812	$10,121	$10,314	$10,509	$10,607	$10,773
15	SW Complete	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
16	**Integration**	$3,382	$3,413	$3,462	$3,552	$3,657	$3,795	$3,910	$4,006	$4,087	$4,160	$4,290	$4,406	$4,519	$4,640	$4,713	$4,799	$4,895	$5,005	$5,153	$5,252	$5,352	$5,395	$5,483
17	Testing	$3,382	$3,413	$3,462	$3,552	$3,657	$3,795	$3,910	$4,006	$4,087	$4,160	$4,290	$4,406	$4,519	$4,640	$4,713	$4,799	$4,895	$5,005	$5,153	$5,252	$5,352	$5,395	$5,483
18	**Marketing**	$9,813	$9,830	$9,863	$9,920	$9,979	$10,059	$10,125	$10,178	$10,223	$10,264	$10,333	$10,400	$10,464	$10,539	$10,580	$10,624	$10,677	$10,737	$10,818	$10,876	$10,938	$10,968	$11,065
19	Market Analysis	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
20	Brochure Design	$1,839	$1,859	$1,883	$1,935	$1,988	$2,069	$2,131	$2,180	$2,226	$2,266	$2,337	$2,399	$2,463	$2,535	$2,575	$2,618	$2,670	$2,732	$2,809	$2,870	$2,918	$2,943	$2,997
21	Brochure Printing	$7,883	$7,888	$7,892	$7,902	$7,914	$7,931	$7,943	$7,954	$7,963	$7,971	$7,987	$8,000	$8,013	$8,028	$8,036	$8,046	$8,055	$8,069	$8,084	$8,096	$8,108	$8,113	$8,125
22	Work Complete	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
23	Schedule Margin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
24	Contract Delivery	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

25 rows | No Filter | No Highlight | Sorted on ID | Simulations: 10000, Sensitivity Targets: 0 (schedule), 0 (cost)

Figure 9.2

9.2.2 All Early Finish Percentiles

The **All Early Finish Percentiles** view displays Early Finish dates for every level of the schedule. For each task the Early Finish Dates are shown at various percentiles (levels of confidence). The percentiles displayed are based on the standard percentiles defined in Full Monte. If you have added/removed percentiles (as described in Chapter 15 Manage Percentiles) then you will need to manually add any newly defined percentiles to the view.



Full Monte Demonstration.mpp - Full Monte View: All Early Finish Percentiles (Customized)

File View Help | Risk Analysis | Search for Name or ID

ID	Task Name	Early Finish Percentile (0%)	Early Finish Percentile (0.5%)	Early Finish Percentile (1%)	Early Finish Percentile (2.5%)	Early Finish Percentile (5%)	Early Finish Percentile (10%)	Early Finish Percentile (15%)	Early Finish Percentile (20%)	Early Finish Percentile (25%)	Early Finish Percentile (30%)	Early Finish Percentile (40%)	Early Finish Percentile (50%)	Early Finish Percentile (60%)	Early Finish Percentile (70%)	Early Finish Percentile (75%)	Early Finish Percentile (80%)	Early Finish Percentile (85%)	Early Finish Percentile (90%)	Early Finish Percentile (95%)	Early Finish Percentile (97.5%)	Early Finish Percentile (99%)	Early Finish Percentile (99.5%)	Early Finish Percentile (100%)
0	**Full Monte Demonstratio**	28Jul23	28Jul23	28Jul23	31Jul23	01Aug23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	10Aug23	11Aug23	14Aug23	15Aug23	16Aug23	17Aug23	18Aug23	23Aug23
1	**Sample Project**	28Jul23	28Jul23	28Jul23	31Jul23	01Aug23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	10Aug23	11Aug23	14Aug23	15Aug23	16Aug23	17Aug23	18Aug23	23Aug23
2	Initiate	04May23	04May23	04May23	05May23	05May23	05May23	05May23	05May23	05May23	05May23	05May23	08May23	08May23	08May23	08May23	08May23	08May23	08May23	08May23	08May23	09May23	09May23	09May23
3	**Development**	19Jul23	20Jul23	20Jul23	24Jul23	24Jul23	25Jul23	26Jul23	27Jul23	27Jul23	28Jul23	28Jul23	31Jul23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	11Aug23	16Aug23
4	**Hardware**	18Jul23	19Jul23	19Jul23	21Jul23	24Jul23	25Jul23	26Jul23	26Jul23	27Jul23	27Jul23	28Jul23	31Jul23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	11Aug23	16Aug23
5	HW Design	26May23	29May23	29May23	29May23	30May23	31May23	31May23	01Jun23	01Jun23	01Jun23	02Jun23	02Jun23	05Jun23	06Jun23	06Jun23	06Jun23	07Jun23	07Jun23	08Jun23	08Jun23	08Jun23	09Jun23	09Jun23	12Jun23
6	HW Part A	21Jun23	21Jun23	22Jun23	23Jun23	26Jun23	27Jun23	27Jun23	28Jun23	28Jun23	29Jun23	30Jun23	30Jun23	03Jul23	04Jul23	05Jul23	05Jul23	06Jul23	06Jul23	07Jul23	10Jul23	11Jul23	12Jul23	14Jul23
7	HW Part B	20Jun23	20Jun23	21Jun23	22Jun23	23Jun23	26Jun23	26Jun23	27Jun23	27Jun23	28Jun23	29Jun23	29Jun23	30Jun23	03Jul23	03Jul23	04Jul23	05Jul23	05Jul23	06Jul23	07Jul23	10Jul23	10Jul23	12Jul23
8	HW Integrate	18Jul23	19Jul23	19Jul23	21Jul23	24Jul23	25Jul23	26Jul23	26Jul23	27Jul23	27Jul23	28Jul23	31Jul23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	11Aug23	16Aug23
9	HW Complete	18Jul23	19Jul23	19Jul23	21Jul23	24Jul23	25Jul23	26Jul23	26Jul23	27Jul23	27Jul23	28Jul23	31Jul23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	11Aug23	16Aug23
10	**Software**	11Jul23	11Jul23	12Jul23	13Jul23	14Jul23	17Jul23	18Jul23	18Jul23	19Jul23	19Jul23	20Jul23	21Jul23	24Jul23	25Jul23	25Jul23	26Jul23	26Jul23	27Jul23	28Jul23	31Jul23	01Aug23	02Aug23	04Aug23
11	SW Design	25May23	25May23	25May23	26May23	26May23	29May23	29May23	30May23	30May23	30May23	31May23	31May23	01Jun23	02Jun23	02Jun23	02Jun23	05Jun23	05Jun23	06Jun23	06Jun23	07Jun23	07Jun23	08Jun23
12	SW Code A	16Jun23	16Jun23	16Jun23	19Jun23	20Jun23	21Jun23	22Jun23	22Jun23	23Jun23	23Jun23	26Jun23	26Jun23	27Jun23	28Jun23	28Jun23	29Jun23	29Jun23	30Jun23	03Jul23	04Jul23	04Jul23	05Jul23	07Jul23
13	SW Code B	15Jun23	15Jun23	16Jun23	19Jun23	19Jun23	20Jun23	21Jun23	21Jun23	22Jun23	22Jun23	23Jun23	23Jun23	26Jun23	27Jun23	27Jun23	28Jun23	28Jun23	29Jun23	30Jun23	30Jun23	03Jul23	04Jul23	06Jul23
14	SW Integrate	11Jul23	11Jul23	12Jul23	13Jul23	14Jul23	17Jul23	18Jul23	18Jul23	19Jul23	19Jul23	20Jul23	21Jul23	24Jul23	25Jul23	25Jul23	26Jul23	26Jul23	27Jul23	28Jul23	31Jul23	01Aug23	02Aug23	04Aug23
15	SW Complete	11Jul23	11Jul23	12Jul23	13Jul23	14Jul23	17Jul23	18Jul23	18Jul23	19Jul23	19Jul23	20Jul23	21Jul23	24Jul23	25Jul23	25Jul23	26Jul23	26Jul23	27Jul23	28Jul23	31Jul23	01Aug23	02Aug23	04Aug23
16	**Integration**	26Jul23	27Jul23	27Jul23	28Jul23	31Jul23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	10Aug23	11Aug23	14Aug23	15Aug23	16Aug23	17Aug23	18Aug23	23Aug23
17	Testing	26Jul23	27Jul23	27Jul23	28Jul23	31Jul23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	10Aug23	11Aug23	14Aug23	15Aug23	16Aug23	17Aug23	18Aug23	23Aug23
18	**Marketing**	25Jul23	26Jul23	26Jul23	26Jul23	27Jul23	27Jul23	27Jul23	27Jul23	28Jul23	28Jul23	28Jul23	28Jul23	31Jul23	31Jul23	31Jul23	01Aug23	01Aug23	01Aug23	01Aug23	02Aug23	02Aug23	02Aug23	03Aug23
19	Market Analysis	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23	10Jul23
20	Brochure Design	19Jul23	19Jul23	19Jul23	20Jul23	20Jul23	20Jul23	21Jul23	21Jul23	21Jul23	21Jul23	21Jul23	21Jul23	24Jul23	24Jul23	24Jul23	24Jul23	25Jul23	25Jul23	25Jul23	25Jul23	26Jul23	26Jul23	26Jul23
21	Brochure Printing	25Jul23	26Jul23	26Jul23	26Jul23	27Jul23	27Jul23	27Jul23	27Jul23	28Jul23	28Jul23	28Jul23	28Jul23	31Jul23	31Jul23	31Jul23	01Aug23	01Aug23	01Aug23	01Aug23	02Aug23	02Aug23	02Aug23	03Aug23
22	Work Complete	28Jul23	28Jul23	28Jul23	31Jul23	01Aug23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	10Aug23	11Aug23	14Aug23	15Aug23	16Aug23	17Aug23	18Aug23	23Aug23
23	Schedule Margin	28Jul23	28Jul23	28Jul23	31Jul23	01Aug23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	10Aug23	11Aug23	14Aug23	15Aug23	16Aug23	17Aug23	18Aug23	23Aug23
24	Contract Delivery	28Jul23	28Jul23	28Jul23	31Jul23	01Aug23	01Aug23	02Aug23	03Aug23	03Aug23	04Aug23	04Aug23	07Aug23	08Aug23	09Aug23	10Aug23	10Aug23	11Aug23	14Aug23	15Aug23	16Aug23	17Aug23	18Aug23	23Aug23

25 rows | No Filter | No Highlight | Sorted on ID | Simulations: 10000, Sensitivity Targets: 0 (schedule), 0 (cost)

Figure 9.3

9.2.3 Date Diagnostic

The Date Diagnostic view is designed to help the basis of the results calculated by Full Monte.

There are two columns of particular note: Early Start Basis and Early Finish Basis. These columns contain information showing the percentage of time a task was driven by specific predecessors during the simulation and whether actual or target dates affected the results.

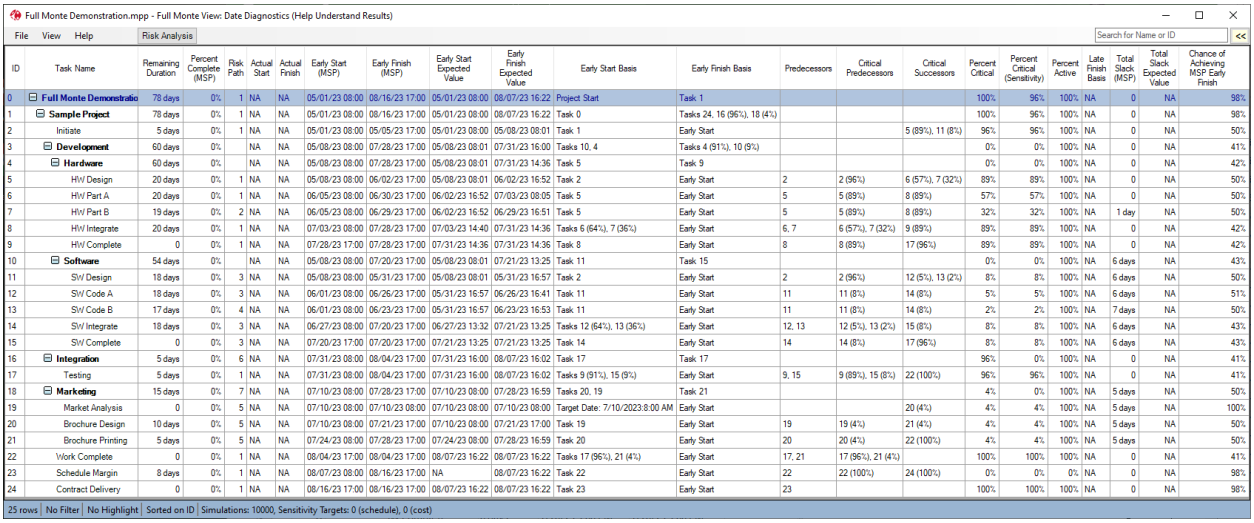


Figure 9.4

9.2.4 Graphs View

The view **Graphs** comprises a table of buttons from which you can view all the graphical results of risk analysis. The report is illustrated in figure 9.5.

Note: The Graphs view can also be displayed by clicking the Graphs quick-launch button on the Activity Edit view menu bar.

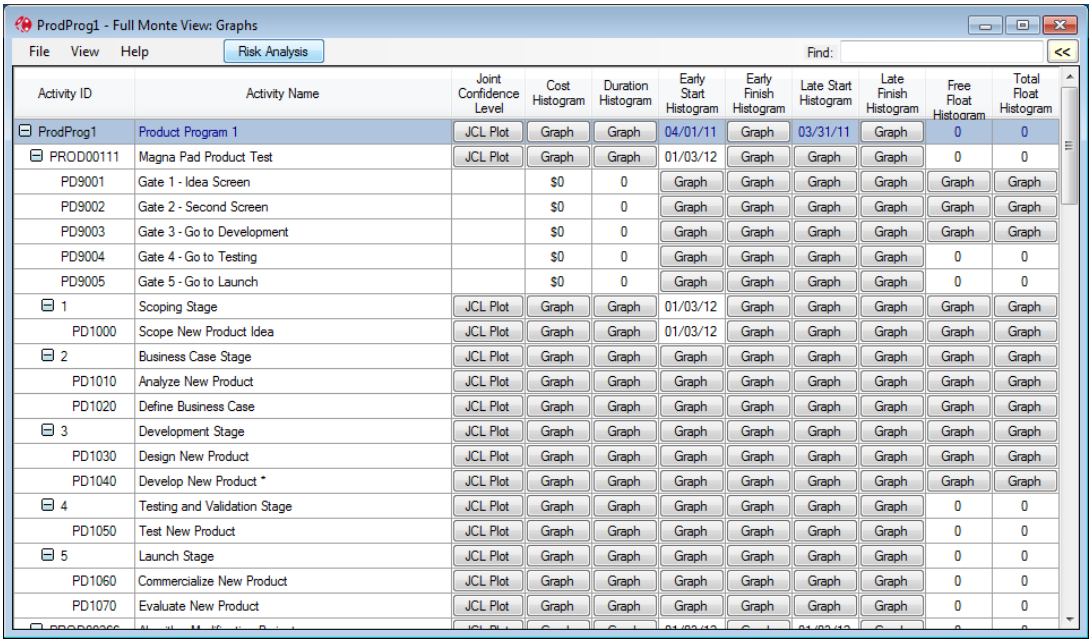


Figure 9.5

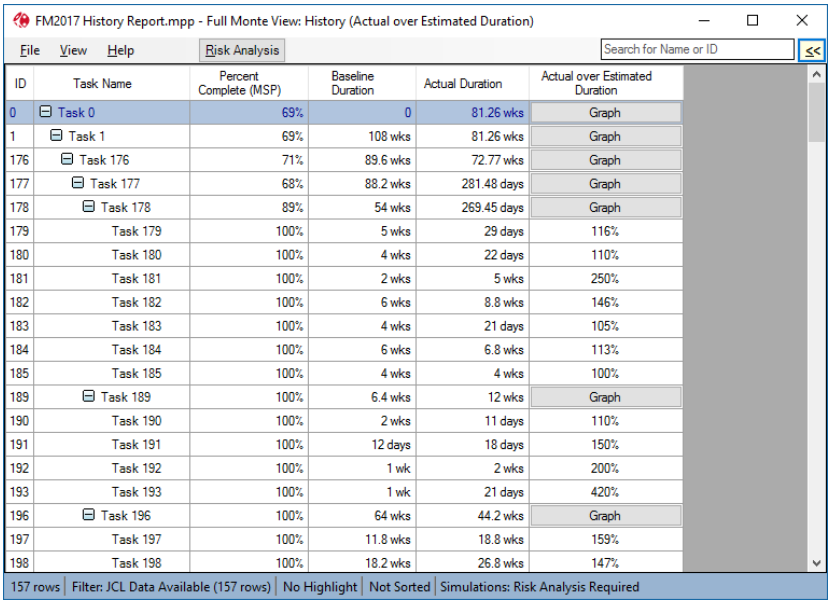
There are buttons to display the joint confidence level (JCL) plot (described in Chapter 12), as well as histograms of cost, duration, and the various dates and floats (described in Chapter 10).

Some of the cells contain a value instead of buttons. This is because the value in question was always the same, so there would be a single histogram bar and a step function for the S-curve. This would not be very interesting or useful, so it is easier just to show what that single value is.

9.2.5 History View

The **History view** is designed to show how reliable past estimates have been on completed or partially completed projects. Shown in figure 9.6, it compares the actual duration with the original estimate. The column **Actual/Expected Duration** either shows this ratio for a single activity or a button from which you can see a histogram of the ratio for all completed activities in that WBS (work breakdown structure).

Note: As Microsoft Project adjusts the task duration as progress and Actual Finish dates are updated the History report relies on Baseline Duration for the original estimate in Microsoft Project. The baseline must have been created before the project was statused.



ID	Task Name	Percent Complete (MSP)	Baseline Duration	Actual Duration	Actual over Estimated Duration
0	Task 0	69%	0	81.26 wks	Graph
1	Task 1	69%	108 wks	81.26 wks	Graph
176	Task 176	71%	89.6 wks	72.77 wks	Graph
177	Task 177	68%	88.2 wks	281.48 days	Graph
178	Task 178	89%	54 wks	269.45 days	Graph
179	Task 179	100%	5 wks	29 days	116%
180	Task 180	100%	4 wks	22 days	110%
181	Task 181	100%	2 wks	5 wks	250%
182	Task 182	100%	6 wks	8.8 wks	146%
183	Task 183	100%	4 wks	21 days	105%
184	Task 184	100%	6 wks	6.8 wks	113%
185	Task 185	100%	4 wks	4 wks	100%
189	Task 189	100%	6.4 wks	12 wks	Graph
190	Task 190	100%	2 wks	11 days	110%
191	Task 191	100%	12 days	18 days	150%
192	Task 192	100%	1 wk	2 wks	200%
193	Task 193	100%	1 wk	21 days	420%
196	Task 196	100%	64 wks	44.2 wks	Graph
197	Task 197	100%	11.8 wks	18.8 wks	159%
198	Task 198	100%	18.2 wks	26.8 wks	147%

Figure 9.6

Figure 9.7 shows an example of a histogram based on historical data.

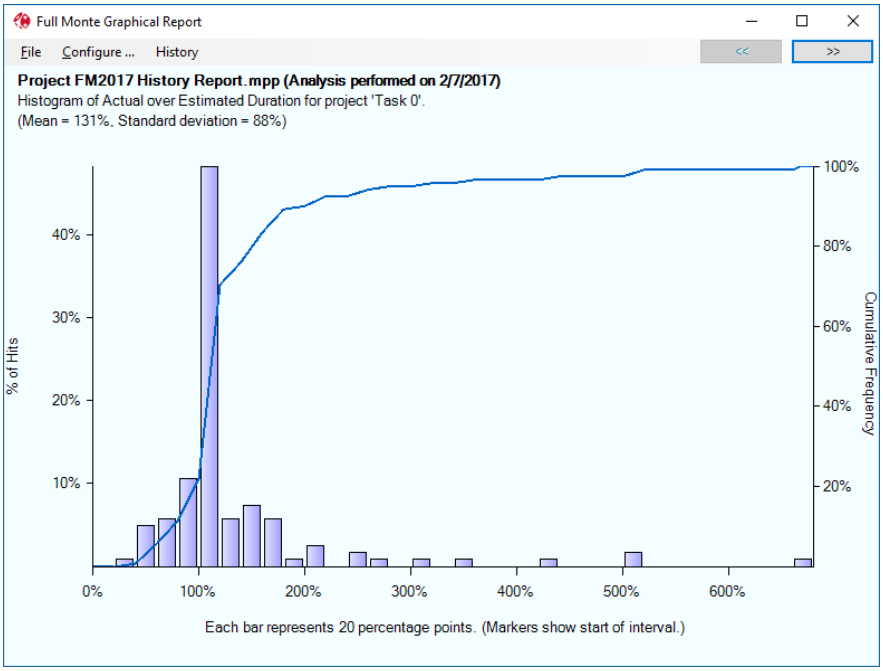


Figure 9.7

While the bulk of the data is between around 50% and 200% on the x-axis, we can see outliers all the way to over 600%. These outliers may be due to data entry errors (bad actual dates) or perhaps represent very short activities that overran. The tabular view can be sorted to find these extreme values and determine the cause.

The History, Options dialog shown in Figure 9.5 can be used to exclude outlying values if required.

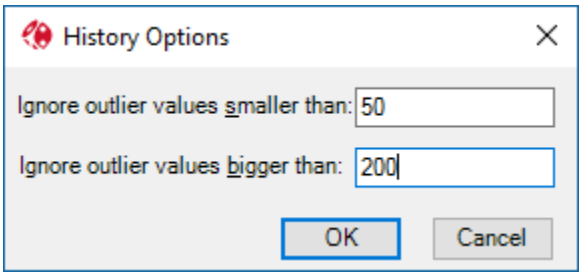


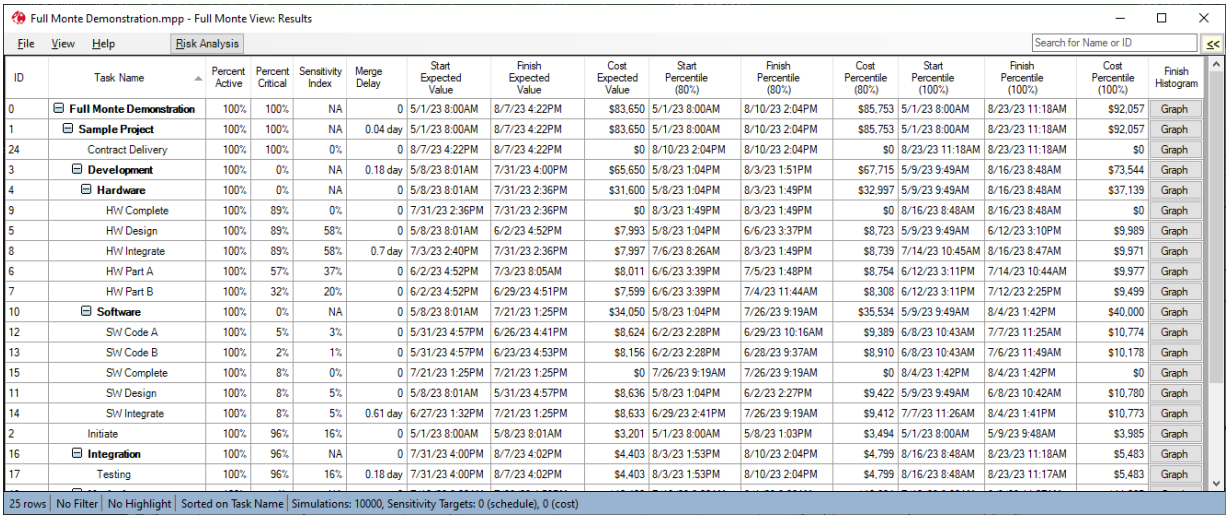
Figure 9.8

9.2.6 Message Log View

The view **Message Log** displays any warning messages that were generated by the most recent risk analysis.

9.2.7 Results View

The **Results view**, shown in figure 9.9, provides an overview of some the results from the risk analysis. These include Merge Delay, Expected (mean) Start/Finish/Costs and the same data at 80% and 100% confidence.



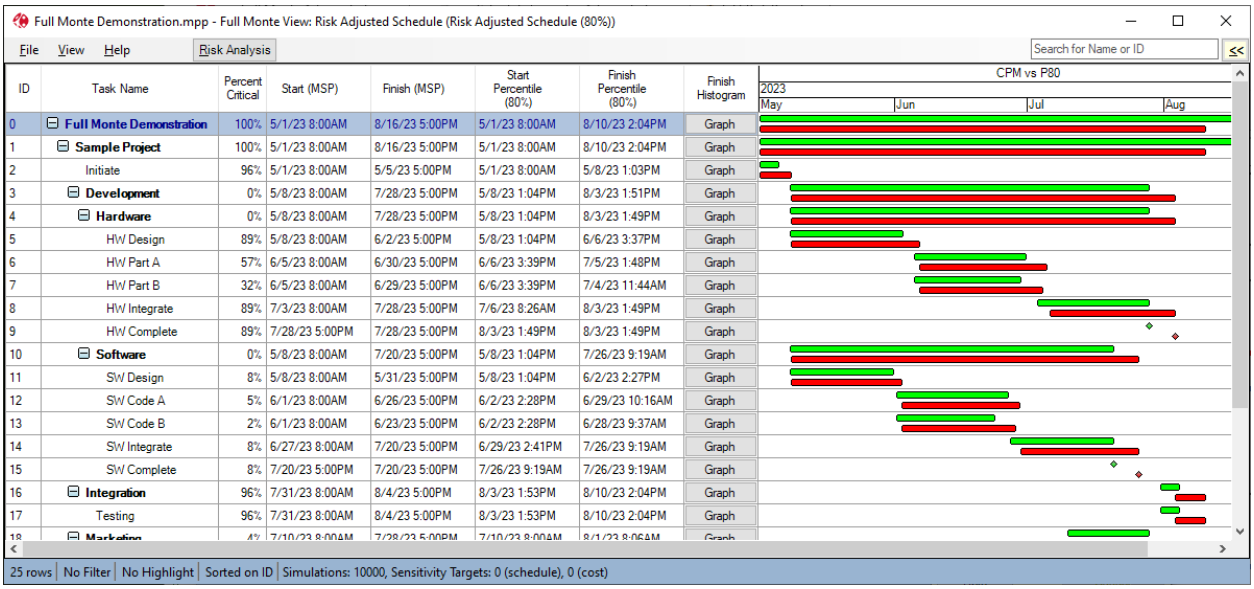
ID	Task Name	Percent Active	Percent Critical	Sensitivity Index	Merge Delay	Start Expected Value	Finish Expected Value	Cost Expected Value	Start Percentile (80%)	Finish Percentile (80%)	Cost Percentile (80%)	Start Percentile (100%)	Finish Percentile (100%)	Cost Percentile (100%)	Finish Histogram
0	**Full Monte Demonstration**	100%	100%	NA	0	5/1/23 8:00AM	8/7/23 4:22PM	$83,650	5/1/23 8:00AM	8/10/23 2:04PM	$85,753	5/1/23 8:00AM	8/23/23 11:18AM	$92,057	Graph
1	**Sample Project**	100%	100%	NA	0.04 day	5/1/23 8:00AM	8/7/23 4:22PM	$83,650	5/1/23 8:00AM	8/10/23 2:04PM	$85,753	5/1/23 8:00AM	8/23/23 11:18AM	$92,057	Graph
24	Contract Delivery	100%	100%	0%	0	8/7/23 4:22PM	8/7/23 4:22PM	$0	8/10/23 2:04PM	8/10/23 2:04PM	$0	8/23/23 11:18AM	8/23/23 11:18AM	$0	Graph
3	**Development**	100%	0%	NA	0.18 day	5/8/23 8:01AM	7/31/23 4:00PM	$65,650	5/8/23 1:04PM	8/3/23 1:51PM	$67,715	5/9/23 9:49AM	8/16/23 8:48AM	$73,544	Graph
4	**Hardware**	100%	0%	NA	0	5/8/23 8:01AM	7/31/23 2:36PM	$31,600	5/8/23 1:04PM	8/3/23 1:49PM	$32,997	5/9/23 9:49AM	8/16/23 8:48AM	$37,139	Graph
9	HW Complete	100%	89%	0%	0	7/31/23 2:36PM	7/31/23 2:36PM	$0	8/3/23 1:49PM	8/3/23 1:49PM	$0	8/16/23 8:48AM	8/16/23 8:48AM	$0	Graph
5	HW Design	100%	89%	58%	0	5/8/23 8:01AM	6/2/23 4:52PM	$7,993	5/8/23 1:04PM	6/6/23 3:37PM	$8,723	5/9/23 9:49AM	6/12/23 3:10PM	$9,989	Graph
8	HW Integrate	100%	89%	58%	0.7 day	7/3/23 2:40PM	7/31/23 2:36PM	$7,997	7/6/23 8:26AM	8/3/23 1:49PM	$8,739	7/14/23 10:45AM	8/16/23 8:47AM	$9,971	Graph
6	HW Part A	100%	57%	37%	0	6/2/23 4:52PM	7/3/23 8:05AM	$8,011	6/6/23 3:39PM	7/5/23 1:48PM	$8,754	6/12/23 3:11PM	7/14/23 10:44AM	$9,977	Graph
7	HW Part B	100%	32%	20%	0	6/2/23 4:52PM	6/29/23 4:51PM	$7,599	6/6/23 3:39PM	7/4/23 11:44AM	$8,308	6/12/23 3:11PM	7/12/23 2:25PM	$9,499	Graph
10	**Software**	100%	0%	NA	0	5/8/23 8:01AM	7/21/23 1:25PM	$34,050	5/8/23 1:04PM	7/26/23 9:19AM	$35,534	5/9/23 9:49AM	8/4/23 1:42PM	$40,000	Graph
12	SW Code A	100%	5%	3%	0	5/31/23 4:57PM	6/26/23 4:41PM	$8,624	6/2/23 2:28PM	6/29/23 10:16AM	$9,389	6/8/23 10:43AM	7/7/23 11:25AM	$10,774	Graph
13	SW Code B	100%	2%	1%	0	5/31/23 4:57PM	6/23/23 4:53PM	$8,156	6/2/23 2:28PM	6/28/23 9:37AM	$8,910	6/8/23 10:43AM	7/6/23 11:49AM	$10,178	Graph
15	SW Complete	100%	8%	0%	0	7/21/23 1:25PM	7/21/23 1:25PM	$0	7/26/23 9:19AM	7/26/23 9:19AM	$0	8/4/23 1:42PM	8/4/23 1:42PM	$0	Graph
11	SW Design	100%	8%	5%	0	5/8/23 8:01AM	5/31/23 4:57PM	$8,636	5/8/23 1:04PM	6/2/23 2:27PM	$9,422	5/9/23 9:49AM	6/8/23 10:42AM	$10,780	Graph
14	SW Integrate	100%	8%	5%	0.61 day	6/27/23 1:32PM	7/21/23 1:25PM	$8,633	6/29/23 2:41PM	7/26/23 9:19AM	$9,412	7/7/23 11:26AM	8/4/23 1:41PM	$10,773	Graph
2	Initiate	100%	96%	16%	0	5/1/23 8:00AM	5/8/23 8:01AM	$3,201	5/1/23 8:00AM	5/8/23 1:03PM	$3,494	5/1/23 8:00AM	5/9/23 9:48AM	$3,985	Graph
16	**Integration**	100%	96%	NA	0	7/31/23 4:00PM	8/7/23 4:02PM	$4,403	8/3/23 1:53PM	8/10/23 2:04PM	$4,799	8/16/23 8:48AM	8/23/23 11:18AM	$5,483	Graph
17	Testing	100%	96%	16%	0.18 day	7/31/23 4:00PM	8/7/23 4:02PM	$4,403	8/3/23 1:53PM	8/10/23 2:04PM	$4,799	8/16/23 8:48AM	8/23/23 11:17AM	$5,483	Graph

Figure 9.9

9.2.8 Risk Adjusted Schedule

The Risk Adjusted Schedule view is a Gantt chart configured, as an example, to compare the original schedule dates (green bars) against bars drawn at the 80th percentile (80% confidence) dates (red bars) calculated by risk analysis.

