PTC®

Getting Started Guide

Windchill Quality Solutions 10.0

November 2011

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Introduction to Windchill Quality Solutions

Thank you for your interest in Windchill Quality Solutions®. Windchill Quality Solutions represents the next generation in reliability analysis software, and it is your key to achieving reliability excellence.

With Windchill Quality Solutions, you can predict the reliability and maintainability of your system, evaluate critical failure modes, model your complete system to analyze reliability and availability metrics, and perform a wide array of additional reliability analysis functions.

Once installed, your Tryout version is active for 30 days. When the 30-day trial period expires, a message box will appear when you attempt to operate Windchill Quality Solutions. Please contact us at that time if you are ready to purchase Windchill Quality Solutions or need further information about your evaluation.

The Tryout version limits the amount of data you can add to your Projects, but it will still enable you to fully explore all of the software's capabilities. During operation, if the data limit for a particular data element is reached, you will receive a warning message that no further data can be added.

There are a few important points to take note of when using this guide:

- First, please review the sections Getting Started on page 9 and Common Features on page 23. These sections will introduce you to the basic concepts of Windchill Quality Solutions. Once you have reviewed these sections, you may

continue with any of the module-specific sections or progress step-by-step through each section.

- You do not have to complete the module-specific sections in any particular order. However, this guide assumes that, individually, each section is completed from beginning to end.
- This guide assumes that you are operating the Windchill Quality Solutions Tryout version. You may also use this guide with a licensed version of Windchill Quality Solutions.
- The Windchill Quality Solutions Tryout version is based on the Team Edition. You may use this guide with the Enterprise Edition as well. While there will be some notable differences in these cases, the overall features and functionality will remain the same across the Editions. One significant difference is that in the Enterprise Edition, you are required to log in using a Windchill Quality Solutions user name and password. It is also possible that some of the functions detailed in the guide may be unavailable to you in the Enterprise version, depending on the permissions established for you by your Windchill Quality Solutions Administrator.
- You can open an Adobe Acrobat® version of this guide by clicking **View the Getting Started Guide PDF** in the **Links** section of the **Start Page**. You may also print the PDF version if you prefer a hard copy of this guide.

We hope that you find this guide helpful as an introduction to Windchill Quality Solutions. Once you are comfortable with the basics, you will find further details on the wide array of features available by accessing the help; the help provides comprehensive information about all aspects of your Windchill Quality Solutions package.

Welcome!

2

Getting Started

This section of the *Windchill Quality Solutions Getting Started Guide* introduces you to the interface and describes how to work with projects. You learn how to start and exit Windchill Quality Solutions and how to use the **Project Navigator** to create new Projects and open and close existing Projects.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Starting Windchill Quality Solutions

You can start Windchill Quality Solutions using either of the standard Windows® methods:

- Double-click the shortcut to **Windchill Quality Solutions 10.0 Tryout** on your Windows desktop.
- From the Windows Start menu, select **[All] Programs ▸ Windchill Quality Solutions 10.0 Tryout ▸ Windchill Quality Solutions 10.0 Tryout**.

Note

If you are running a licensed version, the program name does not include the word "Tryout."

Selecting the Modules to Evaluate

Once Windchill Quality Solutions is started, the **Modules Selection** window opens. The **Modules Selection** window lists all modules. In the Tryout version, no modules are selected for use by default, and you must select at least one module to start. Clicking a module button alternates between enabling and disabling the module for use.

1. Click **Prediction**. Make sure that this button is enabled (depressed) and all other buttons are disabled (raised).

   Note

   *If you are not using a Tryout version, all the product modules that you have purchased are available for selection. Click **Clear All** and then click **Prediction**.*

2. Click **OK** to display the **Start Page**

Exiting Windchill Quality Solutions

To exit Windchill Quality Solutions at any time, do one of the following:

- Select **File ▸ Exit**.
- Click the **Close** button in the top right corner of the application window.

Start Page

The **Start Page** is the startup center for Windchill Quality Solutions. The following sections provide all of the information you need to put the many advanced features of the **Start Page** to immediate use.

The following topics discuss:

Start Page Sections

The **Start Page** has a number of sections designed to help you use your Windchill Quality Solutions package efficiently.

Recent Files

The **Recent Files** list displays the latest files that you have opened. When file names appear in this list, you can simply click the file name to open the file.

Notice also the **New Project** link in the title bar of the **Recent Files** list. Clicking this link starts the **New Project Wizard**, allowing you to create a new Project right from the **Start Page**. This window and the **New Project Wizard** are described later in this guide.

Announcements

The **Announcements** section provides the ability to post announcements and to review announcements posted by others. This is a great mechanism for communication within your team.

Each announcement includes a title, the name of the person posting the announcement, and the announcement itself. Announcements marked “High Priority” appear in red.

To add a new announcement:

1. Click **New** on the right side of the **Announcements** title bar. The **Add New Announcement** window opens.
2. For **Title**, enter `ANew Announcement`.
3. For **Message**, enter `I've posted my first announcement`.
4. For **Expiration**, use the date control to select tomorrow's date. Do not select the **High priority** check box for this announcement.
5. When finished, click **OK** to post your new announcement in the list.

To delete an announcement:

1. Right-click the announcement you just entered and select **Delete**.
2. Click **OK** when asked to confirm the deletion.

   Your announcement is deleted from the list.

Note that there is also an **Edit** command on the menu which enables you to update an announcement title or message.

Links

The **Links** section enables you to add a hyperlink to your Start page for quick and easy access to a specific internet resource. For example, if you have a website that you visit frequently, you can create a link to it and include it in the **Links** section.

Several important links are already listed for you, including:

1. The **Getting Started Guide: A Step-by-Step Tutorial** link displays this guide on your screen.
2. The **View the Getting Started Guide PDF** link displays an Adobe Acrobat version of the *Windchill Quality Solutions Getting Started Guide*.
3. The **Windchill Quality Solutions Website** link takes you to the Windchill Quality Solutions home page on the PTC website.
4. The **PTC Customer Support** link takes you to the technical support area of the PTC website. To access some features of the technical support area, you must have an active customer support online account.

To add a link:

1. Click **New** on the right side of the **Links** title bar. The **Add New Link** window opens.
2. For **Display text**, enter `Google`.
3. For **Link**, enter `www.google.com`.
4. Click **OK** to add the Google® link to the **Links** list. If you have Internet access, you can click this link to go to this website.

To delete a link:

1. Right-click the Google link and select **Delete**.
2. Click **OK** when asked to confirm the deletion.

Note that there is also an **Edit** command on the menu, which you can use to modify a link.

Note

If you are using the Enterprise Edition, two additional sections appear on the ***Start Page****:* ***Workflow*** *and* ***Alerts****.*

Workflow

Workflow capabilities allow you to control your process flow by notifying appropriate personnel when actions are required. By utilizing the Workflow feature, you can effectively manage your processes to keep your reliability activities on track.

The **Workflow** section of the **Start Page** displays all the workflow items assigned to you. When you place the mouse cursor over an item in the Workflow list, a popup window displays the email message associated with that workflow item. If you click an item in the list, Windchill Quality Solutions opens the corresponding file and displays the associated data.

Alerts

The Alert application automatically notifies users when specified events occur. By monitoring your reliability data, this application detects when key events occur and then automatically sends out alert emails.

Similar to the **Workflow** section, the **Alerts** section displays all alerts that have been sent to you. Simply place the mouse cursor over an item in the **Alert** list; a popup window displays the email message associated with that alert item. When you click an item in the list, Windchill Quality Solutions opens the corresponding file and displays the associated data.

Start Page Additional Features

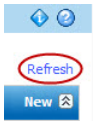
The **Start Page** includes the following additional features.

Expand/Collapse

In the right corner of each section's title bar, notice the small icon that looks like two arrows. This is the **Expand/Collapse** button. If you want to collapse a particular section of the **Start Page**, click the collapse button  . To expand the section back, click the expand button  .

Refresh

On the upper right side of the **Start Page**, there is a **Refresh** link. If you click this link, the **Start Page** is updated with the most current information.

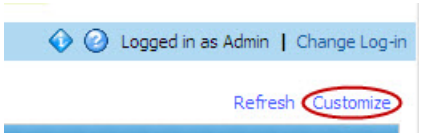


Customize

In the Enterprise Edition, the **Customize** link appears to the right of the **Refresh** link. If you click this link, the **Customize Start Page** window opens. In this window, you can selectively enable and disable the five sections that appear on the **Start Page** in Enterprise Edition: Recent Files, Announcements, Workflow, Alerts, and Links.

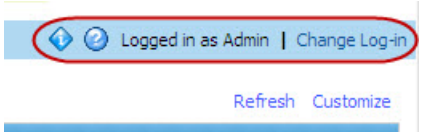
Note

*The **Customize** link appears **only** in the Enterprise Edition.*



Link Bar

In the header area of the **Start Page**, a number of icons and links appear on the rightmost side.



- The about icon displays information about your software.
- The help icon opens the Help.
- In the Enterprise Edition, the **Logged in as** information displays the user name you used when you logged in to this session.
- In the Enterprise Edition, the **Change Log-in** link allows you to change your login to a different user without having to restart.

Note

*The **Logged in as** option and **Change Login** link appear **only** in the Enterprise Edition.*

Let’s put some of these features to use.

1. Click the about icon  to open the **About Windchill Quality Solutions** window.

   When using this type of window, you can click any item in the left pane to change the contents in the right pane so that the selected property page is shown.

   a. If the **Copyright** page is not selected, select it. You can see the copyright notice about your software.

   b. Select the **License** page. If you are running a licensed version, your Customer ID, Serial Number, and Edition are displayed.

   c. Select the **Authorized Options** page. On this page, you can see all the modules that you can activate.

   d. Select the **File Versions** page. You can see a listing of the Windchill Quality Solutions files and their identifying version numbers and dates.

   e. Select the **My Data Directories** page. You can see the where your data files, Library files, and personal options are stored.

   f. To close the **About Windchill Quality Solutions** window, press **OK**.

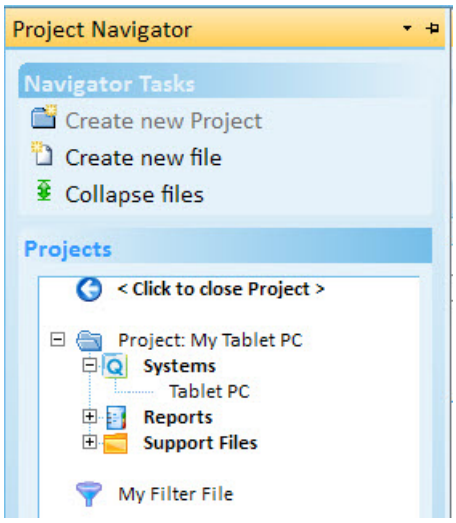
2. The help icon  activates the HTML-based help system installed with your software.

   For more information, see “Windchill Quality Solutions Documentation and Help” in the “Welcome!” section of the help.

Project Navigator

At the heart of Windchill Quality Solutions is the **Project Navigator**.

The **Project Navigator** allows you to easily open Projects and files, generate reports and graphs, create files, and access many other frequently used functions from a single location. The following section describes the **Project Navigator**.



The **Project Navigator** is an auto-hide window. Initially, it is in auto-hide mode. A tab for sliding this window out into view is located on the left side of the main window.

When you place the mouse cursor over this tab, the window slides into view. When you move the mouse cursor outside of the **Project Navigator** window (or any window operating in the auto-hide mode), the window slides out of view. Thus, the **Project Navigator** can easily be shown when you need it, then hidden when you do not.

You can also dock the window, so that it is always available to you. To take the window out of the auto-hide mode:

1. Place the mouse cursor over the **Project Navigator** tab to bring the window into view.
2. Click the pushpin icon in the upper right corner of the window.

The pushpin icon changes to a vertical orientation ( ), indicating that the window is now "pinned" into place. This means that the **Project Navigator** does not slide out of view when you move the mouse cursor outside of the window. Any time the pushpin icon in the upper right corner of an auto-hide window is shown vertically, the window is pinned into place.

To unpin the window and put it back into auto-hide mode, click the pushpin icon again. The pushpin icon changes to a horizontal orientation ( ), indicating that the window is now operating in the auto-hide mode.

You can either keep the **Project Navigator** in the auto-hide mode, sliding it in or out of view as needed, or dock it into place in the main window. Select the setting that you prefer.

With the exception of the **Project Navigator**, auto-hide windows can be closed by clicking the **x** in the upper right corner of the window.

Working with Projects

Your starting point is the Project. The Project contains the framework in which you enter data, run calculations, generate reports and graphs, and perform all of your reliability analysis tasks.

In some cases, you may want to start with a new Project. In other instances, you may want to create a Project based on an existing Project.

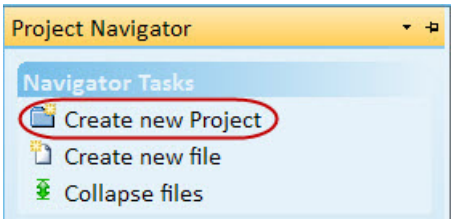
We begin by creating a Project.

Note

If someone has previously run through the Windchill Quality Solutions Getting Started Guide *using the same copy of the software, the Project* ***My Tablet PC*** *would be listed in the* ***Project Navigator*** *and/or the* ***Recent Files*** *list on the* ***Start Page****. Before running through the rest of this guide, delete this Project by right-clicking on the Project name in the* ***Project Navigator*** *and selecting* ***Delete****.*

Creating a Blank Project

1. In the **Project Navigator**, click **Create new Project**.



When the **Create Tryout Project** window opens, the **Directory** and **Name** fields are filled in.

2. In the **Name** field, enter `My New Project`.
3. Select **Run New Project Wizard**.
4. Click **OK**.

   Note

   If a Project with this name is found, Windchill Quality Solutions displays a message that the Project already exists. You would need to either cancel the Project creation or enter a different name to create the Project.

   The **New Project Wizard** starts and displays the **Select Project Starting Point** page.
5. Select **Create a new Project** and click **Next**. The **Select Project Modules** page appears.

   You can use the **Select All** and **Clear All** buttons to select or clear all check boxes. Repeatedly clicking a check box switches between selecting and clearing it.
6. Click **Select All** and then click **Next**. The **Set Project Properties** page appears. For this Project, accept the defaults.
7. Click **Next**. The **Select Common Library Files** page opens. It lists all of the files in the Common Library, a special Project where you keep the files that you want available to all Projects that you create. All of the supplied Report Design and Graph Template files are included in the Common Library by default. For this Project, accept the defaults.
8. Click **Next**. The **Specify FMEA Setup** page appears.
9. Use the default selection of **Set up FMEA now** and click **Next**. The **Select FMEA Worksheet Type** page appears.

   The **FMEA Worksheet Type** allows you to select from a set of supplied standard FMEA layouts for performing your FMEA (Failure Mode and Effects Analysis) tasks.
10. Use the default selection of **FMEA Standard Template**, and then click **Next**. The **Select FMEA Modes Library** page appears.

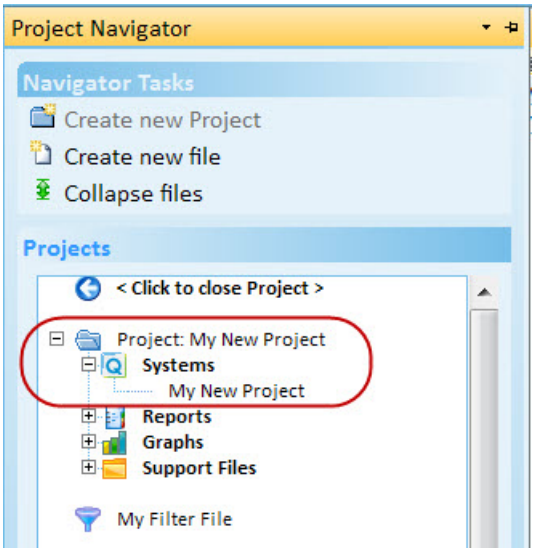
    The **Select FMEA Modes Library** allows you to select from the list of FMEA Modes Libraries to use when performing component FMEAs.
11. Use the default selection of **FMD97 Modes - Tryout**; then, click **Next**. The **Set FMEA Options** page appears.

    This page enables you to specify whether any local effects that are entered during FMEA data entry are automatically rolled up as failure modes at the

next level of your FMEA hierarchy. You can also enable the display of tables for control plans and DVPs here.

12. For this example, make sure all check boxes are cleared so that modes are not rolled up and control plans and DVP are not enabled. Then, click **Next**. The **Wizard Complete** page appears.
13. Click **Finish** to complete Project creation.

    Progress indicators appear as the Project is created and opened. Once the process is completed, an empty System file opens.
14. Slide the **Project Navigator** into view. Your newly created Project is now open and appears in the **Project Navigator** list. You can see the name of your new Project in the top heading designated by the open folder icon - **My New Project**.



    The term Project is used to denote the entire entity that encompasses all of your analysis files. For example, in the **Project Navigator**, you can see Systems, Reports, and Graphs headings. These are some of the types of files that are contained in your Project.

    The first heading, Systems, refers to the main files which contain reliability analysis data. For example, all of your data is stored in System files. In this case, you can see one System file listed: `My New Project`. You may have more than one System file open in a Project; in this case, we only use one.

    The other files in your Project, such as Reports and Graphs, are used to support your reliability tasks, such as generating reports and graphical outputs of your data.
15. Slide the **Project Navigator** out of view. Because your new System is empty, there is no data displayed in the windows.

Closing a Project File

Close the `My New Project` Project.

1. Slide the **Project Navigator** into view.
2. Click **Click to close Project**.

The **Project Navigator** shows a list of Projects, which includes the supplied samples as well as the new Project that you just created.

Opening a Project and System File

To open a System file, follow these steps:

1. In the **Project Navigator**, under **My New Project**, click **My New Project** to open your System file.
2. Once again, close your Project by clicking **Click to close Project** in the **Project Navigator**.

   Notice that `My New Project` appears in the **Recent Files** list on the **Start Page**.

   Tip

   *Clicking the links in the **Recent Files** list is another way to open Project and System files.*

Creating a Project from an Existing Project

In some cases, you might want to create a new Project from an existing Project. The existing Project can be one you set up yourself or it can be created from a supplied template. Windchill Quality Solutions includes both sample Projects and templates that can be used as a starting point for creating your own Project. You may find they are close to what you require and only need some minor modifications.

This topic describes how to create a Project based on the `Tablet PC Sample` Project. The new Project that we create in this section can then be used as a basis for the remainder of this guide.

1. In the **Project Navigator**, click **Create new Project**. The **Create Tryout Project** window opens.
2. In the **Name** field, enter `My Tablet PC`.
3. Select **Run New Project Wizard**.
4. Click **OK**. The **New Project Wizard** starts and displays the **Select Project Starting Point** page.

If a Project with this name is found, a window appears with the message that the Project already exists. You can either cancel the Project creation or enter a different name to create the Project.

5. Select the **Create from a Sample Project** option and click **Next**. The **Select Project** page appears.
6. Select the **Tablet PC Sample** Project and click **Next**. The **Wizard Complete** page of the wizard appears.
7. Click **Finish** to complete Project creation.

Progress indicators appear as the Project is created and opened. Once the process is completed, the System file opens and shows all of the data from the System file in the `Tablet PC Sample` Project.

Module Selections Toolbar

In the procedures in this guide, we make use of the **Module Selections** toolbar. This toolbar is enabled by default and appears in the toolbar area at the top of the window.

The **Module Selections** toolbar allows you to activate and deactivate modules. Using this toolbar enables you to concentrate on the modules you are actively working with, making your desktop easier to navigate. For this guide, we activate one module at a time in order to show only the windows associated with the modules we are actively working with.

If you selected only the Prediction button in the **Modules Selection** window when first starting Windchill Quality Solutions, only the Prediction button is enabled. The buttons for enabled modules are highlighted.

1. Click the FTA icon  on the **Module Selections** toolbar to enable Windchill FTA along with Windchill Prediction.

   With both Windchill FTA and Windchill Prediction enabled, tabbed windows for both of these modules are shown.

2. Click the Prediction icon  to remove the Windchill Prediction windows.

   You can also hide and show the windows associated with particular modules using the first button on the toolbar. The tooltip for this button indicates that it opens a window for configuring selected modules.

3. Click the all modules icon  on the **Module Selections** toolbar.

A window opens for making multiple module selections.

4. In this window, do the following:
   a. Click **Clear All**.
   b. Click **Prediction**.
   c. Click **OK**.

Moving On

This section introduced you to some of the introductory features of Windchill Quality Solutions. You can now explore some of the features common to all of the modules.

3

Common Features

Windchill Quality Solutions supports a number of features common across all modules. You can run calculations, view outputs such as graphs or reports, import information from files, filter for desired data, and customize tables.

Although the functions covered in this section are available across all modules, they are covered here, rather than in the specific module sections, in order to avoid the constant repetition of these common tasks. Instead, this section uses Windchill Prediction as a starting place for reviewing this functionality.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Getting Started

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill Prediction module. For more information, see Starting Windchill Prediction on page 24.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project:** label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill Prediction

On the **Module Selections** toolbar at the top right of the window, make sure the Prediction icon  is selected and all other module icons are deselected.

Tour of the Interface

When you open a system, the tables and forms for the selected module(s) appear by default in the upper and lower panes of the main window. When multiple tables and forms are available in either the upper or lower pane, tabs are shown. To display the window for a particular table or form, select its tab.

In the Prediction module you are currently viewing, you see the **System Tree Items** in the top pane and information for the selected system tree item in the bottom pane; the type of information displayed in the bottom pane depends on the tab selected. These are the default views; however, almost all elements of your user interface can be customized. You customize the appearance of your tables in a later section.

Reviewing Data

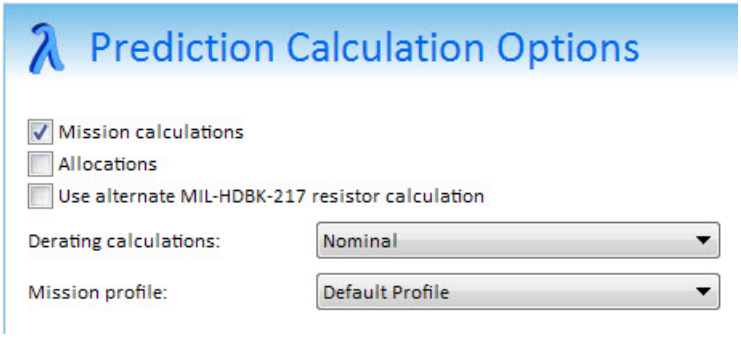
1. In the **System Tree Items** table, select the **Motherboard** assembly.
2. If necessary, select the **Prediction Parts** table in the lower pane to make it active. The list of parts that make up the Motherboard assembly is shown.
3. In the **Prediction Parts** table, click the **Static RAM** part. This part has a part number of SRAM031.
4. Review the fields available in the **Prediction Parts** table. You can see that this part is a memory device. There are four of these parts on the Motherboard, which are assigned reference designators of U3 through U6.
5. Click **Prediction Data** to view the specific parameters associated with this part.
6. Click **General Data** to view the general data associated with this part.

Performing Calculations

To perform calculations:

1. Select **System** ▸ **Calculate**, or click the calculate  icon on the **Standard** toolbar. The **Calculate** window opens.
2. In the left pane, select **Calculation Selection** (if necessary).
3. In the right pane, click **Clear All** and select **Prediction** to perform calculations only for the Prediction module.
4. In the left pane, select **Prediction**.
5. Leave **Mission calculations** selected and all other check boxes cleared.

6. Leave **Derating calculations** set to **Nominal** and **Mission profile** set to **Default Profile**.



7. Click **OK** to perform the calculations. The **Calculation Progress** pane opens and displays status information. When the calculations are complete, the **View Calculation Results** window opens.

   Tip

   *You can print your calculation results by clicking **Print** in the **View Calculation Results** window. You can also save them to a Microsoft® Excel® spreadsheet by clicking **Excel**.*

8. Click **Close** when you have finished reviewing results.

To redisplay the results at any time, select **System ▸ View Calculation Results**. If you have only one module enabled, the results are displayed for that module. If you have more than one module enabled, select the appropriate page to view the results. When finished, click **Close**.

Generating Reports

The reporting capabilities within Windchill Quality Solutions are extensive, and include the ability to view a report, print a report, generate a report to a file, and create a custom report. We begin by selecting one of the supplied Report Designs to generate a report.

Viewing a Report

1. In the **Project Navigator**, under **Reports > Prediction Reports,** select **(Common) Prediction (Summary)** to generate this default report in the **Preview** window.

   This report outputs data on all assemblies in the System file, including assembly names, part numbers, reference designators, quantities, and calculation results for failure rate and MTBF.

   You can use the various toolbar buttons in the **Preview** window to page through your report, zoom in and out, and print the report.

2. When finished viewing the report, do one of the following to close the **Preview** window:
   - Select **Preview** ▸ **Close**.
   - Click the close icon on the toolbar.

Alternatively, you can preview a report by selecting **File** ▸ **Print Preview**.

Printing a Report

When previewing a report, you can print it by clicking the print icon in the **Print Preview** toolbar.

You can also print directly to a printer:

1. Select **File** ▸ **Print**. The **Select Report to Print** window opens.
2. Select the appropriate report.
3. Click **OK**. The **Print** window opens and allows you to select the printer.

Generating a Report to a File

You may also print a report to a file, which is useful if you wish to email report files to colleagues or save report files for later viewing. Windchill Quality Solutions supports several file formats for reports.

1. Select **File** ▸ **Print**. The **Select Report to Print** window opens.
2. Select **(Common) Prediction (Summary)**.
3. For **Print to file**, click the browse icon to display the **Print to File** window.
4. For **Save as type**, select a file format that you know you can view on your computer. For example, if you have Adobe Reader installed, you can select **PDF Format (*.pdf)**. If you have Microsoft Word installed, you can select **Microsoft WordDocument (*.doc)**. If you are unsure, select **Rich Text Format(*.rtf)**.
5. For **File name**, enter `My Reliability Prediction`.
6. Ensure **Open file in editor after printing** is selected.

Note

If you were unsure in step 4 whether you have the correct application needed for viewing the file, such as Microsoft Word® or Adobe® Reader®, please clear ***Open file in editor after printing****. If this option is selected and the appropriate viewing application is not installed, the file is created, but it cannot be opened on-screen.*

7. Click **Create**. The **Select Report to Print** window becomes active again, with the **Print to file** field completed appropriately.
8. Click **OK**. Progress bars appear while the report file is generated and opened in the associated application.
9. When you have finished viewing this file, close the application. Or, if the file is opened in the main window, select **File ▸ Close**.

Creating Custom Reports

The **Report Wizard** enables you to easily create custom Report Designs to use. The wizard provides a step-by-step process to walk you through a series of questions regarding the Report Design to create. Once you have created a Report Design, you can save it for continued use.

1. To start, select the **Prediction Parts** table in the lower pane to make it active.
2. Select **Tools ▸ Report Wizard**. The **Report Wizard** starts, and the **Select Data Fields** page appears.

   Notice that the fields that are shown in the **Prediction Parts** table are automatically selected for you. The **Report Wizard** initializes the selected fields based on the table or form you have selected to ease the creation of the Report Design.
3. For **Table type**, select **Prediction Parts**. Ensure the selected fields include **Name (Prediction Parts)**, **Part Number (Prediction Parts)**, and **Part Classification (Prediction Parts)**. If this is not the case, click **Cancel** to exit the **Report Wizard** and start over at step 1 again.
4. For **Selected fields**, select **Part Classification (Prediction Parts)** and click **Remove** to remove it from the list.

   Also remove the following fields:

   - **Calculation Model (Prediction Parts)**
   - **Tagged Part? (Prediction Parts)**
   - **Failure Rate, Percentage (Prediction Parts)**

     Make sure the following fields are in the **Selected fields** list: **Name (Prediction Parts)**; **Part Number (Prediction Parts)**; **Category (Prediction Parts)**; **Subcategory (Prediction Parts)**; **Reference Designator (Prediction**

Parts); **Quantity (Prediction Parts)**; and **Failure Rate, Predicted (Prediction Parts)**.

5. Click **Next**. The **Select Filter** page appears.
6. For **Filter**, leave **– No Filter –** selected and click **Next**. The **Specify Data Grouping** page appears. Here you can group data into categories.

   For example, if you selected to group based on the field **Category**, your report would show all integrated circuits together in a section, all resistors together in a section, etc. For this example, we do not group items in any way.
7. Leave **Selected fields** blank and click **Next**. The **Specify Sort** page appears.
8. In the first selection box, select **Failure Rate, Predicted (Prediction Parts)**. Clear the **Ascending** check box so that the failure rate data is sorted in descending order; then, click **Next**. The **Select Layout** page appears.
9. For **Layout**, select **Horizontal**.
10. For **Orientation**, select **Landscape**, then click **Next**. The **Report Style** page appears.
11. Select **Corporate** and click **Next**. The **Report Title** page appears.
12. For the **Title**, enter `My Prediction Report` and click **Next**. The **Wizard Complete** page appears.
13. Click **Finish**. The report is generated and displayed on-screen, where you see a listing of all parts in order of descending failure rate.

    You may notice a few items you want to modify in the Report Design. For example, perhaps you want to rename a column heading to make it more descriptive or to shorten it.

    Also, notice that some columns are wrapping. In this case, you can choose to edit the Report Design to change the width of these columns. The **Report Wizard** is designed to create a Report Design file similar to what you want, which you can then modify to suit your needs. Though you can directly place data fields onto your report using the Report Designer, the **Report Wizard** is far more efficient. All you need to do is modify the resulting Report Design file to make the necessary minor adjustments.
14. Select **Preview ▸ Close** to close the report preview. The Report Design file remains open.

    In the Report Design view, you can see the layout used to generate the report. In the Design view, you can do things like add new data fields, delete fields, change column widths, rename column labels, and change the report heading, as well as change colors, fonts, and other visual properties. You can also access more advanced features such as sorting, grouping, and filtering data, and defining formulas to be used on reports. The Report Designer is extremely

powerful and supports a wide array of features and functions that enable you to completely customize reports to suit your needs.

15. At this point, you can choose to save the Report Design file. To save the Report Design file:
    a. Select **File** ▸ **Save As**. The **Save File As** window opens.
    b. For **Name**, enter `My Prediction Report` and click **OK**.
    c. Select **File** ▸ **Close** to close the Report Design file. If you are asked if you want to save your changes, click **No**.

Your new Report Design file is now available in the **Project Navigator** under **Reports > Prediction Reports**. To regenerate this report at any time, select the report name in the **Project Navigator**.

Reports can also include subreports, grouping, sorting, as well as embedded calculations. For more information on all the reporting features and functions available, please refer to the help.

Creating Graphs

Windchill Quality Solutions has an extensive array of impressive graphical capabilities, including the ability to view a standard graph or create a custom graph. You begin by viewing one of the supplied graphs.

Viewing a Graph

1. In the **Project Navigator**, under **Graphs > Prediction Graphs,** select **(Common) Prediction FR v Temperature 3D** to generate this supplied graph.

   This graph displays as a three-dimensional line graph the predicted failure rate for each assembly in the system tree for a range of temperatures from 0 to 100 degrees C, in increments of 10.
2. When finished viewing the graph, do one of the following to close the graph.
   - Select **File** ▸ **Close**.
   - Click the **X** in the upper right corner of the window.

Alternatively, you may select **Tools** ▸ **Graph** or click the graph icon  on the **Standard** toolbar. When the **Select Graph Template** window opens, select the appropriate graph.

Creating a Custom Graph

The **Graph Wizard** enables you to easily create custom graphs of your System data. The Wizard walks you through a series of questions about the graph you wish to create. Once you have created a graph, you can save the selections you have made to a Graph Template file, which enables you to quickly recreate the same graph at a later time.

1. Select **Tools** ▸ **Graph Wizard**. The **Graph Wizard** starts and displays the **Load Graph Template** page.
2. Select **Create a custom graph** and click **Next**. The **Prediction Graph Type** page appears.
3. Select **Calculation result by System Tree item (uses last calculation result)** and click **Next**. The **Select Calculation** page appears.
4. Select **Failure Rate, Predicted** and click **Next**. The **Filter Data** page appears.
5. Select **Graph only assemblies** and click **Next**. The **Graph Options** page appears. The default type is a cylinder bar graph.
6. For **Graph title**, enter `My Prediction Graph`.
7. Select **3D** and **Pareto**. Leave all other options cleared.
8. Click **Next**. The **Save Graph Template** page appears.
9. To save the settings to a Graph Template file, do the following:
   a. For **File name**, click the browse button  . A window opens, listing all existing Graph Template files.
   b. Click **< Create new file >** and enter `My Prediction Graph`.
   c. Click the green checkmark  .
   d. Make sure the **Create corresponding Report Design file** check box is cleared.
10. Click **Next**. The **Wizard Complete** page appears.
11. Click **Finish** to generate the graph.

    The resulting graph shows the assemblies in your system ordered by overall failure rate. This is a good way to see the items in your system that contribute the most to overall system failure rate.

Modifying the Graph

You can rotate your 3-D graphs while they are displayed to view your graphs from different angles.

1. Select **Graph** ▸ **Enable Mouse Rotation** to allow rotation of your graph.
2. Move the mouse cursor into the **Graph** window. The cursor changes to a hand cursor.
3. Hold down the left mouse button and move the mouse cursor to change the angle of your graph. While moving, the graph appears unclear. Once you release the mouse button, the graph redraws clearly.
4. Select **Graph** ▸ **Enable Mouse Rotation** again to turn off mouse rotation.
5. You can also modify the appearance of your graph. In the **Graph** window, right click and select **Properties** to bring up the **Graph Properties** window. You can view the many graph settings that you can modify. Click **Cancel** to close the **Graph Properties** window.
6. Select **File** ▸ **Close** to close the graph.
7. If you are asked if you want to save your changes, click **No**.

Filtering Data

When viewing your System data, you may want to view a portion of all the items in your Project. With large quantities of data, filtering techniques enable you to display a subset of items that are of interest to you. Filters can be applied not only for viewing purposes but also prior to performing calculation, reporting, and graphing functions.

The filtering capabilities enable you to view items matching a certain parameter or multiple parameters, find a specific item or set of items based on a parameter entered “on the fly” and even sort items. It is helpful to experiment with the filtering features.

Windchill Quality Solutions supports both fixed-value filters and parameterized filters. When you create a parameterized filter, you must supply a parameter value when the filter is applied. You can also build filters with multiple parameters. When building a parameterized filter, be aware that the request for a parameter value occurs whenever the filter is used, even during report or graph generation.

Using Predefined Filters

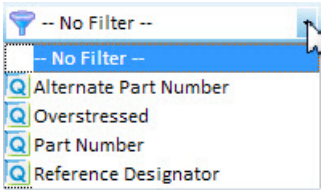
Windchill Quality Solutions includes a number of predefined filters that can be applied.

1. In the **System Tree Items** table, select **Motherboard**.
2. Select the **Prediction Parts** table. The list of parts in the Motherboard assembly are shown.

3. In the toolbar, use the **Filter** selection box to select the **Reference Designator** filter.

   Tip

   *If you do not see the Reference Designator in the **Filter** dropdown menu, ensure you have the **Prediction Parts** table selected.*



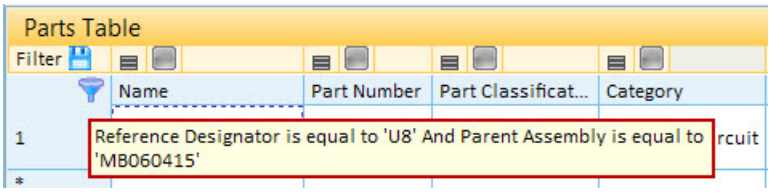
   Note

   The filters available in the Filter dropdown depend on the pane or window selected.

   The **Select Filter** window opens. Since this type of filter is a parameterized filter, you must supply a parameter before the filter can be applied.

4. For **Reference Designator is equal to**, enter `U8` and click **OK**.

   The item with the matching reference designator appears in the **Prediction Parts** table. If you place the mouse cursor over the filter icon in the upper left corner of the **Prediction Parts** table, parameters for the filter are shown as a tooltip.



5. Use the **Filter** selection box to select the **– No Filter –** option and remove the applied filter.

Creating Custom Filters

You can create custom filters for ad hoc queries. To create a custom data filter:

1. Select the **Prediction Parts** table.
2. Select **Filter ▸ Filter Wizard**. The **Filter Wizard** starts and displays the **Specify Filter Features** page.
3. Select **Selects records only** and click **Next**. The **Specify Filter Field** page appears.
4. For **Select the table type**, select **Prediction Parts**.

5. From the list of data fields, select **Temperature Rise** and click **Next**. The **Specify Condition** page appears.
6. Select **is greater than or equal to** and click **Next**. The **Specify Field Value** page appears.
7. Select **Use a fixed value (specify the value below)**.
8. For **Specify the value here**, enter `20` and click **Next**. The **Review Filter** page appears.
9. Leave **I want to add more conditions to the filter** clear, to indicate that the filter is complete and click **Next**. The **Save Filter** page appears.
10. Select **I want to save my filter for later use**.
11. For **Filter name**, enter `Prediction - High Temperature Parts`.
12. Select **Save filter to My Filter File**.

    You have the option of saving filters to two different locations.

    - If you select **Save filter to My Filter File**, your new filter is stored in a file accessible only to you; the filter is not accessible to other users with filter permissions.
    - If you select **Save filter to the Filter File in this Project**, the filter is accessible to other users with filter permissions.

      In some cases, you may be creating a filter that is for your own use. In that case, it is best to save it to the My Filter file. In other cases, if you are creating a filter you know would be helpful to all team members, save it to the Project Filter file to allow everyone to use it.
13. Click **Next**. The **Wizard Complete** page appears.
14. Click **Finish**.

    If this is the first time you have saved a filter, Windchill Quality Solutions asks to create a Filter file in which to store your newly constructed filter. In the **Create Support File** window, click **Yes** to create this Support file. If you have previously created a Filter file, this message does not appear. If a message appears asking you if you want to overwrite or use the existing file, select the **Use Existing** option.

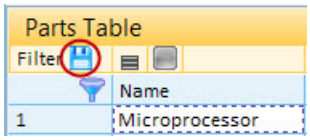
    The filter is applied to your data so that all parts with a temperature rise of 20 degrees Celsius or higher are shown. Your new filter is shown in the **Filter Selection** box. Notice that when you drop down the list in the **Filter Selection** box, your new filter, **Prediction - High Temperature Parts**, is preceded with a person icon instead of a Windchill Quality Solutions icon. This indicates that

the filter is stored in your My Filter file and not the Project Filter file, because Project filters are preceded with a folder icon.

15. To return to the original data view, select **– No Filter –** in the **Filter** selection box.

You can also modify your filters. Open the Filter file by selecting the **Filter** option under the **Support Files>Setup** headings in the **Project Navigator**. New filters can then be added directly to the Filter file.

Additionally, you can quickly build filters using the **Filter Bar**, which is located above the column headers of the table. You can use the **Filter Bar** to sort records and/or select the data to be shown in the table. You can also save filters created using the **Filter Bar** by clicking the save icon at the top left of the **Filter Bar**.



Customizing Tables

Virtually all tables in the System file can be customized using the **Format Builder**, which enables you to easily change the layout of your tables.

For this example, we modify the layout of the **Prediction Parts** table.

1. Right-click the **Prediction Parts** table and select **Format Builder**. The **Format Builder** opens and displays all of the fields available for insertion in the table. The checkboxes to the left of the fields indicate which fields are shown in the table. If the checkbox is cleared, the field is not shown.
2. Select the **217 Quality** check box. The **Prediction Parts** table is updated to include this column at the end. If you cannot see the last column, use the scroll bar to view it.
3. Now, clear the **217 Quality** checkbox to remove this field.
4. Close the **Format Builder**.

When you use the **Format Builder**, fields are inserted at the end of the table. If a column is not in the desired location, you can click and drag it to where you want it.

Importing Data

The **Import Wizard** enables you to easily import data into your System by asking you a series of questions about the data that you wish to transfer. When you have completed the process once, you can save the selections you have made to an Import/Export Template file. This template enables you to perform the same import or corresponding export process later without needing to complete the wizard.

For this example, we import data into a new System file.

1. Under **Navigator Tasks** in the **Project Navigator**, click **Create new file**. The **Create File** window opens. The **Project** field is automatically filled in with the current Project.
2. Set the **File type** to **System**. For **Name**, enter `My Imported Data` and make sure the **Run Create File Wizard** option is cleared. Click **OK** to create and open the new System file.
3. Select **Tools** ▸ **Import Wizard**. The **Import Wizard** starts and displays the **Load Template** page.
4. Select **Perform a custom import** and click **Next**. The **Select Source File** page appears.
5. For **Source file name**, click the browse button  . The **Open** window opens.
6. For **Files of type**, choose **Microsoft Excel**.
7. Navigate to the `My Tablet PC` directory under your `My Windchill Quality Solutions Files` directory. Select **ReliabilityPredictionImport.xls** and click **Open**. You are returned to the **Select Source File** page, where the selected file and its directory location are shown.
8. Click **Next**. The **Specify Worksheet Format** page appears.
9. Leave **First row of cells has column names** selected and click **Next**. The **Select Data Type** page appears.
10. Select **Parts only** and click **Next**. The **Select Import Type** page appears.
11. Select **I want to add records** and click **Next**. The **Select Field Assignments** page appears. In this page, you map the data being imported to Windchill Quality Solutions fields. The first column is automatically selected.
12. Map the data:
    a. For **Data field**, select **Part Number**. The column heading of the first column changes to **Part Number**.

       To make selections, you can either scroll through the **Data Field** choice list, or you can type in the letters of the field name until the correct match is located.

    b. Click the second column and, for the **Data field**, select **Quantity**.

c. Click the third column and, for the **Data field**, select **Reference Designator**.

d. Click the fourth column and, for the **Data field**, select **Name**.

13. Click **Next** to indicate that mapping is complete. The **Save Template** page appears. For this example, we do not save our selections to an Import/Export Template file.
14. Click **Next**. The **Wizard Complete** page appears.
15. Click **Finish**. Importing begins and the **Parent Assembly Selection** window opens.
16. Select **System** as the parent assembly and select **Do not ask me this again. Use the current selections as the default**. This lets the **Import Wizard** know which parent assembly you want to associate the new imported parts with.
17. Click **OK** to continue the import. When the import is complete, the **Import/Export** window shows "Import completed." If errors or warnings occur during your imports, you can select the **View Log** button to review them. In this case, there are no errors or warnings, and all parts were imported.
18. Click **Close** to dismiss the **Import/Export** window. You can see the newly imported parts in the **Prediction Parts** and **System Tree Items** tables.
19. When you are finished reviewing your new data, select **File** ▸ **Close**.

    For this example, we are going to delete the newly created System file.
20. In the **Project Navigator**, right-click the System file named **My Imported Data** and select **Delete**.
21. When asked if you are sure, click **Yes**.

Moving On

While these two introductory sections introduced you to some basic features, Windchill Quality Solutions offers an extensive array of additional capabilities to explore. By completing this section, you have a foundation on which to move forward into any of the following sections about the analysis modules. These sections assume that you have successfully completed this section and are comfortable with the features described.

At any time during operation, help is available. To access the help at any time, do one of the following:

- Click the help icon on the **Start Page**.
- Select **Help** ▸ **Help**.
- Press the **F1** key to display context-sensitive help.

4

Windchill Prediction

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about reliability predictions and how to perform this type of analysis using Windchill Prediction. In this section, you learn how to enter data, perform calculations, and view outputs such as reports and graphs.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Reliability Prediction Overview

Reliability prediction is a quantitative analysis technique used to predict the failure rate of a system based on the components of the system and its operating conditions. A reliability prediction is typically performed using an accepted, published handbook, which defines failure rate equations for various components used in the system design. These equations were developed by using statistical techniques to analyze failure data gathered on actual operating equipment. The equations take into account the various parameters, such as part quality and operating stresses, which have an effect on component reliability.

To begin a reliability prediction analysis, you must first define your system and all of its component parts. You then use the model equations to determine the failure rate of each particular component in your system. To get the overall system failure rate, you add up all the component failure rates.

For example, consider a system that is comprised of subsystem A and subsystem B. Assume subsystem A has 5 parts, each of which has a predicted failure rate of 1 failure/million hours obtained from using failure rate equations from a selected handbook. Assume subsystem B has 5 parts, each of which has a failure rate of 3 failures/million hours, computed using the same handbook. The failure rate of subsystem A is 5 failures/million hours and the failure rate of subsystem B is 15 failures/million hours. Thus, the failure rate of the overall system is 20 failures/million hours.