The project should always be managed against the underlying schedule (as normal) while the risk adjusted bars show where we anticipate work may ultimately be performed as uncertainty has its effect. Commit to the red bars, execute against the green bars.



ID	Task Name	Percent Critical	Start (MSP)	Finish (MSP)	Start Percentile (80%)	Finish Percentile (80%)	Finish Histogram
0	**Full Monte Demonstration**	100%	5/1/23 8:00AM	8/16/23 5:00PM	5/1/23 8:00AM	8/10/23 2:04PM	Graph
1	**Sample Project**	100%	5/1/23 8:00AM	8/16/23 5:00PM	5/1/23 8:00AM	8/10/23 2:04PM	Graph
2	Initiate	96%	5/1/23 8:00AM	5/5/23 5:00PM	5/1/23 8:00AM	5/8/23 1:03PM	Graph
3	**Development**	0%	5/8/23 8:00AM	7/28/23 5:00PM	5/8/23 1:04PM	8/3/23 1:51PM	Graph
4	**Hardware**	0%	5/8/23 8:00AM	7/28/23 5:00PM	5/8/23 1:04PM	8/3/23 1:49PM	Graph
5	HW Design	89%	5/8/23 8:00AM	6/2/23 5:00PM	5/8/23 1:04PM	6/6/23 3:37PM	Graph
6	HW Part A	57%	6/5/23 8:00AM	6/30/23 5:00PM	6/6/23 3:39PM	7/5/23 1:48PM	Graph
7	HW Part B	32%	6/5/23 8:00AM	6/29/23 5:00PM	6/6/23 3:39PM	7/4/23 11:44AM	Graph
8	HW Integrate	89%	7/3/23 8:00AM	7/28/23 5:00PM	7/6/23 8:26AM	8/3/23 1:49PM	Graph
9	HW Complete	89%	7/28/23 5:00PM	7/28/23 5:00PM	8/3/23 1:49PM	8/3/23 1:49PM	Graph
10	**Software**	0%	5/8/23 8:00AM	7/20/23 5:00PM	5/8/23 1:04PM	7/26/23 9:19AM	Graph
11	SW Design	8%	5/8/23 8:00AM	5/31/23 5:00PM	5/8/23 1:04PM	6/2/23 2:27PM	Graph
12	SW Code A	5%	6/1/23 8:00AM	6/26/23 5:00PM	6/2/23 2:28PM	6/29/23 10:16AM	Graph
13	SW Code B	2%	6/1/23 8:00AM	6/23/23 5:00PM	6/2/23 2:28PM	6/28/23 9:37AM	Graph
14	SW Integrate	8%	6/27/23 8:00AM	7/20/23 5:00PM	6/29/23 2:41PM	7/26/23 9:19AM	Graph
15	SW Complete	8%	7/20/23 5:00PM	7/20/23 5:00PM	7/26/23 9:19AM	7/26/23 9:19AM	Graph
16	**Integration**	96%	7/31/23 8:00AM	8/4/23 5:00PM	8/3/23 1:53PM	8/10/23 2:04PM	Graph
17	Testing	96%	7/31/23 8:00AM	8/4/23 5:00PM	8/3/23 1:53PM	8/10/23 2:04PM	Graph
18	**Marketing**	4%	7/10/23 8:00AM	7/28/23 5:00PM	7/10/23 8:00AM	8/1/23 8:06AM	Graph

Figure 9.10

9.2.9 Risk Path Gantt

The Risk Path Gant is described in more detail in Section 8.2.2. Full Monte calculates a 'risk path' number for all tasks that affect the sensitivity target outcome during the analysis. Path 1 is the most likely chain of tasks to drive the outcome.

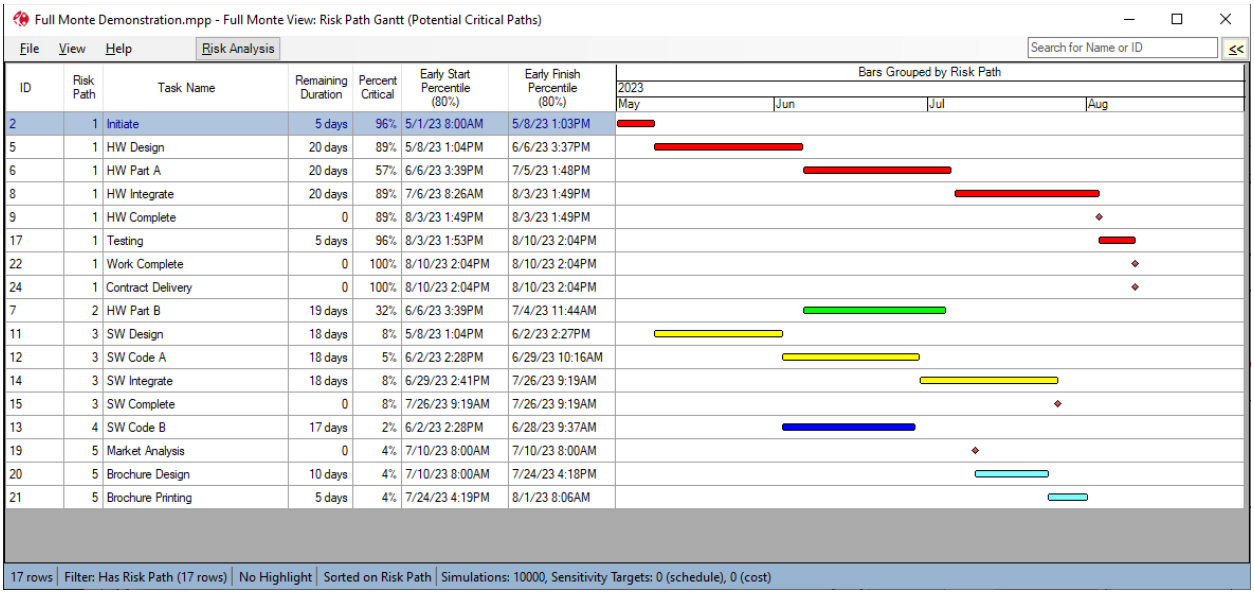


Figure 9.11

9.2.10 Tornado Charts

The three tornado charts are described in Chapter 11 – Exploring Sensitivity.

9.3 Special Features of Certain Standard Reports

1. The report Graphs contains a filter so that only rows with at least one Graph button will be displayed.
2. All the Tornado charts contain a filter so that only rows with bars will be displayed.
3. All the Tornado charts respond to clicking on the bars to do a full sensitivity analysis as explained in Chapter 10.
4. The Tornado reports contain special code to display the bars in two colors, split at the point of the expected date of the sensitivity target. The user can control only the left-hand color.

There is no explicit user interface to include these behaviors in nonstandard views, but they will be inherited by any user-defined reports based on them.

Chapter 10: Graphical Views

One final user interface element is the graphical view, which is accessed from the **Graph** buttons on any histogram column included in a spreadsheet or the docked panel in tabular views. An example is shown in figure 10.1. Specific customer configurations may vary.

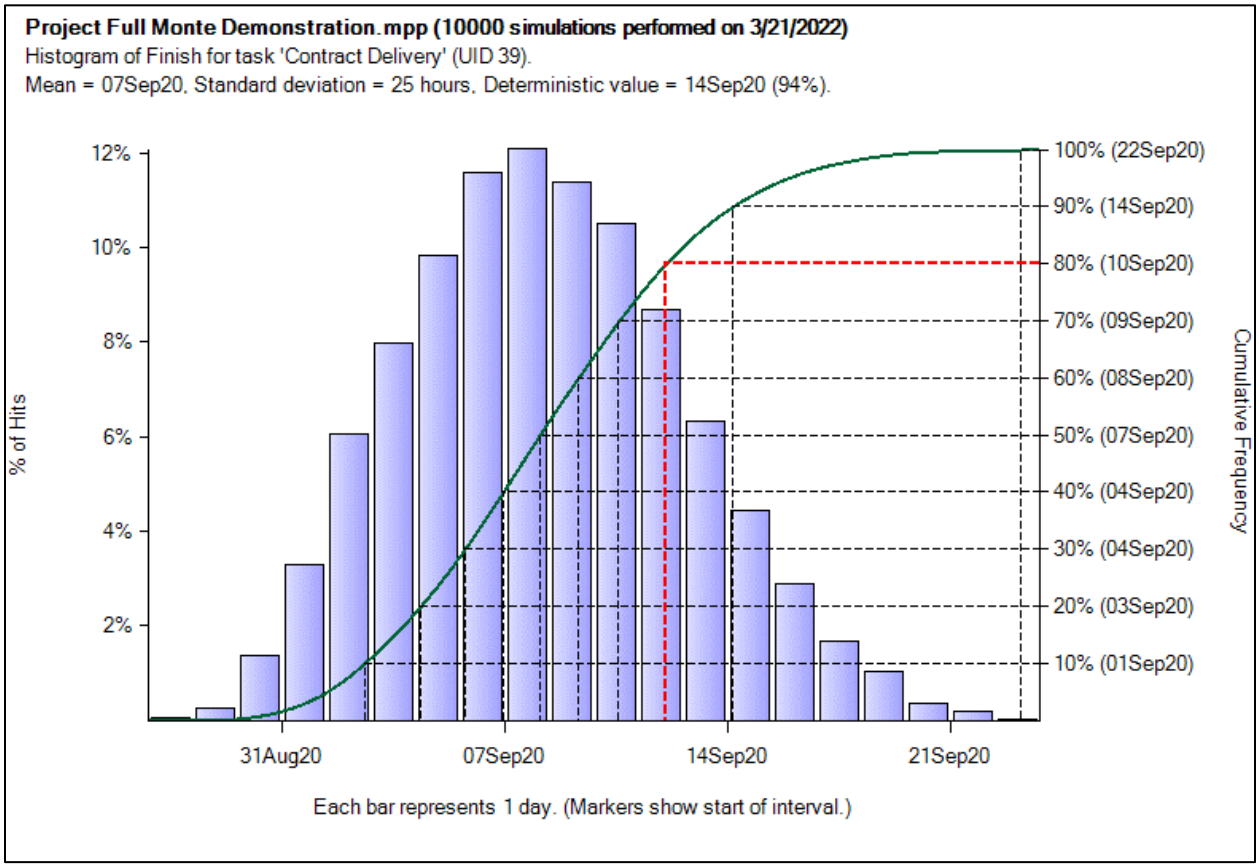


Figure 10.1.

The histogram bars show the frequency function measured against the left-hand scale, whereas the S-curve shows the cumulative frequency function measured against the right-hand scale. You can produce graphs at any level of the project structure for:

Cost
Duration
Early Start
Early Finish
Late Start (if Full Backward Pass is enabled on the Risk Analysis dialog)
Late Finish (if Full Backward Pass is enabled on the Risk Analysis dialog)
Free Float (if Full Backward Pass is enabled on the Risk Analysis dialog)
Total Float (if Full Backward Pass is enabled on the Risk Analysis dialog)

The chevron buttons (<< and >>) allow you to move backward and forward through the list of tasks.

The **File** menu allows you to:

Print the view
Show a print preview of the view
Copy the view to the clipboard
Close the view

The **Configure** menu item takes you straight to the configuration dialog illustrated in figure 10.2.

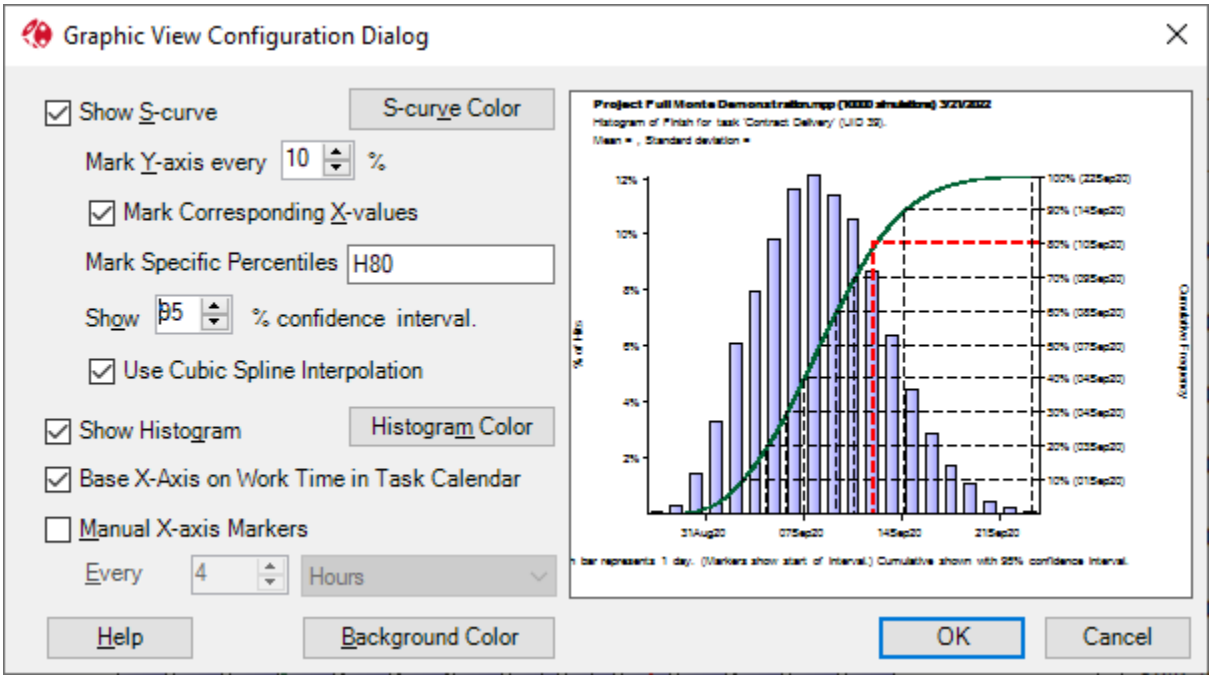


Figure 10.2

From this dialog you can:

Suppress the histogram or S-curve (but not both)
Select the color of histogram bars and S-curve
Select how frequently you want the right-hand Y-axis markers to be shown
Select whether you want the corresponding X-values shown
Choose to mark or highlight specific percentile values
Select whether you want to show a confidence range around the S-curve (see below)
Select whether to use cubic spine or linear interpolation to form the S-curve (see below).
Select whether to base the X-axis on the task calendar (see below).
Define frequency of X-axis markers
Select the background color

Every time you make a change it is reflected in the preview on the dialog.

Mark Y-axis every

This allows the user to select how frequently the right Y-axis (or left Y-axis if the histogram is not displayed) is marked.

> *Note: The intersecting lines drawn when 'Mark Corresponding X-values' is selected will only ever be drawn on multiples of the 'Mark Y-Axis every'. This includes values specified in the 'Mark*

Specific Percentiles' option. For example, if the 'Mark Y-axis every' is set to 20% and the 'Mark Specific Percentiles' is set to '50,80', then only the intersecting line for 80% will be drawn as 50% is not a multiple of 20%.

Mark Corresponding X-values

The 'Mark Corresponding X-values' option draws an intersecting line between the relevant X and Y axis values, based on the 'Mark Y-axis every' value.

Mark Specific Percentiles

The 'Mark Specific Percentiles' feature can be used to modify the standard 'Mark Corresponding X-values' behavior as follows:

If the user enters specific Y axis values such as '50,80' then only those interesting lines will be drawn. All other intersecting lines will be suppressed as shown in the preview in Figure 10.3.

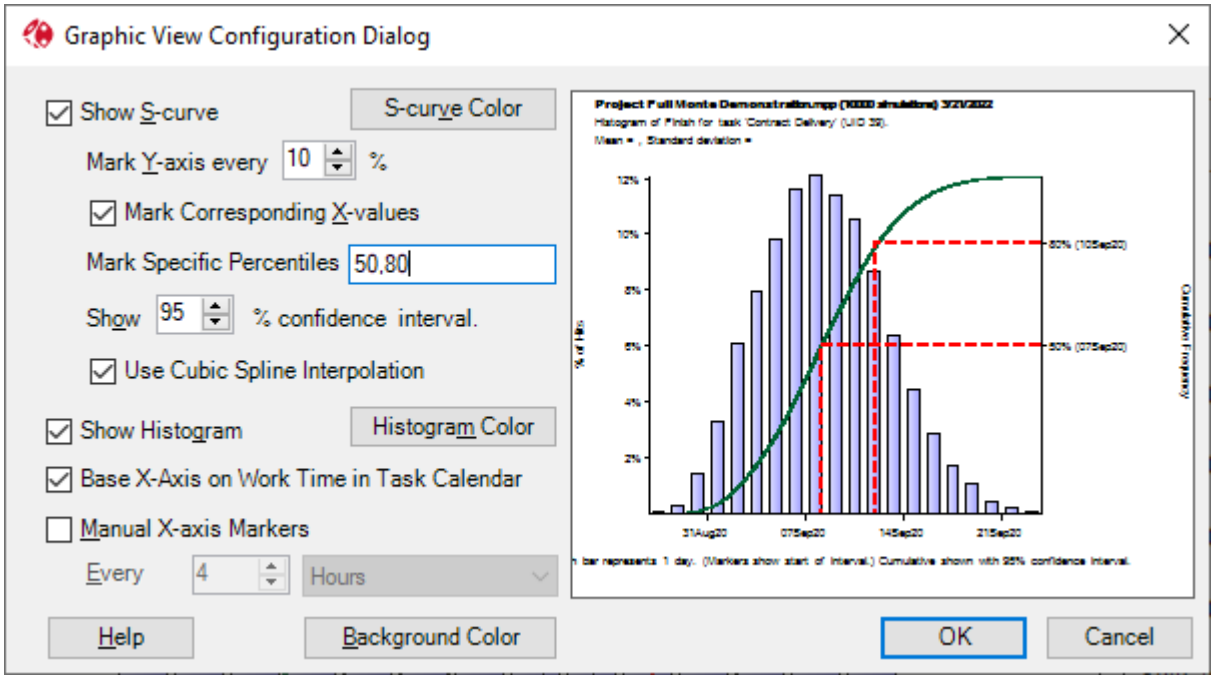


Figure 10.3

If the letter 'H' (for highlight) is included in the 'Mark Specific Percentiles' entry, then all percentiles will be marked but those listed will be highlighted as shown in Figure 10.4.

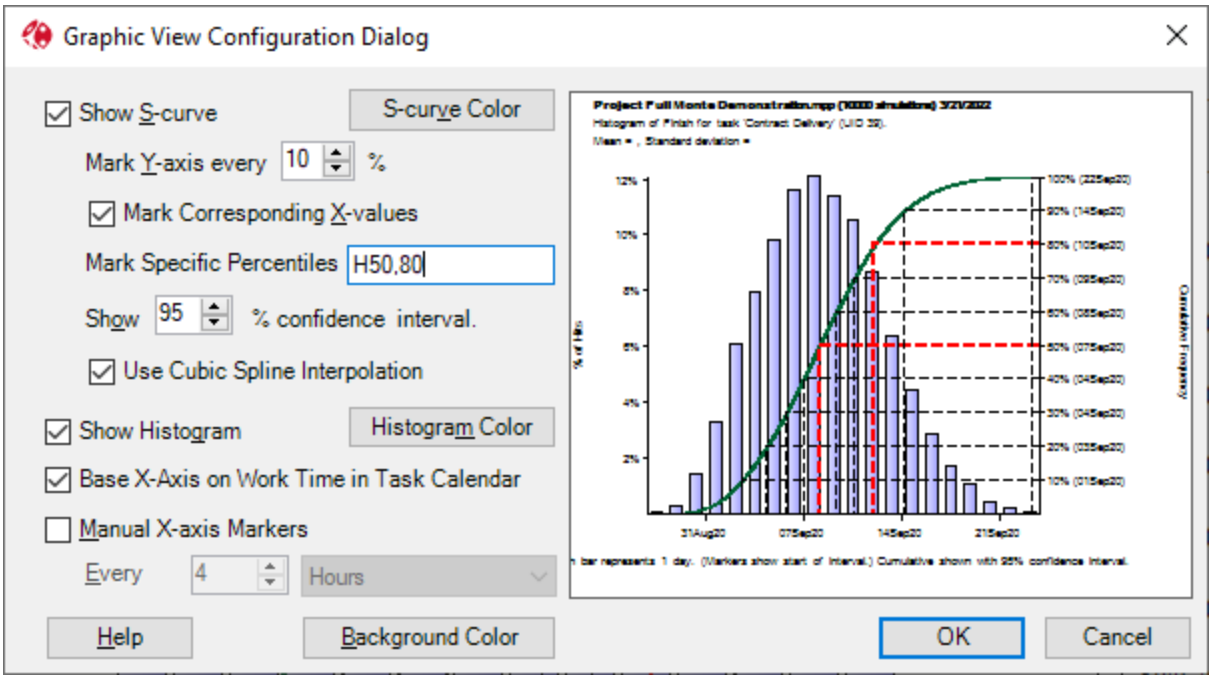


Figure 10.4

Lastly, if the letter 'P' is included in the 'Mark Specific Percentiles' entry, then the Y-axis labels will change from displaying percentages (i.e. 90%) to using the Pnn notation (i.e. P80) favored on some projects as shown in Figure 10.5.

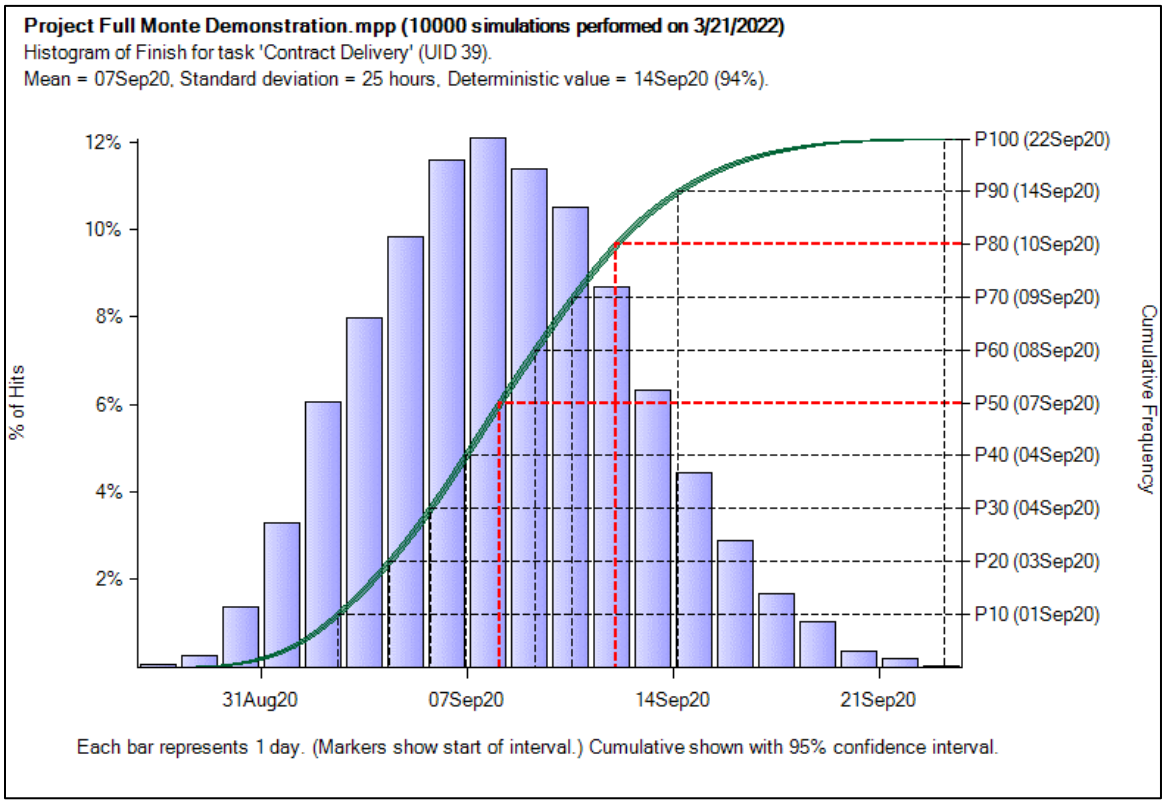


Figure 10.5

Show nn% confidence interval

In the example in figure 10.6, the confidence interval for the S-curve has been set to 95%. This causes the S-curve to be replaced by an envelope such that there is 95% confidence that the true cumulative probability lies within it.

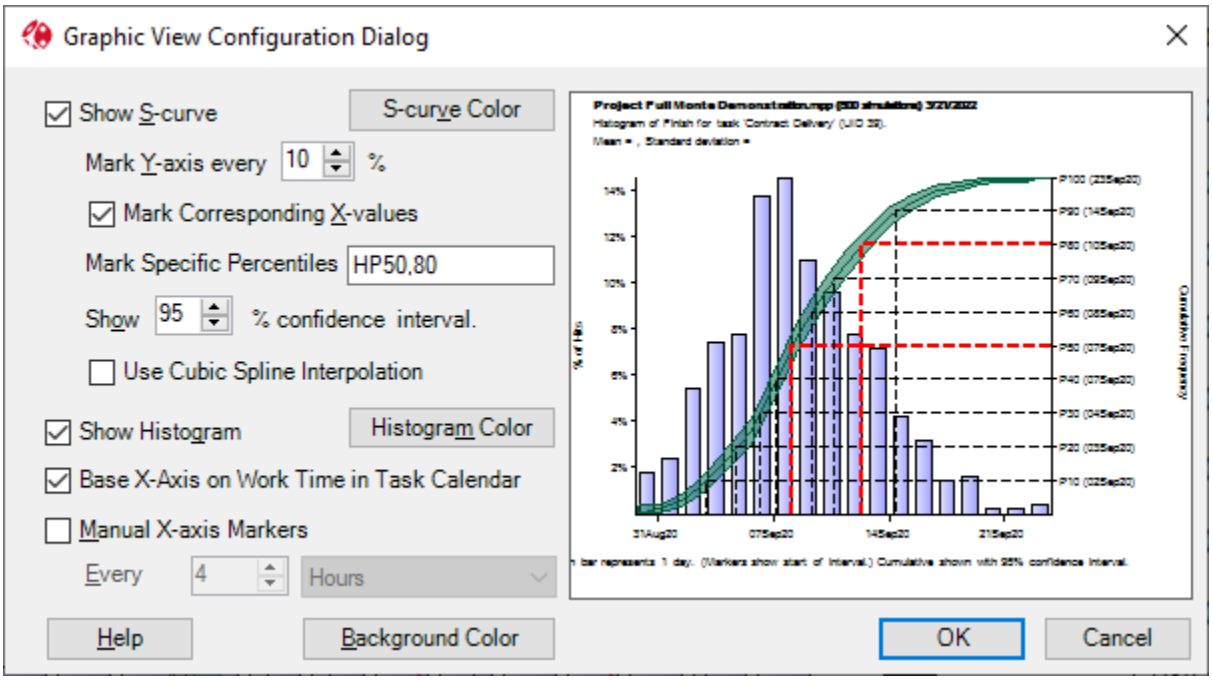


Figure 10.6

NOTE: In this case, only 500 iterations have been performed. The more iterations you do, the narrower the envelope will be.

The S-curve is formed by interpolating between the cumulative values at the end of each histogram interval. This can be done either linearly or using a technique called a cubic spline. This fits a cubic function to each line segment such that where it meets its neighboring segments it has the same gradient, avoiding sharp corners at these points. It generally produces a smoother and more realistic curve, but in some cases (usually when too few iterations have been performed or when elapsed time is used for the X-axis as dscussed below) it may be misleading.

Base X-axis on Work Time in Task Calendar

The X-axis can be dispayed either using elapsed time (i.e. allowing space for non-work time such as weekends) or usng the task calendar. Depending upon the histogram interval, using elapsed time may result in gaps in the histogram (and horizontal lines in the S-curve) representing weekends or overnight hours. Using the task calendar for the X-axis will not allocate any space for non-work time, eliminating any spaces and making the S-curve smooth.

> *NOTE: The space allocated to each interval is actually proportional to the amount of work time in it. This is normally either 0 or a constant value (e.g 0 on Sunday, 480 minutes on Monday) so every period which is actually shown will be the same width. However, if for example the calendar* INDICATES *a half-day on Saturday, then Saturdays will be allocated half the width of the a normal weekday. To compensate, the height of the bar is doubled so that the area of the bar*

represents the probabililty in that interval and the tops of the histogram bars are comparable to the surrounding bars.

When you have finished making changes, you can apply them by clicking on **OK** or cancel them by clicking on **Cancel**.

Note: Any changes you make will apply to the current session only, unless when you close the view from which you invoked the graph you elect to save it. If you do save it, it will be stored with the view specification.

Note: The date formats for the graph heading and axis markers are inherited from the parent tabular view (the view from which the graph view was opened).

Chapter 11: Exploring Sensitivity

11.1 Overview

Sensitivity analysis is sometimes seen as an alternative to Monte Carlo simulation as a way to deal with uncertainty. Barbecana believes it is a valuable tool that not only augments simulation results, but needs to be done in conjunction with the simulation.

To see why this is necessary, consider a sensitivity analysis done in isolation, sometimes called a "local analysis." The typical local analysis varies one variable at a time within certain limits and examines the effects, all other things being equal.

The devil is in the detail of those last five words, because "all other things being equal" is generally interpreted as meaning "all other variables taking their expected values." To see how misleading this can be, suppose you had 10 identical activities in parallel with a common successor, each of which could take three to seven weeks with an expected value of four weeks. Looking at each of these activities one at a time and assuming that the other nine took their expected value of four weeks, it would look as if each of the activities had the potential to change the expected start of the successor by three weeks. In fact, fixing one of them at three weeks and doing a full simulation would show that it has little effect, because one or more of the other nine activities would be almost bound to take seven weeks to complete. This "local" analysis ignores merge bias among all the other activities.

Full Monte therefore uses sophisticated statistical techniques to estimate the true sensitivity of each activity during the simulation. Before going further, we should also note that it does sensitivity for both cost and schedule, and that the user can choose the identity of the "sensitivity target" in each case. The sensitivity target is the date or WBS (work breakdown structure) cost whose sensitivity to the input variables one wishes to measure. The schedule sensitivity target defaults to the project finish but can be set to any milestone. The cost sensitivity target defaults to the total project but can be set to any WBS element.

NOTE: Only one of each type of target can be specified in any given risk analysis run.

The main sensitivity outputs are:

Sensitivity, Optimistic Finish of Target: This is an estimate of the expected early finish date of the schedule sensitivity target **if the current activity's duration** were to take its most optimistic value.

Sensitivity, Pessimistic Finish of Target: This is an estimate of the expected early finish date of the schedule sensitivity target **if the current activity's duration** were to take its most pessimistic value.

Sensitivity Index: This field gives an indication of how sensitive the early finish of the schedule sensitivity target is to variation in the activity's duration. It is computed as the percent critical multiplied by the standard deviation of the duration and divided by the standard deviation of the early finish of the sensitivity target.

NOTE: The field 'Percent Critical (Sensitivity)' is used in the Sensitivity calculation rather than the regular 'Percent Critical' field. The field 'Percent Critical (Sensitivity)' differs in two ways from the regular 'Percent Critical' field: it indicates whether the task is critical specifically to the sensitivity target; and it reflects whether the duration of the task affects this target (so it does not count as critical tasks which have the critical path passing through their starts or finishes but not through their durations.

Sensitivity, Optimistic Cost of Target: This is an estimate of the expected cost of the cost sensitivity target if the current activity's duration were to take its optimistic value.

Sensitivity, Pessimistic Cost of Target: This is an estimate of the expected cost of the cost sensitivity target if the current activity's duration were to take its pessimistic value.

NOTE: The above two measures are produced for resource costs as well as for tasks.

NOTE: The cost sensitivity measures are more reliable than the schedule ones because costs generally interact in simpler ways – i.e. they just add up. But note that schedule delays may affect costs due to pushing a task into a time of higher unit cost due to escalation, while conditional or probabilistic branching also make cost sensitivity non-trivial.

11.2 The Effect of Correlations on Schedule Sensitivity Calculations

In previous versions of Full Monte (and still used by most if not all other products) the methods used to estimate the above measures of sensitivity (except for the sensitivity index) were statistical techniques based on a comparison of the inputs (the durations sampled for each activity) and outputs (the early finish of the sensitivity target) as if the project network were a "black box." They were therefore vulnerable to being misled by correlations. If activity A and B are correlated and if activity A is sometimes critical but activity B is not, then a correlation will nonetheless be observed between the target date and the duration of task B, and this could result in a spurious indication that the target date is sensitive to the duration of B.

The new technique used in Full Monte is based upon the relationship between the task duration and the project finish date (or other specified target milestone date) only when the task is critical, avoiding any errors due to correlation. It is still the case however that the only way to get completely reliable estimates of the sensitivity to a particular task duration, while all other task durations are uncertain, is to do two full risk analyses as described in section 10.4.

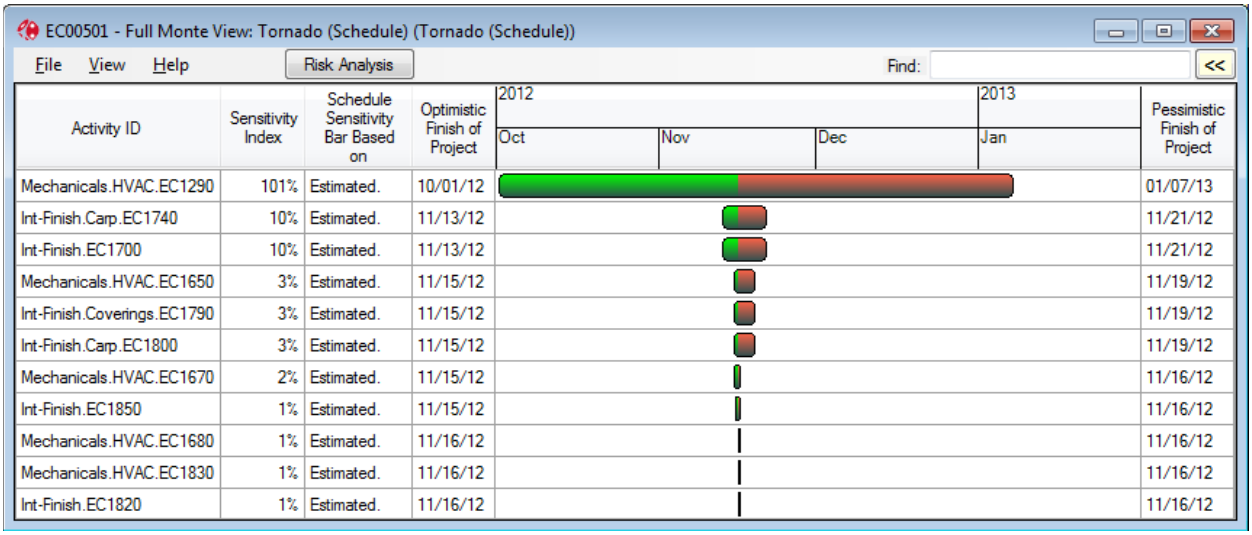
11.3 The Tornado Charts

The split tornado chart is illustrated in figure 10.1. The bars indicate the range of the expected finish date based on possible variation in the duration of each of eight tasks. It was based on 10,000 iterations, so we can be fairly sure that this is a definitive list. (It does not list activities for which the sensitivity is not statistically significant.)

The chart is shown in descending order of the length of the bars, and the other measures of sensitivity are in line. The dates upon which the bars are based are also shown in the columns on either side of the bar chart. The bars are split by color at the expected finish date of the target.

NOTE: The bars are not necessarily symmetrical and will often not be.

Clicking on a bar will do a full sensitivity analysis.



Activity ID	Sensitivity Index	Schedule Sensitivity Bar Based on	Optimistic Finish of Project	Pessimistic Finish of Project
Mechanicals.HVAC.EC1290	101%	Estimated.	10/01/12	01/07/13
Int-Finish.Carp.EC1740	10%	Estimated.	11/13/12	11/21/12
Int-Finish.EC1700	10%	Estimated.	11/13/12	11/21/12
Mechanicals.HVAC.EC1650	3%	Estimated.	11/15/12	11/19/12
Int-Finish.Coverings.EC1790	3%	Estimated.	11/15/12	11/19/12
Int-Finish.Carp.EC1800	3%	Estimated.	11/15/12	11/19/12
Mechanicals.HVAC.EC1670	2%	Estimated.	11/15/12	11/16/12
Int-Finish.EC1850	1%	Estimated.	11/15/12	11/16/12
Mechanicals.HVAC.EC1680	1%	Estimated.	11/16/12	11/16/12
Mechanicals.HVAC.EC1830	1%	Estimated.	11/16/12	11/16/12
Int-Finish.EC1820	1%	Estimated.	11/16/12	11/16/12

Figure 11.1

The cost tornado chart provides similar information for cost.

11.4 Full Sensitivity Analysis

Full sensitivity analysis for a particular task entails doing two risk analysis simulations, one with the duration of the task set to its optimistic value and one with it set to its pessimistic value. In both cases, all other tasks are allowed to vary randomly as defined by their distributions.

It is possible to do this full analysis for all the tasks shown in the view, or for individual tasks.

To do it for an individual task, click on the bar. You will get a dialog similar to the one shown in figure 11.2.

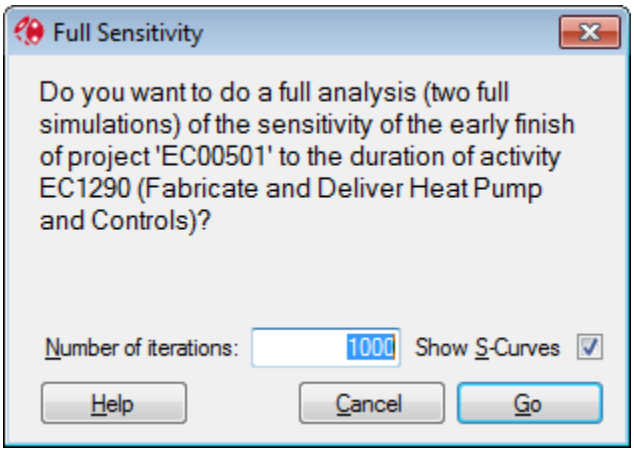


Figure 11.2

Clicking on Go sets off the full analysis which has three results:

1. A view showing the s-curves generated by the two simulations, as shown in figure 10.3, is displayed. (This can be suppressed by unchecking the checkbox in the previous dialog.)
2. The dates and bars on the tornado view are updated to reflect the results of the full analysis.
3. The value of the "Schedule Sensitivity Bar Based on" field is changed to "Full Analysis".

The view shown in figure 10.3 shows a pair of S-curves representing the cumulative frequency function for the project finish on two alternative assumptions: that the duration of activity EC1290 takes its most optimistic value and that it takes its most pessimistic value.

So now we have not just an estimate of the sensitivity of the expected value of the finish date, but of the whole distribution! Furthermore, we can confirm that the sensitivity is about 3 months, and at the 50% point this spans the dates 10/2 TO 1/7 as indicated on the tornado bar at the bottom of the view.

NOTE: The two S-curves are not always closely parallel as they are here. It is possible that a target is considerably more sensitive to a task in one direction than the other.

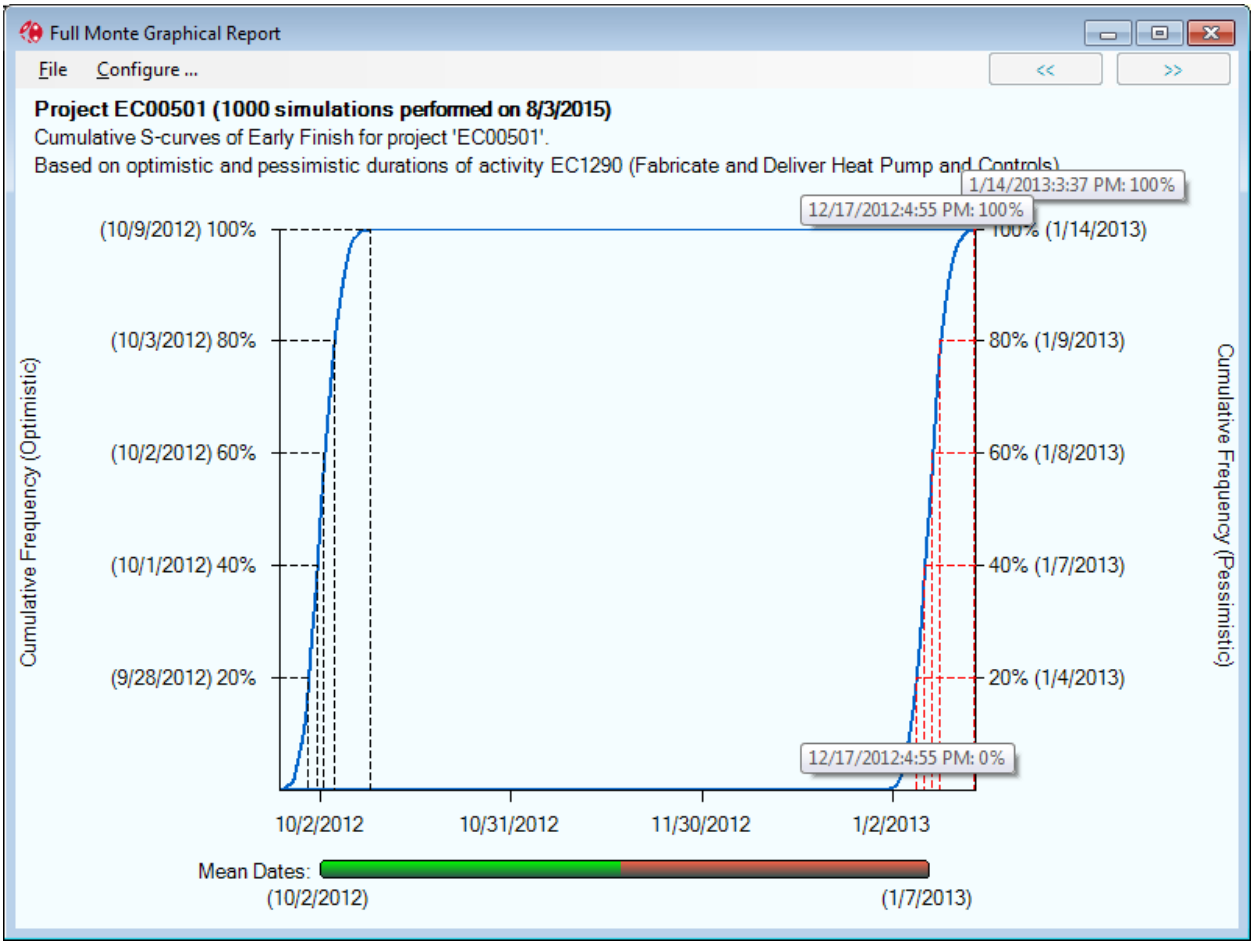
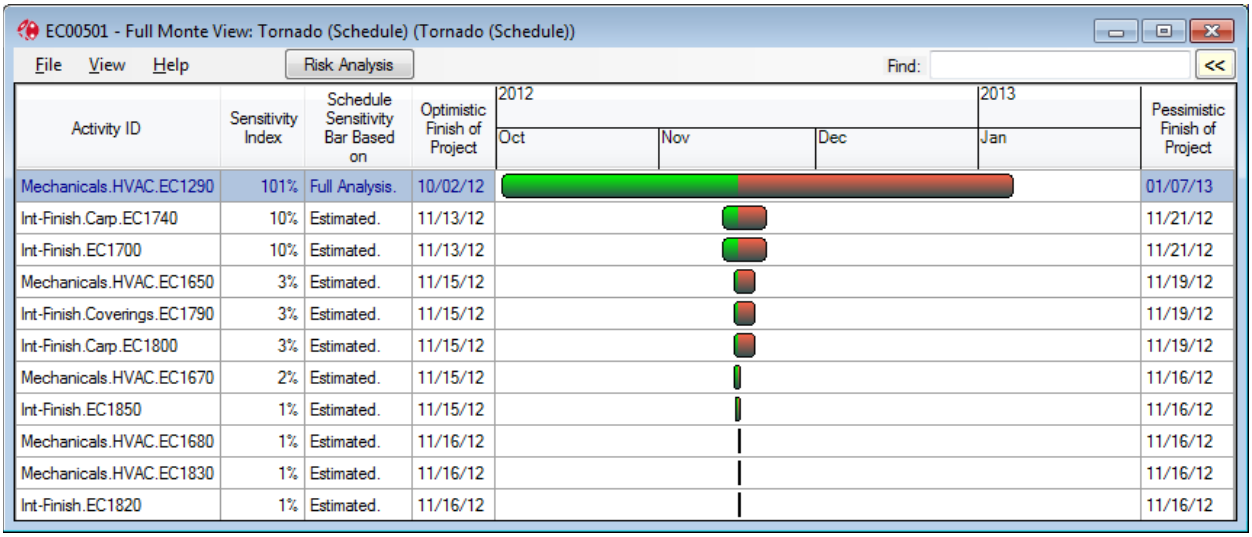


Figure 11.3

When a full sensitivity analysis has been performed for a particular task, this is indicated in the field "Schedule Sensitivity based on" or "Cost Sensitivity based on" as shown for the second task in figure 11.4.



Activity ID	Sensitivity Index	Schedule Sensitivity Bar Based on	Optimistic Finish of Project	Pessimistic Finish of Project
Mechanicals.HVAC.EC1290	101%	Full Analysis.	10/02/12	01/07/13
Int-Finish.Carp.EC1740	10%	Estimated.	11/13/12	11/21/12
Int-Finish.EC1700	10%	Estimated.	11/13/12	11/21/12
Mechanicals.HVAC.EC1650	3%	Estimated.	11/15/12	11/19/12
Int-Finish.Coverings.EC1790	3%	Estimated.	11/15/12	11/19/12
Int-Finish.Carp.EC1800	3%	Estimated.	11/15/12	11/19/12
Mechanicals.HVAC.EC1670	2%	Estimated.	11/15/12	11/16/12
Int-Finish.EC1850	1%	Estimated.	11/15/12	11/16/12
Mechanicals.HVAC.EC1680	1%	Estimated.	11/16/12	11/16/12
Mechanicals.HVAC.EC1830	1%	Estimated.	11/16/12	11/16/12
Int-Finish.EC1820	1%	Estimated.	11/16/12	11/16/12

Figure 11.4

To perform a full analysis on all the tasks shown, right mouse on the bar column header and select "Do Full Analysis for All Bars." This invokes a dialog as shown in figure 11.5. This is similar to the previous dialog but note that by default the checkbox is now unchecked.

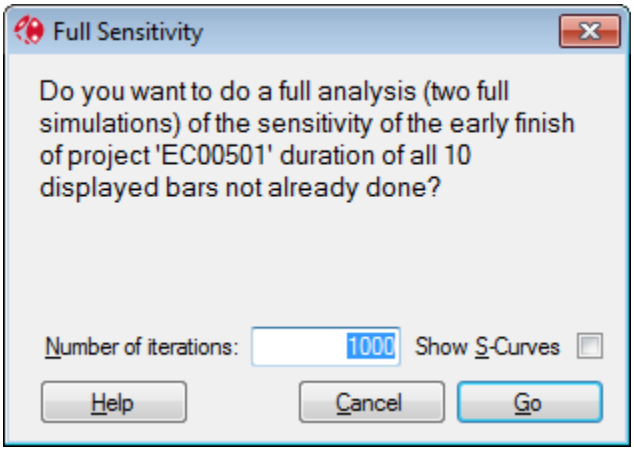


Figure 11.5

NOTE: As noted above, cost sensitivity is generally simpler than schedule sensitivity. Nevertheless, Full Monte supports the same functionality for costs to get a totally reliable estimate from a full analysis. This will differ from the initial estimate only if branching or escalation are involved.

11.5 Tornado Bar Column Title Configuration

Right-Click on the bar column heading date scale and various options are displayed as shown in figure 11.6 and described in more detail in section 14.3.

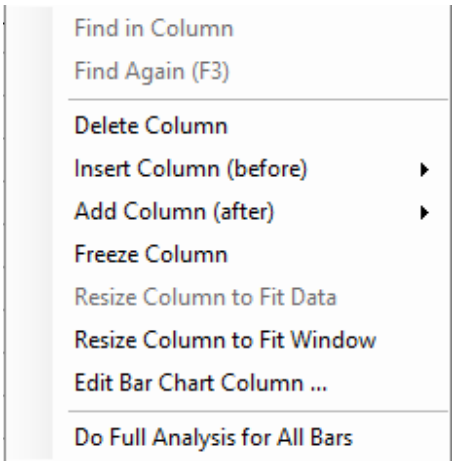


Figure 11.6

Select the option 'Edit bar Chart Column…' and the dialog shown in figure 11.7 is displayed.

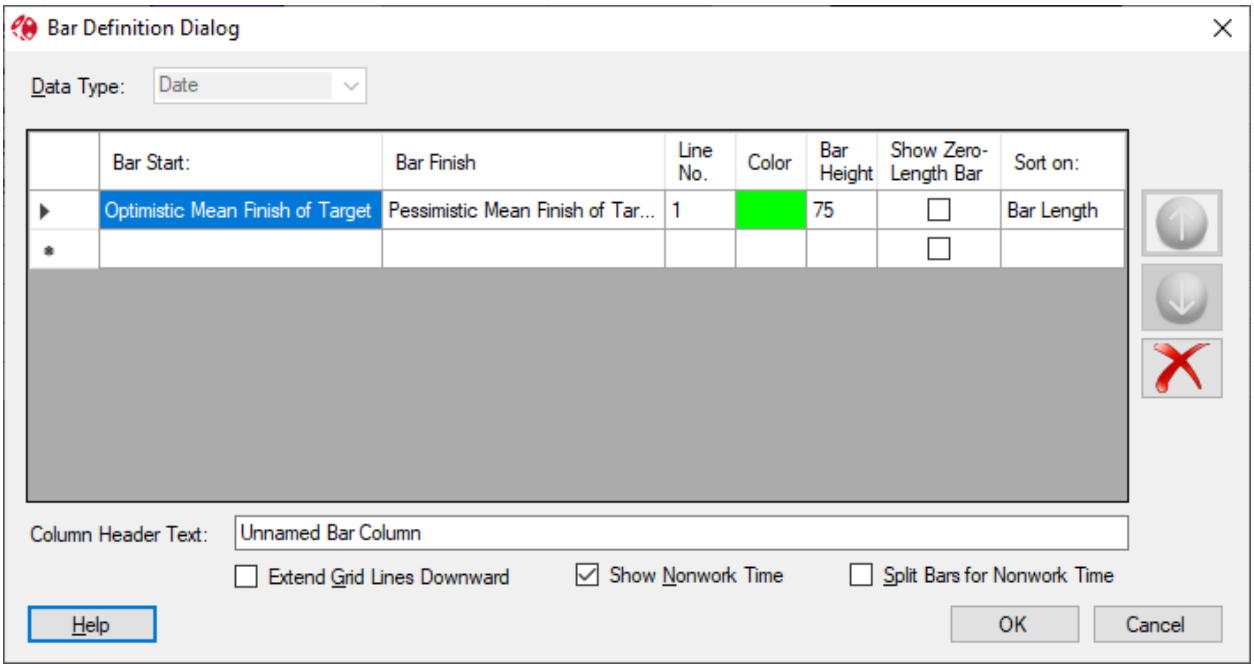


Figure 11.7

The Column Header Text will contain 'Unnamed Bar Column' if the title for the bar column is currently undefined. The bar column heading will not have any header text as shown in figure 11.8.

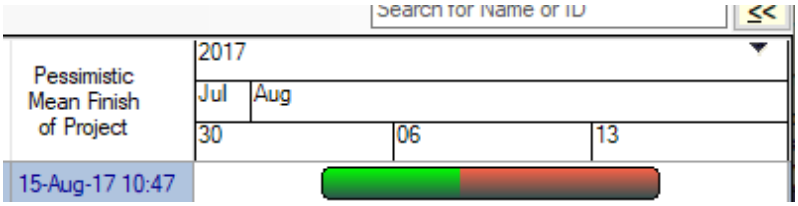


Figure 11.8

Enter 'Default' in the column header text as shown in figure 11.9.

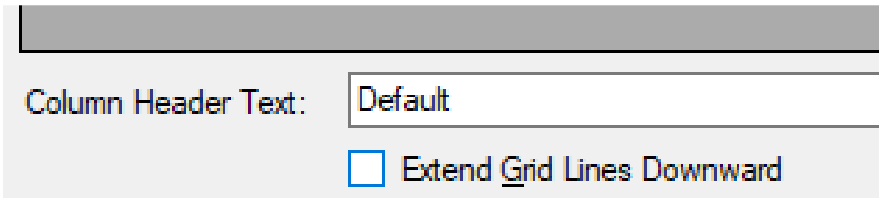


Figure 11.9

The split bar column will now have an automatic header that includes the Sensitivity Target task and the mean finish date for that task. This is the split point between the bars in the view.