Doing this analysis by hand can be tedious, time-consuming, and error prone. Using a software application such as Windchill Prediction to perform this work can dramatically increase the efficiency and accuracy in performing analyses.

If you are unfamiliar with reliability prediction analysis and would like to study this topic in more detail, the following selections are excellent references:

- Reliability: A Practitioner's guide (Chapter 3)
- Practical Reliability Engineering by Patrick D.T. O'Connor, 4th edition, John Wiley & Sons Ltd. (2002)
- The specific reliability prediction handbook of interest to you. For details, see the “Ordering Reliability Standards” help topic.

Getting Started with Windchill Prediction

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill Prediction module. For more information, see Starting Windchill Prediction on page 41.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project**: label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill Prediction

On the **Module Selections** toolbar at the top right of the window, make sure the Prediction  button is selected and all other module buttons are deselected.

The tabbed panes for the Prediction module are shown in Windchill Quality Solutions window.

Using Windchill Prediction

In the top pane, the **System Tree Items** table shows the hierarchical breakdown of your system. In the bottom pane, the **Prediction Parts** table shows a complete listing of all the components in the assembly selected in the system tree. Depending on whether an assembly or part is active, the bottom pane may also display additional tabbed panes.

When an assembly is selected in the **System Tree Items** table, the **General Data** pane displays general information about the selected assembly, and the **Calculation Data** pane displays the calculation parameters to be used for the selected assembly. When a part is selected in the **System Tree Items** or **Prediction Parts** tables, the **Prediction Data** pane displays calculation parameters to be used for the selected part, and the **General Data** pane displays general information about the selected part.

Reviewing Prediction Data

1. In the **System Tree Items** table, select the **Motherboard** assembly.
2. Select **Prediction Parts**. The list of parts that make up the Motherboard assembly is shown.
3. In **Prediction Parts**, click the **Static RAM** part with a part number of SRAM031.
4. Review the fields available in **Prediction Parts**. You can see that this is a memory device. There are four of these parts on the Motherboard.
5. Select the **Prediction Data** tab to view the parameters associated with this part.
6. Click **Pi Factors** to display the factors used in the equation for computing the failure rate of this part. In the **Pi Factors** window, you can also see the failure rate of the part. For information about how these factors are computed, as well as the failure rate equations, refer to the help.
7. Click **Close** to close the **Pi Factors** window.

Entering Assemblies and Parts

Perform the following steps to enter a new assembly and its parts:

1. In the **System Tree Items** table, select the **Hard Disk Assembly** assembly.
2. Select **Insert** ▸ **Sibling Assembly** to insert a new assembly at the same level as Hard Disk Assembly. Inserting a child assembly inserts an assembly one level below the currently selected assembly.
3. For **Name**, enter `My Demo Assembly` for the new assembly.
4. Select the **Prediction Parts** table. Notice that there are currently no parts in the new assembly.

5. In the empty row, leave the **Name** field blank, enter `ABC` as the **Part Number**, and press **Tab**.

   The first time that you enter a part number, Windchill Prediction initializes all the Prediction Parts Libraries that are enabled for searching. As a result, this first entry may take a few moments.
6. If not already selected, for **Part Classification**, select **General**.
7. For **Category**, select **Integrated Circuit**.
8. For **Subcategory**, select **Logic, CGA or ASIC**.
9. For **Reference Designator**, enter `U27`.
10. Select the **Prediction Data** tab. All the data fields are blank. To accurately compute a failure rate, correct values should be entered in these fields.
11. Click **Defaults**.

    A number of data fields are now filled in with values. These values represent average values for these fields; the calculation engine uses these average values if you do not enter specific data values. Because Windchill Prediction uses typical values for this part to produce preliminary failure rate estimates, using these default values is a good way to start your analyses. As data becomes available, you can go back and enter it on the **Prediction Data** tab.
12. Click **Defaults** again to hide the default values from view.

    The **Defaults** button is there only for informational purposes. Windchill Prediction automatically uses the defaults "behind the scenes" during calculations, and you do not need to click the **Defaults** button in order for this to occur.
13. Click **Pi Factors** to see the computed failure rate of your newly inserted part.
14. Click **Close** to close the **Pi Factors** window.

Using the Prediction Parts Libraries

A much more efficient way of entering parts is to use the extensive Prediction Parts Libraries supplied with the Prediction module. These component databases include hundreds of thousands of parts, along with the associated data needed for performing reliability prediction analysis.

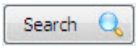
1. Select **Prediction Parts**.
2. In the empty row at the end of the table, for **Part Number**, enter `74LS00` and press **Tab**. The Prediction module searches through the Prediction Parts Libraries and automatically fill in the appropriate part information.
3. Select the **Prediction Data** tab and review the data that has been automatically entered. You can see that almost all of the data fields have been filled in. A few

fields, such as **InitialTemperature Rise**, are dependent on the operating conditions of your system, and you would need to enter these types of values.

Viewing the Parts in the Parts Libraries

In some cases, you may not know an exact part number. In these cases, you can browse through the information in the Prediction Parts Libraries to select the component.

1. Select **Prediction Parts**.
2. Right-click the table row with the asterisk (*) and select **Browse Libraries**. The **Library Browse** window opens.
3. Leave **Search for** set to **Prediction Parts**.
4. For **Part Number**, enter `74HCT*` and click **Search**.

   All parts that begin with 74HCT are shown in the **Results** table below.
5. In the **Results** table, scroll down to locate 74HCT373.
6. Click this row to see the associated part parameter values in the **Preview** pane below.
7. Click the + **Insert** button in the **Results** pane to insert the part into **Prediction Parts** on the right.

Tip

*You may also drag and drop parts to insert them into **Prediction Parts**. Select the desired part's row in the **Results** pane and, holding down your left mouse button, drag the part to **Prediction Parts**.*

Filtering to Locate Parts

1. In the **Search** pane of the **Library Browse** window, for **Part Number**, clear the field.
2. For **Description**, enter `*transistor*` and click **Search**.

   The **Results** pane lists all the parts that include the text "transistor" in any part of the **Description** field. As you can see, you can perform a wide variety of filtered searches using all types of configurations for searching parameters.

Entering Parts Using the NPRD/EPRD Libraries

Windchill Prediction also includes libraries of failure rates based on collected field information on a number of electro-mechanical parts. This data is stored in databases known as the NPRD and EPRD libraries. To access the data in these libraries:

1. In the **Library Browse** window, for **Search for**, select **NPRD Parts**.
2. For **Category**, select **Battery**
3. For **Subcategory**, select **General**.
4. Click **Search**. The resulting matches for a general battery in the NPRD Library appear in the **Results** pane.
5. Select **NPRD-610** by clicking it.
6. Click **+ Insert** in the **Results** pane to insert the part into the **Prediction Parts** table.
7. Close the **Library Browse** window by clicking the **X** at the top right of the pane.

Performing Calculations

The Windchill Prediction tool calculates a number of metrics, including failure rate, MTBF, reliability, availability, and MTTR, which are briefly described below. For more information, see the help.

Calculation	Description
Failure Rate	In a reliability prediction analysis, failure rate is a value which represents the number of failures likely to occur over a time period, usually defined in units of failure per million hours (FPMH) or failures per billion hours (FITs). For example, if a unit has a failure rate of 2 FPMH, that unit is likely to fail twice in a million hours. Failure rates are predictive values computed using equations based on statistical field data analysis.
Mean Time Between Failures (MTBF)	The Mean Time Between Failures (MTBF) represents the number of hours a unit operates between failures. For units which cannot be repaired once a failure occurs (i.e. non-repairable units), the MTBF is equivalent to Mean Time to First Failure (MTTF). Therefore, the terms "MTBF" and "MTTF" are sometimes used

Calculation	Description
	interchangeably, though the usage is not theoretically accurate. In Windchill Prediction, however, the term MTBF is used.
Reliability	The probability that a system remains operational until a specified time. Reliability is a time-based probability value, so it is always a metric between 0 and 1. A reliability of 0 means that a system is infinitely unreliable, or never functioning. A reliability value of 1 indicates that a system is infinitely reliable, or always operating.
Availability	The probability that a system is operating properly at a specific time point. Availability, like Reliability, is a time-based probability metric between 0 and 1. Availability is a function of both reliability (how quickly a system fails) and of maintainability (how quickly the system can be repaired). The common term "five nines" refers to a system which has an availability of 0.99999, i.e. is operational 99.999% of the time.
Mean Time to Repair (MTTR)	Mean Time to Repair (MTTR) is the average time it takes to repair a failed unit and return it to an operational state, based on the average repair time for its replaceable components. The MTTR is calculated by rolling up the average repair times for lower-level components to subassembly and system repair values. If Windchill Maintainability is used in conjunction with Windchill Prediction, the MTTR values of components and subassemblies can be obtained from Maintainability computed MTTR values. Units for MTTR values are typically hours or minutes. MTTR is also referred to as Mean Corrective Time (MCT).

Windchill Prediction can also compute these same measures utilizing mission phases. To utilize mission calculations, you define a mission profile, which describes the phases of a mission your system experiences. For example, the mission of an airplane may consist of three phases – take-off, flight, and landing –

each one involving different environments and conditions. You can also define phases as dormant or active in order to factor in the lower failure rates experienced during dormant phases.

The Prediction module performs mission-based calculations by factoring in the environment, temperature, state (dormant or active), and percentage of time in each phase. You can view the compiled metrics of the entire mission as well as individual phase metrics.

Windchill Prediction supports derating analysis as part of prediction calculations. Derating analyses allow you to assess which components in your system are overstressed. You can use the results of derating analyses to ensure your system components are operating within acceptable limits.

The Prediction module can also be used to compute reliability allocations based on a variety of supported allocation methodologies. Reliability allocations allow you to allot the MTBF values across the subassemblies and/or components of your system, and then, based on specified weighting factors, calculate the projected failure rate of the components and/or subassemblies within that system.

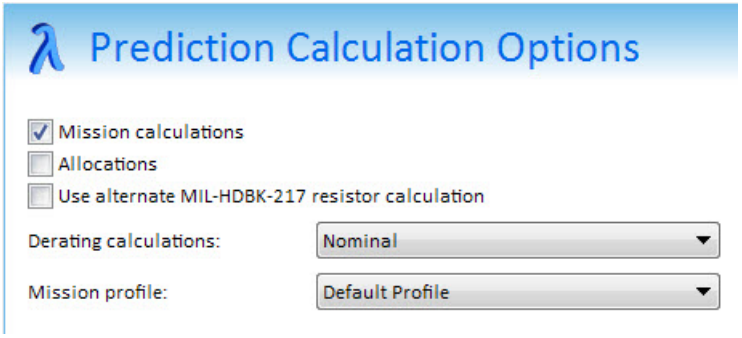
Reliability allocations are useful when you have reliability goals which must be met. For example, if contractual requirements dictate that your overall system MTBF must be at least 10,000 hours, you can split up that 10,000 hour goal across the various items in your system based on a weighting system of your choosing. Perhaps you allow one highly complex subsystem to meet a 5,000 hour MTBF, while all other subsystems must meet a combined 5,000 MTBF. In this way, you can apportion MTBF goals to ensure that your overall objectives are met.

Running Calculations

To compute the predicted failure rate of your system:

1. Select **System** ▸ **Calculate**, or click the calculate  icon on the **Standard** toolbar. The **Calculate** window open.
2. In the left pane, select the **Calculation Selection** page (if necessary).
3. In the right pane, click **Clear All** and select **Prediction** so that Prediction calculations are performed.
4. In the left pane, select the **Prediction** page.
5. Leave **Mission calculations** selected and all other check boxes cleared.

6. Leave **Derating calculations** set to **Nominal** and **Mission profile** set to **Default Profile**.



7. Click **OK** to perform the calculations. The **Calculation Progress** window displays status information. When the calculations are complete, the **View Calculation Results** window opens.

   Tip

   *You can print your calculation results by clicking **Print** in the **View Calculation Results** window. You can also save them to a Microsoft Excel spreadsheet by clicking **Excel**.*

8. Click **Close** when you have finished reviewing results.

To redisplay the results at any time, select **System ▸ View Calculation Results**. If you have only one module enabled, the results are displayed for that module. If you have more than one module enabled, select the appropriate page to view the results. When finished, click **Close**.

Viewing a Report

1. In the **Project Navigator**, under **Reports > Prediction Reports,** select **(Common) Prediction (Summary)** to generate this default report in the **Preview** window.

   This report outputs data on all assemblies in the System file, including assembly names, part numbers, reference designators, quantities, and calculation results for failure rate and MTBF.

   You can use the various toolbar buttons in the **Preview** window to page through your report, zoom in and out, and print the report.

2. When finished viewing the report, do one of the following to close the **Preview** window:

- Select **Preview** ▸ **Close**.
- Click the close icon  on the toolbar.

Alternatively, you can preview a report by selecting **File** ▸ **Print Preview**.

Graphing Data

1. In the **Project Navigator**, under **Graphs > Prediction,** select **(Common) Prediction FR v Temperature 3D** to generate this supplied graph.

   This graph displays a three-dimensional line graph of the predicted failure rate for each assembly in the system tree for a range of temperatures from 0 to 100 degrees C, in increments of 10.
2. When finished viewing the graph, do one of the following to close the graph.
   - Select **File** ▸ **Close**.
   - Click the **X** in the upper right corner of the window.

Alternatively, you may select **Tools** ▸ **Graph** or click the graph icon  on the **Standard** toolbar. When the **Select Graph Template** window opens, select the appropriate graph.

Windchill Prediction Features

Many more features and functions are available within Windchill Prediction. A brief listing of other topics of interest is shown below. To try out these features, please refer to the help.

- Support for all current prediction standards, including MIL-HDBK-217, Telcordia, PRISM, 217Plus, HRD5, RDF 2000, IEC TR 62380, NSWC Mechanical, Chinese 299, Siemens SN 29500, and FIDES.
- For high-powered analyses, combine models within a Project, and apply MTBF adjustment techniques such as PRISM Process Grades and Telcordia Methods, across any model.
- Prediction Derating files store minimum and maximum derating criteria based on the part type.
- Prediction Defaults files store default part parameters based on the part type.
- Prediction Values files store your own user-defined environments and quality levels.
- Mission profile files store data associated with various mission phases, including dormancy information and the total mission time.

- User-defined Prediction Parts Libraries can be created and saved and then used along with Parts Libraries.
- Prediction Correlation Library files allow you to search library components based on in-house part numbers instead of manufacturer part numbers.
- Prediction Process Grade files store a scoring profile whose total value is translated into a quantitative Pi-factor multiplier that impacts the predicted failure rate.
- Prediction Bayesian files store test and field data in order to modify predicted failure rates with known field data for more real-world predicted values.

5

Windchill FMEA

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about a FMEA (failure modes and effects analysis) and how to perform this type of analysis using Windchill FMEA. In this section, you enter FMEA data, perform calculations, and view reports and graphs.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

FMEA Overview

A FMEA consists of breaking a system down into what can fail, how it can fail, and why it fails, and then determining the effects of those failures on your system. FMEAs can also include the analysis of criticality, and in this case is referred to as FMECAs (failure mode, effects, and criticality analysis).

FMEAs are typically performed based on published standards or guidelines; however, some organizations develop their own guidelines for FMEA. The most common FMEA standards include MIL-STD-1629, various automotive FMEA standards, and SAE ARP5580.

The FMEA process is a bottom-up approach to system analysis. The analyst begins at the lowest level desired for analysis, such as a part or a step in a process, and ascertains the possible failure modes associated with that item. The next step is to establish, based on system knowledge, what the resulting effect of the failure modes are. Along with each end effect, the analyst might also determine the severity of that effect, the probability of occurrence of that effect, and how the effect could be detected.

This process continues up the system tree until overall system end effects are evaluated. Once this detailed analysis is complete, some type of ranking criteria is employed. The ranking is then used to determine how critical failures can be eliminated or the risks mitigated. The main objective of a FMEA is to evaluate all parts of your system or process to ensure that system reliability and safety objectives are met.

If you are unfamiliar with FMEA/FMECA and would like to learn more, the following selections are excellent references:

- Reliability: A Practitioner's guide (Chapter 6)
- Failure Mode and Effect Analysis - FMEA from Theory to Execution by D.H. Stamatis
- Failure Modes & Effects Analysis by Paul Palady

Getting Started with Windchill FMEA

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable Windchill FMEA; for more information, see Starting Windchill FMEA on page 53.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project**: label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill FMEA

On the **Module Selections** toolbar, select the FMEA button  and deselect all other module buttons.

The tabs for Windchill FMEA are shown in your System file.

Using Windchill FMEA

The top pane contains the following tabbed panes:

- **System Tree Items**, which shows the hierarchical breakdown of your system, and which is shared with several other modules.
- **FMEA Table**, which shows a list of all your FMEAs.
- **FMEA Tree Items** tab, which shows the hierarchical breakdown of your FMEA structure. By default, the name of the **FMEA Tree** tab contains Functional, Process, or Component to indicate the type of FMEA selected in the **FMEA Table**.

Additional tabs display control and DVP data.

The lower pane displays the **FMEA Worksheet**, where failure mode, cause, and effect data is entered for each item.

In Windchill FMEA, you can customize FMEAs. You can select which data fields appear and give them custom names. You can also change the appearance of FMEA cells, adding in fonts, colors, notes, and checkmarks as you like. With this functionality, you can completely customize the structure of your FMEA data.

Additionally, you can perform FMEA activities on the web using the web version of Windchill Quality Solutions.

Types of FMEAS

FMEAs can basically be classified into one of three possible types: process, functional, or component. All three of these FMEA types assess the impact of failures on system performance and safety to determine which failure modes require efforts to prevent, mitigate, or detect occurrence. The selection of a particular FMEA type indicates the intended scope of the analysis.

For example, you might choose to limit your assessment of possible failures to those that can occur during the manufacturing or assembly process of a product. Or, you might choose to limit it to failures that prevent you from meeting the functional requirements for a product design. When a comprehensive assessment of a product design is required, you would not want to limit your assessment in any manner but rather consider all possible failure modes for all system components.

The advantage of Windchill FMEA is that it supports any type of FMEA you want to perform. Additionally, if you have your own hybrid type of FMEA, or some customized FMEA format, the FMEA module can be adapted to meet your needs.

For the examples in this guide, we discuss and show the most common types employed: process, functional, and component. The following sections briefly discuss these types.

Process FMEA

A process FMEA examines the ways that failures in a manufacturing or assembly process can affect the operation and quality of a product or service. A process FMEA can be performed at any level to evaluate possible failure modes in the process and limitations in equipment, tooling, gauges, or operator training. The information collected can help to determine what can be done to prevent potential failures prior to the first production run. You can then take actions to reduce your exposure to risks deemed unacceptable.

Functional FMEA

A functional FMEA examines the intended functions that a product, process, or service is to perform rather than the characteristics of the specific implementation. When a functional FMEA is developed, a functional block diagram is typically used to identify the top-level failures for each block in the diagram. For example, a functional FMEA would consider that a capacitor is intended to regulate voltage and then to analyze the effects of the capacitor failing to regulate voltage. It would not analyze what would occur if the capacitor fails open or fails shorted.

Component FMEA

A component FMEA examines the characteristics of a specific implementation to ensure that the design complies with requirements for failures that can cause loss of end-item function, single-point failures, and fault detection and isolation. Once individual items of a system are identified in the later design and development phases, component FMEAs can assess the causes and effects of failure modes on the lowest-level system items. Component FMEAs for hardware, commonly referred to as piece-part FMEAs, are the most common type.

Reviewing Types of FMEAs

To review the types of FMEAS:

1. Select the **FMEA Table**.
2. Select the **System Functional FMEA**.
3. In **FMEA Tree Items - Functional**, select **Processing Section**.
4. In the lower pane, select the **FMEA Worksheet** to review the functional FMEA for the processing section of the tablet PC.
5. In **FMEA Tree Items - Functional**, select **Touchpanel** to review a functional FMEA for the touchpanel section of the tablet PC.
6. Select the **FMEA Table** again.
7. Select the **Battery Process FMEA**.
8. In **FMEA Tree Items - Process**, expand **Battery**, and then select **Solder** to review a process FMEA for the process that occurs during soldering of the battery for the Tablet PC.
9. In **FMEA Tree Items - Process**, select **Assembly** to review a process FMEA for the process of assembling the battery of the Tablet PC.
10. Select the **FMEA Table** again.

11. Select the **Tablet PC Component FMEA**.
12. In **FMEA Tree Items - System**, expand **Industrial Tablet PC** and select **Motherboard** to review a component FMEA for the motherboard of the tablet PC.

Entering Data

1. Select the **FMEA Table**.
2. Select **System Functional FMEA**.
3. In **FMEA Tree Items - Functional**, select **Processing Section**.
4. Select the **FMEA Worksheet**.
5. Select the Function/Process **Transfer data and provide computing functions**.
6. Select **Insert ▸ Mode** to insert a new failure mode for this function.
7. For **Failure Mode**, enter `Hard drive failure`.
8. For **Mode Percentage**, enter `25`. Change the **ModePercentage** for the other three failure modes to `25`.

   Failure Mode percentages of all failure modes for a single item should add up to 100 percent. For this example, we're going to assume that all our failure modes have an equal likelihood of occurring. In real-world situations, some failure modes are more likely to occur than others, and this can be reflected by designating the appropriate failure mode percentages.
9. For **Local Effect**, enter `Hard drive cannot be accessed` and press **Tab**.

   The **Add List Item** window opens. Because the local effect you just entered is new, you are being asked whether to add it to the list of possible effects for this FMEA. A significant advantage of keeping a list of effects in FMEA is to ensure consistency. The next time a failure results in "Hard drive cannot be accessed," you would not need to type in the phrase again, but can simply select it from the list.
10. Click **Yes** to add the new effect to the list.
11. For **End Effect**, select **Tablet PC not functional** from the list.
12. For **Sev**, which stands for "Severity," select **9** to indicate a high severity.
13. Leave **Class** blank.
14. For **Cause of Failure**, enter `Bad sector on hard drive`.
15. For **Occ**, which stands for "Occurrence," select **2** to indicate a low probability of occurrence.
16. For **Current Controls**, enter `Test hard drive on bootup`.