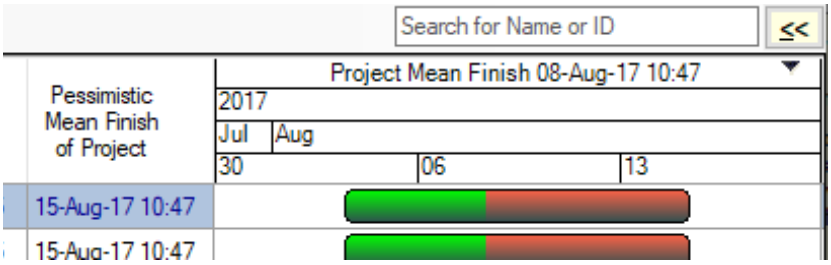


Figure 11.10

Chapter 12: The Joint Confidence Level View

The joint confidence level (JCL) view is a scatter diagram showing the combined distribution of the early finish date and the cost of the project or any activity or WBS (work breakdown structure) element. It can be accessed by adding a column to the grid in the Project or Activity views or from a button on the docked panel in the Project view. The view looks like figure 12.1.

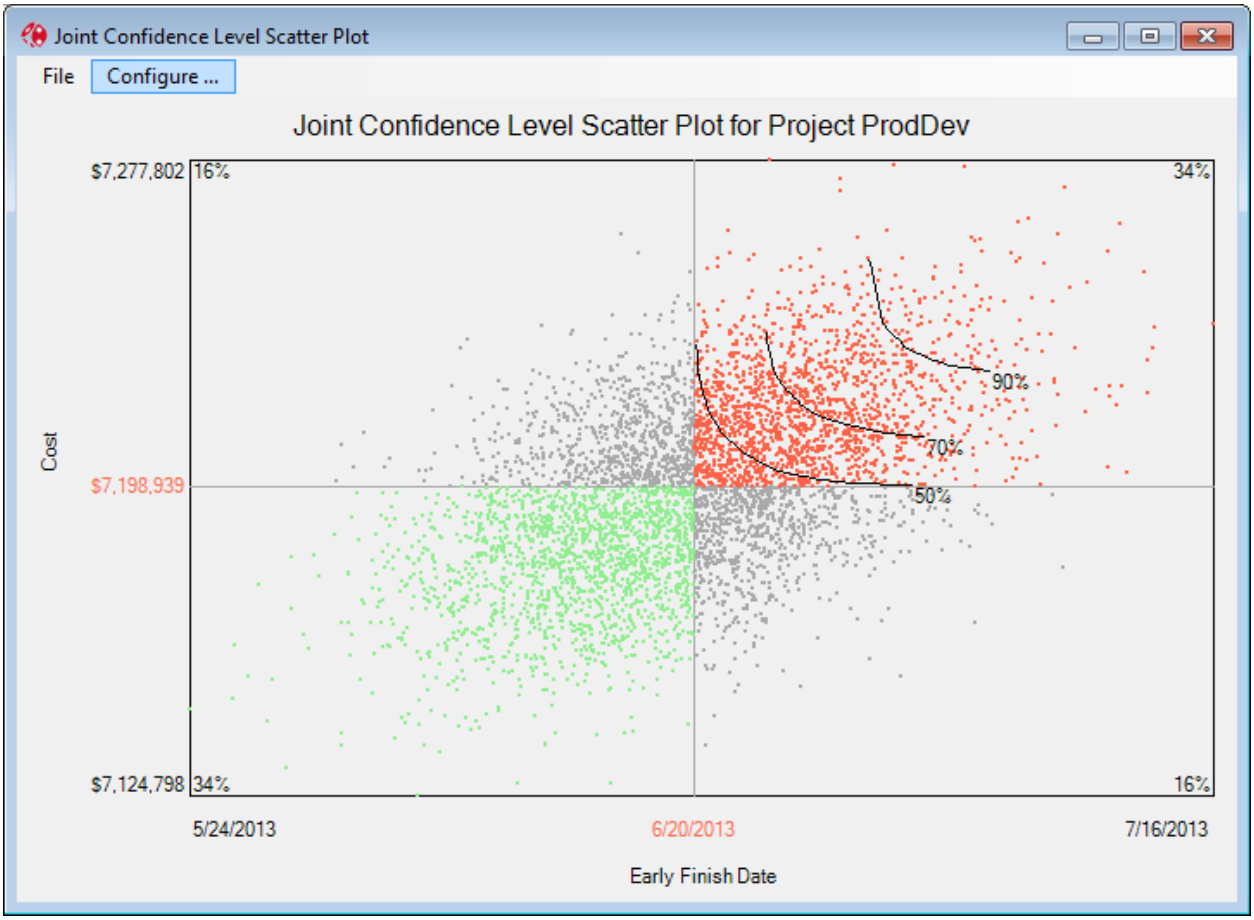


Figure 12.1

Note that unlike other views, the data for this is not stored but is generated by doing a risk analysis when required. For this reason, it takes some time to appear, especially for large projects and/or when the project is not open. (The number of iterations performed is fixed at 5,000.) Because of this, you will first see a dialog containing a progress bar and a Cancel button, as shown in figure 12.2.

NOTE: On very large projects that are not yet open, it may take 10 or 20 seconds for the progress bar to appear. If you intend to open the project anyway, it is best to open it first and then access this view from the grid.

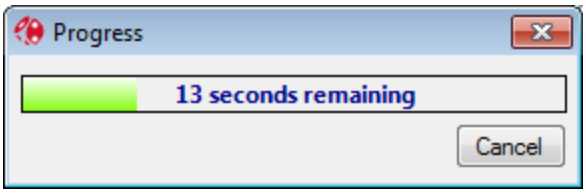


Figure 12.2

If you proceed, you will see that the view is divided into four quadrants based on a target date and a target cost. When the view first appears, these are both set to the 50th percentile, as in the example. The green quadrant is where both cost and schedule are better than the target, while the red quadrant is where they are both worse. The percentages in the corners give the percentage of observations in each quadrant. (Because the view is initially centered on the 50th percentile, the percentages in opposite quadrants are always equal. The more they differ from 25%, the more correlated the cost and schedule.)

The view also shows three lines indicating points that have the same joint confidence level of 50%, 70%, and 90%, respectively. (For example, any point on the 70% line has 70% of the points below and to the left of it.)

The **Configure** menu item brings up the dialog shown in figure 12.3.

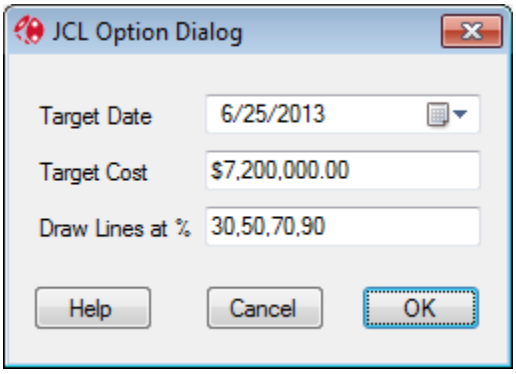


Figure 12.3

Here you can enter the real project targets, as well as a list of the constant JCL lines you want shown.

NOTE: Both targets must be within the ranges shown in the original plot.

This results in the report shown in figure 12.4. Note that there is roughly a 50% chance of meeting or beating both the target date of 6/25 and the target cost of $7.2 million. (Note that there are many combinations of date and cost target for which this is true, indicated by the 50% line.)

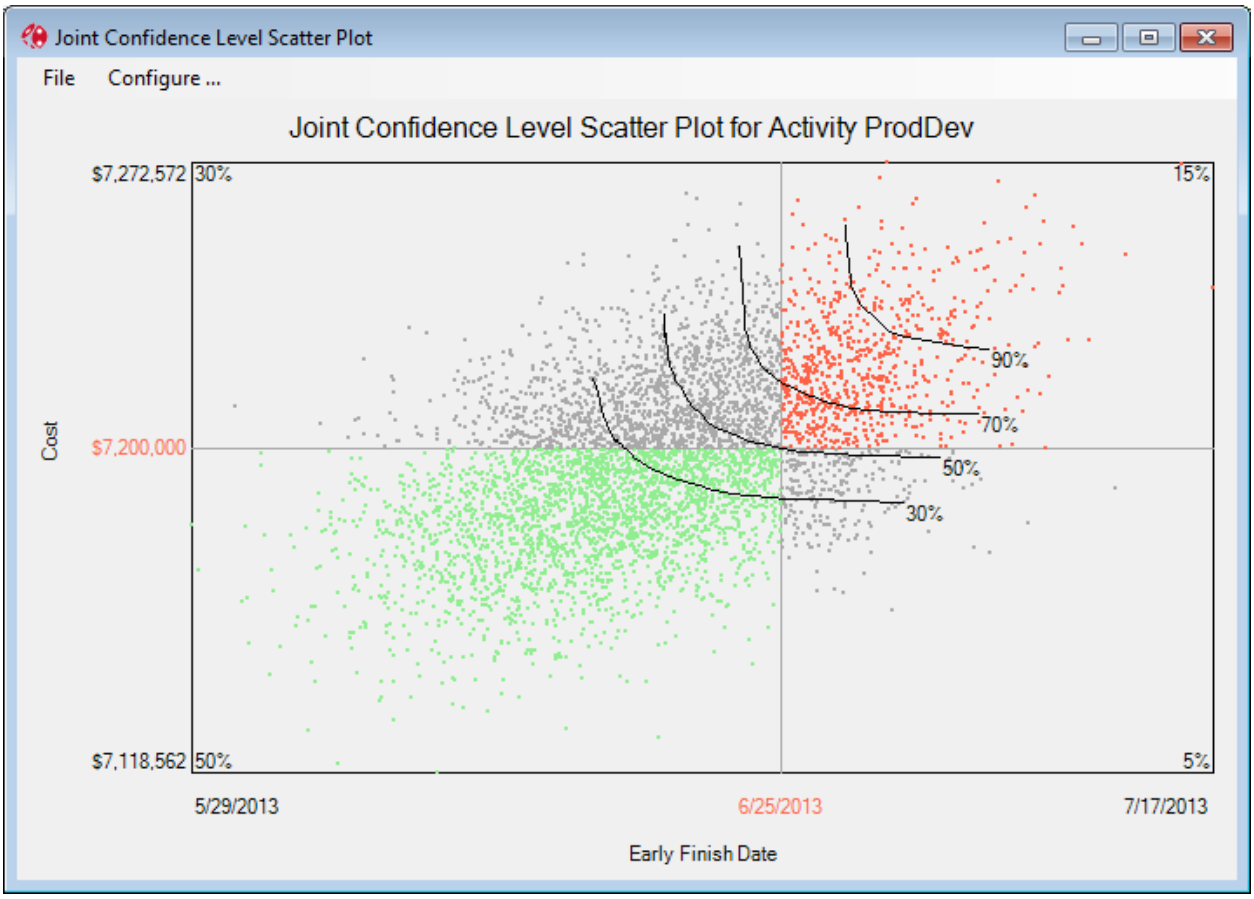
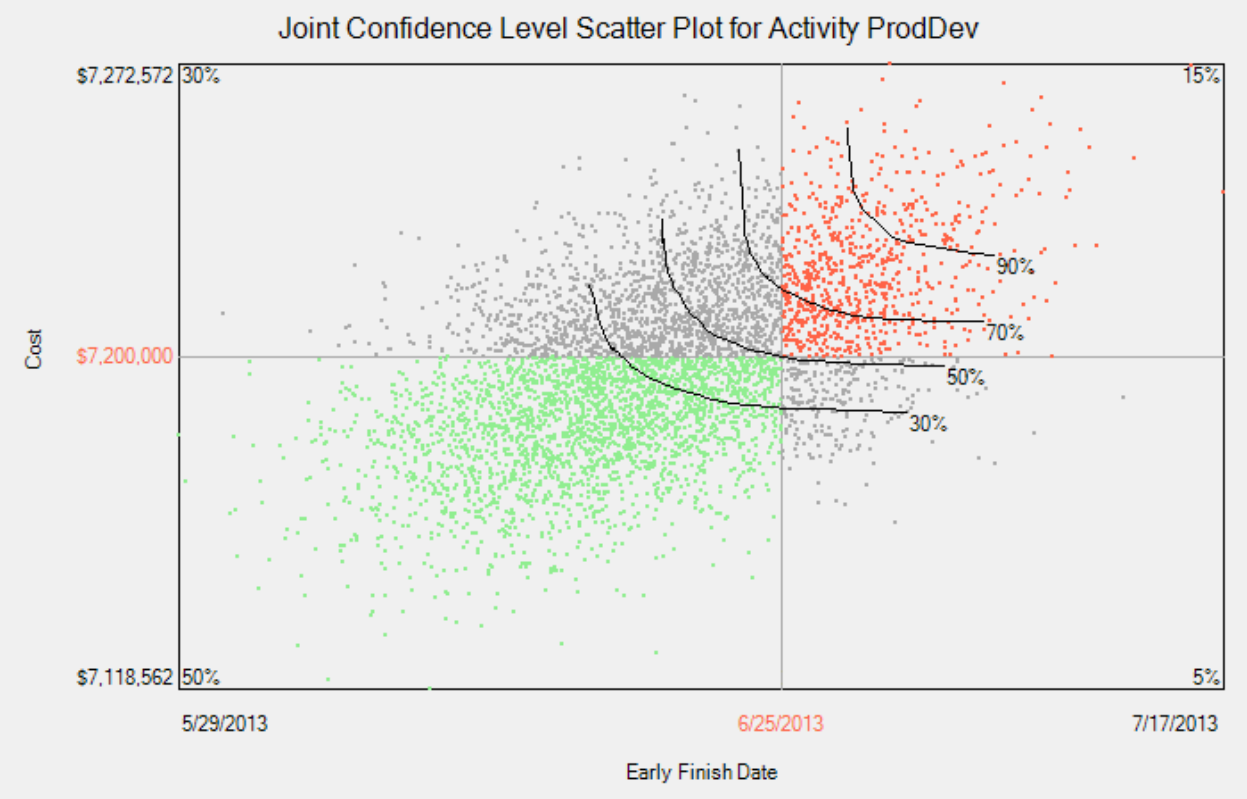


Figure 12.4.

The view can be printed or copied to the clipboard. The latter strips off the window border, as shown in figure 12.5. (If you want the border, use Alt-PrtScrn.)


Joint Confidence Level Scatter Plot for Activity ProdDev
$7,272,572
30%
15%
90%
70%
50%
30%
Cost
$7,200,000
$7,118,562
50%
5%
5/29/2013
6/25/2013
7/17/2013
Early Finish Date
Figure 12.5

Chapter 13: The History (Actual/Expected) View

The purpose of this view is to see how good your estimates have been in the past, so it is not very useful until you have built up some history of completed projects. (You do not have to have performed risk analysis on these projects though.) It can be done at any level in the WBS (work breakdown structure), which contains at least two completed activities and plots the distribution of ratio of actual to expected duration.

This data is accessed through the **History** view as illustrated in figure 13.1

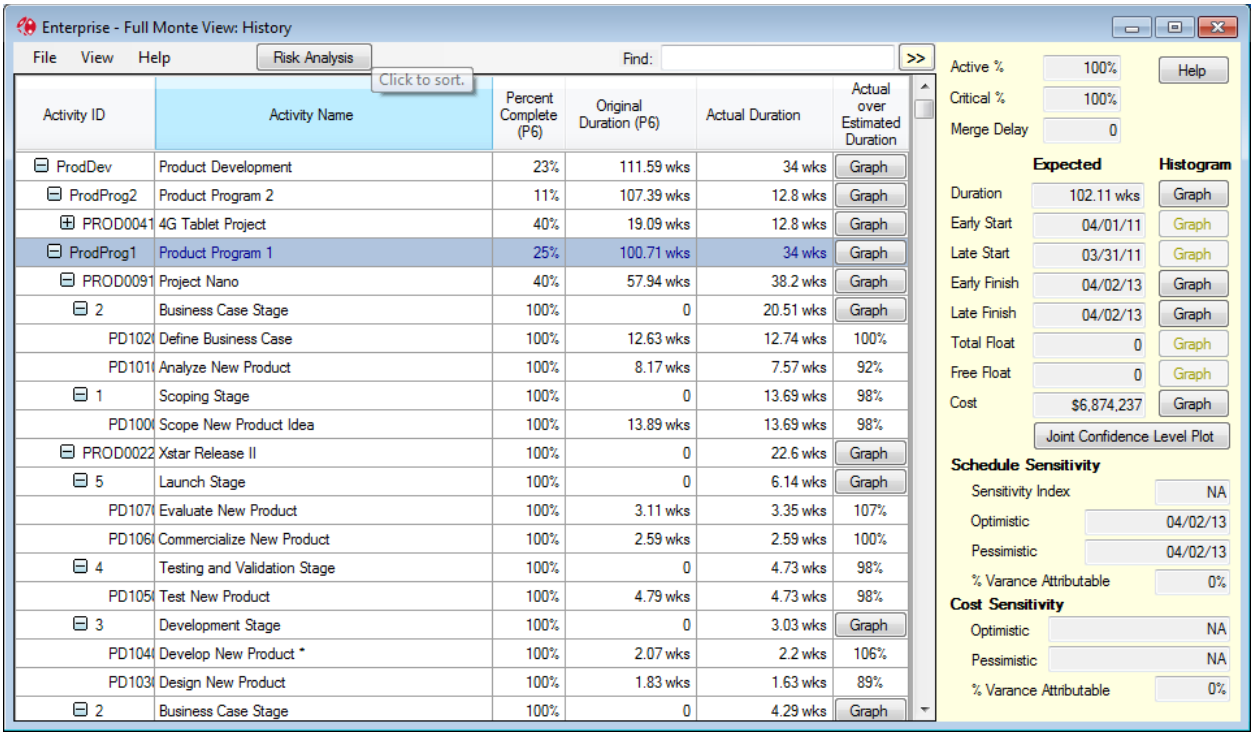


Figure 13.1

Clicking the **Graph** button on the top line produces the graph in figure 13.2. It shows the proportion of activities throughout the entire organization/project/WBS element that completed on the ratio shown on the X axis. This example is somewhat compromised by a single outlier, which took 250 times as long as planned, but still you can see a familiar pattern. A little over 20% took between 50 and 100 percent, and a little over 60% took between 100 and 150 percent of the expected value.

If you want to delve deeper, you can of course go down a level or two, though this reduces the sample size. In figure 12.3, we have drilled down to one area of the organization, and you can see that while the individual estimates vary widely, the overall average is remarkably good, at 104%.

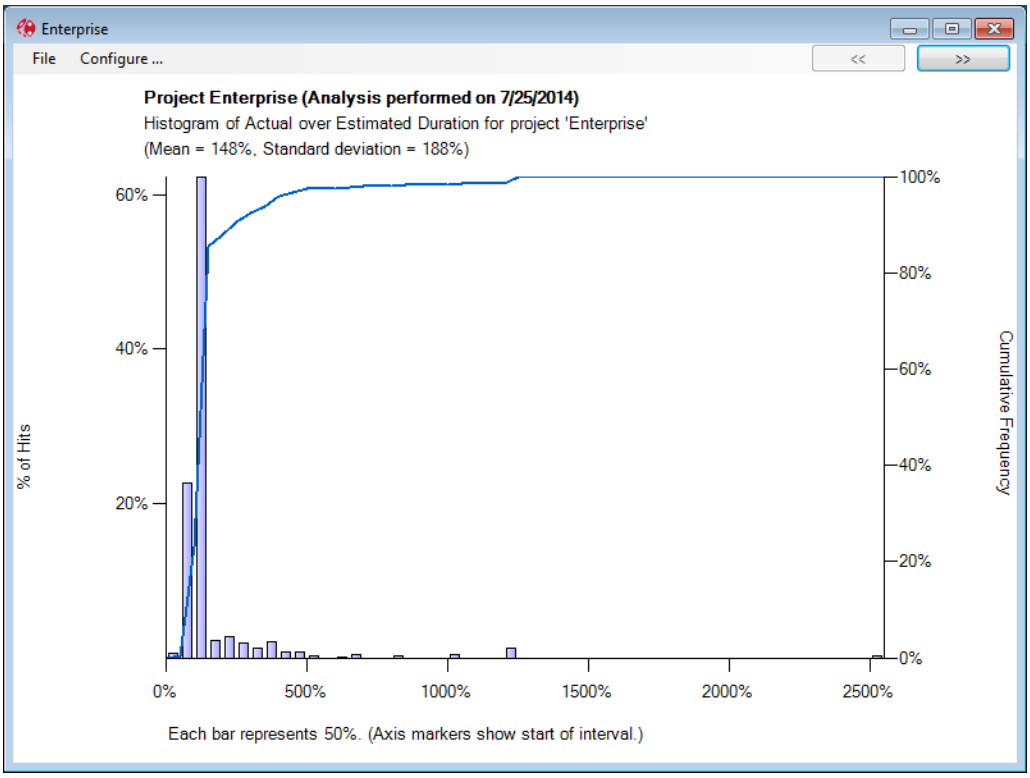


Figure 13.2

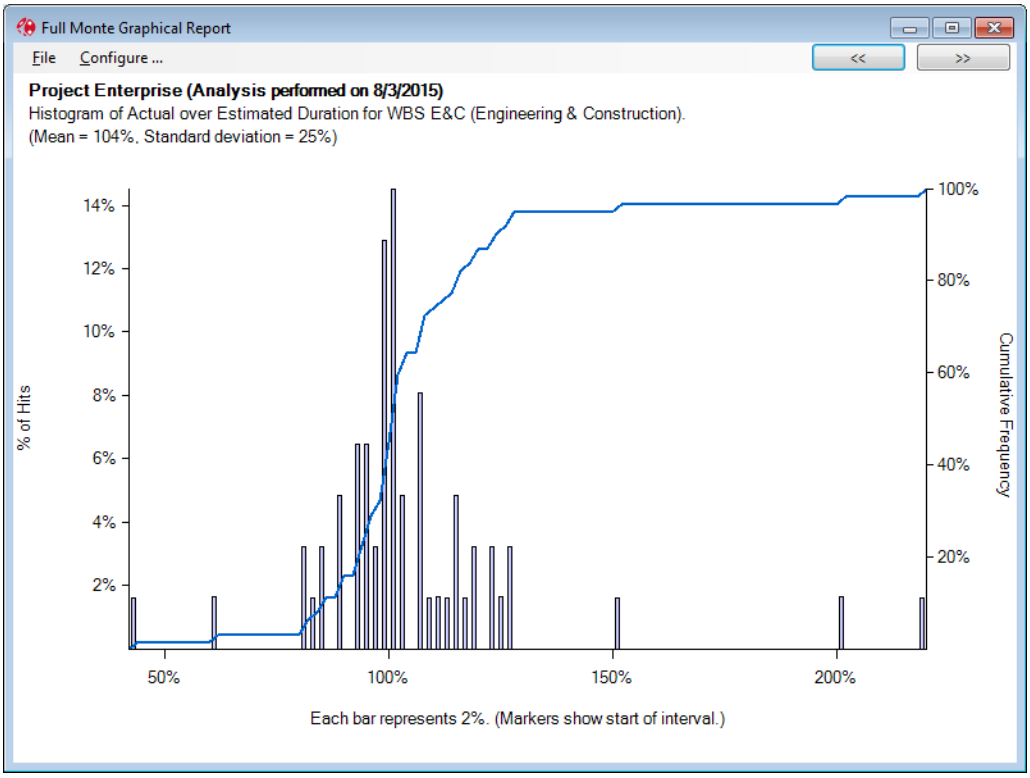


Figure 13.3

Going back to the History report, we can also drill down in another way. Suppose we want to find that 2500% outlier. You will notice in figure 13.1 that in the graph column in some rows there is a percentage instead of a button. This is true for all individual activities and for any WBS (work breakdown structure) that contains only one completed activity. Using the right-click menu on the column header, select **Find in Column** and type 2500. The result is shown in figure 13.4, from which we can see that the culprit is activity A1470. It was a very short activity, so it may be of little consequence.

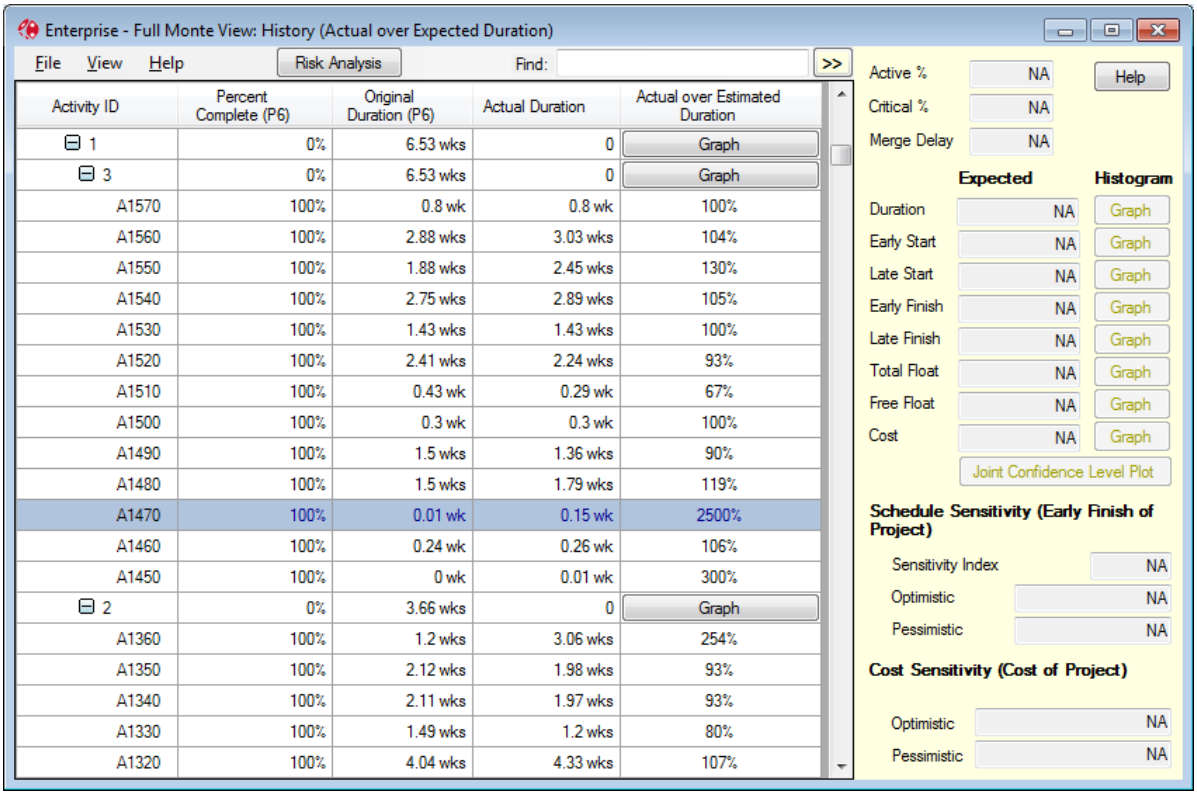


Figure 13.4

We were a little lucky there; we read off the value 2500% from the graph and searched for it, but it might not have been *exactly* 2500%. An alternative would be to switch the hierarchy off and sort on the graph column in descending order. All the graph buttons get sorted first and then the individual values in descending order as shown in figure 13.5.

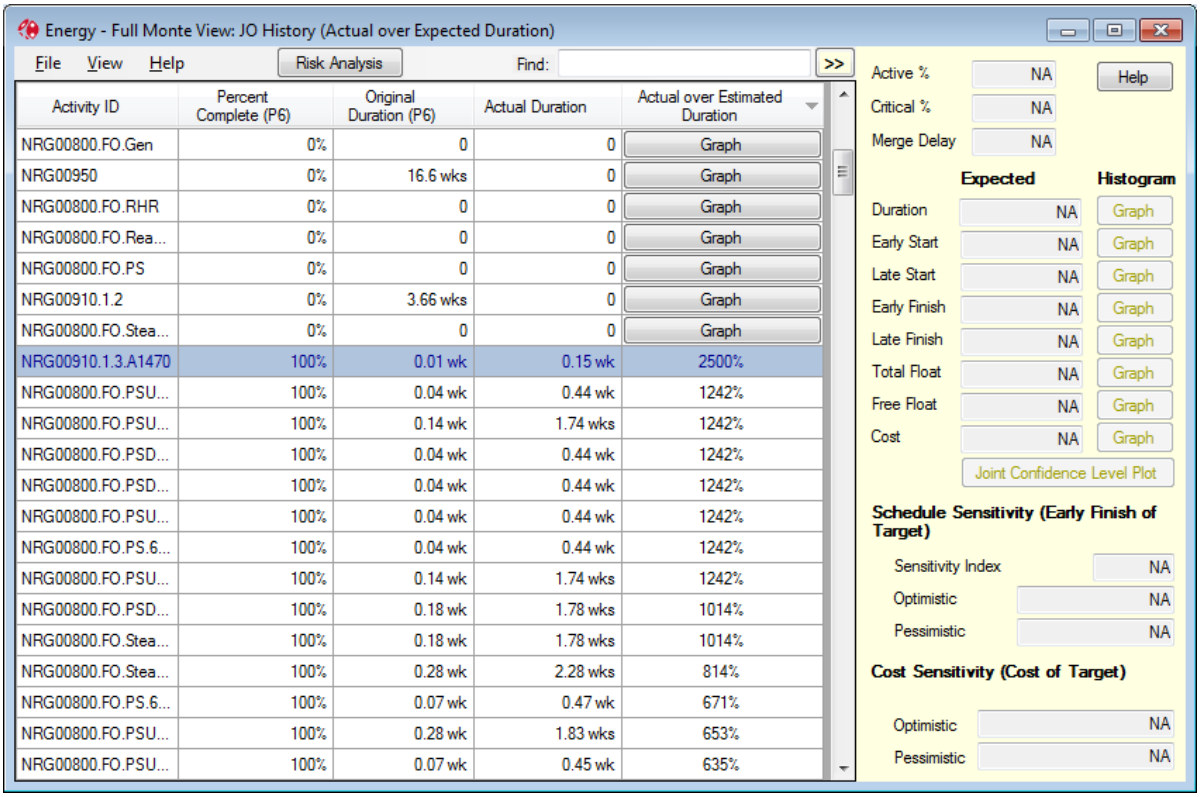


Figure 13.5

There are three common reasons for unusually high ratios (those large percentages) in the historical data.