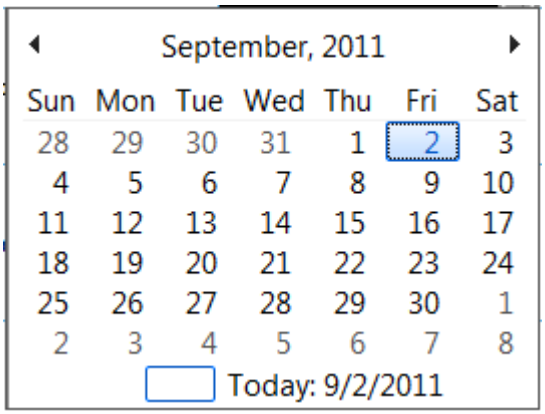
17. For **Det**, which stands for "Detection," select **6** to indicate a moderate detection mechanism is in place; press Tab to move to the next field.

    Note that Windchill FMEA has automatically computed the RPN (Risk Priority Number) for this failure mode. Depending on your system and your requirements, you may need to determine the RPN values that represent high, medium, and low risk. Failure modes identified to be high risk should be further analyzed to determine if controls can be established either to eliminate or mitigate the risk of their occurrence.

18. For **Recommended Actions**, enter `Add periodic hard drive tests during normal operation`.

19. For **Responsibility**, enter `Anthony - HD Engr`.

20. For **Target Date**, click the calendar icon  . The Calendar control appears.



21. Select one month from today for the target completion date.

Once the recommended actions have been put into place, you would complete the remaining data fields: **Actions Taken**, **Severity Results**, **Occurrence Results**, and **Detection Results**.

You have now completed data entry of a new failure mode. Entry of additional FMEA data can be accomplished in the same manner. You may enter any level of FMEA data – items, modes, causes, and effects – by using the **Insert** commands on the menu and on the shortcut menu accessed by a right-mouse click. You may also enable the **Insert FMEA Items** toolbar to insert FMEA data by accessing toolbar buttons.

FMEA data structures are customizable, so you can vary the hierarchical relationship of your FMEA data, as well as the data to collect.

Working with the List Library

List Library files allow you to define list items that are used throughout your FMEA, which ensures that your FMEA data is consistent and organized. The sample Project you are using contains a List Library file.

1. In the **Project Navigator**, click **Expand files** to display Support files.

   Note

   *If this option is not available, click **Collapse files**, then **Expand files**.*

2. Under **Support Files > Setup > List Library**, select **List Library** to open it.
3. Select the following values in the **List Definition** table to view corresponding list choices in the **List Choices** table: **Location**, **Local Effect**, and **Manufacturers**.
4. When complete, close the List Library file by selecting **File ▸ Close**.
5. In the **Project Navigator**, click **Collapse files** to hide all Support files.

As you saw while editing the `My Tablet PC` file, you can select the **Local Effect** column to see the list and select an item from it. You can also choose to enter an entirely new local effect by directly typing it in the cell. In that case, Windchill FMEA asks if you want to add this new item to the List Library file.

You see how using List Library files can ensure that you and all team members use the same wording consistently.

Performing Calculations

FMEA calculations are designed to help you determine what failures in your system need to be addressed and, after a redesign to address critical failures, how much those changes have affected the overall risk of failure in your system.

The metrics calculated by the FMEA module include:

Calculation	Description
Risk Priority Number (RPN)	The RPN reveals the overall risk of a particular failure mode occurring in your system. The RPN is calculated as: Severity * Occurrence * Detection Where: • Severity is an assigned value that indicates the severity of the effect of a particular failure mode. • Occurrence is an assigned value that designates how frequently that particular failure mode is likely to

Calculation	Description
	occur. • Detection is an assigned value that indicates how often that particular failure mode can be detected. While RPN values are computed automatically as you enter the severity, occurrence, and detection values, they are computed again when you perform FMEA calculations to ensure that all your RPN values are current.
RPN Results	RPN Results are RPN values calculated after design changes are implemented to address failure modes with high RPNs. The RPN Result is calculated as: Severity Results * Occurrence Results * Detection Results
RPN Improvement Percentage	RPN Improvement Percentage indicates the percentage of improvement between the original RPN (before any corrective actions have been taken) and the RPN Result (after corrective actions have been taken).
Criticality Rank	The Criticality Rank is a value that provides an assessment of the failure mode's severity and probability of occurrence. A failure mode with a rank of 1 is the most severe with the highest likelihood of occurring. The result is a categorized breakdown of failure modes based on risk. This approach is described in the SAE FMEA 5580 document.
Item Failure Rate	The number of failures of a specific item over a time period, usually defined in units of failures per million hours (FPMH) or failures per billion hours (FITs).
Mode Failure Rate	The number of occurrences of a specific failure mode over a time period, usually defined in units of failures per million hours (FPMH) or failures per billion hours (FITs).
Mode Criticality	How critical the failure mode is under a particular severity classification. This criticality value is calculated as described in MIL-STD-1629, *Procedures for Performing a Failure Mode, Effects and Criticality Analysis*: Mode Failure Rate * Mode Operating Time * Failure Effect Probability Where:

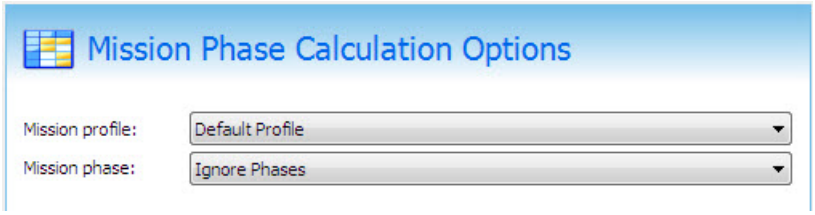
Calculation	Description
	• Mode Failure Rate is a value representing the number of occurrences of a specific failure mode over a time period. • Mode Operating Time is the duration of applicable mission phase(s), usually expressed in hours or number of operating cycles. • Failure Effect Probability is the probability that the failure occurs.
Detection Percentage	The probability that the failure mode is detected.
Detection Failure Rate	A value representing the number of detectable occurrences of a failure mode over a time period, usually defined in units of detectable failures per million hours (FPMH) or detectable failures per billion hours (FITs).
Isolation Percentage	The percentage of probability that the failure mode can be attributed to a specific part.
Isolation Failure Rate	A value representing the number of occurrences of a failure mode over a time period that can be attributed to a specific part, usually defined in units of isolation failures per million hours (FPMH) or isolation failures per billion hours (FITs).

Running Calculations

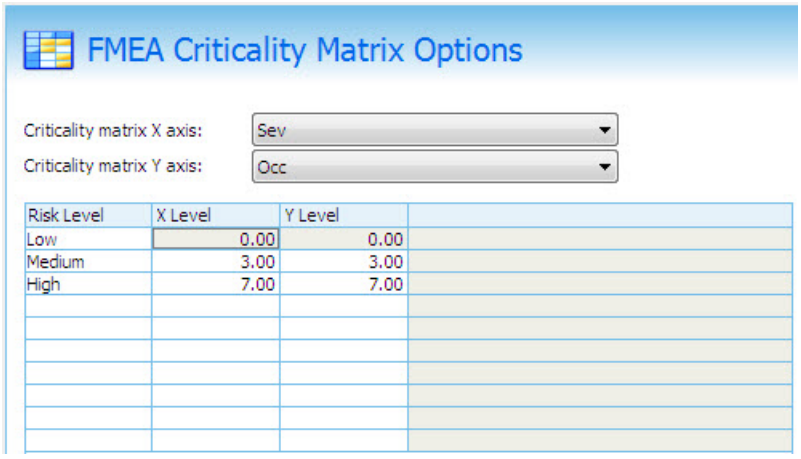
To compute FMEA results:

1. Select **System** ▸ **Calculate**, or click the calculate  icon on the **Standard** toolbar. The **Calculate** window appears.
2. In the left pane, select the **Calculation Selection** page (if necessary).
3. In the right pane, click **Clear All** and select the **FMEA** check box to perform calculations only for the FMEA module.
4. In the left pane, expand the **FMEA** heading, then select the **Mission Phase** page.

   You can see that you have options to select the mission profile and the mission phase for your FMEA calculations. In this example we are not considering mission phases. Leave **Mission profile** set to **Default Profile** and **Mission phase** set to **Ignore Phases**.



5. In the left pane, under **FMEA**, select the **Risk** page. This page allows you to customize risk level calculations and graphs. For this example, accept the default settings.



6. Click **OK** to perform the calculations. The **Calculation Progress** window displays status information. When the calculations are complete, a window opens.
7. Click **OK** to dismiss the window.

Viewing a Report

1. In the **Project Navigator**, under **Reports > FMEA Reports**, select **(Common) FMEA Standard Design**. The **Select FMEA** window opens.
2. Select **System Functional FMEA** and click **OK** to generate this default report in the preview window.

   You can use the toolbar buttons in the **Preview** window to page through your report, zoom in and out, and print the report.
3. When finished viewing the report, do one of the following to close the **Preview** window:
   - Select **Preview ▸ Close**.
   - Click the close icon  on the toolbar.

Graphing Data

1. In the **Project Navigator**, under **Graphs > FMEA Graphs**, select **(Common) FMEA Top 10 RPN** to view a graph of the failure modes with the highest RPN values. The **Select FMEA** window opens.
2. Select **System Functional FMEA** and click **OK** to generate the graph.

   This graph displays the failures modes with the highest RPN (risk priority number) values in a cylinder bar graph.
3. When finished viewing the graph, select **File ▸ Close**.

Windchill FMEA Features

Windchill Quality Solutions supports many more FMEA features and functions. A brief listing of other topics of interest is shown below. For more information on these features, see the help or guide for Windchill FMEA.

- You can use the web version of Windchill Quality Solutions to perform your FMEA analyses across the Web. This zero-client, web-based interface provides a rich Windows-like user interface, enabling FMEA analysts to move between the desktop and web versions with ease. The web version of Windchill Quality Solutions provides significant advantages for enabling FMEAs to be performed in a collaborative environment through its global accessibility.
- You can use the unique Roll Up FMEA and Build FMEA features to construct FMEAs more effectively. These features ensure your FMEAs are comprehensive and efficient. The Roll Up FMEA feature is used to roll up local effects as failure modes for the next higher level in the FMEA Worksheet. The Build FMEA feature is used to progress down through FMEA data levels to fill in end effects, next effects, severities, and failure effect probabilities.
- You can create custom calculations to perform any number of FMEA computations. This feature also enables you to override built-in RPN calculations, so if you have another method of computing them, you can set specify your custom equations.
- The FMEA Design file allows you to customize your FMEA data hierarchy for ultimate flexibility in meeting the needs of your FMEA process.
- The FMEA Modes Library file includes failure modes associated with specific component types. By using a FMEA Modes Library file along with your Windchill Prediction analyses, your FMEA process can be streamlined by the automatic addition of failure modes to piece-part FMEAs. Windchill FMEA is also supplied with a number of standard FMEA Modes Library files.
- You can create completely customized FMEA forms for data entry of your FMEA information.

- The “on-the-fly” Format Builder allows you to modify the columns of your FMEA Table, FMEA Tree, and FMEA Worksheet with a simple right-click.
- Windchill FMEA supports all types of FMEAs: component, functional, and process. You can select which FMEA type to use during new FMEA creation.
- The FMEA Fault Equivalence file provides for consistency and efficiency in FMEA construction by supporting the concept of fault equivalencies as defined in the SAE FMEA standard. Essentially, fault equivalencies reduce the level of effort needed to complete a FMEA by allowing you to group failure consequences based on failure modes. If failure modes are duplicated in your FMEA, the resulting like consequence data can be automatically pulled in from your FMEA Fault Equivalence file.
- Windchill Quality Solutions includes support for control plans in the FMEA module. Control plans provide a structured plan for designing, selecting, and implementing controls for the system, which ensures that the process remains in a state of control throughout the product life cycle.
- Windchill Quality Solutions also includes support for DVP&R (design verification planning and reporting). A DVP&R is a group of tests that help ensure product designs are meeting customer specifications and that product development is correctly focused.

6

Windchill FTA

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about fault tree analysis and how to build and evaluate fault trees using Windchill FTA. In this section, you enter fault tree data, perform calculations on the data, and view outputs such as reports and graphs.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Fault Tree Analysis (FTA) Overview

FTA is an event-oriented analysis technique, which means that it allows for the consideration of hardware failures and other undesirable events, such as software failures, human errors, operation and maintenance errors, and environmental influences. Fault tree analysis offers a simple and powerful approach for reliability and safety analysis. It is a deductive, top-down approach that begins with a single event to be analyzed, usually an undesirable or catastrophic failure, and then aids in the process of determining the specific causes which may lead to the occurrence of that event. It is based on a simple set of rules and logic symbols (e.g. AND gates, OR gates, and many others) from probability theory and Boolean algebra. Fault tree analysis consists of generating a logic model that allows for both qualitative and quantitative evaluation of system reliability or availability.

A fault tree is a pictorial representation of a system and the events that could lead to an undesired event in the system. From a qualitative perspective, you can generate minimal cut sets, which are the smallest sets of events, such that if they all occur, cause the undesired top-level event to occur. From a quantitative perspective, you can determine the likelihood of occurrence of the top event and any intermediate events given the necessary probabilities of the contributing lower-level events.

If you are unfamiliar with fault tree analysis and would like to study this topic in more detail, the following selections are excellent references:

- Reliability: A Practitioner's guide (Chapter 5)
- Fault Tree Analysis Application guide from the Reliability Information Analysis Center
- Fault Tree Handbook, NUREG-0492, from the U.S. Nuclear Regulatory Commission

Getting Started with Windchill FTA

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill FTA module; for more information, see Starting Windchill FTA on page 67.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project**: label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill FTA

On the **Module Selections** toolbar, select the FTA button  and deselect all other module buttons.

The FTA panes are shown in your System file.

Using Windchill FTA

The two Windchill FTA panes display the same information about your fault tree, but in different formats.

The **FTA Table** at the top displays a table with columns of data. It provides an expandable/collapsible spreadsheet-like view of the same fault tree data contained in the graphical view. This table provides a compact, convenient method of reviewing the various gates and events and their relationships. Using the table, you can quickly view and edit the properties of the gates and events.

The **FTA Diagram**, below, displays a graphical view of the fault tree, which is the most common format for developing and modifying fault trees. The top figure in this window is referred to as the top event. This is the primary event that the fault tree is built around. Shown below the top event is a set of gates and events. The events, either alone or in combination, cause the top event to occur. You can double-click a gate or event to view and edit its properties.

Reviewing Gate and Event Properties

All gates and events have properties associated with them. You can edit the properties of a gate or event by double-clicking it, or by right-clicking it and selecting **Properties**. To review these properties:

1. In the **FTA Diagram**, double-click the **TS-1** event (labeled **Temperature Sensor Failure**). The **Properties** window for this event appears. Review the data values on the various pages.
   - The **General** page displays the event type and identifying text.
   - The **Calculation Data** page displays information about the event's quantitative properties, used during fault tree calculations.
   - The **Library Event** page displays information about the library associated with this event. In this case, this event was not inserted from a library.
   - The **Graphic** page enables you to associate a graphic image of your choosing with the event.
   - The **User Properties** page provides extra data fields you can use for any purpose you desire.
   - The **Remarks** page allows you to enter a lengthy notation about this particular event.
2. Click **Cancel** to close the **Properties** window.
3. Double-click the **BAT-FIRE** gate labeled **Battery catches on fire**. This gate is also referred to as the top gate of the fault tree. The **Properties** window for this gate appears. You can see that there are several more pages of information associated with gates, along with those pages that appear for events. Review the additional pages:
   - The **Inputs** page provides a table view of all the events and gates which are inputs to this gate.
   - The last three pages, **Cut Sets**, **Reliability Importance Measures**, and **FTA Results**, display the results from calculations. If calculations have not been performed, no data appears on these tabs.
4. Click **Cancel** to close the **Properties** window.

Inserting a New Fault Tree

For this example, you create a new fault tree to model the failure of the hard drive of our tablet PC.

1. Select **Insert** ▸ **New Top Gate**. A new fault tree diagram opens and shows a new top gate.
2. In the **FTA Diagram**, double-click the new gate to show the properties for this gate.
3. In the left pane, select the **General** page.
4. For **Identifier**, enter `HD Failure`.
5. For **Description**, enter `Hard drive not functioning`.
6. Click **OK**.

Inserting and Editing Individual Gates and Events

To insert and edit gates or events one at a time:

1. In the **FTA Diagram**, select the **HD Failure** OR gate.
2. Right-click and select **Insert Input**. The **Insert Input** window opens.
3. Select **OR Gate** as the input type and click **OK** to insert the gate.
4. Double-click the new gate to bring up the properties.
5. In the left pane, select the **General** page.
6. For **Identifier**, enter `Mech Fault`.
7. For **Description**, enter `Mechanical failure` and click **OK**.
8. Select the OR gate labeled **HD Failure** again.
9. Right-click and select **Insert Input** to insert another OR Gate.
10. Double-click the new gate to bring up the properties.
11. In the properties, for **Identifier**, enter `Elec/SW Fault`.
12. For **Description**, enter `Electrical or software failure` and click **OK**.
13. Select the **HD Failure** OR gate.
14. Right-click and select **Insert Input** to insert another **OR Gate**.
15. Double-click the new gate to bring up the properties.
16. In the properties, for **Identifier**, enter `Ext Fault`.
17. For **Description**, enter `External failure` and click **OK**.

Inserting Multiple Gates or Events

To insert multiple gates or events:

1. In the **FTA Diagram**, select the **Mech Fault** OR gate.
2. Select **Insert** ▸ **Event**. The **Insert Event** window opens.

   The default input type is **Basic Event**.
3. Click **OK** to insert a basic event.

   The mouse cursor changes shape to show the type of gate or event you are inserting. In this case, it is the circle icon, which indicates a basic event, along with a label showing a plug. The red warning symbol around the plug icon indicates that you cannot insert a basic event in that location.

   
4. Move the cursor so that the circle shape is over the gate labeled **Mech Fault** and notice that the warning symbol on the plug icon disappears, indicating that you can insert a basic event in this location.

   
5. Click to insert a basic event. The cursor retains the shape of the basic event so you can continue to insert basic events.
6. Insert one more basic event under the **Mech Fault** gate.
7. Move the mouse over to the **Elec/SW Fault** gate and insert a single basic event.
8. Right-click to exit the insertion mode. The mouse cursor returns to its normal shape.

Changing an Event to a Gate

At times, you may need to change an event to a gate or a gate to an event. For this example, assume that rather than completing the External Failure logic at this time, we'd prefer to change it to an Undeveloped Event, indicating that we can come back later and more fully analyze this failure path. This type of failure may be caused by such events as the tablet PC being dropped, or someone spilling coffee on it. For now, we'll leave this open-ended. We can further develop this branch when we have more information.

1. In the **FTA Diagram**, double-click the OR Gate **Ext Fault**. The **Properties** window for this gate open.
2. For **Type**, select **Undeveloped Event**.
3. For **Identifier**, enter `External Fault`.
4. For **Description**, `External failure - Undeveloped`.
5. Click **OK**.

Editing Event Properties

All gates and events have properties associated with them. You can edit the properties of a gate or event by double-clicking it or by right-clicking it and selecting **Properties** from the right mouse menu. To review these properties:

1. In the **FTA Diagram**, beneath the OR gate labeled **Mech Fault**, double-click the left event that you inserted. The **Event Properties** window opens.
2. On the **General** page, for the **Identifier**, enter `Bearing Fault`.
3. For **Description,** enter `Mechanical Bearing Failure`.
4. In the left pane, select the **Calculation Data** page. Leave **Input Type** set to **Constant probability**.
5. For **Probability**, enter `0.0015`.
6. Click **OK**.
7. In the **FTA Diagram**, beneath the OR gate **Mech Fault**, double-click the second event that you inserted.
8. On the **General** page, for **Identifier**, enter `Media Fault`.
9. For **Description,** enter `Hard drive media failure`.
10. In the left pane, select the **Calculation Data** page.
11. For **Input Type**, select **Failure rate/MTBF**.
12. For **Failure rate**, enter `0.0001`.
13. Click **OK**.
14. In the **FTA Diagram**, beneath the OR gate labeled **Elec/SW Fault**, double-click the event that you inserted.
15. On the **General** page, for **Identifier**, enter `Controller Fault`.
16. For **Description**, enter `Hard drive controller failure`.
17. In the left pane, select the **Calculation Data** page. Leave **Input Type** set to **Constant probability**.
18. For **Probability**, enter `0.0125`.
19. Click **OK**.
20. In the **FTA Diagram**, double-click the Undeveloped Event **External Fault**.
21. Select the **Calculation Data** page. Leave the **Input Type** set to **Constant probability**.
22. For **Probability**, enter `0.0002`.
23. Click **OK**.

Using Transfer Gates

In some situations, fault trees can become quite large and complex with many gates and events. In these cases, for ease of analysis, it may be helpful to break the single fault tree up into smaller fault trees that are all linked together. Additionally, in some cases you may want to repeat the same logic in two different places. In both of these cases, a type of gate called a transfer gate is very useful. Transfer gates are not associated with any logic operation themselves, but they enable you to break up fault trees for visual reasons as well as to handle repeated logic.

1. In the **FTA Diagram**, select the gate **Mech Fault**.
2. Right-click and select **Break into Transfer**.

   A new fault tree is inserted. The Mech Fault gate is the top gate and all of its lower inputs are intact. The triangular symbol shown with this top gate indicates that it is part of another fault tree.
3. To return to the original fault tree, right-click the top gate of the new fault tree and select **Transfer ▸ HD Failure**. In the original fault tree, a Mech Fault Transfer gate has replaced the Mech Fault OR gate.

   You can bring the newly created Mech Fault fault tree back into its original location in the main fault tree.
4. Right-click the new **Mech Fault** Transfer gate and select **Transfer ▸ To Mech Fault** to go back to the Mech Fault tree.
5. In the Mech Fault tree, right-click the **Mech Fault** gate and select **Collapse Transfer** to return the fault tree to its original state.

New Transfer gates can also be inserted directly into your fault trees just like any other gate.

Performing Calculations

Windchill FTA includes both qualitative and quantative calculations. Qualitative calculations analyze the unwanted event (the top gate in the fault tree) and determine the minimum combination of events that cause that event to occur. These calculations are useful for identifying unexpected root cause combinations, designing for weak points in a system, and finding common causes for an issue. Quantitative calculations measure the unreliability and unavailability of the system based on the fault tree, and provide a more precise and less subjective evaluation of a fault tree.

A sampling of supported calculations is outlined below and very brief descriptions are provided. For more details on these calculations, see the help or guide for Windchill Quality Solutions.

Calculation	Description
Minimal cut sets	A cut set identifies which unique combination of component failures and/or events can cause an undesired event to occur. A minimal cut set is the smallest set of events, which, if they all occur, cause the top event to transpire.
Reliability Importance Measures	A method of ranking the basic events in the fault tree to show their relative culpability in causing the top event to occur. Importance measures are used to detect critical design weaknesses and component failures. They can assist you in identifying the fault tree event that, if improved, is most likely to produce the greatest improvement in system performance. They can also help you determine if allocating additional resources or adding redundancy to the system would improve the overall system reliability.
Unavailability	The probability that, at a given time, the system does not function, due to either a failure or a repair.
Unreliability	The probability that, during a given time period, the top event occurs, and the system is unable to function.
Frequency	The frequency of failures over a time period.
Number of failures	The number of failures in a period of time.

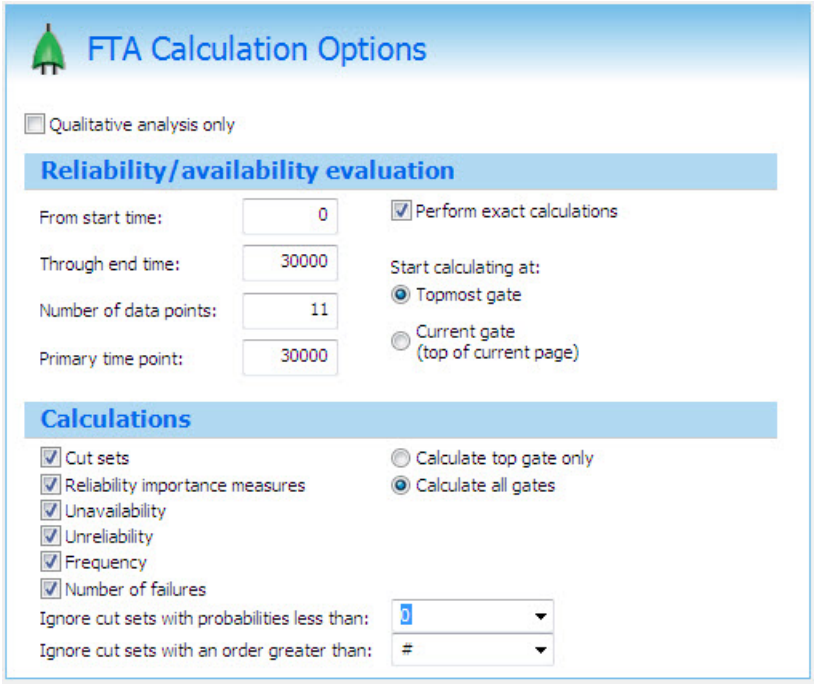
Running Calculations

To perform a fault tree calculation:

1. In the **FTA Table**, select **BAT-FIRE**.
2. Select **System** ▸ **Calculate**, or click the calculate  icon on the **Standard** toolbar. The **Calculate** window opens.
3. In the left pane, select the **Calculation Selection** page (if necessary).
4. In the right pane, click **Clear All** and select **FTA** to perform calculations only for the FTA module.
5. In the left pane, under **FTA**, select the **General** page.

   The **General** and **Advanced** pages contain a number of calculation options.
6. Under **Reliability/Availability Evaluation**, for **Through end time**, enter `30000`.
7. For **Primary time point**, enter `30000`.
8. Select **Perform exact calculations**.

9. Under **Calculations**, leave **Cut sets** selected. Select the following options as well:
   - Reliability importance measures
   - Unavailability
   - Unreliability
   - Frequency
   - Number of failures
10. Select **Calculate all gates**.
11. Leave the remaining options set to the defaults.



12. In the left pane, select the **Advanced** page.
13. For **Calculation method**, select **Exact**.

    For more information regarding all of these options, click the help icon to access the help.

14. Click **OK** to perform the calculations. The **Calculation Progress** window displays status information. When the calculations are complete, the **View Calculation Results** window opens.

    Tip

    *You can print your calculation results by clicking **Print** in the **View Calculation Results** window. You can also save them to a Microsoft Excel spreadsheet by clicking **Excel**.*

15. Click **Close** when you have finished reviewing results.

To redisplay the results at any time, select **System** ▸ **View Calculation Results**. If you have only one module enabled, the results are displayed for that module. If you have more than one module enabled, select the appropriate page to view the results. When finished, click **Close**.

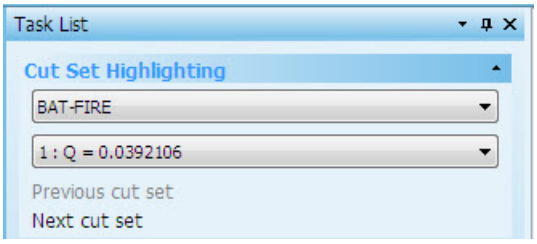
Viewing Cut Sets

A cut set is a set of events that together cause the top event to occur. A Minimal Cut Set (MCS) is the smallest set of events, which, if they all occur, cause the top event to occur.

During calculations, cut sets are determined if you select them in the Calculation settings. You can view the cut sets on screen. You can cycle one at a time through all the cut sets. To view cut sets:

1. Select the **FTA Diagram** if it is not active.
2. In the **FTA Diagram**, select the top **BAT-FIRE** gate.
3. Select **FTA** ▸ **Highlight Cut Sets**.

   The **Cut Set Highlighting** window opens and the first cut set is highlighted in blue in the **FTA Diagram**.



Note

*If you have the **Project Navigator** pinned into view, you may choose to temporarily unpin it and slide it out of view while viewing cut sets.*

4. Click **Next cut set** to view the next cut set for the BAT-FIRE gate. You can continue clicking this button until it becomes unavailable, indicating that the last cut set has been viewed. To go back, click **Previous cut set**.

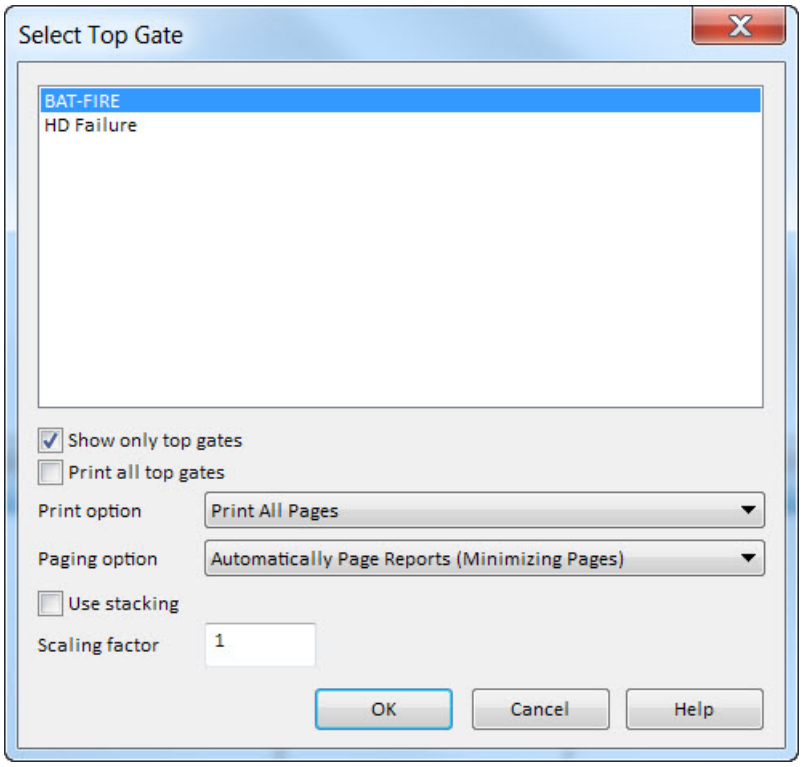
   Note

   *If the **Next cut set** and **Previous cut set** buttons are both unavailable, there is only one cut set to view.*

5. On the **FTA** menu, clear **Highlight Cut Sets** to turn off cut set highlighting.

Viewing a Report

1. In the **Project Navigator**, under **Reports > FTA Reports**, select **(Common) Fault Tree (Summary)**. The **Select Top Gate** window opens.
2. If **BAT-FIRE** is not selected, select it.
3. For the remaining parameters, use the values automatically set as the defaults.



4. Click **OK** to generate this default report in the **Preview** window.

   This report outputs data related to a fault tree (top gate) in the System file, and includes calculation data, gate and event details, and the fault tree diagram.

You can use the various toolbar buttons in the **Preview** window to page through your report, zoom in and out, and print the report.

5. When finished viewing the report, do one of the following to close the **Preview** window:
   - Select **Preview** ▸ **Close**.
   - Click the close icon  on the toolbar.

Graphing Data

1. In the **Project Navigator**, under **Graphs > FTA Graphs**, select **(Common) Fault Tree Unavailability v Time**. The **Select the Gate to Graph** window opens.
2. Select **BAT-FIRE** and click **OK** to generate the graph.

   This graph displays system unavailability for gates at the points in time specified in the **Calculate** window for FTA calculations.
3. When finished viewing the graph, select **File** ▸ **Close**.

Windchill FTA Features

Windchill Quality Solutions supports many more fault tree features and functions. A brief listing of other topics of interest is shown below. For more information, see the help or guide for Windchill Quality Solutions.

- Common cause failures (CCFs) are supported. An event or mechanism that can cause two or more failures (basic events) simultaneously is referred to as a common cause, and such failures are referred to as common cause failures.
- Repeated events are supported. Repeated events are basic events that are used in more than one place in the fault tree but are identical.
- Commonly used failure and repair parameters may be stored in a Fault Tree Event Library file. This allows you to enter frequently used data once and retrieve it as needed.
- Exact calculations are supported. Cut set approximations are also supported to expedite the analysis of large trees.
- The appearance of gates and events, including colors, fonts, bitmap images, and sizing, may be customized.
- You may define very long descriptions for your gates and events and have the size of the figures automatically increased to fit the text.
- You can link Windchill FTA events to other modules. If the linked data changes, these changes are automatically reflected within Windchill FTA. This

module can link to Windchill Prediction, Windchill FMEA, and Windchill Markov.

- Automatic paging is supported to help in the management of large fault trees.
- A Windchill FTA license includes Windchill Event Tree, which provides full ETA (event tree analysis) capabilities. Event trees enable you to analyze the consequences that result from a sequence of events occurring in your system.

7

Windchill RBD

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about building and evaluating block diagrams using Windchill RBD. In this section, you learn how to create a block diagram, insert and link blocks, and assign calculation properties. You also run calculations and view reports and graphs.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Block Diagrams Overview

Block diagrams are used to model systems which incorporate varying configurations outside of the basic series (in-line) configuration, and are especially useful in analyzing configurations that include redundant components.

When system components are connected in series, it indicates that all components must be operational for the system to be successful. Once a single component fails in the chain, the entire system is non-operational. But if the system utilizes backups for components, then one failure does not cause the entire system to fail. Instead, a backup unit can take over to keep the system up and running. Designing redundancy into a system can, therefore, often lead to increased reliability and availability.

There are different types of redundancy, such as parallel operating and standby non-operating. When items are in a parallel operating configuration, all are not necessarily needed to be operational in order for the system to be operating. For example, in a simple system, there may be two batteries set up in redundant configuration so that if one battery fails, the backup battery can take over. In this simple scenario, only one of the two components needs to be operational for system success. In block diagram terms, this is usually described as a 1::2 parallel operating configuration. In the case of a standby non-operating configuration, a system component is in standby mode awaiting failure of the first unit. In block diagram terms, this is referred to as a 1::2 standby configuration.

Models may become even more complex when you begin to consider factors such as the switch delay encountered in standby situations when the backup unit must be switched on. You may also need to account for the fact that a parallel operating unit may have a higher failure rate than a standby unit because it is always powered. You can envision how analyzing reliability metrics of these systems can become difficult without the help of software analysis packages.

Redundancy in system design is essential in cases where repair is either impossible, such as in a launched space probe, or extremely costly, such as in a ship at sea. In other systems, redundancy can play a vital role in ensuring system availability is kept to a maximum.

Block diagrams can be used to model series systems, parallel systems, and combinations of series and parallel systems. Parallel systems can be operating or in standby.

If you are unfamiliar with block diagrams and would like to study this topic in more detail, the following are excellent resources:

- Reliability: A Practitioner's guide (Chapter 4)
- Practical Reliability Engineering by Patrick D.T. O'Connor, 4th edition, John Wiley & Sons Ltd. (2002)
- Reliability Analysis and Prediction: A Methodology Oriented Treatment by K. B. Misra, Elsevier Science Publishers B.V. (1992)

Optimization and Simulation

While a standard block diagram process lets you compute reliability and availability, optimization and simulation tools take this a step further by allowing you to incorporate information on maintenance activities, spare parts, and repair resources.

Optimization and simulation tools such as Windchill RBD effectively address multiple facets of component maintenance, including the definition and allocation of repair teams, the stocking and shipping to and from offsite spares pools, and more. You can define maintenance plans that specify the time interval, cost, and the type of maintenance being performed. You can also specify labor costs and designate if repair is partial or perfect.

If you are unfamiliar with optimization and simulation techniques and would like to study this topic in more detail, the following is an excellent resource:

- Optimal Reliability Design, by Way Kuo, V. Rajendra Prasad, Frank. A. Tillman, Ching Lai Hwang, Cambridge University Press (2001)

Getting Started with Windchill RBD

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the RBD module. For more information, see Starting Windchill RBD on page 82.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project:** label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill RBD

On the **Module Selections** toolbar, select the RBD button  and disable all other module buttons.

Tabbed panes for Windchill RBD are shown in your System file.

Using Windchill RBD

The **RBD Diagrams** table in the top pane lists all the diagrams present in the active System file. These diagrams are organized into two folders: Block Diagrams and Phase Diagrams. This System file currently contains three block diagrams. The first two model the entire Tablet PC in different phases of use, while the third models the hard drive assembly, which includes two hard drives. These hard drives are placed in parallel in order to increase availability through the use of redundancy. In addition, this System file includes a phase diagram, which is designed to evaluate the components of Tablet PC during various phases of the mission.

The **RBD Blocks** tab in the top pane displays a table view of the block diagram selected in **RBD Diagrams**.

The **RBD Diagram** pane below displays a graphical view of the block diagram selected in the **RBD Diagrams** table. For ease of viewing, you may want to resize your **RBD Diagram** using the splitter control, which appears when you hover the mouse cursor between the two panes.

For this example, you add an additional block diagram to model the memory board assembly of the tablet PC. First, you create a simple block diagram and insert blocks into it. Then you connect the blocks, assign calculation properties, and link one of the blocks to an assembly in the system tree.

Creating a Simple Block Diagram

1. In the **RBD Diagrams** table, select the **Block Diagrams** heading.
2. Select **Insert** ▸ **New Block Diagram**. A new block diagram is listed under the Block Diagrams heading and, in the **RBD Diagram** tab below, a new block diagram appears with only Start and End nodes present.

   All block diagrams start at the Start node and then provide one or more paths through the blocks to the End node. When a functioning path exists from the Start node through the End node, the system is operating.
3. For **Identifier**, enter `Memory Board`, and then press the **Tab** key.
4. For **Description**, enter `Block Diagram for the Memory Board Assembly`. Do not press the **Tab** key.

Inserting Blocks into a Block Diagram

1. Ensure you have selected the **Memory Board** block diagram.
2. Select the **RBD Diagram** pane.
3. Right-click and select **Insert Default Block**. The cursor changes in appearance to show that you are inserting blocks.
4. Click near the start node to insert a block.
5. Move to the right and click again to insert another block.
6. Right-click to exit insertion mode.

Connecting Blocks in a Block Diagram

1. Hover the mouse cursor over the triangle connection point on the right side of the Start node, until the cursor changes shape to a long arrow.
2. Select the triangle connection point on the start node.

3. Select the first block to connect the start node to the block. The two are connected.
4. Repeat to connect the first block to the second block and the second block to the end node.

Tip

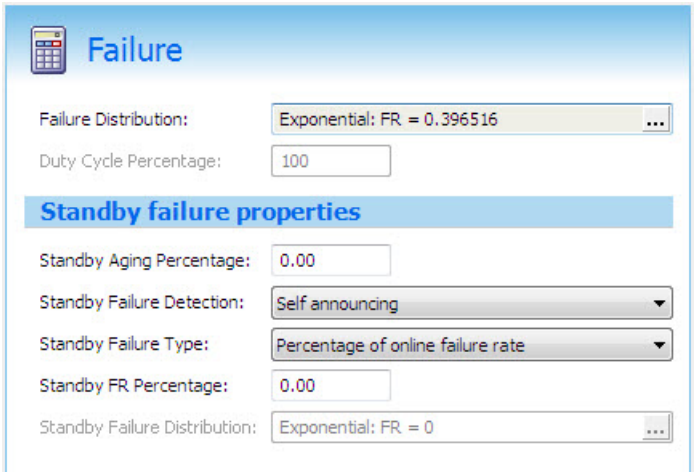
*You can also select **RBD** ▸ **Auto Connect Blocks** to automatically connect blocks based on entry order.*

Assigning Calculation Properties

The memory assembly consists of the memory board controller and two memory boards. For the purposes of this example, we'll assume that the memory boards are operating in a redundant configuration so that we can learn how to model redundancy in Windchill RBD.

1. Double-click the left block to display the **Calculation Properties** window.
2. On the **General** page, for **Assembly,** enter `MEM061789`.
3. For **Part Number,** enter `DRAM512-31`.
4. In the left pane, select the **Failure** page.
5. For **Failure Distribution**, click the browse button  to show the **Distribution** window.
6. Leave **Distribution** set to **Exponential**.
7. From the dropdown menu, select **Failure rate**, and then enter `0.396516` for the failure rate.
8. Click **OK** in the **Distribution** window to save your selections. The specified Exponential Failure Rate is displayed in the **Calculation Properties** window.

9. For the remaining parameters, use the default values:



10. In the left pane, select the **Redundancy** page.
11. For **Quantity**, enter `2`.
12. For **Redundancy Type**, select **Parallel Operating**.
13. Leave **Quantity Required** as `1` and **Switch Probability of Success** as `1.000000`.
14. When finished, click **OK**. The first block is redrawn to show redundancy is designated.

Linking Blocks to Other Modules

If the block diagram you are creating includes assemblies from your system tree, there is a more efficient way to access this data.

RBDs can be linked to data from other modules in order to pull in information obtained from other analyses. Not only does linking the data make data entry much easier, it has the additional advantage of keeping the linked data up-to-date, so if you make changes to your assemblies and recompute failure rates, the new values are automatically used in your block diagram.

To create a block that is linked to an assembly in the system tree:

1. Right-click the right-most block and select **Data Linking** ▸ **Link Data**. The **Link Data** window opens.
2. For **Data Source**, select **Prediction** to link to Windchill Prediction results.
3. For **Configuration**, click the dropdown control to display a selection window.
4. Select **Configuration1**.
5. For **System Tree Item**, click the dropdown control to display a selection window.

6. Expand the memory assembly **MEM061789** and select the **DRAMC7001** part.
7. Click **OK** to close the **Link Data** window.

The block now appears with a small link icon  in the upper right corner as a visual indicator that the block is linked to data in another module. You can see that the DRAMC7001 part information now appears in the block.

Additionally, if both Windchill Prediction and Windchill RBD are enabled, you can drag items from your system tree and drop them into the RBD module to create linked blocks.

Performing Calculations

Windchill RBD computes a variety of reliability and availability metrics. A sampling of supported calculations is outlined below and very brief descriptions are provided. For more information on calculations, see the guide or help for Windchill Quality Solutions.

Calculation	Description
MTBF	The Mean Time Between Failures (MTBF) represents the mean number of hours between two consecutive system failures in a long run. It includes both operational and downtime hours between two consecutive failures, and is the average distance in hours between two failures in a long run. In Windchill RBD, the run length is specified using **Number of System Failures to Reach Steady-State**, which is available in the **RBD Advanced Calculation Options**.
MTTF	The Mean Time To Failure (MTTF) or the expected time to failure. The MTTF is the average time to failure, in hours. For repairable systems, it is the average time to reach the first system failure. Hence, it is also called Mean Time To First Failure (MTTFF). When **Account for Repair in Reliability** is selected, then reliability is calculated using blocks' failure and repair information, and this function is used to calculate MTTF.
MTTR	Mean Time To Repair (MTTR) is the average time it takes to repair a failed system and return it to an operational state, based on the repair time distributions for its repairable components or blocks. The MTTR can be calculated by considering the frequency of each failure scenario and its respective average repair times.

Calculation	Description
Optimal Number of Spares	The Optimal Number of Spares is the number of spares that minimizes or maximizes a specified objective function (or the goal). If the goal is minimizing the total cost, then the Optimal Number of Spares represents the number of spares corresponding to the minimum total cost. Similarly, if the goal is maximizing the mean availability, then the Optimal Number of Spares is the number of spares that maximizes the mean availability. The optimal number of spares is calculated by evaluating the function specified in the goal with varying number of spares. For example, if the goal is minimizing the total cost, then the total cost is calculated for different number of spares. The optimal number of spares corresponds to the minimum value of the total cost.
Optimal Maintenance Intervals	The Optimal Maintenance Intervals value is the value of the periodic maintenance interval that minimizes or maximizes a specified objective function or the goal. If the goal is minimizing the total cost, then it is the value of the maintenance interval corresponding to the minimum total cost. The optimal maintenance intervals are calculated using optimization algorithms integrated within the simulation engine.
Optimal Repair Resources	The Optimal Repair Resources value is the number of the repair resources that minimizes or maximizes a specified objective function or the goal. If the goal is minimizing the total cost, then it is the number of repair resources corresponding to the minimum total cost. The optimal repair resources are calculated using optimization algorithms integrated within the simulation engine.
Reliability	The probability that a system remains operational until a specified time. Reliability is a time-based probability value, so it is always a metric between 0 and 1. A reliability of 0 means that the system always fails before the specified time or never functions until the specified time. A reliability value of 1 indicates that the system is always successful or never fails during the specified time.