- Data entry errors (entering the wrong actual dates).
- Short duration tasks. If a 1 days task takes 2 days that's a 200% overrun however it should probably not be counted as particularly significant.
- Risks (threats) that were not previously identified occurring during the execution of the activity causing it to take much longer than expected. Such risks should have been properly identified before execution and modelled using techniques like probabilistic branching.

Chapter 14: Customizing Views

14.1 Customization Options

The **View** menu allows you to:

1. Open a new named view
2. Save or Save As the current named view
3. Reset current view to its default settings (for unnamed views only)
4. Toggle whether to observe the hierarchy
5. Expand all nodes (disabled when hierarchy not shown)
6. Collapse all nodes (disabled when hierarchy not shown)
7. Apply existing or create new Filters
8. Apply Highlighting based on a Filter
9. Manage Sorting.
10. Select format used to display dates
11. Set the default duration unit
12. Resize all columns to fit the displayed data.

Right-click on a column header to:

1. Find a value in the column
2. Delete the column
3. Add a column before or after the column
4. Freeze the column (so it and all columns to its left stay put when you scroll)
5. Unfreeze the column (so it and all columns to its right scroll)
6. Resize the column to fit the largest item of data
7. Widen the column if necessary to make the total width of the grid fill the space
8. Edit the bar-chart definition (for bar-chart columns only)

Other customizations include:

1. Resizing columns by dragging or double-clicking the right edge of the header cell
2. Moving columns by dragging the header cell
3. Sorting on a column by clicking on the header cell (first time on a column ascending, second time descending) and using Ctrl+Click to add further columns to an existing sort.
4. Show or hide the information panel by clicking on the chevron button (<< or >>)

14.2 Adding Columns to the View

To add a column, right mouse on the column heading before or after where you want the new column to appear and select “Insert Column” or “Add Column”.

NOTE: If you get the position wrong, you can easily move it later.

Available fields are organized by topic in a cascading menu. In the example shown in figure 14.1 it is expanded down to a set of percentiles available for the duration.

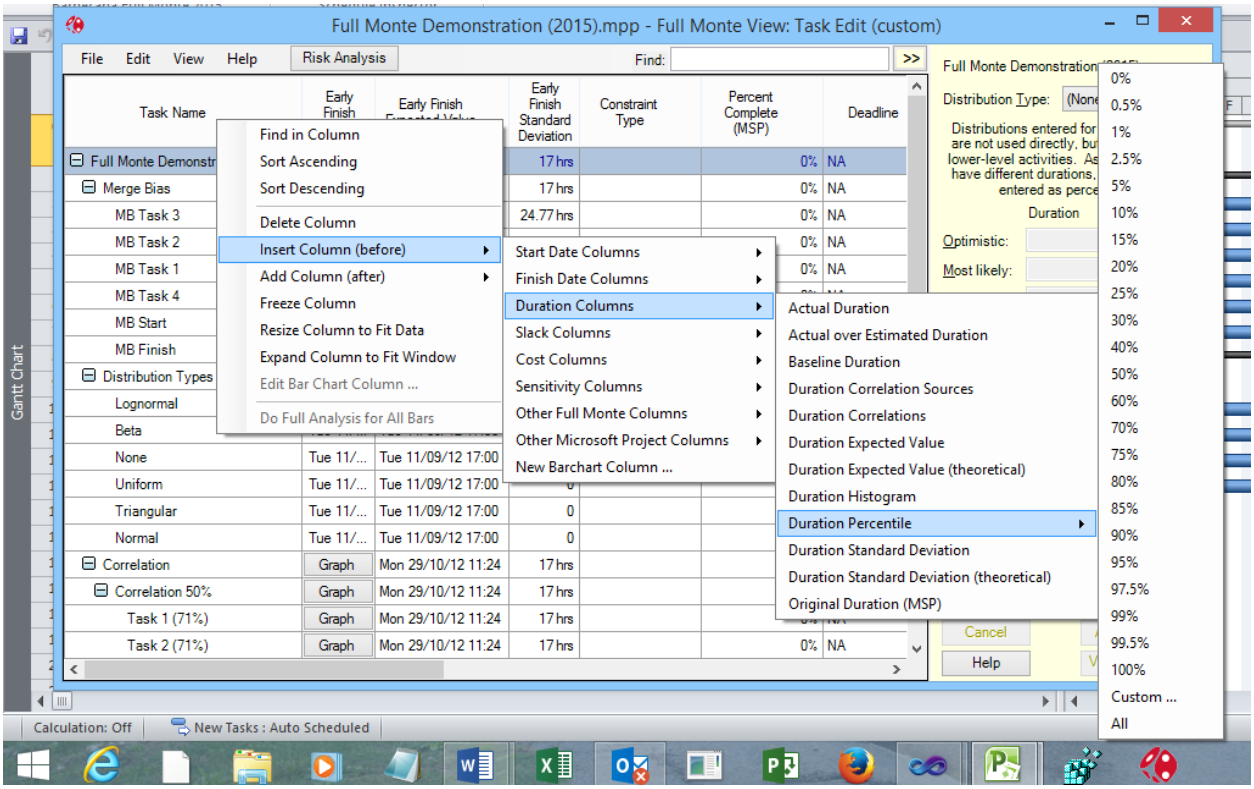


Figure 14.1

14.3 Creating and Editing Bar-chart Columns

In Full Monte, a bar chart is just a special kind of column, so you can have any number of them in one view.

To add a bar-chart column, right-click on a column header. Select **Add** or **Insert**, then **Bar Chart Column**. You will see the Bar Definition Dialog, as shown in figure 14.1.

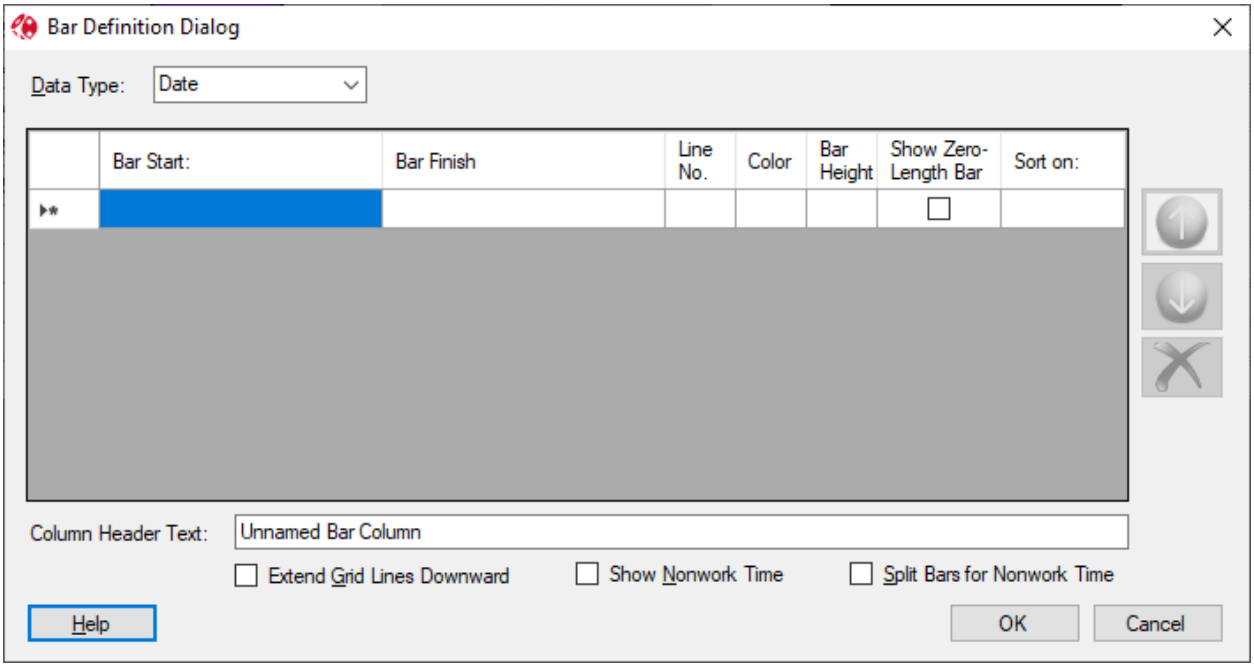


Figure 14.1

The drop-down menu at the top of the dialog allows you to select the type of data to display. This must be date, duration, or cost/numeric. Since you cannot mix these types, once you have defined a bar this control is disabled.

In the grid, you can define any number of bars and/or milestone symbols. Bars extend from Bar Start to Bar Finish. For a milestone symbol, leave out one of the values. For example, for a finish milestone, leave out the Bar Start or select "(None)." For a start milestone, leave out the Bar Finish. Select fields by selecting from the drop-down list that appears when you click on the cell or by right-clicking on the cell. For cost/numeric bars, there is an additional option for the Bar Start or Finish to be zero, enabling you to display bars with lengths that represent the value of a particular cost or numeric field.

Enter a line for each bar or symbol you want to define. The grid will scroll if necessary. Figure 14.2 shows a completed Bar Definition Dialog. Here is an explanation of the data:

Bar Start: The variable representing the start of the bar. Note that on the third row, this is set to "(None)," making it a finish milestone symbol.

Bar Finish: The variable representing the start of the bar. Note that on the second row, this is set to "(None)," making it a start milestone symbol.

Line Number: The line number allows you to separate bars and symbols vertically.

NOTE: Bars are displayed in the order in which they are defined. Unless you know that they won't overlap, you probably want to either separate them vertically or make the latter bar thinner. You can alter the display order using the up and down arrow buttons to the right of the grid.

Lines are numbered from top to bottom within the cell, and the numbers do not have to be consecutive (Full Monte closes up any gaps). If you don't enter a line number, it will be taken as 1.

NOTE: A bar or symbol will not appear if the dates are not populated. For example, if you want to draw a bar from actual start to early start to show progress, it will appear only if the activity has been progressed.

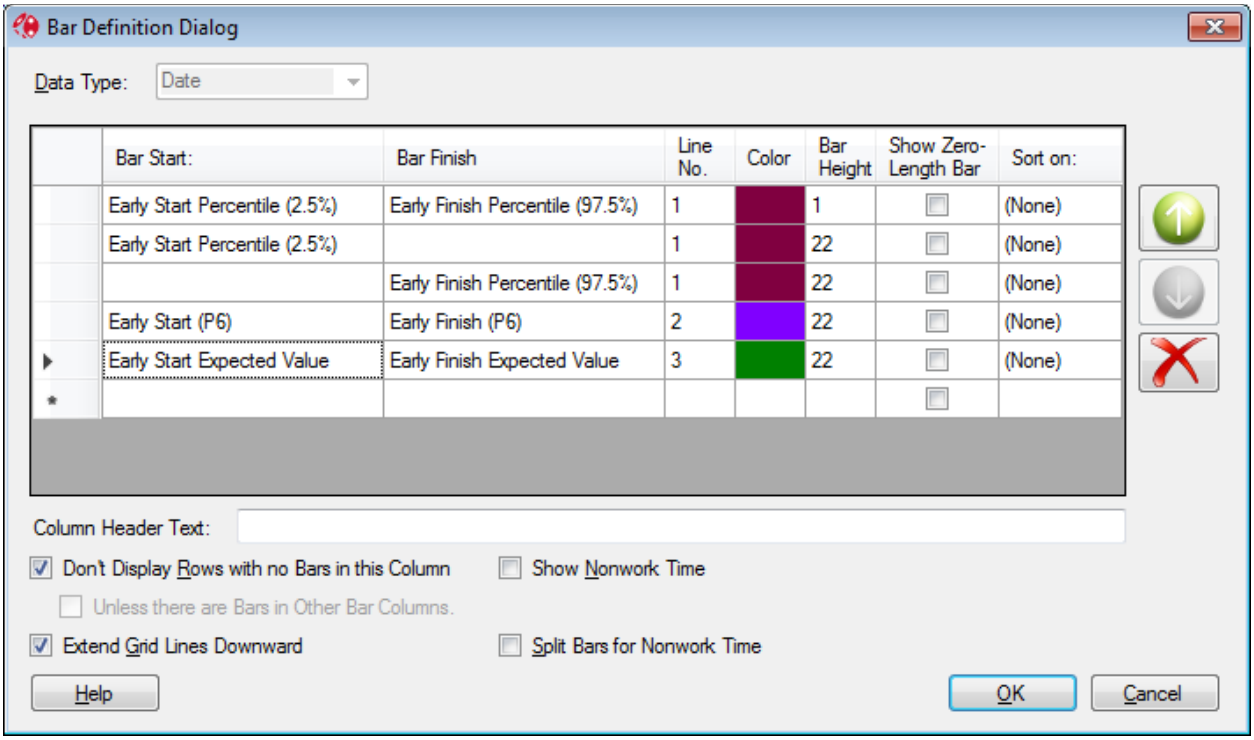


Figure 14.2

Color: Clicking on the next cell invokes a color choice dialog where you choose the color of the bar or symbol.

Bar Height: It is very important to enter the bar height, because a zero-height bar will simply not display. The bar height is expressed as a percentage of the total cell height. The heights are scaled if necessary, so that their total does not exceed 90%.

NOTE: A bar height of 1, as on the first row in the example, will produce a thin line. If you want to temporarily suppress a bar without losing its definition, set its bar height at 0.

Full Monte applies a height to each line based on the bar or symbol with the greatest height in that line, and then it applies the rule to the line heights. This avoids double counting bars and symbols on the same line.

Show Zero-Length Bars: This check box specifies whether to print a symbol when the start and finish of the bar are identical so that the bar would otherwise not display. (It has no effect if one end of tte bar s "(None)" and it does not display if the end of the bar is to the left of the start of the bar.)

Sort Order: The final column in the grid controls the sort order.

NOTE: It does not actually sort the report; it defines what will happen when you sort on this particular column by clicking on its header.

Click on the cell and select the sort order from the drop-down menu at the top of the screen or by right-

clicking on the cell. You can sort on only one bar or symbol, so when you select one the others will revert to (None). For *bars*, you can choose to sort on either end or on the length of the bar. For *symbols,* you can sort only on the value that it is based on.

There is also a text box and there are also five checkboxes controlling the display of the bar-chart column as a whole:

Column Header Text allows you to annotate the column.

Don't Display Rows with no Bars will suppress any rows for which there are no bars. The main reason for there to be no bars is that the dates at both ends of the bar are the same for this particular activity. For example, in the tornado report the bars appear only for activities that can affect the project finish date, which is often a very small subset.

NOTE: If there is more than one bar-chart column, checking the checkbox **Unless there are Bars in Other Bar Columns** on all of them will not suppress the row unless there are no bars in any column.

Extend Grid Lines Downward extends the lines from the lowest level of the date grid in the header row downward over the data rows.

Show Nonwork Time causes nonwork time to be displayed as a gray stripe underneath the bars. It displays these only to the granularity of the lowest-level grid markings, so weekends will not show up unless the grid is marked in days or less.

NOTE: This and the following checkbox are disabled if the data type is not Date.

Split Bars for Nonwork Time causes nonwork time to be indicated by a break in the bars. This break will be either white or gray depending on the setting of the previous option. It splits the bars only to the granularity of the lowest-level grid markings, so weekends will not show up unless the grid is marked in days or less.

When you are done, click on **OK**. A column will appear before or after the place you right-clicked, looking similar to the bar chart shown in figure 14.3. In this example, the **Extend Grid Lines Downward** checkbox was checked.

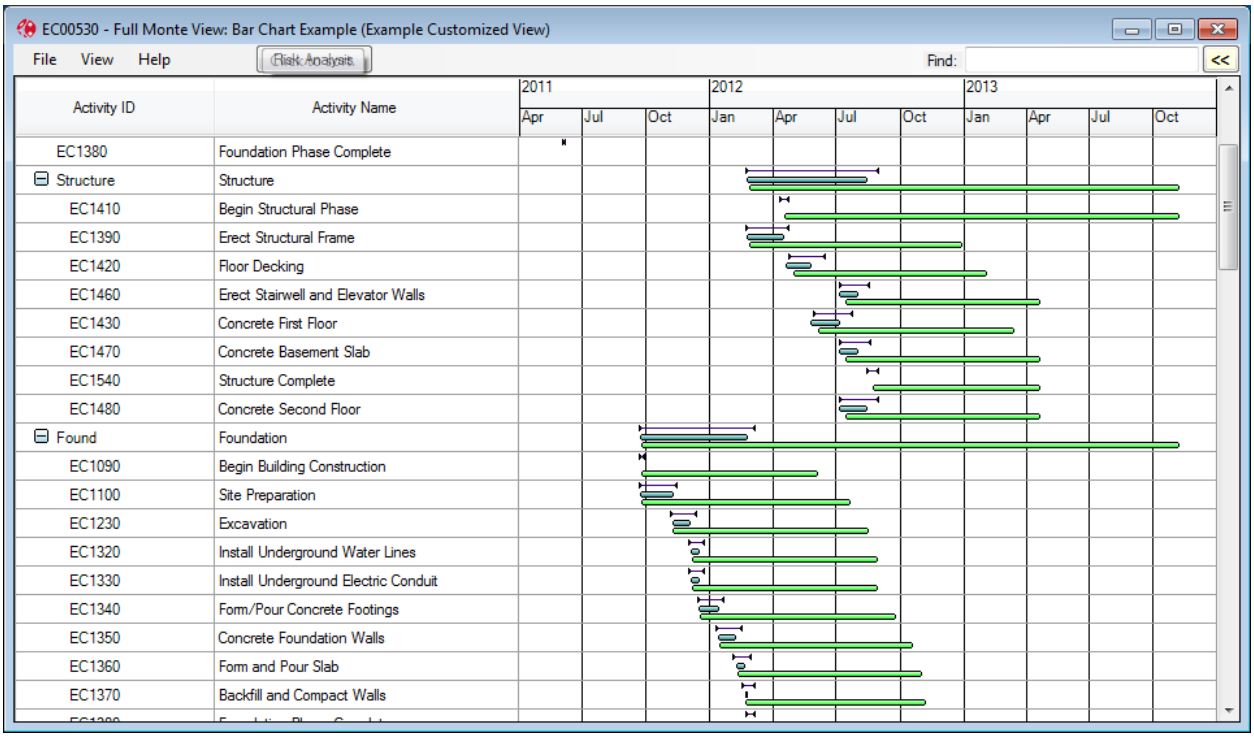


Figure 14.3

NOTE: Right-clicking on the bar-chart header and selecting **Edit Bar Chart Column** will bring up the dialog shown in 14.2 again so you can make changes.

14.4 Saving Your Customizations

For standard named views (those that appear above the line on the **Open Named View** drop-down menus, you can save your changes to a new view name, using **View/Save View Specification As**.

For nonstandard named views you can do as above, or you can overwrite the original using **View/Save View Specification.**

NOTE: With either type of named view, if you make changes during a session, you will be prompted as to whether you want to save them when you close the view.

For unnamed views (that is the Project View and the three views used to edit activities, resources, and calendars), any changes are automatically saved on a per-user basis and used the next time you access that view. (As noted above, there is an option to revert to the original default.)

Chapter 15: Managing Percentiles, Templates, and Views

Percentiles, Templates, and Views are stored in the database [P6] or on the local disc [Microsoft Project], and Full Monte provides simple dialogs to manage them.

Management dialogs are accessed from the **Edit** menu.

15.1 Managing Percentiles

Selecting **Edit**/**Manage Percentiles** allows you to manage the list of percentile values offered to you when you add a percentile column to a view, using the dialog shown in figure 15.1.

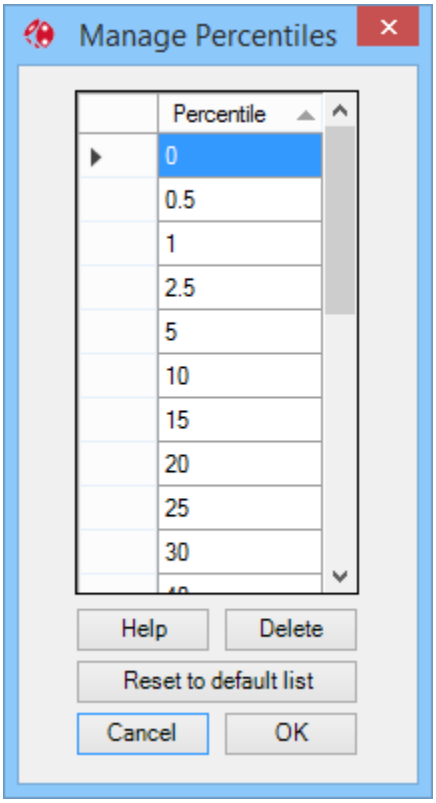


Figure 15.1

You can:

- edit the values in the Percentile column;
- delete values by selecting the row (clicking on the left hand cell) and clicking the **Delete** button or pressing the **Delete** key; or
- add values by scrolling to the bottom and typing into the empty Percentile cell.

The list starts out sorted, but the sort order is not maintained when you make changes. You can re-sort it by clicking on the column header.

> *NOTE: The dialog does not prevent you from temporarily creating duplicate values, but these will be removed when you click* **OK**.

There is also a button to revert to the system default as supplied by Barbecana when installed.

When you are done, click OK. Full Monte will sort the values, remove duplicates and update the list.

> *NOTE: These are personal preferences. They are stored on the local machine in the MSP version and by user in the P6 version.*

15.2 Managing Templates

The **Manage Templates** dialog is shown in figure 15.2. This allows you to add, modify, and delete templates. You cannot delete the template called "Default," but you can redefine it.

NOTE: Full Monte remembers each user's active template between sessions. Since the P6 version templates are global, it is possible that one user's active template can get deleted by another user. If this happens, Full Monte defaults to the one called "Default."

To modify an existing template, select it from the drop-down menu and change the data as required. Click **Save** to save the changes or **Cancel** to cancel them.

The actual data that you can specify are the distribution type and parameters and correlations. These work as discussed in Chapter 4. (For obvious reasons, you cannot create template data for branching.)

To add a new template, click on **New** (which gives you a copy of the currently selected template), give it a name, and change the data as required. Click on **Save** to save the changes or **Cancel** to cancel them.

To delete a template, select it from the drop-down menu and click on **Delete**.

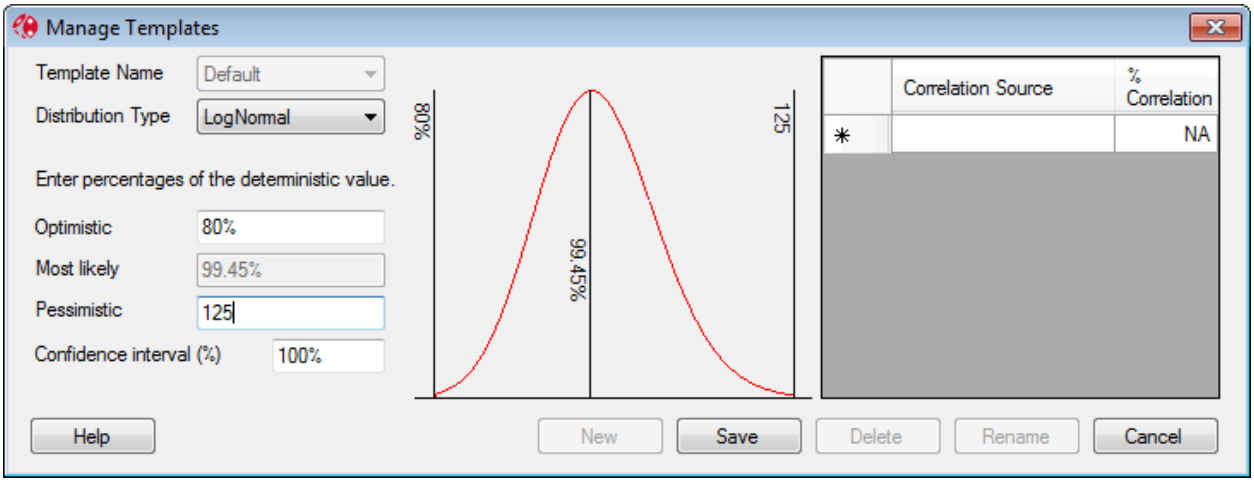
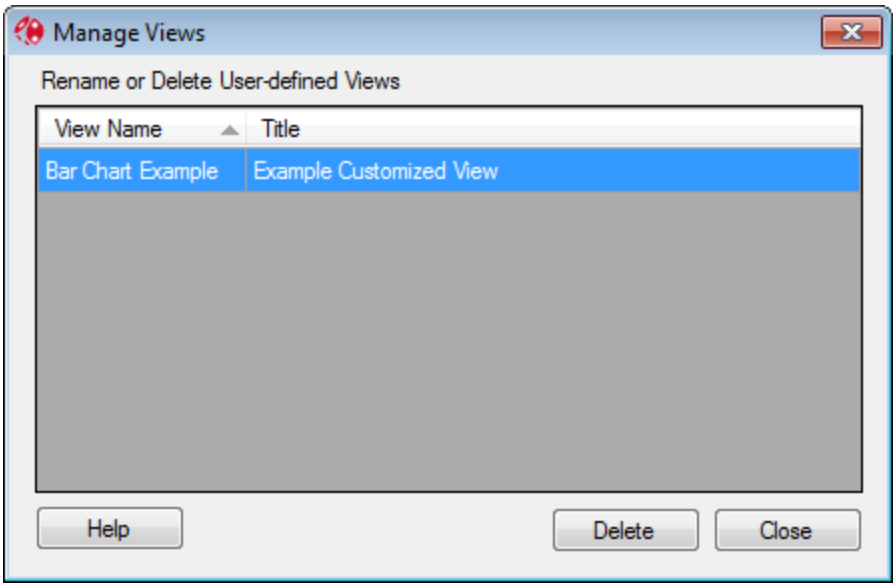


Figure 15.2

15.3 Managing Views

The **Manage Views** dialog is shown in figure 15.3. Operation is self-explanatory. It is used only to delete or rename views, since they are created as described in Chapter 14. Note that it does not display the standard views, which cannot be changed.


Manage Views
Rename or Delete User-defined Views
View Name
Title
Bar Chart Example
Example Customized View
Help
Delete
Close
Figure 15.3

Chapter 16: Linked Projects (Master / External Subprojects)

Most scheduling tools allow a collection of projects to be linked to form a larger composite project, sometimes known as an Integrated Master Schedule. This allows individual projects to be maintained separately but considered together for the purposes of calculations.

Microsoft project

In Microsoft Project this is achieved by creating a 'master' project into which all the component projects are inserted. Once this has been completed, dependencies (links) between tasks in different projects can be created.

If an individual component project is opened independently, any tasks linked to tasks in other projects will have a grayed out 'foreign' task placeholder to show the linked task.

Full Monte can process both the individual projects and the 'master'. If a Risk Analysis is performed on an individual project, then any linked 'foreign' tasks will be treated as fixed constraints.

There are several options for performing an analysis on a master project with linked projects.

1) Open each individual linked project individually to specify the Full Monte field mappings *before* the master is opened and processing performed. This can be quite tedious with many inserted subprojects.