Calculation	Description
	The system reliability value is calculated using both the system configuration specified in the block diagram and the failure distribution specified in the calculation properties of the blocks. If all blocks are in series, and all of them follow exponential failure distributions, then the system itself follows an exponential failure distribution, and the failure rate is the sum of the failure rates of its components. When **Account for Repair in Reliability** is selected, then reliability is calculated using both the failure information and the repair information specified in the block properties.
Unreliability	The probability that a failure occurs during a given time period.
Failure Rate	It indicates the chances of failure at a specified time given that the system is not yet failed. It also represents the expected number of system failures per unit time given that no failure has occurred in the system until the specified time. It is a time-based metric and also known as instantaneous failure rate. The failure rate function can be used to study the behavior of the system's failure over time. Furthermore, the failure rate function, (t), is an important representation in the lifetime modeling of the system due to its intuitive interpretation as the amount of risk of failure associated with the system at time *t*. When **Account for Repair in Reliability** is selected, then reliability is calculated using blocks' failure and repair information, and this function is used to calculate failure rate.
Availability	The probability that the system is operating properly at a specified time. Availability, like reliability, is a time-based probability metric, so it is always a metric between 0 and 1. Hence, it is also called point availability or instantaneous availability. When availability is calculated without considering logistic delays, then it is called inherent availability. When logistic delays are considered in the availability calculation, then it is called Operational Availability. Therefore, Windchill RBD can calculate either Availability or Operational Availability in a single calculation. Availability is a function of both reliability (how quickly the system fails) and maintainability (how quickly the system is repaired).

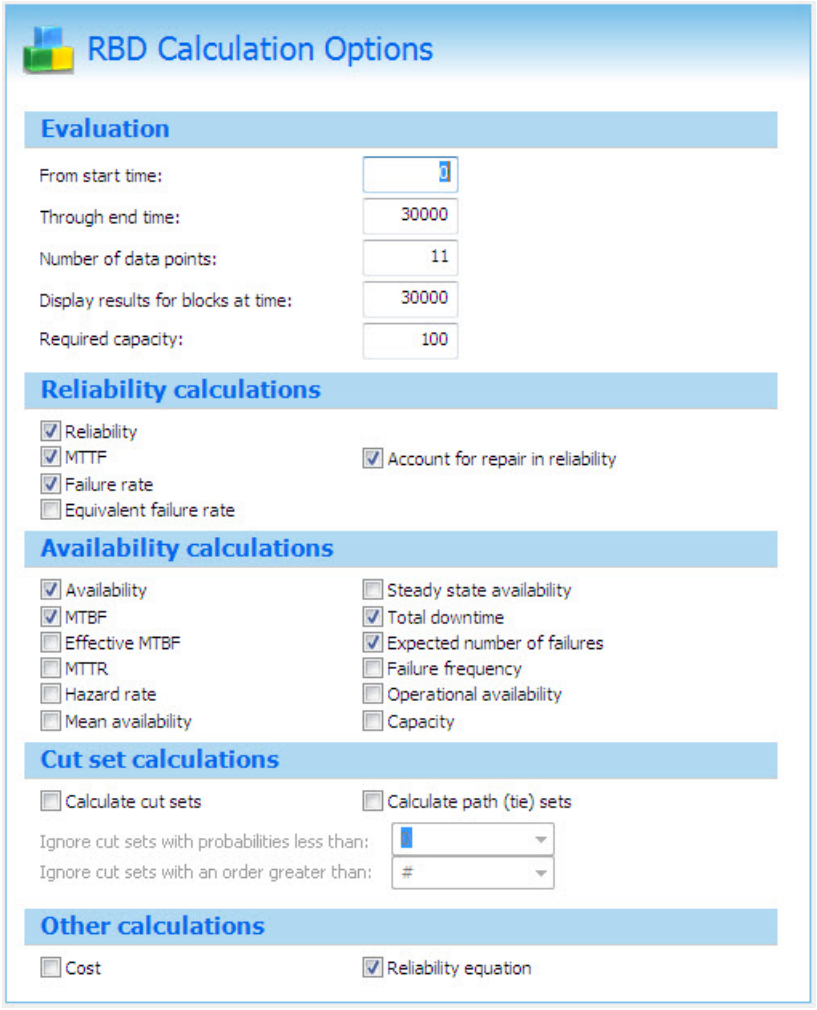
Calculation	Description
	A common term, "five nines", refers to a system which has an availability of 0.99999, i.e., it is operational 99.999% of the time.
Mean Availability	Mean availability is the average availability over a specified time interval. It is the ratio of the mean total uptime to the total time over a specified interval.
Steady State Availability	The steady-state availability is the availability in a long run, i. e. as time tends to infinity. It is the ratio of the total uptime to total time in a long run. In Windchill RBD, the run length is specified using **Number of System Failures to Reach Steady-State**, which is available in the **RBD Advanced Calculation Options**.
Unavailability	The probability that, at a given time, the system does not function, due to either a failure or a repair.
Total Downtime	The total downtime of the system during the specified time interval.

Running Calculations

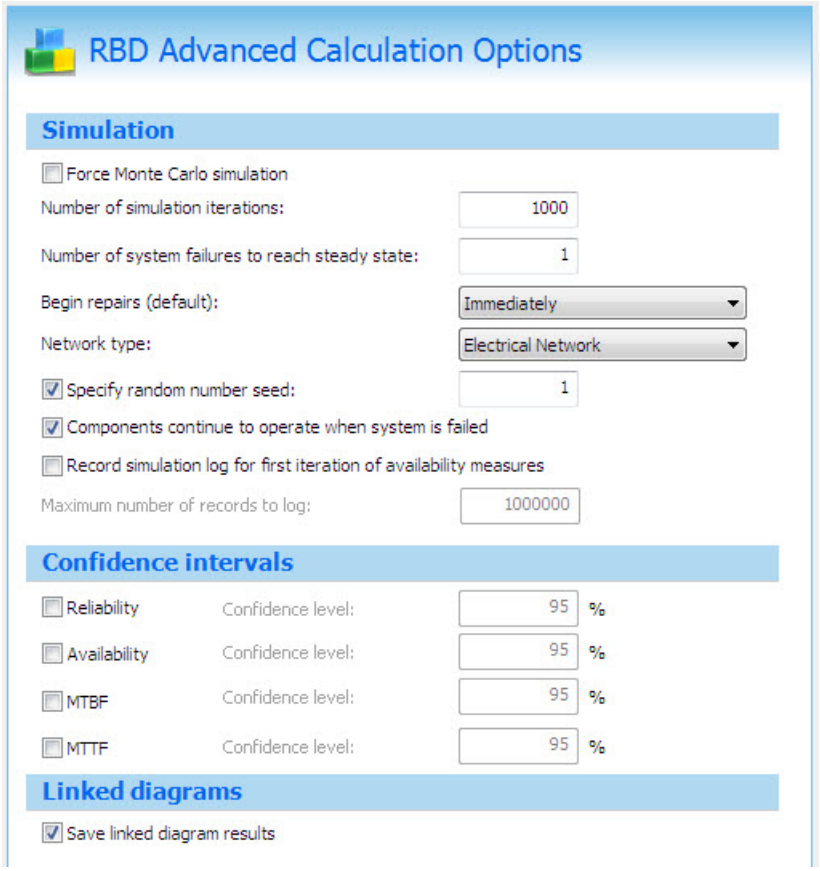
To calculate results:

1. In the **RBD Diagrams** table, select **Tablet PC**.
2. Select **System** ▸ **Calculate**, or click the calculate  icon on the **Standard** toolbar. The **Calculation Properties** window appears.
3. In the left pane, select the **Calculation Selection** page (if it is not already selected).
4. In the right pane, click **Clear All** and then select **RBD** to perform calculations only for the RBD module.
5. In the left pane, under **RBD**, select the **General** page.

   The **General** and **Advanced** pages contain a number of calculation options.
6. Leave all defaults. The page should appear as follows:



7. In the left pane, select the **Advanced** page.
8. Leave the defaults. The page should appear as follows:



9. When finished, click **OK** to perform the calculations. When completed, the **View Calculation Results** opens.
10. In the left pane, under **RBD Results**, select the **General** page to view the results.

Tip

*You can print your calculation results by clicking **Print** in the **View Calculation Results** window. You can also save them to a Microsoft Excel spreadsheet by clicking **Excel**.*

11. Click **Close** when you have finished reviewing results.

To redisplay the results at any time, select **System** ▸ **View Calculation Results**. If you have only one module enabled, the results are displayed for that module. If you have more than one module enabled, select the appropriate page to view the results. When finished, click **Close**.

Viewing the Reliability Equation

When Windchill RBD analytically computes the diagram results, you can view the equation which was used for the calculation. To obtain the Reliability Equation, select **Reliability Equation** under **Other Calculations** when calculating.

To view the reliability equation:

1. In the **RBD Diagrams** table, select **Tablet PC**.
2. Select **System** ▸ **View Calculation Results**. The **View Calculation Results** window opens.
3. If necessary, expand the **RBD Results** heading.
4. In the left pane, select the **Equation** page to view the reliability equation used to calculate the results for the Tablet PC diagram.
5. Click **Close** to close the **View Calculation Results** window.

Viewing a Report

1. In the **Project Navigator**, under **Reports > RBD Reports**, select **(Common) RBD (Summary) Portrait** to preview this report on-screen. The **Select Block Diagram** window opens.
2. Select **Tablet PC** from the list of diagrams.
3. Select **Select single diagram** and click **OK** to generate the report in the **Preview** window.

   You can use the various toolbar buttons in the **Preview** window to page through your report, zoom in and out, and print the report.
4. When finished viewing the report, do one of the following to close the **Preview** window:
   - Select **Preview** ▸ **Close**.
   - Click the close icon  on the toolbar.

Graphing Data

1. In the **Project Navigator**, under **Graphs > RBD Graphs**, select **(Common) RBD Reliability v Time 3D** to generate this graph. The **Select RBD Diagrams** window opens.
2. Leave **Tablet PC** selected and click **OK** to generate the graph.
3. When finished viewing the graph, select **File** ▸ **Close**.

Windchill RBD Features

Windchill RBD supports many more block diagram features and functions. A brief listing of other topics of interest is shown below. For more information, see the help or guide for Windchill Quality Solutions.

- To change the visual properties of a block, select the block, right-click, and select **Visual Properties**. To change the visual properties of a connector, select the connector, right-click and select **Properties**.
- Windchill RBD supports a wide array of system complexities including limited repair resources, fixed and variable costs, switching mechanisms, switch delays, transportation delays, and logistic delays.
- To place a bitmap in your diagram, right-click the block and select **Visual Properties** to display the **Block Visual Properties** window. On the **Graphic** tab, use the browse button  from the **Image file** field to navigate to and select a graphic file.
- Windchill RBD supports hot, cold, and warm spares.
- To insert a junction, which can be used to connect multiple connectors together, select **Insert** ▸ **Junction**. Junctions can be used to model a redundant configuration.
- Windchill RBD supports conditional repair policies.
- To display multiple pages in the **Block Diagram** window, select **Diagram** ▸ **Properties** and complete the **Pages** page in the **Diagram** window.
- Windchill RBD can compute confidence intervals for various reliability metrics.
- To link blocks together to create child diagrams, diagram links can be used. Right-click a block and select **Diagram Linking** ▸ **Set Diagram Link**. The **Select Diagram Link** window opens so that you can select the diagram to which to link.
- The RBD module supports a large number of distributions, including exponential, lognormal, normal, Rayleigh, time independent, Weibull, uniform, and constant time.
- Windchill RBD supports both Electrical and Flow type networks.

8

Windchill FRACAS

This section of the *Windchill Quality Solutions Getting Started Guide* provides information about a FRACAS (failure reporting, analysis, and corrective action system) and how to use it to track, measure, and ultimately improve the reliability of a product, service, process, or software application.

In this section, you learn how to enter incidents in Windchill FRACAS, how to filter your data, and how to view outputs such as reports and graphs.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Overview of FRACAS

A FRACAS is a closed-loop incident reporting and corrective action system. This type of system is also known as a DRACAS (data reporting, analysis, and corrective action system), PRACA (problem reporting, analysis, and corrective action), and various other names. Reducing the cost of poor quality (COPQ), improving the next generation of product design, reducing warranty costs, and ensuring compliance are some of the key reasons organizations deploy closed-loop corrective action systems.

A FRACAS can be the means by which the reliability of a product, service, process, or software application is tracked, measured, and ultimately improved. A FRACAS must provide for accurately recording and analyzing significant incident information so that effective corrective actions can be quickly identified, implemented, and verified.

Windchill FRACAS allows you to create a completely customized FRACAS tool for data entry, analysis, and reporting.

If you are unfamiliar with FRACAS and would like to study this topic in more detail, the following are some recommended resources:

- Failure Reporting, Analysis, and Corrective Action System (FRACAS) Application and guidelines, a 1999 publication of the Reliability Analysis Center (RAC)
- MIL-STD-2155(AS): Failure Reporting, Analysis and Corrective Action System

Getting Started with Windchill FRACAS

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill FRACAS module; see Starting Windchill FRACAS on page 97 for more information.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project**: label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill FRACAS

On the **Module Selections** toolbar, select the FRACAS  button and deselect all other module buttons.

The tabbed Windchill FRACAS panes are shown in your System file.

Using Windchill FRACAS

The upper pane displays the **System Tree Items** table, which is the hierarchical representation of your system assemblies and components and is shared with several other modules. The lower pane displays all your FRACAS specific data.

FRACAS applications built with Windchill FRACAS are extensively customizable. You can select which fields appear on your FRACAS and the names of the fields, as well as completely customize your data entry forms and reports.

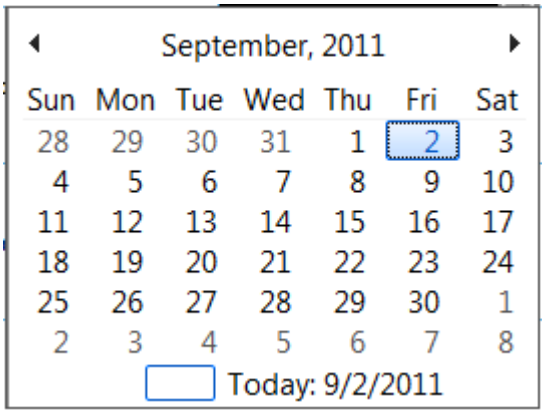
Additionally, you can perform your FRACAS activities on the Web using the web version of Windchill Quality Solutions.

Entering Incidents

The main data element of your FRACAS is an incident or a failure report of some type. The data associated with the entry of an incident can be completely customized in Windchill FRACAS. For our example, we'll enter an incident using our sample Project, but please note that the entire data entry screen can be modified to suit your needs.

1. In the **System Tree Items** table, select **Touchpanel** to display the incidents associated with the touchpanel assembly in the **FRACAS Incidents** table in the lower pane.
2. In the **FRACAS Incidents** table, click the last row, labeled **< Click here to insert a new record >**. A new incident is entered and **Incident ID** and **System Tree Item** are filled in automatically.

   Note that the newly selected incident appears in red. We have our table set to display all open incidents in red in order to highlight them. This is an optional setting that you can customize.
3. For **Location,** select **Austin**.
4. For **Technician**, select **Arnold Palmer**.
5. For **Serial Number,** enter **42661**.
6. Click **Occurrence Date** and click the calendar icon  . The **Calendar** control appears.



7. Select today's date.
8. Tab to **Incident Description**, enter `Customer reports that the touchpanel is non-responsive in a certain area`. Press **Tab**.

Closed? is used to indicate if the incident has been analyzed and corrective action implemented. Because this is a new incident report, leave **Closed?** cleared.

9. View the other data fields in the **FRACAS Incidents** table. Most of these fields are related to subsequent steps in the FRACAS process, such as corrective action, analysis, and close out. For this example, do not enter any further data.

It may often be easier to enter and modify your FRACAS data in a form view. A form allows you to view the data for one record at a time in a larger format for ease of editing. Deciding whether to use a table view or a form view is a personal preference. One of the advantages of Windchill FRACAS is that both views can be available so that you can select the method you find most comfortable.

To review the incident data on a form:

1. Select the **FRACAS Incident Form** tab.
2. In the **Incident Analysis** section, for **Date**, enter today's date.
3. For **Analysis By,** select **Ethan**.
4. For **Analysis Description,** enter `Found hairline crack in upper right portion of the touch panel. Contacted customer who reported that original shipping container had arrived slightly damaged.`
5. For **Failure Mode,** select **Cracked, Fractured**.
6. Click the **FRACAS Incidents** tab to return to the table.

Filtering Data

Due to the large number of incidents that can be accumulated over time, Windchill Quality Solutions supports data filtering to allow you to view a subset of your entered data set based on criteria you specify. For example, you can view only the incidents for which you are responsible, all the incidents that are currently open, or a combination of the two.

Windchill FRACAS supports both fixed-value filters and parameterized filters. When you create a parameterized filter, you must supply a parameter value when the filter is applied. You can also build filters with multiple parameters. When building a parameterized filter, be aware that the request for a parameter value occurs whenever the filter is used, even during report or graph generation.

Using Predefined Filters

Windchill FRACAS is supplied with a number of predefined filters.

1. Select the **FRACAS Incidents** tab in the lower pane.
2. In the toolbar, use the **Filter** selection box to select **Open Incidents**. The data is filtered to show only incidents not marked as closed.
3. In the **Filter** selection box, select **– No Filter –** to remove the applied filter.

Creating Custom Filters

To create a custom data filter:

1. Select **Filter ▸ Filter Wizard**. The **Filter Wizard** starts and displays the **Specify Filter Features** page.
2. Leave **Selects records only** selected and click **Next**. The **Specify Filter Field** page appears.
3. For **Table type**, select **FRACAS Incidents**.
4. From the list of fields, select **Technician** and click **Next**. The **Specify Condition** page appears.
5. Leave **is equal to** selected and click **Next**. The **Specify Field Value** page appears.
6. Leave **Use a fixed value (specify the value below)** selected.
7. For **Specify the value here**, click the dropdown control to display a selection window.
8. Select **Hugh Downs** and click the green checkbox icon  .
9. Click **Next**. The **Review Filter** page appears.
10. Make sure **I want to add more conditions to the filter** is cleared to indicate that the filter is complete and click **Next**. The **Save Filter** page appears.
11. In the **Save Filter** page, select **I want to save my filter for later use**.
12. For **Filter name**, enter `Technician Hugh Downs`.
13. Select **Save filter to My Filter File** .

    You have the option of saving filters to two different locations.

    - If you select **Save filter to My Filter File**, your new filter is stored in a file accessible only to you; the filter is not accessible to other users with filter permissions.
    - If you select **Save filter to the Filter File in this Project**, the filter is accessible to other users with filter permissions.

      In some cases, you may be creating a filter that is for your own use. In that case, it is best to save it to the My Filter file. In other cases, if you are

creating a filter you know would be helpful to all team members, save it to the Project Filter file to allow everyone to use it.

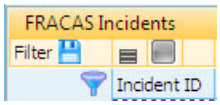
14. Click **Next**. The final page of the wizard appears.
15. Click **Finish**.

    If this is the first time you have saved a filter, you are asked if you want to create a Filter file in which to store your newly constructed filter. In the **Create Support File** window that opens, click **Yes** to create this Support file. If you have previously created a Filter file, this message does not appear. If a message appears asking you if you want to overwrite or use the existing file, select the **Use Existing** option.

    The filter is applied to your data so that all incidents handled by technician Hugh Downs are shown. Your new filter is shown in the **Filter Selection** box. Notice that when you drop down the list in the **Filter Selection** box, your new filter `Technician Hugh Downs` is preceded with a person icon instead of a Windchill Quality Solutions icon. This indicates that the filter is stored in your My Filter file and not the Project Filter file.
16. From the **Filter** selection box, select the **– No Filter –** option to return to the original data view.

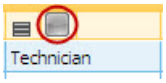
You can also modify your filters by selecting the **My Filter File** option in the **Project Navigator** to open up the Filter file. New filters can then be added directly to the Filter file.

Additionally, you can quickly build filters using the **Filter Bar**, which is located above the column headers of the table. You can use the **Filter Bar** to sort records and/or select the data to be shown in the table. You can also save filters created using the **Filter Bar** by clicking the save icon at the top left of the **Filter Bar**.



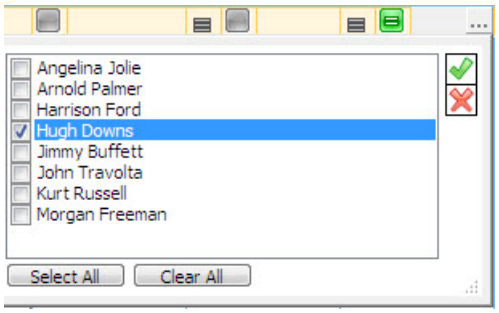
You can create the same custom filter from the previous exercise using the **Filter Bar**:

1. Select the **FRACAS Incidents** table by clicking it.
2. In the **Filter Bar**, for **Technician**, click the icon for selecting a filtering condition.

3. Select **is equal to** as the condition.
4. To the right of this condition, click the dropdown control to display a selection window.

5. Select **Hugh Downs** from the list.



6. Click the green checkbox icon  .

   The selection window closes and the **FRACAS Incidents** table reflects the newly applied filter.

7. If you want to save your filter, click the save icon  to save for later use.
8. To return to the original data view, in the **Technician** column, click the filter selection box and select **(not filtered).**

Viewing a Report

1. In the **Project Navigator**, under **Reports > FRACAS Reports,** select **(Common) FRACAS Incidents by Part Number** to generate this report in the **Preview** window.

   This report outputs data on all incidents by part number. For each part number, this summary report includes incident identifiers, descriptions, and incident occurrence and entry dates. It also indicates who entered the incidents and analyzed the incidents, supplies descriptions of the corrective actions taken, and notes which incidents are closed.

   You can use the various toolbar buttons in the **Preview** window to page through your report, zoom in and out, and print the report.

2. When finished viewing the report, do one of the following to close the **Preview** window:

   - Select **Preview ▸ Close**.
   - Click the red **Close** button on the toolbar.

Graphing Data

1. In the **Project Navigator**, under **Graphs > FRACAS Graphs**, select **(Common) FRACAS Incidents per Part Number** to generate this graph.