2) Use the Full Monte Configuration option USE MASTER MAPPINGS FOR NEW SUBPROJECTS to have Full Monte automatically apply the master project field mappings to all inserted subprojects that do not currently have individual field mappings defined. If the master project does not currently have field mappings, then they will be applied from the User Default Field Mappings or, if these are not defined, from the System Default Field Mappings.

3) Use the Full Monte Configuration option FORCE MASTER MAPPINGS ONTO SUBPROJECTS to have Full Monte apply the master project field mappings to each inserted subproject regardless of whether they have current mappings defined. This can be useful if the master project mappings are updated, and you wish to use the new mappings when subsequently opening individual subprojects.

See Chapter 17 for a full list of available options.

Chapter 17: Full Monte Options

Full Monte features several user configurable options to enable features as required.

The Options dialog is available from the Full Monte File Menu as shown in Figure 17.1.

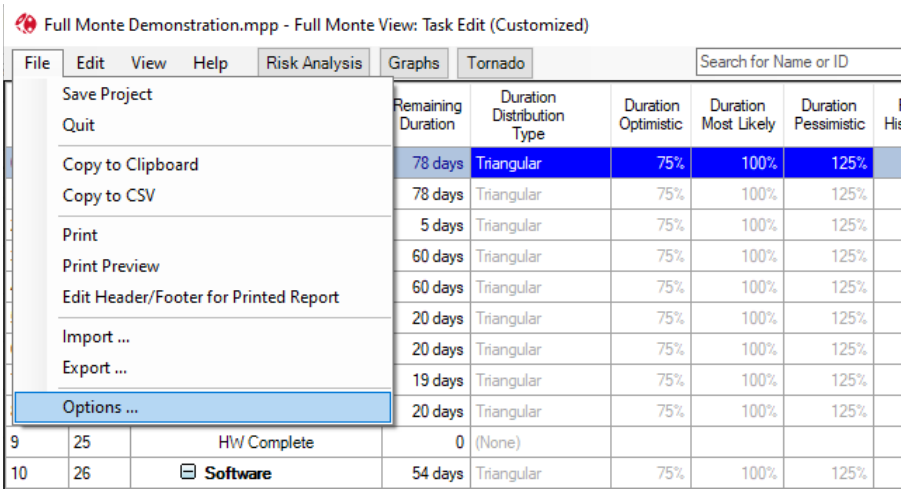


Figure 17.1

The exact configurable options depend on the host scheduling tool.

Risk Analysis

This tab, shown in Figure 17.2, configures the Risk Analysis Convergence feature. See section 8.3 for more detailed information about this feature.

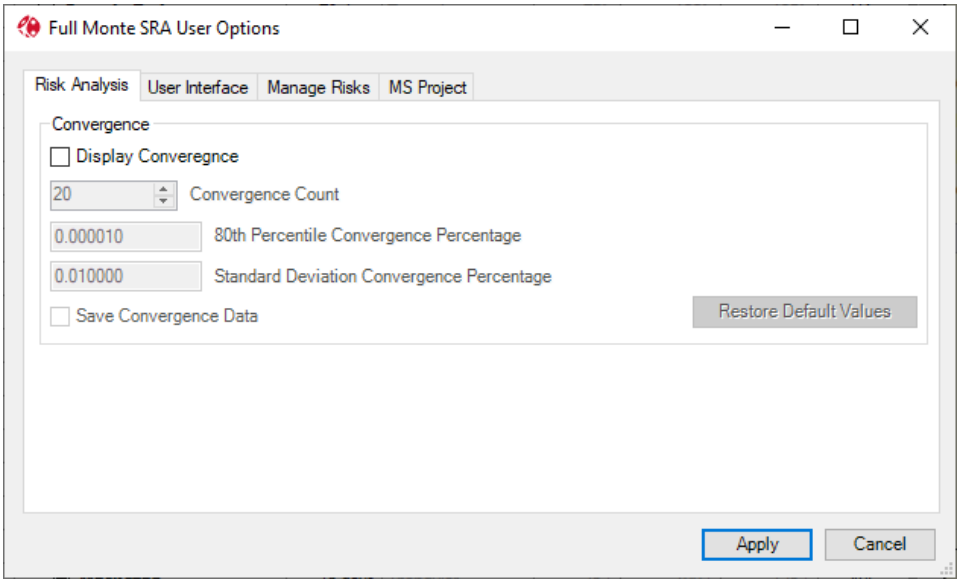


Figure 17.2

User Interface

This tab configures certain aspects of the user interface and is shown in Figure 17.3.

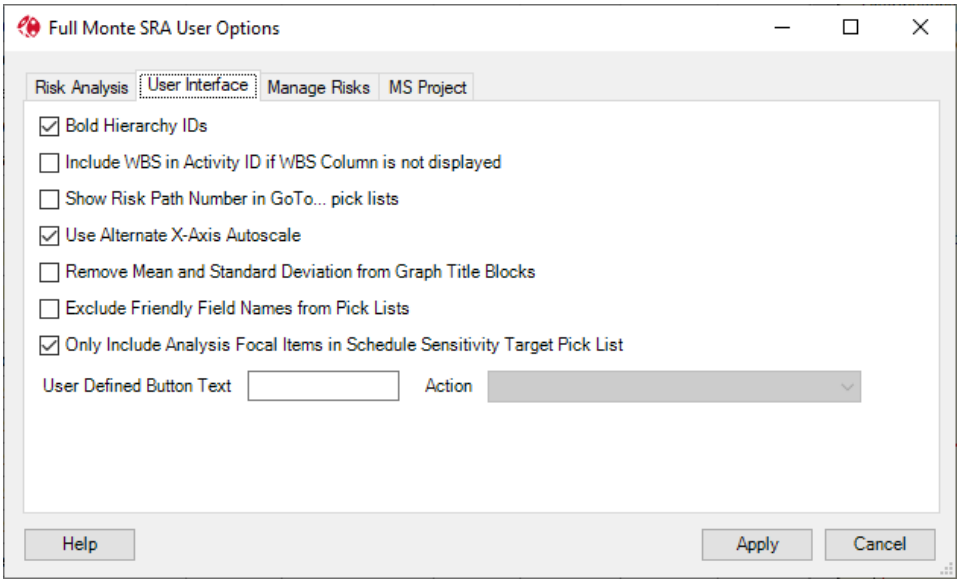


Figure 17.3

Bold Hierarchy IDs – If the View, Observe Hierarchy, or for Full Monte for P6, Group by WBS, is enabled then setting this option will cause the Task Name (Full Monte for MS Project) or Activity ID (Full Monte for P6) to be displayed in a bold font.

Include WBS in Activity ID if WBS Column is not displayed – If the schedule WBS is not included as a displayed column, then this option will cause the WBS to be included with the Task Name (Full Monte for MS Project) or Activity ID (Full Monte for P6).

Show Risk Path Number in Go To… Pick Lists – In the Full Monte views, the right-click context menu includes a **Go To…** option that displays a list of immediate predecessors/successors for the selected task. Selecting this option will include the Risk Path number in the pick list to make it simpler to trace specific logic chains.

> Note: The Risk Path number is only available after a Risk Analysis has been performed.

Use Alternate X-Axis Autoscale – Enabling this option will cause graphs to use an alternative X-Axis auto scale mechanism. Users may prefer the alternative as it displays more frequent X-Axis markers.

Remove Mean and Standard Deviation from Graph Title Blocks – This option simplifies the standard graph title block by hiding Mean and Standard Deviation.

Exclude Friendly Names from Pick Lists – If, for example, custom field Text1 has been renamed to WBS in Microsoft Project, Full Monte will display both Text1 and WBS in field picklists. This option will suppress adding WBS as a separate item in the pick list.

> Note: The 'friendly' name will still be displayed in parenthesis after the field name.

Only Include Analysis Focal Items in Schedule Sensitivity Target Pick List – Provided the Analysis Focal Item field has been populated, either using Field Mapping or File, Import, if this option is selected then the list of milestones displayed for the Schedule Sensitivity Target will be limited to those marked as Analysis Focal Items. See Appendix G for further information.

User Defined Button Text – If the user enters some text in this control, then an additional Button will be added to the Full Monte menu bar, named with the user test, and the action selected from the adjacent action list will be performed. Actions include all standard and customer created views along with Import and Export.

Manage Risks (MS Project Only)

This tab configures certain aspects of the Edit, Manage Risks functionality.

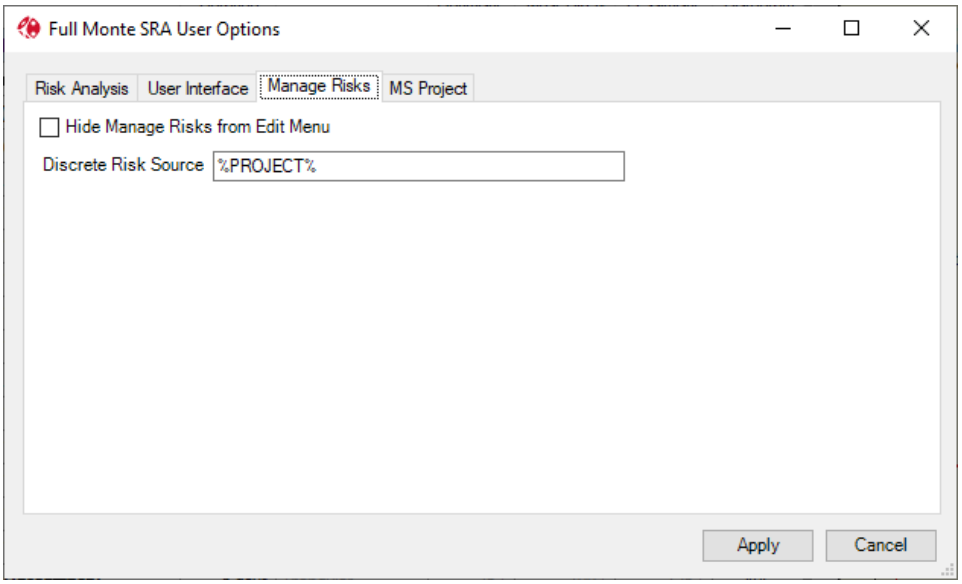


Figure 17.4

Hide Manage Risks from Edit Menu – If the user is using the Full Monte Risk Plan functionality then they may wish to hide the simpler Manage Risks functionality so it is not used by mistake.

Discrete Risk Source – This option configures the source of risks displayed in Edit, Manage Risks. By default (field is blank) then all risks for all projects are stored in a single file called FullMonteDiscreteRisks.txt. The Discrete Risk Source can be populated with a specific file name or the keyword %PROJECT%. If %PROJECT% is used then Full Monte will store the risks in a file called <Project Name>.rsk.

MS Project (MS Project Only)

The options shown in Figure 17.5 are specific to Microsoft Project.

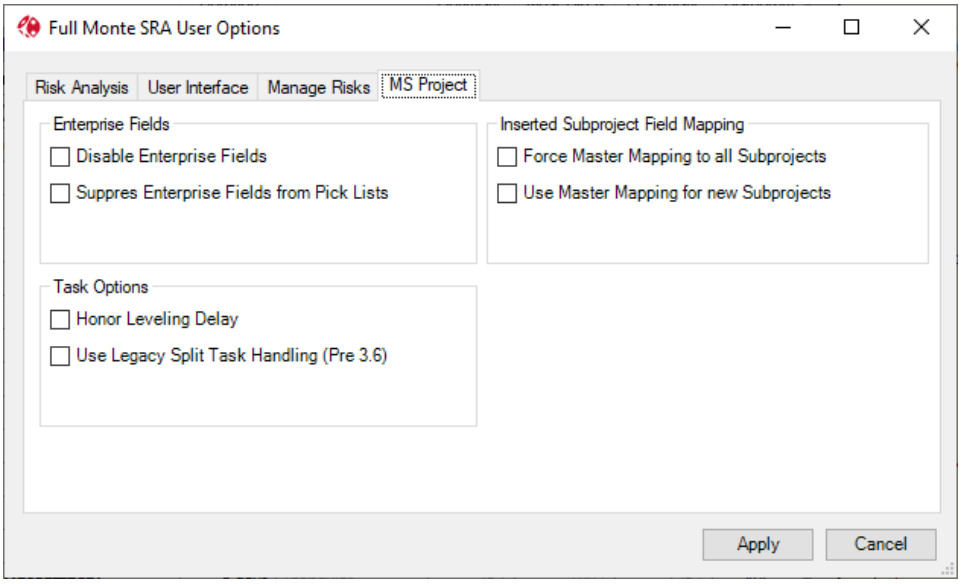


Figure 17.5

Disable Enterprise Fields – If the user is working with projects that were created in Microsoft Project Server or Project Online) it is possible that they contain Enterprise Fields that conflict with Full Monte (wrong field type etc.). Setting this option will cause Full Monte to ignore any Enterprise Fields defined for the project. This will include any fields specifically created for Full Monte. There will be no automatic mapping of such fields.

Suppress Enterprise Fields from Pick Lists – if there are a significant number of Enterprise Fields defined in the project, Full Monte field pick lists can become quite lengthy. Enabling this option will hide Enterprise Fields from pick lists although automatic mapping of fields named for Full Monte will still occur as normal.

Force master Mappings to all Subprojects – This option will cause Full Monte to force subprojects inserted into a master project to use the master project mappings. This both avoids the user having to open individual subproject first to define Full Monte mappings and ensure that all projects use the same fields mappings to simplify cross-project reporting in Microsoft Project. See Chapter 16 for further information.

> Note: If this option is enabled, the master field mappings are forced onto all inserted subprojects with no opportunity for the user to review any data that may be overwritten.

Use Master Mapping for new Subprojects – This option will cause Full Monte to apply the master mapping to any inserted subprojects that do not already have Full Monte field mappings defined. This avoids the user having to open new subprojects individually to apply Full Monte field mappings.

Honor Leveling Delay – If a schedule has been resource leveled in Microsoft Project, Full Monte typically ignores the leveling information and schedules tasks as early as possible, taking into account any delays

caused by uncertainty on predecessor tasks. Enabling this option will cause Full Monte to not schedule tasks any earlier than any previous resource leveling allows.

Use Legacy Split Task handling (Pre 3.6) – Prior to Full Monte version 3.6, manual splits in Microsoft Project tasks were ignored and the task duration used in Full Monte was simply the sum of the splits. This could result in the finish date calculated by Full Monte being earlier than the finish calculated by Microsoft Project. With this option disabled (the default in 3.6 onward), Full Monte calculates the task duration as the sum of the splits and the gaps between them, so the overall span duration (from the start of the first split to the end of the last split) is the same as Microsoft Project.

> Note: As Full Monte is using the span duration, which is longer than the original task duration in Microsoft Project, uncertainty may be exaggerated for split tasks during the simulation. However, on balance the results are more realistic.

Appendix A: Probability Distributions

A probability distribution for a random variable is a function defining the probability of that variable having a particular value. (The distributions used in Full Monte are continuous, which means that the probability of any particular value is infinitesimal. It would be more accurate to talk about "the probability density at a particular value." Since Full Monte actually works in whole minutes and approximates the continuous distribution by a discrete one, we can set aside this nicety for now.)

Both the inputs to Full Monte (activity durations, etc.) and the resulting outputs (dates, floats, and costs) are probability distributions. The ones that come out are empirical, which means that we don't have a formula for the function; we have only an estimate based on simulation. Here we are concerned with the probability distributions we input for activity durations and cost rates, where we do have such a formula.

Full Monte supports five families of probability distributions. Here we discuss what they are, how you choose among them, how the parameters are interpreted, and how Full Monte samples from them.

Uniform distribution

The simplest distribution type is the *uniform distribution*, in which any value in a specified range is equally likely. Unfortunately, it is also the least useful because it is unlikely to be realistic in practice. (If you think that an activity will take between four and six weeks, the actual value is probably more likely to be toward the center of the range rather than near the outer edges.)

Sampling is merely a matter of translating a pseudorandom number (which emulates a true random variable distributed uniformly between 0 and 1) to the specified range. That range is specified by the user on the Full Monte Edit dialog. Since the distribution is symmetrical, there is no need to input a middle value. (The dialog calculates and displays what it calls the most likely value, though in this particular case it is actually the mean value. By definition, no value is more likely than any other.) An example of the uniform distribution as generated by Full Monte is illustrated in figure A.1.

Figure A.1

All the other distribution types taper off to zero at their edges. Users are advised not to use the uniform distribution unless they have very good reason to expect the data to be uniform.

Normal distribution

The other symmetrical distribution supported by Full Monte is the *normal distribution*, which is much more useful. It follows a familiar bell-shaped curve and is often used to model a variety of natural phenomena. (Perhaps this is because if you add together a lot of random variables from *any* distribution, the result tends toward normal. This is called the Central Limit Theorem.)

The normal distribution has infinite tails, so the optimistic and pessimistic duration estimates cannot be interpreted literally. Full Monte interprets them as 3-sigma (or three standard deviations) away from the mean. Thus, the standard deviation is one-sixth of the difference between the optimistic and pessimistic values. About 0.27% of samples from a real normal distribution would fall outside these limits, but Full Monte uses a sampling technique that resembles the normal curve almost perfectly but without generating samples outside the specified range.

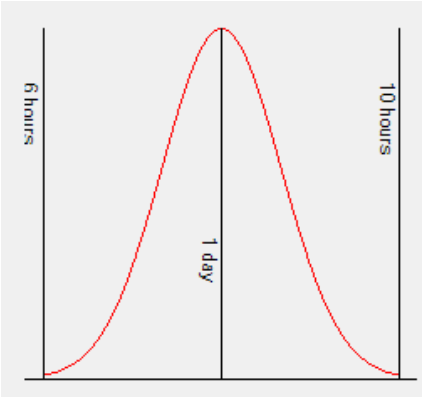


Figure A.2

Use this or the lognormal for most activities unless you have a reason to expect the distribution to be asymmetrical. The remaining three distributions supported by Full Monte — lognormal, beta, and triangular — are asymmetrical, or “skewed.”

Lognormal distribution

The *lognormal distribution* is skewed in a very special way. It is the distribution of a variable whose logarithm is distributed normally, which means it is defined by just two parameters. Therefore, you cannot specify the most likely value, so you cannot determine the skew independently of the optimistic and pessimistic values.

It is always skewed to the right, or "positively." The tail on the right is longer than the tail on the left. In fact, while it has an infinite tail to the right, its absolute minimum is always zero since the log of minus infinity is zero. When the optimistic and pessimistic values are close together the lognormal differs little from the normal, but as the ratio between the two increases the skew becomes greater.

The lognormal also occurs often in nature for values that can vary by orders of magnitude. (Which is why when you look at a list of populations of cities of all sizes, you find that about 30% of them have 1 as their first digit.) Use the lognormal for situations where the duration is highly uncertain, such as basic research projects, where the pessimistic estimate may exceed the optimistic by an order of magnitude or more. There is even some empirical evidence from Dan Trietsch of the American University of Armenia that the lognormal distribution should be used in all cases. (See mba.tuck.dartmouth.edu/pss/Notes/LognormalParkinson.pdf.)

Two examples of the lognormal distribution as generated by Full Monte are illustrated in figure A.3. The first is less extreme, with the minimum value being 60% of the maximum, making it almost symmetrical, while the second has a minimum, which is only 10% of the maximum.

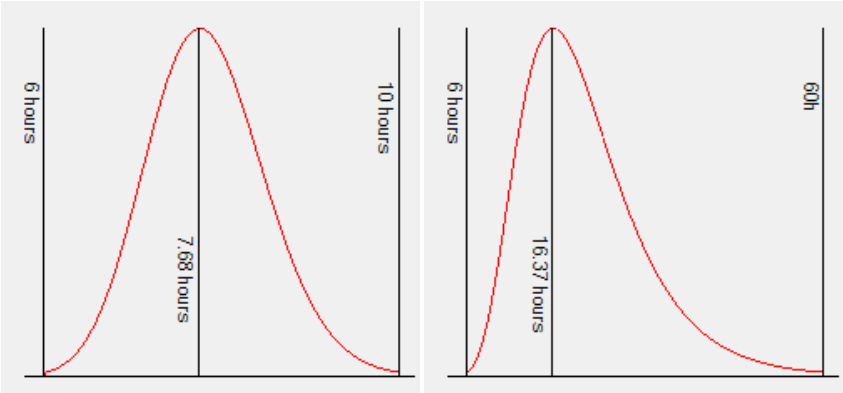


Figure A.3

The final two supported distributions are determined by three parameters and thus give the user complete control over the amount and direction of the skew.

Beta distribution

A true beta distribution is specified by no less than four parameters, which give rise to an astonishing variety of shapes, many of which would not be expected or useful, such as continuously increasing or decreasing or even a U-shape with the lowest point in the middle. (See the Wikipedia entry referenced in the Bibliography. It also includes the uniform distribution as a special case, but in Full Monte we treat this separately.)

Full Monte therefore restricts the choice to a well-behaved subset that rises monotonically from zero at its most optimistic point until it reaches its peak, and then declines monotonically to zero at its most pessimistic point. In fact, the particular subset used by Full Monte when defined to be symmetrical looks almost identical to a similarly defined normal distribution and has an almost identical standard deviation. The standard deviation decreases, however, as the skew increases. Full Monte interprets the input values as 3-sigma limits and uses a sampling methodology that does not produce samples outside the specified range. Two examples of the beta distribution — one symmetrical and one skewed to the right — are illustrated in figure A.4.

NOTE: The particular subset is intended to approximate to the distribution used in PERT, but this is somewhat ambiguous. The formula suggested for the mean — (a + 4b + c) / 6 — implies one subset, while that suggested for the standard deviation — (b – a) / 6 — implies another. Full Monte has chosen the latter, which means that in the symmetrical case the standard deviation is actually equal to that of the normal. (It decreases with increasing skew to about 1/9th of the range.) This also means that the mean is actually given by (a + 6b + c) / 8.

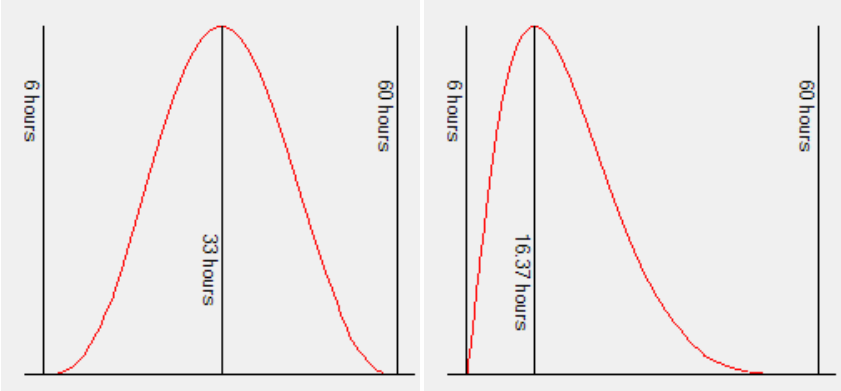


Figure A.4

Use this distribution when you want something similar to a normal distribution but want to control the skew.

Triangular distribution

Finally, the *triangular distribution* has long been used for schedule risk analysis. It does not appear much naturally, but it is simple, and because it puts more emphasis on values close to the limits, it is perhaps more in tune with users' expectations. As its name implies, it is simply a triangle with the base defined by the optimistic and pessimistic estimates, and the apex defined by the most likely value. It is very easy to sample and to understand, but like the uniform distribution, it is unlikely to reflect the real situation. Because its tails are not thin, it has a larger standard deviation than similarly defined distributions of all the other types except uniform. Two example of the triangular distribution — one symmetrical and one

skewed extremely to the right with the same parameters as the beta above — are illustrated in figure A.5.

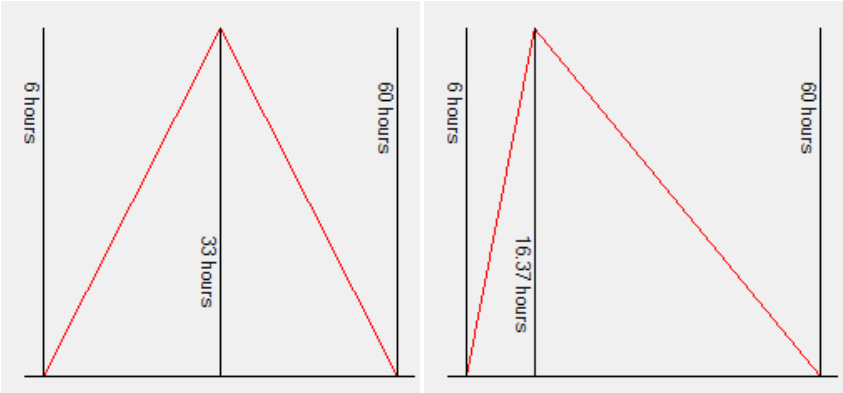


Figure A.5

Appendix B: Correlation

Correlation is the name given to the phenomenon of interdependence between random variables, such that the frequency function for one of them depends on the actual values of the others. For two variables, it is often illustrated visually by a scatter diagram. To fully describe the correlation between two or more variables mathematically, one must define their multivariate distribution function, which is a multidimensional extension of the frequency function defining the probability of each possible combination of values of the variables. For most purposes, however, and certainly for input to Full Monte and other schedule risk analysis software, we summarize this using the concept of correlation coefficients.

A correlation coefficient measures the degree of interdependence between two random variables in terms of a number between -1 and 1. The details are beyond the scope of this guide and there are actually two different correlation coefficient definitions. The interested reader is referred to the URLs listed in the bibliography. Suffice it to say that a coefficient of zero means that the variables are independent, while a coefficient of + or - 1 means that they are perfectly (positively or negatively) correlated, i.e., the value of one variable exactly determines the value of the other.

It is worth noting, since it surprises some people, that perfect correlation can exist even between variables with different distributions, as illustrated in the scatter diagram in figure B.1. (Actually, the Pearson or linear correlation coefficient displayed is not quite 1 but the Spearman correlation coefficient is exactly 1. But more to the point, any particular value of one of the variables precisely determines the value of the other.)

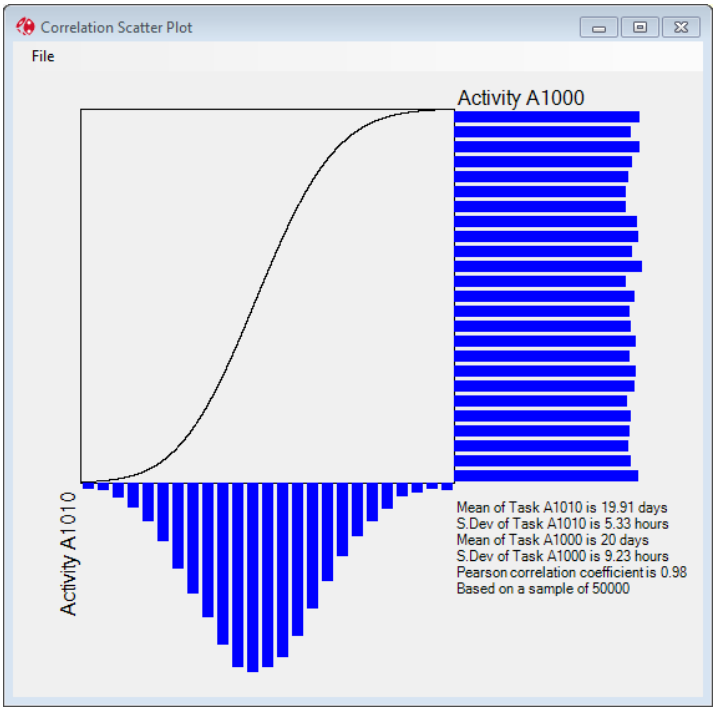


Figure B.1 100% correlation between a uniform and a lognormal distribution

It is also worth noting that the correlation coefficient measures linear, or at least monotonic relationships. A Wikipedia URL referenced in the Bibliography shows how various convoluted relationships can exist between variables that have zero correlation coefficients. The correlations in Full Monte can, however, be relied upon not to exhibit such odd relationships and a typical correlation between two activity durations is illustrated in figure B2.

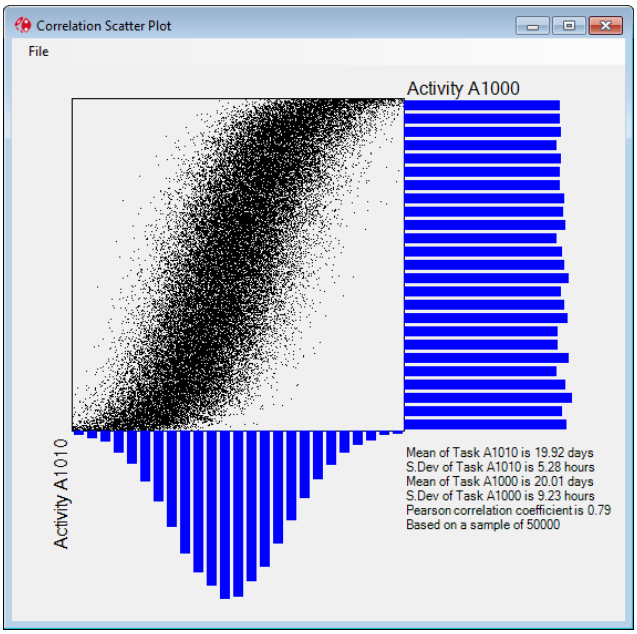


Figure B.2 Approximately 80% correlation between a uniform and a lognormal distribution

So, correlation coefficients provide a shorthand way of defining the joint distribution of two variables, which more generally would require us to define the joint distribution in detail. But even using correlation coefficients, specifying the relationship between three or more variables can be a daunting task. To properly describe the correlations between the three variables, one needs to define the correlations between each of the three possible pairings. And it gets much worse: If there are four variables involved there are six possible pairings, and for five there are 10.

Full Monte handles correlations between the durations of activities differently than other systems. Some allow the user to specify the correlation between the durations of any two activities, but this does not fully define the relationship between a larger set of activities. Suppose that five activities (A through E) are correlated in a symmetrical fashion, i.e., the correlations between any pair are the same. There are 10 possible pairings, but in simple systems only five places (one on each activity) to enter a correlation with another activity. What happens is that you pick an activity arbitrarily (say A) and correlate the others with it. Let's say you put in 50% as the correlation coefficient. The result is that B, C, D, and E are correlated with A at 50%, but are correlated with each other only 25% (50% turned into a fraction and then squared). So the symmetry is not accurately modeled.

Some systems ignore this problem, which means they do not properly handle correlations involving more than two activities, while others require the user to write code to set up the data in a strictly upper triangular matrix. Other systems support “drivers,” an idea discussed in the next section.

Full Monte takes a different approach, recognizing that the usual reason for a correlation between the durations of different activities is that they all depend upon some outside factor, such as their location. We make this explicit, so that however many activities there are, each of them just needs one scalar quantity to define its correlation with a particular factor, and hence with all other activities similarly defined. So all the user has to enter for each activity is the causal factor (which can be given any arbitrary name like “On Site”) and the correlation coefficient. Any number of such factors can be included, and once specified for one activity they appear on the drop-down list for the others.

Of course if the situation really is asymmetrical, so that activities B and C really do depend on activity A (and are therefore more correlated with A than with each other), then all you have to do is define a factor (say activity A) and make A correlated with that with a coefficient of 100%.

Note that in the symmetrical situation described above, one should enter the square root of the correlation you want between each pair of activities. So instead of putting in 50%, one would put in 70% (the square root of .5 is actually about 0.707).

Correlation Sources vs. Drivers

Drivers are a recent development that seems superficially similar to the Correlation Source concept described above, but the concepts are similar only in that they both allow the user to specify one or more outside factors to influence a set of activity durations, but the way in which this influence is specified is very different. In the driver concept, the value of each driver is drawn from a distribution roughly centered on 1, and they are interpreted multiplicatively. For example, if an activity is affected by two drivers, these might be represented by two triangular distributions with parameters:

0 .7, 1.0, 1.2, *and*

0.9, 1.0, 1.4.

On a particular iteration, we might sample 1.04 and .98, so the value sampled for the activity is multiplied by 1.04 times .98, or 1.0192.

While there is appealing logic to this seemingly simple idea, there are a number of problems for the unwary that can be overcome only with the most sophisticated analysis:

1. First, it means that the distribution specified for the activity itself is not actually the distribution you get. Even in the above relatively simple scenario, most statisticians would be hard put to tell you what the final distribution is. In fact, one cannot readily calculate even the expected value or standard deviation. (They are about 1.06 and .15, respectively, by the way.)

2. Second, one cannot readily know what the correlation coefficient between two activity durations actually is.

3. Third, you cannot easily specify that two activities be affected by the same driver but to different degrees. (This is possible, but involves complicated calculations to get the right input data.)

4. Fourth, it is just additional data entry. It has been suggested that it can actually require less data entry, on the basis that all the uncertainty in activity durations is attributable to drivers. Or that any remaining uncertainty can itself be attributed to a special driver. But this is a fallacy. Using the same driver to represent the uncertainty on two activities would make them unintentionally correlated.

The net result is a system, which while it may have value in special circumstances, is likely to mean either much more work or unrealistic results.

By contrast, correlation sources require no extra data other than the name of the source and a percentage. They enable the user to easily specify correlations between any number of activities and any number of sources and to simply calculate the correlation implied between any pair of activity durations. (Full Monte even provides a visual aid in the form of a scatter diagram.) Furthermore, the distribution the user specifies for the activity duration is unaffected by the correlation sources. One incidental advantage of this is that it is easy to assess the effect of correlations.

Appendix C: Branching

Branching is a feature that enables Full Monte to choose at run time, i.e. on each iteration of the simulation, which of a number of alternative paths from an activity is active. Full Monte supports two types of branching: conditional and probabilistic.

In **conditional branching**, the user associates a date with each successor, such that the successor will be active if it can start before that date, and no other successor with an earlier associated date can.

In **probabilistic branching**, the user specifies a set of relative probabilities for the different successors, and the active successor will be chosen randomly based on these probabilities.

NOTE: Either type of branching can be applied to the finish-to-start successors of any activity that has two or more of these. It does not apply to other types of relationships, and you cannot combine the two different types of branching on successors to the same activity.

It is important to understand that branching applies to a path rather than an activity, which can lead to several rather confusing scenarios.

For example, if successor activity C is not on the selected active path out of activity A, it could still itself be active if it has another predecessor B that is active. The general rule is that:

NOTE: An activity is active if it is a start activity or if it has at least one active predecessor relationship from an active predecessor.

Having stated the rules, it is probably best to avoid such confusing situations by using branching judiciously. We suggest that the use of branching be limited to situations where no successor activity has any other predecessors.

Branching and progress

If any of the successors have been progressed, Full Monte assumes that the branch has been determined and will not apply the normal rules. In fact, it is quite possible (though illogical) that more than one of the successors has been progressed. If any of the successors is progressed, Full Monte assumes that all the progressed successors are active and all the unprogressed ones are not.

Branching and the interpretation of calculated dates, floats, and cost

Branching means, in general, that some activities are not always active. This is measured by the statistic "Active Percent," which estimates the percentage probability of each activity being active. Some of the other calculated values are conditional upon the activity being active, and some are not, as follows:

Means and standard deviations of dates are conditional because it is impossible to assign a date value to something that did not happen. The expected finish date reported is the expected finish date, *given that the activity is active.*

Means and standard deviations of floats are also conditional to make them consistent with the dates and because assigning a value of zero to the float of an activity that did not happen is not very meaningful. (Zero float means the activity is critical, yet how can a nonexistent activity be critical?) The expected total float reported is the expected float *given that the activity is active.*

Means and standard deviations of costs are, on the other hand, unconditional. This is reasonable because assigning zero cost to an activity that did not happen makes sense. It is also necessary if the costs are to roll up correctly; if two alternative activities with equal probability have an expected cost of $10,000 and $20,000, respectively, then the expected cost of the pair is $15,000, not $30,000.)

Criticality and sensitivity are also unconditional, though this choice is somewhat arbitrary. The value reported for criticality is the percentage of times overall that the activity was critical, including the times when it was not critical because it was not active. (One can easily calculate the conditional criticality or sensitivity by dividing by the active percentage.)

Histograms (probability density) and **S-curves** (cumulative probability) are all conditional, which, in the case of cost, is somewhat inconsistent with the above. Doing otherwise would mean a tall bar at the origin representing the times when the cost was zero because the activity was not performed, which would severely reduce the precision visible for the interesting part of the graph. It does mean, however, that the expected cost reported (which is *not* conditional) may be nowhere near the middle of the graphed data.

Appendix D: Full Monte Fields

Activity fields

Full Monte reports on eight different items for each activity:

1. Start, Early Start
2. Finish, Early Finish
3. Late Start (only if Full Backward Pass is selected)
4. Late Finish (only if Full Backward Pass is selected)
5. Total Float (only if Full Backward Pass is selected)
6. Free Float (only if Full Backward Pass is selected)
7. Duration
8. Cost

Each of these has the same meaning as it does in the source scheduling tool, except that instead of being represented by a single value, each is a probability distribution represented by three different fields:

1. The expected value
2. The standard deviation
3. The histogram/S-curve data

The histogram data are represented by a button, clicking on which displays the histogram and/or S-curve (see Chapter 9, Graphical Views) and is also used to calculate the percentiles that are available in Full Monte tabular views. (In the event that the value depicted is constant, i.e. not subject to any random variation, this constant value is displayed instead of the button.)

The above accounts for 24 fields and these are named so that fields relating to the same basic data are sorted consecutively. Thus, for example, there are fields named:

- Early Start, expected value
- Early Start, standard deviation
- Early Start, histogram

An additional 27 fields do not fit into the above pattern. They are, in alphabetical order:

Actual over Estimated Duration: This field contains either a number representing the ratio of actual duration over the expected value based upon the specified distribution, or for WBS elements containing two or more finished activities data upon which a histogram and S-curve of this data can be displayed. In the latter case a button is displayed, giving access to the histogram and/or S-curve

Analysis Focal Item: Loaded from the source schedule and used to identify tasks of particular importance for reporting and as schedule sensitivity targets.

Analysis Log Messages: This field contains messages generated during risk analysis and relates to issues with each activity. They can be viewed in the Message Log report, which can be shown automatically after risk analysis.

Chance of Achieving P6 Cost: The probability of completing the project at a cost less than or equal to the deterministic value calculated by P6.

Chance of Achieving P6 Early Finish: The probability of completing the project on or before the deterministic date calculated by P6.

Confidence Interval: This is an editable input field. See Chapter 4, Editing Full Monte Data for Activity Durations.

Correlation Coefficients: A list of correlation coefficients for this activity, separated by commas. (See Appendix B, Correlations.) This is input data, but not editable in the table.

Correlation Sources: A list of correlation sources for this activity, separated by commas. (See Appendix B, Correlations.) This is input data, but not editable in the table.

Correlations: A list of correlation sources and coefficients for this activity, separated by commas. (See Appendix B, Correlations.) This is input data, but not editable in the table.

Cost Sensitivity, Attributable Variance: This is the percentage of the variance in the cost of the "cost sensitivity target," which is attributable to the current activity. (The cost sensitivity target is a WBS element nominated by the user. By default, it is the project WBS element, representing the whole project. See Chapter 7, Running Risk Analysis Simulation.)

Date of Simulation: The date of the risk analysis simulation on which displayed results are based.

Duration Distribution Type: This is an editable input field. See Chapter 4, Editing Full Monte Data for Activity Durations.

Duration Expected Value (theoretical): This is the theoretical expected value of the duration based upon the distribution specified by the duration distribution type and parameters.

Duration Most Likely: This is an editable input field. See Chapter 4, Editing Full Monte Data for Activity Durations.

Duration Optimistic: This is an editable input field. See Chapter 4, Editing Full Monte Data for Activity Durations.

Duration Pessimistic: This is an editable input field. See Chapter 4, Editing Full Monte Data for Activity Durations.

Duration Standard Deviation (theoretical): This is the theoretical standard deviation of the duration based upon the distribution specified by the duration distribution type and parameters.

Level Of Effort (Microsoft Project Only): Loaded from the source schedule and used to identify tasks that should be treated as Level of Effort during the analysis. See Appendix F for further information.

Merge Delay: When an activity has multiple predecessors, it cannot start until all of these predecessors are complete. If two or more of these predecessors are sometimes critical, there will be a gap between the latest of the expected early finishes of the predecessors and the expected early start of the successor, due to the phenomenon known as merge bias. (See Appendix E, Merge Bias.) This field measures the size of this gap.

Number of Trials: The number of risk analysis simulation trials (iterations) on which displayed results are based.

Percent Active: This field merely measures the percentage of trials when the activity was active. (Inactivity is caused by branching, as explained in Appendix C.)

Percent Critical: This field merely measures the percentage of trials when the activity was critical.

Percent Critical (Sensitivity): The field 'Percent Critical (Sensitivity)' differs in two ways from the regular 'Percent Critical' field: it indicates whether the task is critical specifically to the sensitivity target; and it reflects whether the duration of the task affects this target (so it does not count as critical tasks which have the critical path passing through their starts or finishes but not through their durations.

Schedule Margin Flag: Loaded from the source schedule and used to identify tasks representing Schedule Margin. Such tasks will be treated as zero duration during the analysis. See Appendix G for further information.

Sensitivity Index: This field is intended to give a rough guide of how sensitive the early finish of the schedule sensitivity target is to variation in the activity's duration. It is computed as the percent critical multiplied by the standard deviation of the duration and divided by the standard deviation of the early finish of the sensitivity target.

Sensitivity, Optimistic Cost of Target: This is an estimate of the expected cost of the cost sensitivity target if the current activity's cost were to take its optimistic value. (In the column heading, the word "target" is replaced by the identity of the cost sensitivity target of the WBS element selected. See Chapter 7, Running Risk Analysis Simulation, and Chapter 10, Exploring Sensitivity.)

Sensitivity, Optimistic Finish of Target: This is an estimate of the expected early finish date of the schedule sensitivity target if the current activity's duration were to take its most optimistic value. (In the column heading, the word "target" is replaced by the identity of the cost sensitivity target of the WBS element selected. See Chapter 7, Running Risk Analysis Simulation, and Chapter 10, Exploring Sensitivity.)

Sensitivity, Pessimistic Cost of Target: This is an estimate of the expected cost of the cost sensitivity target if the current activity's cost were to take its pessimistic value. (In the column heading, the word "target" is replaced by the identity of the cost sensitivity target of the WBS element selected. See Chapter 7, Running Risk Analysis Simulation, and Chapter 10, Exploring Sensitivity.)

Sensitivity, Pessimistic Finish of Target: This is an estimate of the expected early finish date of the schedule sensitivity target if the current activity's duration were to take its most pessimistic value. (In the column heading, the word "target" is replaced by the identity of the cost sensitivity target of the WBS element selected. See Chapter 7, Running Risk Analysis Simulation, and Chapter 10, Exploring Sensitivity.)

Calendar Fields (P6 Only)

There are just three fields specific to Full Monte:

- Auto-regression Coefficient %

- Distribution Type
- Granularity

All three are editable input fields. See Chapter 7, Editing Full Monte Data for Calendars.

Appendix E: Merge Bias

Merge bias is probably the single biggest reason why deterministic schedules (and PERT schedules) are too optimistic and, therefore, why Monte Carlo simulation is so important. It results when two or more parallel paths merge either at the end of the project or as predecessors to some intermediate task or milestone and when two or more of these paths have a chance of being critical.

> *NOTE: Even if a schedule has multiple finish tasks, these all "merge" for the purpose of this appendix, in the sense that the project is not finished until every path is finished.*

Because the successor cannot start until *all* its predecessors are complete, it is always dependent on the path that happens to finish last, even though that path is not always the same one. This results in the expected start date of the successor being later than the expected finish dates of any of its predecessors. This delay is known as Merge Bias.

Merge Bias can be illustrated by analogy with the throwing of a pair of dice. Each die has equal chances of coming up with any value 1 through 6, so the expected value is 3.5. But if we look at the distribution of the greater of the two scores, which is equivalent to waiting for the longer of two predecessors, the expected value turns out to be about 4.5. This additional 1 represents the Merge Bias.

Merge Bias builds up over the duration of the project, causing greater and greater discrepancies between a deterministic plan and reality, so that while early milestones may be met, the later ones are increasingly likely to be missed. It is truly a bias toward optimism in deterministic schedules, in the sense that there are no countervailing tendencies that might work the other way.

Appendix F: Level of Effort (LOE) Tasks

Many projects have supporting tasks that do not contribute directly to the project deliverable but are included to capture the work/costs associated with this support tasks. Examples might include Information Technology Support and Project Management. Such tasks are called 'Level of Effort' (LOE) because their duration will change as the duration of the discrete project work changes.

The level of Effort work should **never** be on the critical path of the project.

Microsoft Project

Microsoft Project does not directly support the concept of Level of Effort so various workarounds are employed to achieve the objective.

Resources on Summary Tasks

Applying a resource to a summary task meets most of the objectives for Level of Effort. The summary task duration changes automatically as the underlying tasks are updated. However, there are several drawbacks with using summary tasks.

- The inclusion of support resources on the summary task is not obvious (the summary task name will most likely relate to the underlying discrete work).
- The duration of the Level of Effort work cannot be derived from tasks that are contained within different summary tasks.
- Some clients/oversight bodies may not accept resources assigned to summary tasks. For example, the Defense Contract Management Agency (DCMA).

Regular Tasks identified as Level of Effort

A normal task can be used to account for support resources. The major disadvantage is that the duration will not automatically adjust to account for changes in the underlying discrete work. The 'Level of Effort' work may also appear on the critical path.

These shortcomings can be managed with care but become a much bigger issue when duration uncertainty is considered. We need the level of Effort duration to change as the discrete work duration changes during the simulations.

Full Monte solves this problem by supporting a 'Level of Effort' flag on tasks when used in conjunction with appropriate logic (predecessor/successor links).

Level of Effort tasks should be linked to the relevant discrete work using Start-Start and Finish-Finish logic as shown in Figure F.1

Task Name	Duration	Duration Expected Value	Percent Critical	Level of Effort Flag	Cost	Cost Expected Value
LOE Example	**10 days**	**10.51 days**	**100**	**No**	**$8,000.00**	**$8,405.00**
Discrete Work	**10 days**	**10.51 days**	**100**	**No**	**$0.00**	**$0.00**
Work 1	5 days	5.26 days	100	No	$0.00	$0.00
Work 2	5 days	5.25 days	100	No	$0.00	$0.00
Level of Effort	**10 days**	**10.51 days**	**100**	**No**	**$8,000.00**	**$8,405.00**
IT Support	10 days	10.51 days	0	Yes	$8,000.00	$8,405.00

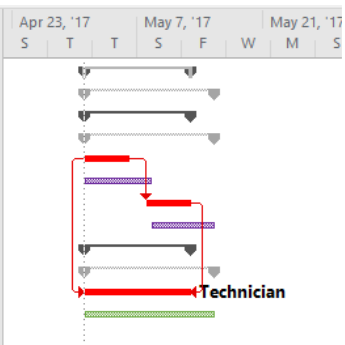


Figure F.1

In the example, the LOE task 'IT Support' has been linked with a Start-to-Start predecessor to the beginning of discrete work 'Work 1' and a Finish-to-Finish predecessor to the end of Discrete Work 'Work 2'.

The Microsoft Project duration for the LOE task has been manually set to 10days to run parallel to the discrete work. Because, in the example, both the discrete work and the task representing LOE both take 10 days they are both shown on the critical path by Microsoft Project. Technically this is not correct (because LOE should never be part of the critical path).

The Full Monte Level of Effort field has been mapped to Flag20 (the column labelled 'Level of Effort Flag' in the example). It has been set to 'Yes' for the task representing the support work.

We can see that following the simulations, the LOE task has the same expected duration as the total discrete work. Note that the IT Support expected cost has increased compared to the original figure (Cost) from Microsoft Project.

Note: Tasks flagged as Level of Effort cannot have Duration Uncertainty information applied in Full Monte.

The 'Percent Critical' for the LOE task has been calculated as 0 by Full Monte since LOE tasks should not be a part of the critical path.

If a task flagged as being Level of Effort has predecessors other than Start-to-Start and Finish-to-Finish, then Full Monte will log a warning and treat the task as a regular task.

Oracle Primavera P6

Oracle Primavera P6 has a special activity type of 'Level of Effort' to easily model support effort. Full Monte supports the use of this activity type and will adjust the duration based on the appropriate discrete work during the simulations. No special action is required by the user.

Appendix G: Schedule Margin

A schedule best practice is to include Schedule Margin (aka Risk Contingency, Risk Buffer) between the planned completion of 'Work' and the Contract Promised/Committed date. The completion of 'Work' is represented by one Milestone and Contract Promised date another. See figure G.1 for an example.

Task Name	Duration	Start	Finish
Integration	**5 days**	**Aug 24**	**Aug 28**
System Test	5 days	Aug 24	Aug 28
~~Integration Rework~~	~~3 days~~	~~Aug 31~~	~~Sep 2~~
Marketing	**15 days**	**Aug 3**	**Aug 21**
Brochure Development	10 days	Aug 3	Aug 14
Brochure Printing	5 days	Aug 17	Aug 21
Project Complete	0 days	Aug 28	Aug 28
Schedule Margin	8 days	Aug 31	Sep 9
Committed Delivery	0 days	Sep 9	Sep 9

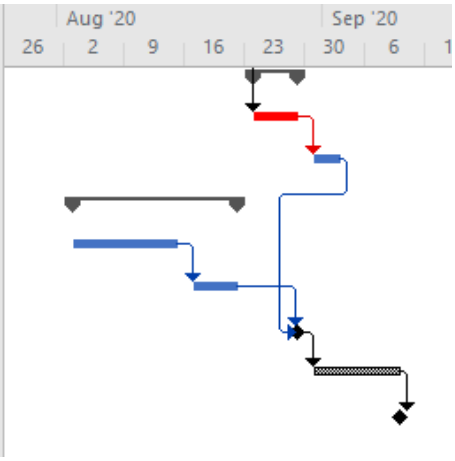


Figure G.1

The schedule is showing a project (Work) Complete on August 28 and a Committed Delivery (from the contract) on September 9. The difference between these two dates is 8 days and is identified in the Schedule by the Schedule Margin task. Full Monte Schedule Risk Analysis can show if the 8 days Schedule margin is sufficient to protect the Committed Delivery at the required level of confidence.

Schedule margin should be removed before performing a Schedule Risk Analysis. Full Monte can do this automatically using the following techniques.

Microsoft Project

In Microsoft Project use a Custom Flag or text field to identify tasks representing Schedule Margin. When using a Flag field simply set it to Yes for the Schedule Margin tasks. If using a custom Text field, then values of "YES", "SM", or "MARGIN" are permissible to identify Schedule Margin tasks.

Use the Full Monte Field Mappings to link the appropriate custom field with the Full Monte Schedule Margin Flag field as shown in figure G.2.

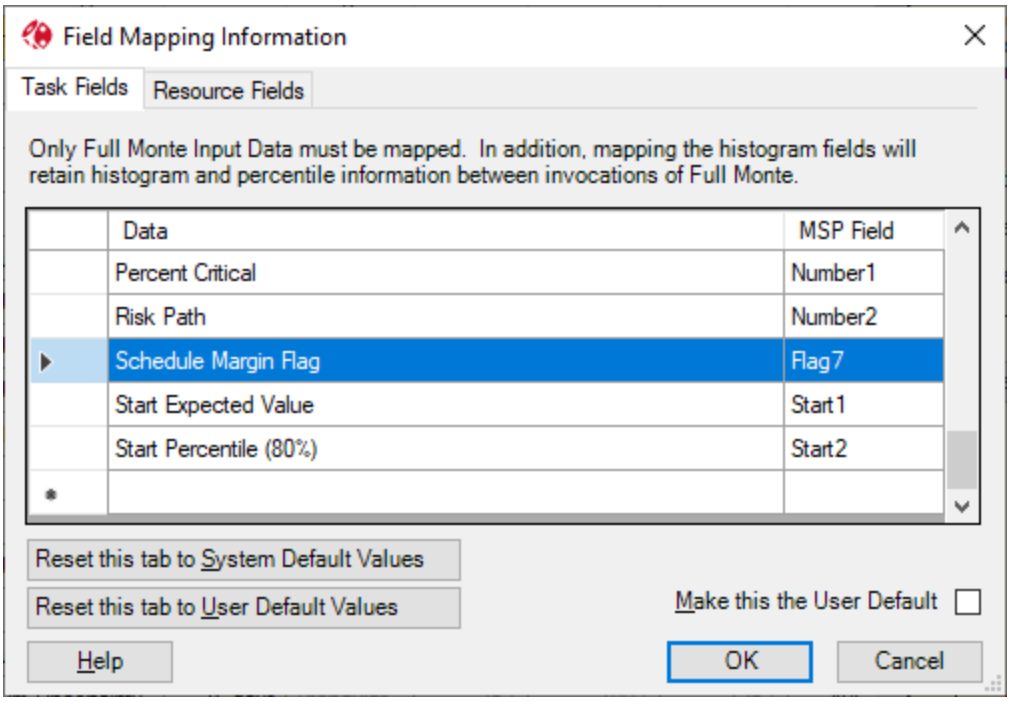


Figure G.2

Oracle Primavera P6

In Primavera P6, create an Activity User Defined Text Field named 'Schedule Margin Flag' as shown in Figure G3.

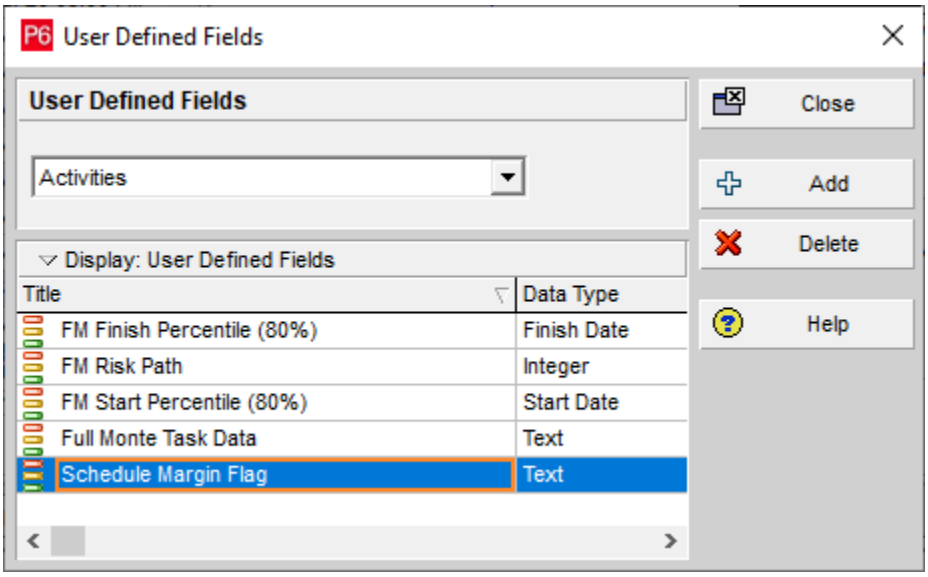
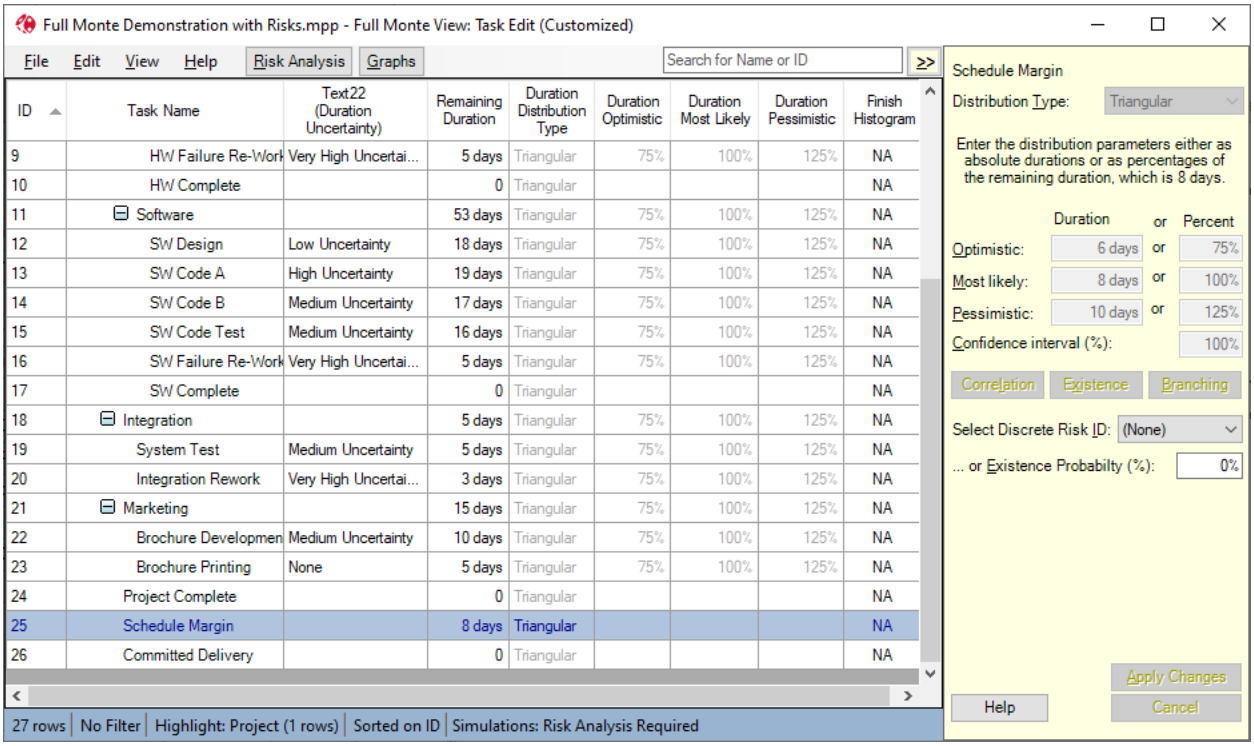


Figure G.3

For Schedule Margin activities, set the Schedule Margin Flag text value to any of "Yes", "True", "SM", or "MARGIN". Any other value will be ignored by Full Monte.