This graph displays the number of incidents for each part number as a cylinder bar graph.

2. When finished viewing the graph, select **File** ▸ **Close**.

Windchill FRACAS Features

Windchill FRACAS includes a number of features and functions. A brief listing of other topics of interest is shown below. For more information, see the help or guide for Windchill Quality Solutions.

- You can use the web version of Windchill Quality Solutions to perform your FRACAS tasks via the Web. This zero-client, web-based interface provides a rich Windows-like user interface. The web version provides significant advantages for enabling FRACAS tasks to be performed in a collaborative environment through its global accessibility.
- Windchill FRACAS can perform MTBF calculations using your actual incident, or field, data. Using the optional Operating Time to track the operational time of your system, the FRACAS module can compute a wide variety of MTBF metrics. Also, MTBF calculations can be customized through filters to provide you with the key metrics you require.
- The Form Designer enables you to create completely custom data entry forms with any fields in any format you choose. The Form Designer provides ultimate flexibility. Additionally, multiple forms can be grouped together in a Form Set to enable you to create different forms for different process steps or different users.
- List Libraries allow you to define a list of selections for choice list fields so that all users working on the same Project use the same terms. List Libraries ensure data consistency as well as process efficiency.
- The Enterprise Edition of Windchill FRACAS supports a customizable workflow process. When an incident is moved from one process state to another, automatic email notifications are sent to the appropriate personnel, notifying them of the update.
- The Enterprise Edition of Windchill FRACAS includes an alerts feature, which enable you to send customized notifications to system users based on criteria you define.
- The **FRACAS Incidents** table and other FRACAS tables can be modified during data entry by invoking the Format Builder with a simple right-click. You can add columns as required “on the fly.”

- FRACAS data can also be imported using the Import Wizard. This feature enables you to directly populate your FRACAS data with incident data collected from other sources.
- The Enterprise Edition of Windchill FRACAS includes an Audit Trail module, which tracks data modifications for audit requirements.
- The Windchill Quality Solutions Implementation Services team is available to aid in design, development, and deployment of your FRACAS.

9

Windchill Weibull

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about Weibull analysis and how to evaluate failure data using Windchill Weibull.

In this section, you create a new data set in Windchill Weibull and find the distribution that best fits the data points. You then view and customize the resulting plot.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Weibull Analysis Overview

The Weibull distribution is widely used in reliability engineering. While the Weibull distribution is important for life data analyses, Weibull packages typically encompass support for various other significant distributions used in statistical analyses, such as exponential, normal, and lognormal.

Weibull techniques can be used on a variety of failure data, including field failures and test failures, and in a wide variety of applications. The idea is to determine a best fit distribution for the collected sample data in order to predict or uncover trends.

In order to perform a Weibull analysis, the first and most important step is to gather sound life data. You must identify the failure usage scale – units for the age of the component or system being tested. Age of the component can be measured in terms of hours, miles, cycles, or any other metric. It is also important to analyze one failure mode at a time.

Once you identify the data associated with failure, you can enter the data, select the distribution and estimation method, calculate and graph the results for the life data set, and predict future trends using the results.

If you are unfamiliar with Weibull analysis or failure data analysis and would like to study this topic in more detail, the following three selections are excellent references:

- Reliability: A Practitioner's guide (Chapter 7)
- The New Weibull Handbook, 5th ed., by Dr. Robert B. Abernethy

  Further details are available at http://www.bobabernethy.com/products_handbook.htm.

Getting Started with Windchill Weibull

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill Weibull module; for more information, see Starting Windchill Weibull on page 107.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project**: label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill Weibull

On the **Module Selections** toolbar, select the Weibull button  and deselect all other module buttons.

The tabbed panes for Windchill Weibull are shown in your System file.

The Windchill Weibull interface consists of three panes.

LDA Navigator

The **LDA Navigator** displays your list of data sets. When you select a data set in the **LDA Navigator**, the other two panes display information specific to that data set.

Data sets are organized into three analysis types, which can be accessed by clicking the appropriate link under **Analysis type**:

1. Life Data, which may consist of Life Data, Non-Parametric Life Data, and Reliability Growth Data, as well as Multiple Data Sets, which enable you to display multiple data sets concurrently on a plot.
2. Warranty Analysis, which enables you to input and analyze warranty information (information about the date a product was produced or sold and the

date it was returned from the field). You can also extrapolate a life data set from warranty data and analyze it using typical life data analysis techniques.

3. Degradation Analysis, which uses the changing rate of degradation of a product and a critical value at which the unit is assumed to fail to create a model for predicting the times at which the product fails in the future. You can also extrapolate a life data set from degradation information and analyze it using typical life data analysis techniques.

In the **LDA Navigator**, you can create new data sets and delete sets you no longer need. You can also further organize your data by creating new sub-folders within the data types.

Weibull Parameters

The pane beneath the **LDA Navigator** consists of any number of tabs, depending on the analysis type. For Life Data, this pane consists of up to three tabs: **Parameters**, **Advanced** (where available), and **Plot Options**. For Warranty Analysis and Degradation Analysis, additional tabs would be available. These tabs display options for specifying plot parameters and displaying plots.

The **Parameters** tab enables you to specify parameters for the selected data set. The **Advanced** tab displays additional options for defining estimation methods and other parameters of the distribution. Finally, the **Plot Options** tab provides control over the number and type of plots displayed in the **Weibull Plot** tab on the right side of the interface.

When a data set is analyzed, the results are displayed at the bottom of all three windows in the **Weibull Parameters** pane. You can also fix one or more of the calculations in the **Calculation results** section. The values displayed in the **Calculations results** area of the **Parameters** window differ based on the distribution selected.

The **Weibull Parameters** pane also includes a toolbar, which gives you access to common tasks, including:

- Calculate
- Show Plot
- Additional Data Set Calculations (Summary Calculator)
- Best Fit Distribution Analysis

Weibull Data Points

To the right of the **LDA Navigator** and **Weibull Parameters** panes is a pane consisting of two tabs – **Weibull Data Points** and **Weibull Plot**.

Weibull Data Points displays information about each item in the data set selected in the **LDA Navigator**. The column headings in this display vary, depending on the selected data type.

Note

You can modify the column heading names to suit your process needs. Simply double-click on the column heading, then specify the desired name in the ***Change Column Name*** *window.*

Weibull Plot displays a plot representing the selected data set and the distribution(s) applied to it. The parameters, distribution, and number of plots displayed in **Weibull Plot** are all controlled by the **Weibull Parameters**.

You can also modify the appearance of your Weibull plots using the **Plot Properties**. You change the plot properties later in this section.

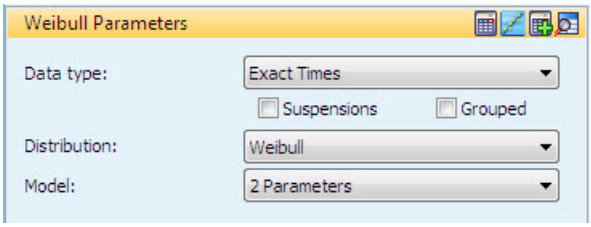
Using Windchill Weibull

You now create a data set, enter data points, and find the distribution that best fits your data points.

Creating a Data Set

To create a new data set:

1. In the **LDA Navigator**, under **Analysis type**, click **Life Data** to ensure you are viewing the Life Data data sets.
2. In **Data Sets**, select **Life Data**.
3. Select **Insert** ▸ **LDA Data Set**. A new Life Data Analysis data set appears under **Data Sets**. This new row is automatically selected.
4. Enter `My Weibull Data Set` as the name of the new data set.
5. Select the **Parameters** tab in the **Weibull Parameters** pane.
6. In **Parameters**, use the data values automatically set as the defaults:

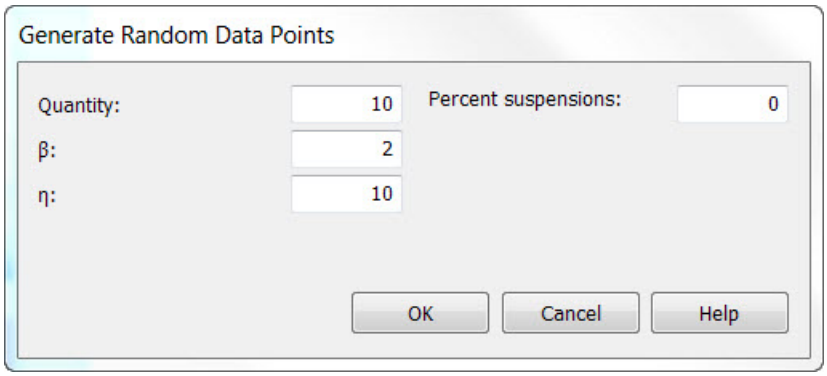


Entering the Data Points

Once the analysis parameters are specified, you can enter data points in the **Weibull Data Points** table. You can either specify the data points manually, or you can copy and paste them from a word-processing file, spreadsheet, or other electronic file.

For this example, you use the built-in random data set generator to automatically create a set of data points. In actual use you would not create a data set in this manner; it is a feature available for testing and example purposes.

1. Select the **Weibull Data Points** tab.
2. Select **LDA ▸ Generate Random Data Points**. The **Generate Random Data Points** window opens.
3. Use the values automatically set as the defaults:



4. Click **OK** to generate the random data points.

Finding the Best Fit Distribution

Once you have entered your data, you can determine the failure distribution that best represents your life data. Windchill Weibull includes a Best Fit Distribution analysis tool that recommends the best possible distribution for the selected data set.

1. Select **LDA ▸ Find Best Fit Distribution**. The **Best Fit Distribution** window opens and shows all of the available failure distributions. You can select which distributions you want to check against the data set, then direct Windchill Weibull to analyze the selected distributions for the one that best fits. In this case, leave all distributions selected.
2. Click **Analyze** to determine the distribution that best fits your data. A ranking for each distribution appears in the Rank column.

   Depending on your data set, the recommended distribution may not be the distribution currently selected for the data set (in this case, the Weibull [2 Parameters] distribution). If the optimal distribution is not Weibull (2

Parameters), you would see the **Change** button at the bottom of the window, along with a query as to whether you want to change the distribution setting to match the optimal determination.

For this example, ignore the **Change** option if it appears, and keep the distribution setting as Weibull (2 Parameters).

3. Click **Close**.

Viewing Calculations

Calculations, which in Windchill Weibull are performed dynamically, are based on the distribution specified. In the case of the Weibull distribution, the Weibull module calculates the Beta (β), the slope of the line; the Eta (η), the characteristic life, or the point at which 63.2% of the items in the data set have failed; the Rho (ρ), a value between -1 and 1 that expresses how well the data fits the probability line; and the Rho-squared (ρ^2), the 10th percentile of the correlation coefficient.

To view these values, select **Parameters** in **Weibull Parameters**.

Viewing Plots

When performing Weibull analyses, the resulting Weibull plots are automatically generated and can be viewed on the **Weibull Plot**. These plots are updated dynamically as you make changes. So, for example, if you change the distribution, the **Weibull Plot** is dynamically updated to display the newly-selected distribution.

To view the resulting Weibull graph:

1. Select the **Weibull Plot** tab.

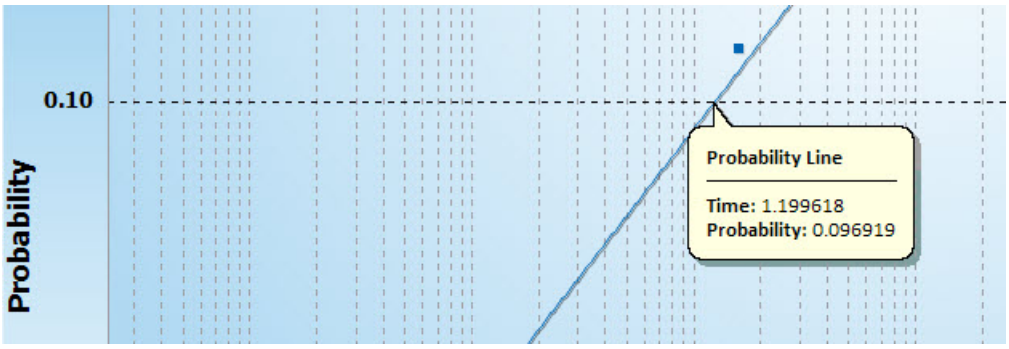
   There are many things you can learn by examining a Weibull plot. For example, if points are concentrated in one particular area, a batch problem may have occurred due to production or assembly processes, maintenance or overhaul schedules, or increases in service usage.

   Sharper corners or dogleg bends, on the other hand, may indicate multiple competing failure sources. For example, many components have a high infant mortality due to production and quality problems, then another group of failures later in life when they begin to wear out. In this case, you may choose to make a separate Weibull plot for each failure mode, with the failure points for other failure modes treated as suspensions, since Weibull analysis is most effective when each data set concentrates on one failure mode.

   You can also determine if the distribution selected is a good fit for your data set. For example, if the failure data points curve in comparison to the best fit

line, then the Weibull distribution probably wasn't the best fit for the data, and you could use Best Fit Distribution Analysis to determine a more appropriate distribution.

2. Determine the B10 Life, which is the time at which 10% of the items in the data set have failed. To do so, move your cursor to the intersection of the plot line and the horizontal line at 0.10 Probability.



Your time varies, depending on the random data points you generated.

Tip

You can always zoom in on a specific area of the plot by holding down the left mouse button and drawing a selection box around the area you want to view more closely. To reset your zoom, right-click and select ***Reset Zoom****.*

Customizing the Plots

The Weibull graph is very easy to customize. The **Plot Properties** window enables you to change the plot colors, labels, and fonts to suit your needs.

1. Select the **Weibull Plot** tab.
2. Right-click in the plot and select **Edit Plot Properties**. The **Plot Properties** window opens.
3. On the **General** page, change **Title** to `My Weibull Plot`.
4. For **Legend location**, select **Inside Movable**.
5. In the left pane, select the **Axis** page. Here you can change the range of your axes, as well as specify a minimum and maximum value. Make no changes.
6. In the left pane, select the **Color** page.
7. Under **Style**, for **Quickstyle**, select **Light Line**. Quickstyles apply a predefined set of colors to the plot and its background. If you set the Quickstyle to General or No Style, you can also specify your own color preferences using the color selection controls in the **Color** section.

8. In the left pane, select the **Series Colors** page. This page enables you to set the colors of each plot line when plotting multiple data sets.
9. In the left pane, select the **Font** and **Font Size** pages. On these pages, you can set specific fonts for the titles and plot labels. You can also adjust the sizes of all fonts using the slider bars and preview the resulting changes as you make adjustments.
10. Click **OK**. Note the changes to your plot. The title is now "My Weibull Plot" the color palette has changed, and the legend is now on top of your plot rather than at the center right of the plot pane. Because you set the legend to **Movable**, you can now place this legend wherever you'd like it on the pane.
11. Hover your mouse pointer over the legend until your cursor changes to a hand. Select the legend and drag it to the bottom right of your plot.

Viewing Plots for Multiple Data Sets

Multiple Data Sets enable you to plot sets with similar parameters and the same distribution simultaneously on the same graph. You can use this type of plot to compare any number of things, including:

- Data sets from different failure modes for the same product
- Data sets collected at different operating conditions (e.g. one data set with circuit board test to failure data at 50 deg C vs. the same at 60 deg C)
- Data sets of similar products (e.g. failure data for bearings from two different suppliers)
- Data sets from different time frames (e.g. if data is recorded by calendar year)
- Data sets collected from a system before and after a redesign

In this case, you view data sets for a hard disk before and after a redesign.

To view both hard disk data sets on one plot:

1. Select the **LDA Navigator**.
2. In **Data Sets**, select **Multiple Data Set Plots**.
3. Select **Insert** ▸ **Multiple Data Set Plot**. A new data set row appears under the **Multiple Data Set Plots** heading. This new row is automatically selected.
4. Enter `My Weibull Multiple Data Set Plot`.
5. In **Weibull Plot Options**, select the following data sets in **Data sets**:
   - Hard Disk Revision A
   - Hard Disk Revision B

   The plot in the **Weibull Plot** tab is automatically updated with each new data set as you add it.

Windchill Weibull Additional Features

Windchill Weibull includes a number of other functions and features. A brief listing of other topics of interest is shown below. For more information about these features, see the help or guide for Windchill Quality Solutions.

- The Set Location Parameter (t0 shift) function allows you to establish a minimum life value for the failure data set, signifying a guaranteed failure-free period at the beginning of the cycle. Typically used with the Weibull distribution, this parameter straightens plots of data values if the data shows a pronounced curve compared to the failure distribution line.
- Windchill Weibull supports reliability growth analysis, which tracks the increase in the reliability of a product over time. In reliability growth analysis, the reliability, mean life, or failure rate is tracked over time, enabling you to predict future reliability values based on the current rate of growth of the measurement of interest. Windchill Quality Solutions uses the Duane/Crow-AMSAA model to perform reliability growth analysis.
- You can analyze data without specifying an underlying distribution using the Non-Parametric Life Data Analysis type. The Weibull module supports the Kaplan-Meier and standard actuarial methods.
- Windchill Weibull includes support for Degradation Analysis, which enables you to forecast future failures based on measurements of degradation or performance over time. The Weibull module supports a number of degradation models, including Linear, Exponential, and Power.
- The General Statistics Calculator enables you to perform a number of different statistical calculations, including Binomial, Chi-Squared, Life-Usage Interaction, Mean and Eta, Poisson, Random Point Interaction, Strength-Load Interaction, and Student T.
- The Test Planning Calculator enables you to determine the number of components to test or the amount of time for which to test. The Test Planning Calculator supports three methods: Parametric Binomial, Non-Parametric Binomial, and Exponential Chi-Squared.
- The Summary Calculator allows you to perform additional calculations on data sets that are analyzed based on parametric distributions, e.g. Life Data Analysis, Reliability Growth, and Warranty Analysis data sets. These additional calculations include Standard Probability, Conditional Probability, Failure Rate, Warranty Time, Time to Failure, etc.
- You can optimize your component replacement strategy with the Optimal Replacement Wizard. Optimizing your replacement strategy can help you

minimize system downtime and the overall cost of the system over the long term.

- The common Windchill Quality Solutions database allows you to link Weibull data with Windchill Prediction and Windchill RBD. This level of integration allows you to incorporate results of Weibull analyses in your reliability predictions and reliability block diagrams for more accurate metrics.

10

Windchill ALT

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about accelerated life testing and how to accomplish it using the Windchill ALT module.

In this section, you create a new data set in Windchill ALT, run calculations, and view the resulting graph.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

ALT Overview

ALT (accelerated life testing) is a technique for finding the reliability characteristics of a product more quickly than with typical reliability estimation methods. When ALT techniques are applied, products are tested in high-stress situations that typically shorten product life or hasten degradation of product performance (where “stress” means any accelerating variable). By statistically fitting an acceleration model to the test data and extrapolating the fitted model, you can then estimate the life or degradation of the product at the lower stress levels encountered in normal use. Thus, accelerated testing plays a key role in meeting the requirements of shorter product development cycles.

This technique is especially useful for determining or demonstrating the field reliability performance of highly reliable products. When tested under normal use stress levels, products with high reliability last so long, or degrade so little, that their performance and lifetime cannot be estimated. Accelerated testing yields reliability estimates of such products in a much shorter time.

In a simple situation, the components under test are divided into multiple groups containing one or more components. Each group of the components is tested at specific combinations of stress levels. You enter the failure and suspended times corresponding to the stress levels in the software. Under this setup, each component is subjected to a specific combination of stresses where the stresses are constant with respect to time. Hence, it is known as a constant stress test.

In some cases, the accelerated stresses on the components are changed with time. The variations in the stresses are specified using stress profiles. Generally, the stresses are increased with time such that the test can be completed within a predetermined time with some failures.

For further information, see the following references.

- Meeker, William Q., and Escobar, Luis A., Statistical Methods for Reliability Data, John Wiley & Sons, Inc., New York, 1998
- Meeker, William Q., A Comparison of Accelerated Life Test Plans for Weibull and Lognormal Distributions and Type I Censoring, Technometrics, Vol. 26, No. 2, pp. 157-171, 1984
- J. E. Dennis, Jr. and Robert B. Schnabel, Numerical Methods for Unconstrained Optimization and Nonlinear Equations, Classics in Applied Mathematics 16
- Numerical Recipes: C++ Version (2007)

Getting Started with Windchill ALT

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill ALT module; for more information, see Starting Windchill ALT on page 119.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project:** label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill ALT

On the **Module Selections** toolbar, select the ALT button  and deselect all other module buttons.

The tabbed panes for Windchill ALT are shown in your System file. The Windchill ALT interface consists of three panes: **LDA Navigator**, **ALT Parameters**, and **ALT Data Points**.

The **LDA Navigator** displays the list of data sets. When you select a data set in the **LDA Navigator**, the other two panes display information specific to that data set. There are two types of data sets, Accelerated Life Testing and Accelerated Degradation.

The bottom left pane, located beneath the **LDA Navigator**, consists of the **Parameters** tab and the **Plot Options** tab. The **Parameters** tab enables you to specify parameters for the selected data set, while the **Plot Options** tab provides control over the number and type of plots displayed in the **ALT Plot** tab on the right-hand side of the interface. When a data set is analyzed, the results are displayed at the bottom of both of these tabs. In this section, the **Calculation results** section, you can also fix one or more of the calculations. This pane also includes a toolbar, which gives you access to common tasks.

On the right is a pane consisting of three tabs – the **ALT Data Points** tab, the **ALT Results** tab, and the **ALT Plot** tab.

The **ALT Data Points** tab displays information about each item in the data set currently selected in the **LDA Navigator**. The column headings in this display vary, depending on the selected data type. The **ALT Results** tab displays the results for the selected data set, while the **ALT Plot** tab displays a plot representing the selected data set and the distribution applied to it. The parameters, distribution, and number of plots displayed in the **ALT Plot** tab are all controlled by the **ALT Parameters** pane.

Using Windchill ALT

You now create a data set, enter data points, and find the distribution that best fits your data points.