Results

When a project is opened in Full Monte and tasks/activities have been identified as Schedule Margin using the appropriate mechanisms described above, the Probability of Existence will be set to 0% and editing of the duration uncertainty values will also be disabled in the Task Edit view spreadsheet as shown in figure G.4.



ID	Task Name	Text22 (Duration Uncertainty)	Remaining Duration	Duration Distribution Type	Duration Optimistic	Duration Most Likely	Duration Pessimistic	Finish Histogram
9	HW Failure Re-Work	Very High Uncertai...	5 days	Triangular	75%	100%	125%	NA
10	HW Complete		0	Triangular				NA
11	Software		53 days	Triangular	75%	100%	125%	NA
12	SW Design	Low Uncertainty	18 days	Triangular	75%	100%	125%	NA
13	SW Code A	High Uncertainty	19 days	Triangular	75%	100%	125%	NA
14	SW Code B	Medium Uncertainty	17 days	Triangular	75%	100%	125%	NA
15	SW Code Test	Medium Uncertainty	16 days	Triangular	75%	100%	125%	NA
16	SW Failure Re-Work	Very High Uncertai...	5 days	Triangular	75%	100%	125%	NA
17	SW Complete		0	Triangular				NA
18	Integration		5 days	Triangular	75%	100%	125%	NA
19	System Test	Medium Uncertainty	5 days	Triangular	75%	100%	125%	NA
20	Integration Rework	Very High Uncertai...	3 days	Triangular	75%	100%	125%	NA
21	Marketing		15 days	Triangular	75%	100%	125%	NA
22	Brochure Developmen	Medium Uncertainty	10 days	Triangular	75%	100%	125%	NA
23	Brochure Printing	None	5 days	Triangular	75%	100%	125%	NA
24	Project Complete		0	Triangular				NA
25	Schedule Margin		8 days	Triangular				NA
26	Committed Delivery		0	Triangular				NA

Figure G.4

Observe the Duration Uncertainty values for task ID 25 (Schedule Margin) are blank, as they are for Milestones, and the Existence Probability (%) has been set to 0%.

After a Risk Analysis has been performed, the Finish Histogram for the Schedule Margin task will show **'NA'** as results are not calculated for tasks that are never active (Probability of Existence = 0%).

We can then review the Finish Histograms for 'Project (Work) Complete and Committed Delivery.

Project Complete

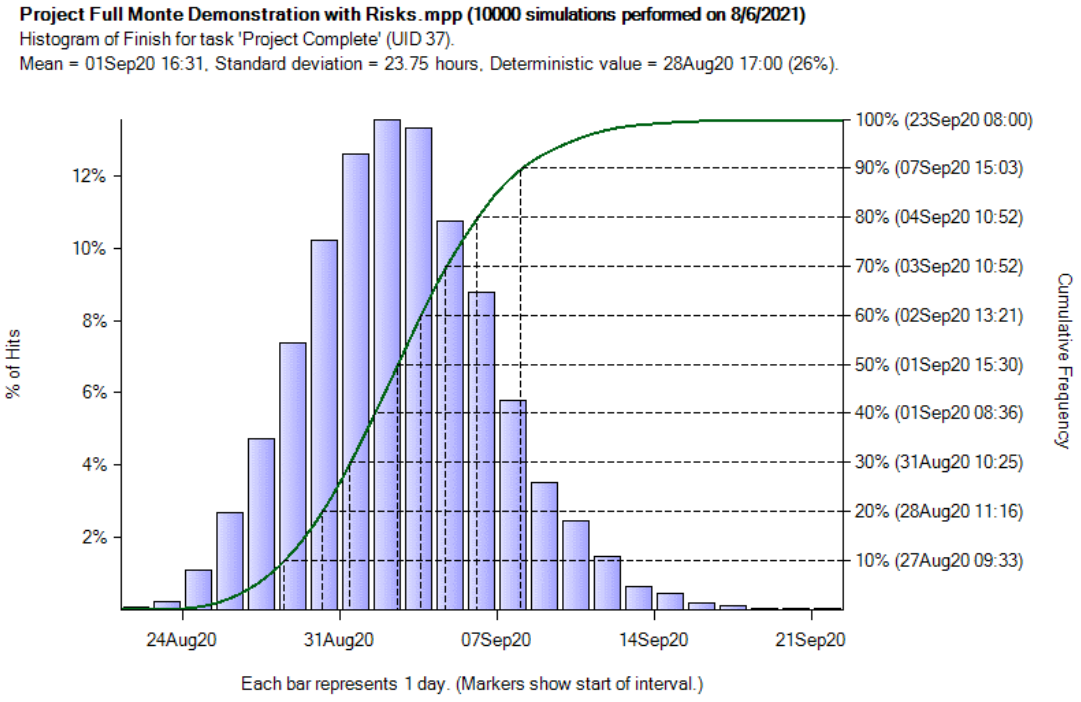


Figure G.5

Committed Delivery

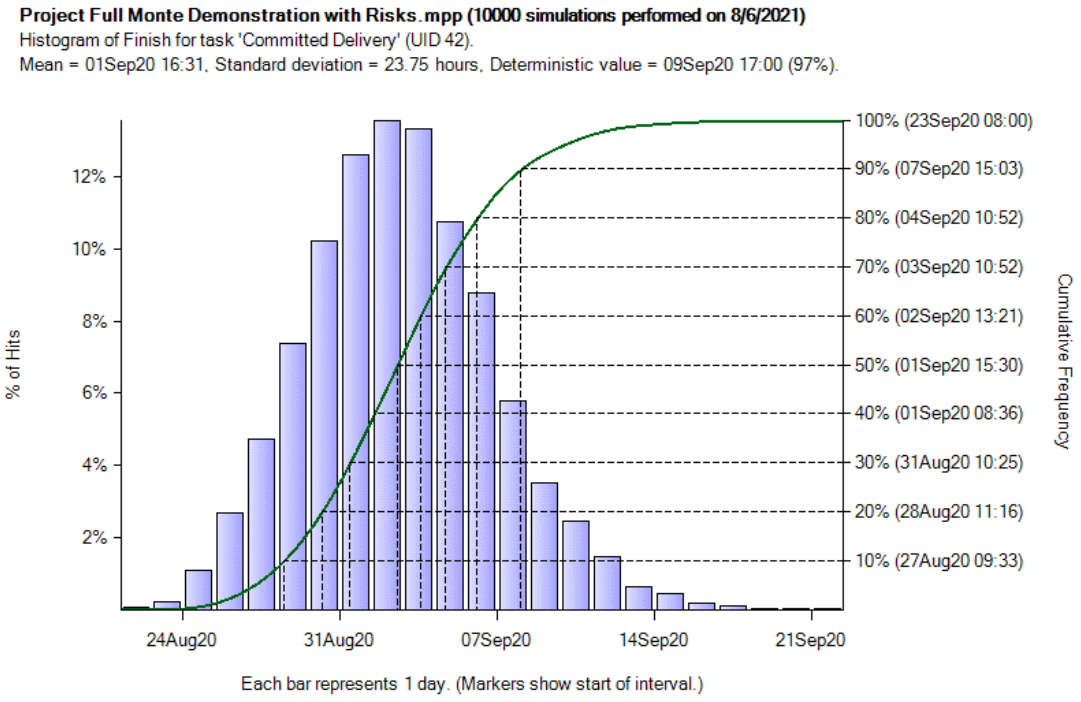


Figure G.6

In figure G.5 we see the probability of achieving the Project Complete deterministic finish of August 28 is just 26%. However, the probability of achieving the Committed Delivery deterministic date of September 9 shown in figure G.6 is 97%.

Assuming our goal is greater than 80% confidence in our ability to deliver to the customer by September 9, we can see that the 8 days Schedule Margin protecting the customer deliverable is more than adequate.

One important point to note is that the Committed Delivery is being logically driven by the Schedule Margin task in the schedule. Do not be tempted to apply a constraint date to the Committed Delivery as this will potentially introduce inappropriate slack/float in the schedule and invalidate the results of the schedule risk analysis.

Appendix H: Analysis Focal Items

Microsoft Project

Tasks in the schedule can optionally be marked/flagged as Analysis Focal Items using a custom Flag field.

A Full Monte Field Mapping can be defined to specify which Flag field is mapped to the Full Monte Analysis Focal Item field as shown in Figure F.1.

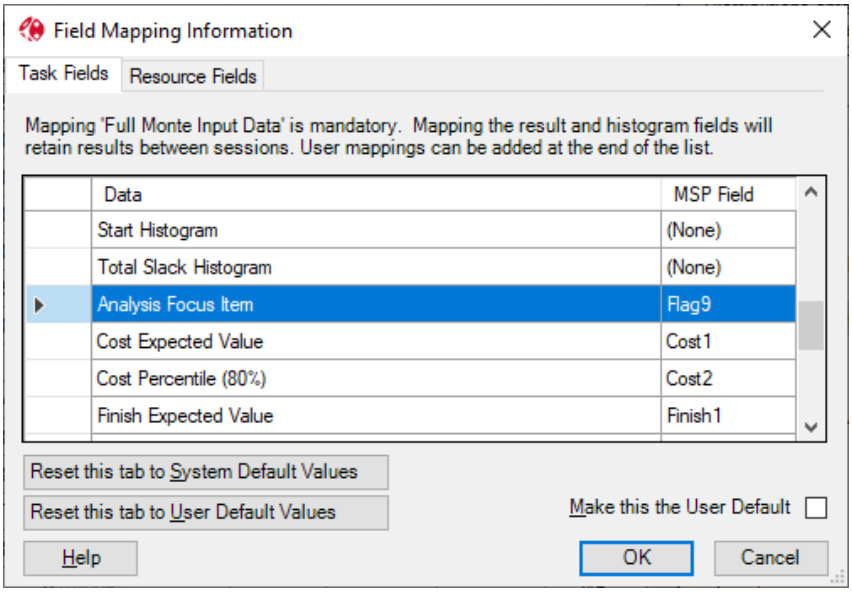


Figure F.1

In this example custom field Flag9 is being used to identify Analysis Focal Items.

Alternatively, if you do not wish to use Field Mapping to link Analysis Focal Items to a specific Flag field, the Full Monte File, Import mechanism can be used to load flag information as shown in Figure F.2.

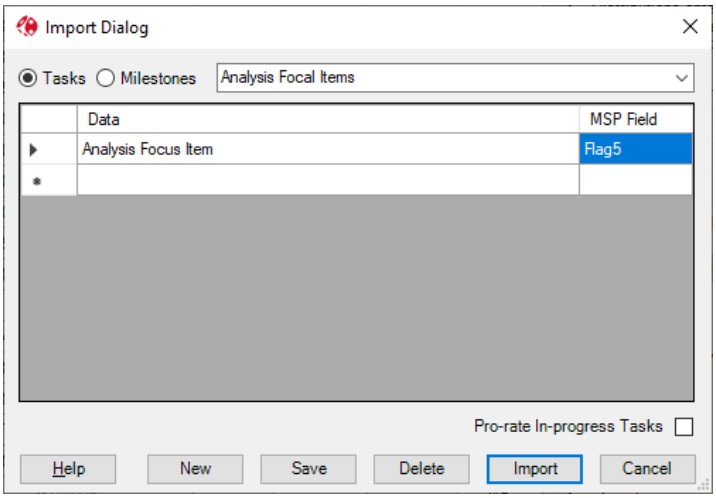


Figure F.2

Oracle Primavera P6

Create a User Defined Field called ‘Analysis Focal Item’ with a type of Text.

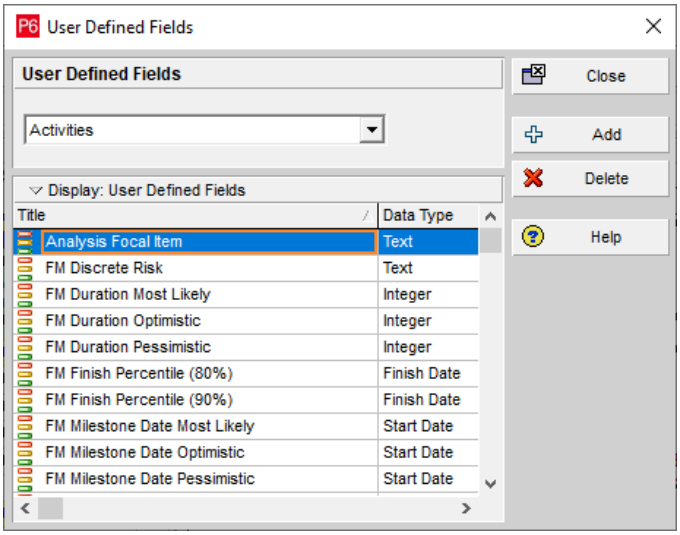


Figure F.3

On the relevant Activities, set the field ‘Analysis Focal Item’ to “Yes”.

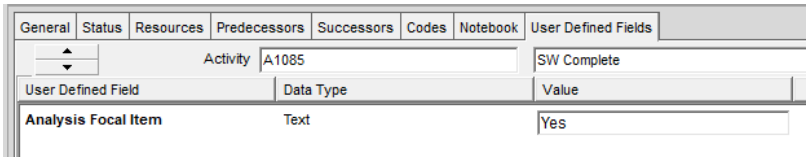


Figure F.4

Using Analysis Focal Item in views.

Create a filter like that shown in Figure F.5

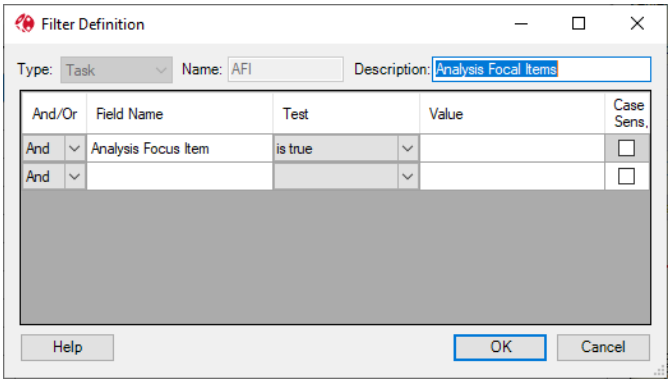


Figure F.5

Apply the filter to a view as shown in Figure F.6.

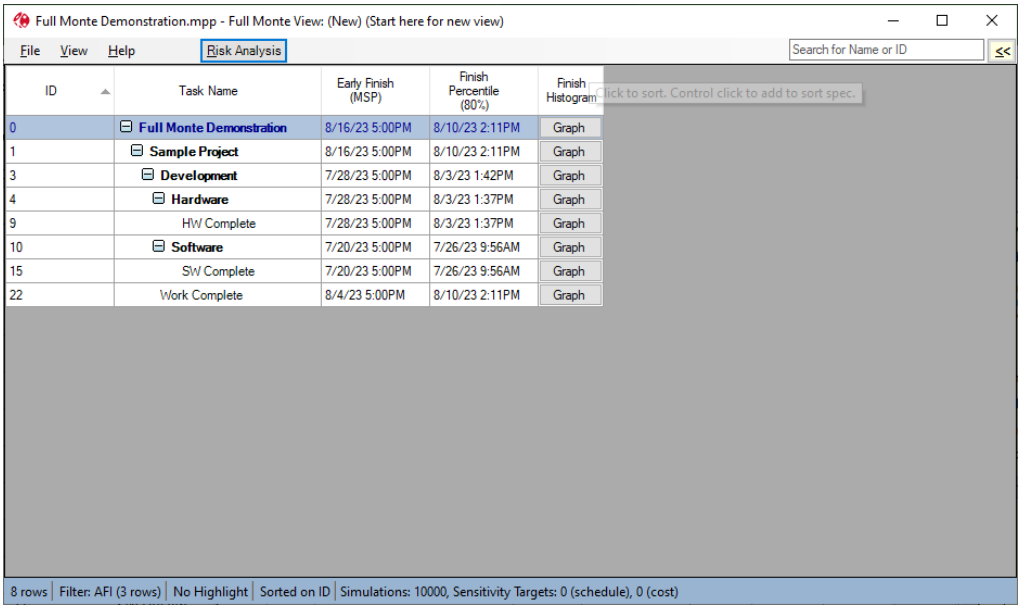


Figure F.6

A customer view has been created (View, Open Named View, (New) and the Analysis Focal Item filter (AFI) has been applied.

Alternatively, the Analysis Filter Items can be highlighted as shown in Figure F.7.

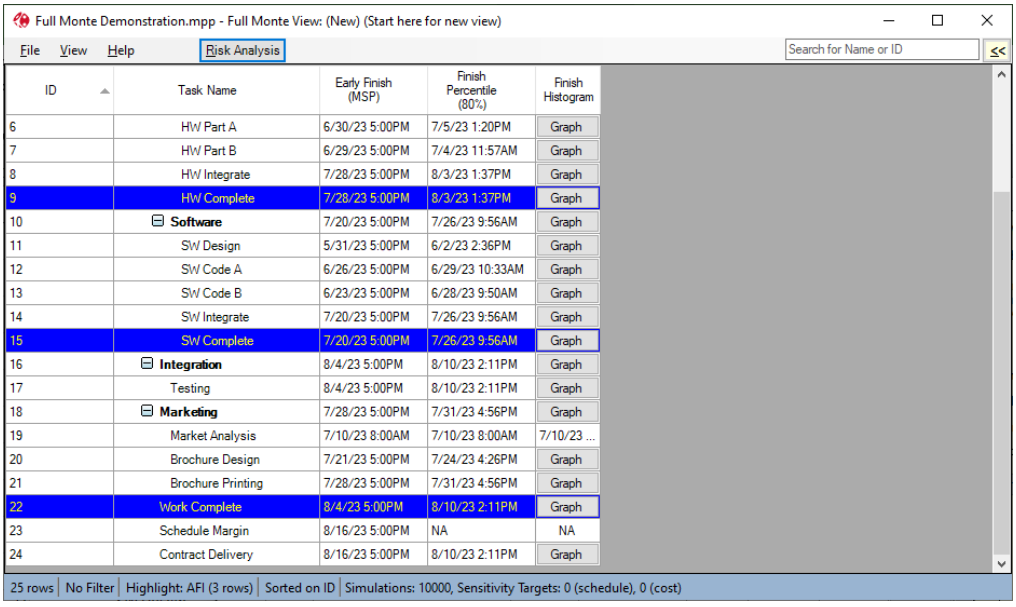


Figure F.7

Of course, you can combine both techniques as shown in Figure F.8.

ID	Task Name	Early Finish (MSP)	Finish Percentile (80%)	Finish Histogram
0	**Full Monte Demonstration**	8/16/23 5:00PM	8/10/23 2:11PM	Graph
1	**Sample Project**	8/16/23 5:00PM	8/10/23 2:11PM	Graph
3	**Development**	7/28/23 5:00PM	8/3/23 1:42PM	Graph
4	**Hardware**	7/28/23 5:00PM	8/3/23 1:37PM	Graph
9	HW Complete	7/28/23 5:00PM	8/3/23 1:37PM	Graph
10	**Software**	7/20/23 5:00PM	7/26/23 9:56AM	Graph
15	SW Complete	7/20/23 5:00PM	7/26/23 9:56AM	Graph
22	Work Complete	8/4/23 5:00PM	8/10/23 2:11PM	Graph

Figure F.8

Filter Schedule Sensitivity Target Pick List using Analysis Focal Items.

On the Full Monte options dialog User Interface tab, there is an option to 'Only Include Analysis Focal Items in Schedule Sensitivity Target Pick List.

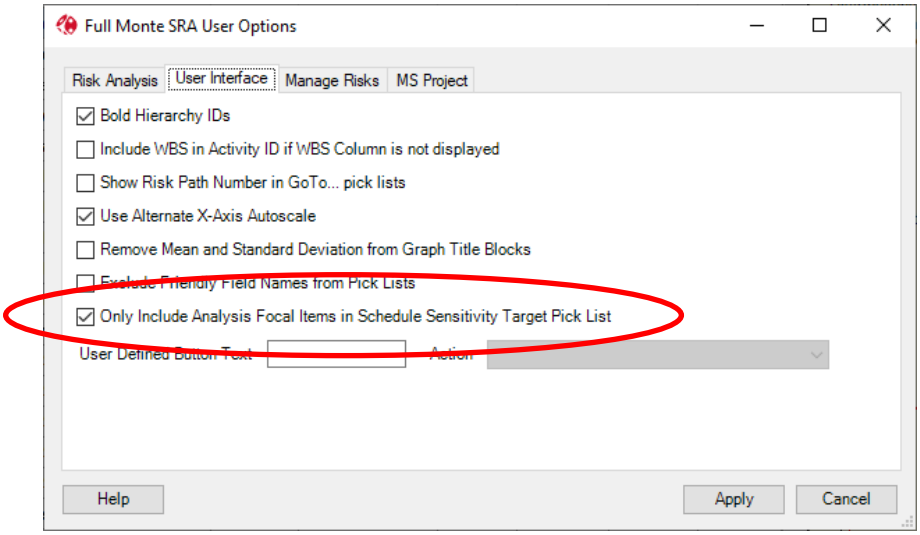


Figure F.9

If this option is enabled, and Analysis Focal Items have been identified, then the pick list for Schedule Sensitivity Target tasks on the Risk Analysis dialog will only show flagged tasks as shown in Figure F.10.

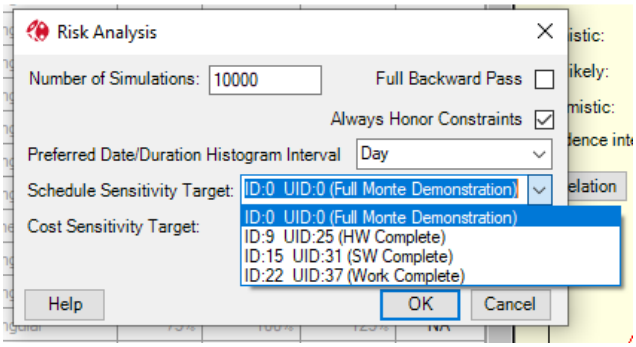
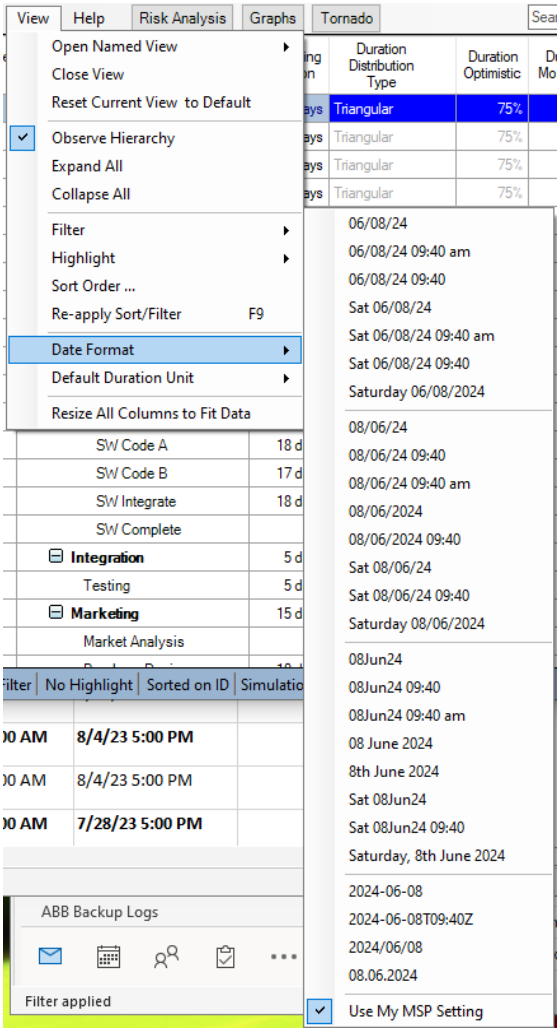


Figure F.10

Appendix I: Date Formats

Full Monte supports a wide range of date formats suitable for different locales and purposes. Each view has its own Date Format setting and any graphs opened from a specific view inherit the date format applied to the parent view.

As well as standard Full Monte date formats, the last option is to use the date format currently applied in the host scheduling tool.



In the Date Format list, the first group are Month/Day/year, the second group are Day/Month/Year, the third group show alphabetic months and the fourth group are ISO and EU standards.

It is also possible for the user to define their own date formats to replace those available in the standard list.

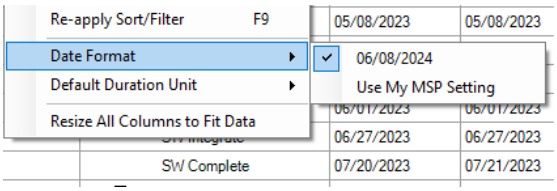
This is managed through a file called FullMonteDateFormats.txt in the Full Monte local folder (default is <documents\Barbecana\Full Monte MSP or P6). The file will need to created by the user.

Note: if the file FullMonteDateFormats exists, then the standard Full Monte date formats are not available.

For example, if we need to display the following date format MM/DD/YYYY that is not included in the standard options, we would add the following line to FullMonteDateFormats.txt.

M/D/Y

And in Full Monte the date format options would display:



You can add multiple format definitions, one per line.

Other examples:

Format	**Example**
M/D/Y	01/31/2024
m/d/y	1/31/24
d.m.y	31/1/24
M/D/y	01/31/24
M/D/y h:tp	01/31/24 10:06am
M/D/y h:tP	01/31/24 10:06AM

Valid format characters are:

d	Day of month with no leading zero
D	Day of month with leading zero for days less than 10
w	Three character day (Mon)
W	Full day (Monday)
m	Month number with no leading zero
M	Month number with leading zero for months less than 10
a	Three character month (Jan)
A	Three character month (JAN)
l	Month in full (January)
L	Month in full (JANUARY)
y	Two digit year
Y	Four digit year
h	Hour (12 or 24 hour format depending on presence of P option)
t	Minutes
p	Lower case am/pm
P	Uppercase AM/PM

Any other characters are included as-is.

For example, d*m*y would display as 31*01*24.

Bibliography

Hoel, Paul G., *Introduction to Mathematical Statistics,* Wiley, 1984.

An academic introductory text on the subject of probability.

Hubbard, Douglas. *The Failure of Risk Management*, Wiley, 2009.
This book is not about project management specifically, but it does mention it in passing. It also has some very useful exercises to calibrate your ability to make subjective probability estimates.

Raydugin, Yuri. Project Risk Management, Wiley, 2013.
An up-to-date and comprehensive guide to all aspects of project risk management, this new book devotes over 80 pages to the Monte Carlo method.

Savage, Sam L. *The Flaw of Averages: Why We Underestimate Risk in the Face of Uncertainty,* Wiley, 2012.
This book is an entertaining read about the danger of using single-point estimates. Again, it is not specifically about project management, but it does cite it as an example of what Sam calls the "Strong Flaw of Averages."

URLs

Empirical arguments for the use of the lognormal distribution:

http://mba.tuck.dartmouth.edu/pss/Notes/LognormalParkinson.pdf

http://mba.tuck.dartmouth.edu/pss/Notes/PERT21.pdf

Full range of the beta distribution:

http://en.wikipedia.org/wiki/Beta_distribution

Scatter plots of variables with different correlation coefficients, including some that have a coefficient of zero but are clearly not independent:

http://en.wikipedia.org/wiki/Correlation_and_dependence

Barbecana How To… documents

https://www.barbecana.com/full-monte/full-monte-documents/

Barbecana White Papers:
https://www.barbecana.com/full-monte/white-papers/