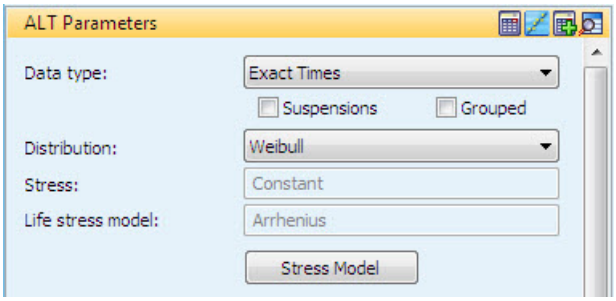
Creating a New Data Set

In this section, you create a random data set and specify the stress factors for this set. Accelerated life test stresses and stress levels should be chosen so that they accelerate the failure modes under consideration but do not introduce failure modes that would never occur under use conditions. Normally, these stress levels fall outside the product specification limits but inside the design limits. If these stresses or limits are unknown, multiple tests with small sample sizes can be performed in order to ascertain the appropriate stress (stresses) and stress levels.

In this case, you specify one stress factor – Temperature.

To create a new data set:

1. In the **LDA Navigator**, under **Analysis type**, click **Accelerated Life Testing** to ensure you are viewing the Accelerated Life Testing data sets.
2. In **Data sets**, select **Life Data**.
3. Select **Insert** ▸ **ALT Data Set**. A new Life Data Analysis data set appears under **Data Sets**. This new row is automatically selected.
4. Enter `My ALT Data Set` as the name of the new data set.
5. Select **Parameters** in **ALT Parameters**.
6. In **Parameters**, use the default values automatically set as the defaults:



7. Click **Stress Model**. The **Stress Model** window opens.
8. In the first row, select **Name** (labeled **Stress 1**) and enter `Temperature`.
9. For **Usage Stress**, enter `310`.
10. For **Default Value**, enter `350`.
11. Click **OK** to dismiss the **Stress Model** window.

Entering the Data Points

Once the analysis parameters are specified, you can enter data points in the table on the **ALT Data Points** tab. You can either specify the data points manually, or you can copy and paste them from a word-processing file, spreadsheet, or other electronic file.

For this example, you use the built-in random data set generator to automatically create a set of data points. In actual use you would not create a data set in this manner; it is a feature available for testing and example purposes.

1. Select the **ALT Data Points** tab.
2. Select **LDA** ▸ **Generate Random Data Points**. The **Generate Random Data Points** window opens.
3. For **Beta β**, enter `6`.
4. For **B**, enter `17000`.
5. For **C**, enter `3.0e-12`.

6. On the right, select **< Click here to add a stress level >**.
7. For **Quantity**, enter `2`.
8. For **Temperature**, enter `493`.
9. Repeat steps 6–8 to add the following:

Quantity	Temperature
4	513
5	533

10. Click **OK** to generate the random data points.

Viewing Calculations in Windchill ALT

Calculations determine the required parameters for the selected life stress model, and are based on the distribution specified.

To run calculations:

1. Select **System** ▸ **Calculate**, or click the calculate  icon on the **Standard** toolbar. The **Calculate** window opens.
2. In the left pane, select the **Calculation Selection** page (if it is not already selected).
3. In the right pane, click **Clear All** and then select **ALT** to perform calculations only for the ALT module.
4. In the left pane, select the **ALT** page.
5. Select **Selected data set only** and click **OK**. When completed, the **View Calculation Results** window opens.

   Tip

   *You can print your calculation results by clicking **Print** in the View Calculation Results window. You can also save them to a Microsoft Excel spreadsheet by clicking **Excel**.*

6. Click **Close** when you have finished reviewing results.

Viewing Windchill ALT Plots

After performing calculations, the resulting ALT plots are generated and can be viewed on the **ALT Plot** tab. Because the plot parameters are based on the stress parameters, you would have to recalculate if you change the distribution, stress type, or stress model.

To view the resulting ALT graph:

1. At the bottom left, select the **Plot Options** tab.
2. For **Plot type**, select **Acceleration Factor vs Stress**.
3. In the right pane, view the plot in the **ALT Plot** tab.

   This plots displays the acceleration factor with respect to the defined Temperature stress. If we had added other stresses, they would have been considered fixed at the usage stress level(s).

   Tip

   You can always zoom in on a specific area of the plot by holding down the left mouse button and drawing a selection box around the area you want to view more closely. To reset your zoom, right-click and select ***Reset Zoom****.*

Windchill ALT Additional Features

includes a number of features and functions. A brief listing of other topics of interest is shown below. For more information, see the help and guide for Windchill Quality Solutions.

- Windchill ALT includes support for both Constant and Time-Varying stresses and the Weibull, Exponential, and Lognormal distributions.
- The ALT module supports all commonly-used accelerated life testing models, including Arrhenius, Eyring, Inverse Power Law, Temperature-Humidity, Temperature-NonThermal, Generalized Eyring, Proportional Hazards, and General Log-Linear.
- While this section demonstrates the Acceleration vs. Stress plot type, you can plot many different types of graphs in Windchill ALT, including Reliability vs. Time, PDF Plot, Life vs. Stress, etc.
- As in Windchill Weibull, you can compare and contrast multiple plots in Windchill ALT by setting the number of plots to Multiple in the ALT Plot Options tab. You can also import data sets, just as you do in Windchill Weibull. For an introduction to this functionality, please see Using Windchill Weibull on page 109.

11

Windchill Maintainability

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about maintainability predictions and how to perform them using Windchill Maintainability.

In this section, you review and enter data in Windchill Maintainability, perform calculations on that data and view a report.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Maintainability Prediction Overview

Maintainability predictions provide metrics related to the repair of equipment. The main goal of performing a maintainability prediction analysis is to determine the amount of time required to perform repairs and maintenance tasks, so that you are aware of the time it would take and what tasks would be required to bring the system back to an operable state after a failure.

The main metric in maintainability predictions is MTTR (mean time to repair), which is computed using various methods depending on the maintainability analysis method employed. Various other repair metrics are important as well, such as MCMT (mean corrective maintenance time) and MPMT (mean preventive maintenance time). MTTR influences system availability, which is the measure of the likelihood that a system is in an operable state. In many industries, availability is a key measure of system performance, so having an accurate measurement of this metric is crucial. Also, availability can be a metric to verify if the system, as designed, would meet operational requirements.

Maintainability predictions can also help you to identify areas of poor maintainability, which may justify a change in design and/or repair procedures.

To complete a maintainability prediction, you would need failure rate data for the repairable items and data regarding the tasks and associated times to complete repairs. Maintainability predictions are often performed based on established standards. One of the most prominent is MIL-HDBK-472, specifically procedures 2, 5A, and 5B.

If you are unfamiliar with maintainability prediction analysis and would like to study this topic in more detail, please refer to MIL-HDBK-472.

Getting Started with Windchill Maintainability

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill Maintainability module; for more information, see Starting Windchill Maintainability on page 127.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project**: label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill Maintainability

On the **Module Selections** toolbar, select the Maintainability button  and deselect all other module buttons.

The panes for Windchill Maintainability are shown in your System file.

Using Windchill Maintainability

When you have activated Windchill Maintainability, the upper pane displays the **System Tree Items** table, which is the hierarchical representation of your system assemblies and components and is shared with several other modules. The lower pane, **Maintainability Data**, displays all your maintainability specific data.

You now review and enter data and learn about Maintainability Task Libraries.

Reviewing and Entering Data

1. In the **System Tree Items** table, select **Motherboard**. The maintainability data for this item is shown in **Maintainability Data**.
2. Review the **Repair definition**, **Repair level**, and other fields on the **Maintainability Data** pane, including the existing Repair tasks.

3. Select **Touchpanel** and **Memory Board** and review the maintainability data for each of those assemblies.
4. Select **Hard Disk Assembly**. Currently there is no data entered for repairing this assembly.
5. In **Maintainability Data**, under **Repair tasks**, click **< Click here to insert a new record >**.
6. In the new record, for **Task Code**, select **Remove HD Assy**.
7. Select **< Click here to insert a new record >** again and for **Task Code**, select **R/R Hard Disk** as the second task.

   Note

   R/R stands for "Remove and Replace."
8. Select **< Click here to insert a new record >** again and for **Task Code**, select **Replace HD Assy** for the third and final repair task for the Hard Drive.

The display-only fields in **Totals**, **Numberof items**, **Total time**, and **Manminutes**, have also been automatically updated.

Maintainability Task Libraries

Maintainability repair times can be stored in Maintainability Task Library files and/or Maintainability FD&I Output files. To see the data in the Maintainability Task Library file for this sample:

1. In the **Project Navigator**, click **Expand files** to display all Support files.

   Note

   *You may have to click **Collapse files** first, then **Expand files**.*
2. Under **Support Files>Maintainability>Task Library**, select **Maintainability Task Library**.
3. Select various tasks in the **Tasks** pane on the left to see the associated repair data.
4. When finished, select **File ▸ Close** to close the Maintainability Task Library file.
5. In the **Project Navigator**, click **Collapse files** to hide the Support files.

Performing Calculations

Windchill Maintainability computes a number of maintenance related values, such as MTTR (mean time to repair), MCMT (mean corrective maintenance time), and MPMT (mean preventive maintenance time).

A sampling of supported calculations is outlined below and very brief descriptions are provided. For more information on these calculations, see the guide or help for Windchill Quality Solutions.

Calculation	Description
Maintainability Index	The total maintenance effort, including both preventive and corrective maintenance, that is required to maintain a product in operational status during a specific time period. Corrective maintenance restores a failed system to operational status by repairing or replacing failed component(s). Preventive maintenance is the practice of replacing components or subsystems before they fail in order to promote continuous system operation. The Maintainability Index is calculated based on MIL-HDBK-472 Procedure 2. This calculation uses the values from both (1) and (2) of the MAMT calculation.
Mean Time to Repair (MTTR)	MTTR is the average time it takes to repair a failed unit and return it to an operational state, based on the average repair time for its replaceable components. The MTTR is calculated by rolling up the average repair times for lower-level components to compute subassembly and system repair values. If Windchill Maintainability is used in conjunction with Windchill Prediction, the MTTR values of components and subassemblies can be obtained from Windchill Maintainability computed MTTR values. Units for MTTR values are typically hours or minutes. MTTR is also referred to as MCT (mean corrective time).
Availability	The probability that a system is operating properly at a specific time point. Availability, like Reliability, is a time-based probability metric between 0 and 1. Availability is a function of both reliability (how quickly a system fails) and of maintainability (how quickly the system can be repaired).
Mean Corrective Maintenance Time (MCMT)	The mean time required to perform all corrective maintenance actions, i.e. the average time required to restore a failed system to operational status by repairing or replacing failed component(s).

Calculation	Description
Mean Active Maintenance Time (MAMT)	The average time required to perform all corrective and preventive maintenance actions. Corrective maintenance restores a failed system to operational status by repairing or replacing failed component(s), while preventive maintenance is the practice of replacing components or subsystems before they fail in order to promote continuous system operation. The calculation is taken from MIL-HDBK-472 Procedure 2.
Max Corrective Maintenance Time (MAXCMT) for Sigma Percentile	The time needed to accomplish the specified percentage of potential corrective maintenance tasks, frequently the 90th or 95th percentile. For example, if you specify a value of 90, the MAXCMT is the time within which 90% of all maintenance actions can be accomplished. The calculation is taken from MIL-HDBK-472, Procedure III.
Mean Maintenance Manhours per Repair (MMH/Repair)	This calculation is identical to the MTTR calculation except manhour values are substituted for time values.
Mean Maintenance Manhours per Maintenance Action (MMH/MA)	This calculation is similar to the MMH/Repair calculation except that the time spent as a result of false alarms is also taken into account.
Mean Maintenance Manhours per Operating Hour (MMH/OH)	The sum of all corrective, preventive, and false alarm repair times divided by the total operating hours.
Mean Maintenance Manhours per Flight Hour (MMH/FH)	The sum of all corrective, preventive, and false alarm repair times divided by the total flight hours.
Mean Preventive Maintenance Time (MPMT)	The mean time required to perform all preventive maintenance actions, i.e. the average time required to replace components or subsystems before they fail in order to promote continuous system operation. The calculation is taken from MIL-HDBK-472 Procedure 2.
Percent Isolation to a Single RI	The percentage of faults detected that can be isolated to a single part.
Percent Isolation to a	The percentage of faults detected that can be isolated to

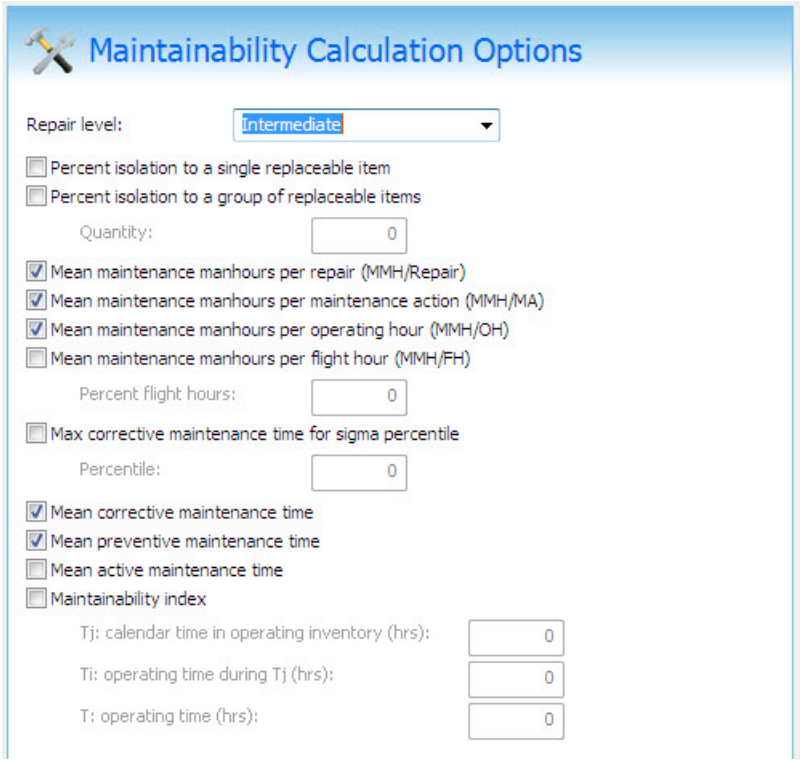
Calculation	Description
Group of RIs	*n* or fewer replaceable items, where *n* is a specified quantity.

Running Calculations

To perform Windchill Maintainability calculations:

1. Select **System** ▸ **Calculate**, or click the calculate icon on the **Standard** toolbar. The **Calculate** window opens.
2. In the left pane, select the **Calculation Selection** page if necessary.
3. In the right pane, click **Clear All** and select **Maintainability** to perform calculations only for the Maintainability module.
4. In the left pane, select the **Maintainability** page.

   A number of calculations are available.
5. Leave the default values:



6. Click **OK** to perform the calculations. The **Calculation Progress** pane displays status information. When the calculations are complete, the **View Calculation Results** window opens.

Values that aren't calculated display a value of #.#. These are calculation options you left unchecked on the **Calculate** window.

Tip

*You can print your calculation results by clicking **Print** in the **View Calculation Results** window. You can also save them to a Microsoft Excel spreadsheet by clicking **Excel**.*

7. Click **Close** when you have finished reviewing results.

To redisplay the results at any time, select **System ▸ View Calculation Results**. If you have only one module enabled, the results are displayed for that module. If you have more than one module enabled, select the appropriate page to view the results. When finished, click **Close**.

Viewing Reports

1. In the **Project Navigator**, under **Reports > Maintainability Reports,** select **(Common) Maintainability Standard** to generate this report in the preview window.

   This report outputs basic maintainability information about the system and its components, including item names, part numbers, reference designators, quantities, and calculated results for failure rate, MMH/OH, and MTTR.

   You can use the various toolbar buttons in the preview window to page through your report, zoom in and out, and print the report.
2. When finished viewing the report, do one of the following to close the preview window:
   - Select **Preview ▸ Close**.
   - Click the red **Close** button on the toolbar.

Windchill Maintainability Additional Features

Windchill Maintainability includes a number of other features and functions. A brief listing of other topics of interest is shown below. For more information on these features, see the help or guide for Windchill Quality Solutions.

- Windchill Maintainability includes a Maintainability Tasks Library file with standard maintenance tasks and repair times taken from MIL-HDBK-472. This data makes the process of entering repair tasks and times more efficient.
- You have the option of performing maintainability calculations based on MIL-HDBK-472 Procedure 2, 5A, or 5B standards. You can select or clear the **Procedure 5A** check box under the **Maintainability** heading in the File Properties for the System file.
- Windchill Maintainability supports user-created Maintainability Tasks Library files. You can create your own Libraries and then use them in any of your Project files.
- Maintainability Groups files support the definition of maintainability groups for use when performing MIL-HDBK-472 Procedure 5A calculations.
- Windchill Maintainability links with other modules such as Windchill Prediction and Windchill RBD.
- Custom repair levels can be defined in place of using the default Organizational, Intermediate, and Depot choices.
- You can export data to LSAR compatible formats. Select **System** ▸ **Generate LSAR File**.

12

Windchill Markov

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about Markov analysis and how to perform one using Windchill Markov.

In this section, you review Markov state properties and create a simple Markov diagram. You then perform calculations and view a standard report and graph on the Markov data.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

Markov Analysis Overview

Markov analysis is a technique used to study dynamic system behavior. In terms of all reliability analysis techniques, Markov analysis is the only method which can be used to accurately model many complex systems which may include common cause failures, imperfect coverage, shared load redundancy, complex repair policies, degradation, shock effects, induced failures, dependent failures, and other sequence-dependent events. While other modeling methods, such as fault trees and reliability block diagrams, can model some of these unique system complexities, Markov analysis provides the broadest capabilities in terms of handling diverse system characteristics.

To complete a Markov analysis, a Markov diagram, also known as a state transition diagram, must be constructed. The state transition diagram is a graphical representation of the system's operational, degraded, and failed states as well as the transitions between them. Most commonly, transition rates are failure rates or repair rates for continuous Markov models. The Markov diagram ultimately represents the system as a set of random variables and their interdependencies. The results of a Markov analysis can include many parameters such as reliability, availability, MTBF, and failure rate.

If you are unfamiliar with Markov analysis and would like to study this topic in more detail, the following is an excellent resource:

- Reliability: A Practitioner's guide (Chapter 8)

Getting Started with Windchill Markov

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill Markov module; for more information, see Starting Windchill Markov on page 137.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project**: label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill Markov

On the **Module Selections** toolbar, select the Markov button  and deselect all other module buttons.

The panes for Windchill Markov are shown in your System file.

Using Windchill Markov

The **Markov Diagrams** table lists all the Markov diagrams in your System file. The **Markov Diagram** pane displays the graphical representation of the Markov model selected in the **Markov Diagrams** table.

The states of the Markov diagram are denoted as colored graphical symbols. The transitions are symbolized by arrows connecting two states together.

You now review Markov state properties and create a simple Markov diagram.

Reviewing Markov State Properties

For ease of viewing, you may want to resize the **Markov Diagram** pane using the splitter control, which appear when you move the mouse cursor between the two panes. You can also use the horizontal and vertical scroll bars in the Markov Diagram pane to reposition the diagram. Finally, you can zoom in on an area of the diagram by right-clicking and choosing a zoom option.

This sample Markov diagram is modeling the sequence of events leading to a memory failure. The memory begins in an operational state. If one SRAM SIM fails, the system operates in a degraded mode, and ultimately fails if all three SRAM SIMs fail.

1. In the **Markov Diagram** pane, double-click **State5** to open the **Calculation Properties** window for this state. Notice that you can set the condition of the state to Good, Failed, or Degraded. You can also associate a Cost Gain or Loss with the state.

   The **Results** page displays the most recent calculated results for this state. Note that if calculations are not yet available, this page is empty.
2. Click **Cancel** to close the **Calculation Properties** window.
3. Select **Markov ▸ View States** to display the **Markov States** window, which contains a listing of all the states currently in your Markov diagram. In this window, you can edit the associated data in one place, which is useful when you have a large Markov diagram and need to manage many states. Click **Close** to close the **Markov States** window.
4. Move the mouse cursor over the leftmost black arrow between **State5** and **State10** in the Markov diagram until the cursor changes to a four-sided arrow; then, double-click. You can see the Rate associated with this transition and also the associated Cost Gain or Loss.

   The **Results** page displays the most recent calculated results for this transition. Note that if calculations are not yet available, this page is empty.
5. Click **Cancel** to close the window for the transition.
6. Select **Markov ▸ View Transitions** to display the **Markov Transitions** window, which contains a listing of all the transitions currently in your Markov diagram. In this window, you can edit the associated data – useful when you have a large Markov diagram and need to manage many transitions.
7. Click **Close** to close the **Markov Transitions** window.

Creating a Simple Markov Diagram

Now that you have seen what a Markov diagram looks like in Windchill Markov, you create a simple diagram:

1. Select the **Markov Diagrams** table.
2. Click **< Click here to insert a new record >** to insert a new diagram.
3. For **Identifier**, enter `My Markov Diagram`. An initial state is already added for you.
4. Select the **Markov Diagram** pane.
5. Select **Insert** ▸ **State**. The **Insert State** window opens.
6. Click **OK** to select the default style. When you move the mouse cursor into the diagram pane, the cursor changes into the shape of the selected style.
7. Move the cursor to the right of the initial state and click the mouse button. The cursor remains in the shape of the figure to let you know that you can continue to insert states, if desired.
8. Right-click to exit the insertion mode.
9. Select **Markov** ▸ **Auto Connect States** to automatically connect the states.
10. Double-click the top transition line to display its **Properties** window.
11. For **Rate**, enter `0.00015` to indicate a failure rate of 0.00015 failures/hour; then, click **OK**.
12. Double-click the bottom transition line to display its **Properties** window.
13. For **Rate**, enter `12.5` to indicate a repair rate of 12.5 repairs/hour; then, click **OK**.
14. Double-click the right-most state to display its properties.
15. For **State**, select **Failed** and click **OK**.

This simple diagram models a system which begins in an operational state then fails at failure rate of 0.00015 failures/hour, at which time the system reaches the failed state. When repaired, at a repair rate of 12.5 repairs/hour, the system returns to the operational, or good, state.

Performing Calculations

Windchill Markov computes an extensive set of reliability related values. A sampling of supported calculations is outlined below and very brief descriptions are provided. For more information on these calculations, see the help or guide for Windchill Quality Solutions.

Calculation	Description
Availability	The probability that a system is operating properly at a specific time point. Availability is a time-based probability metric between 0 and 1.

Calculation	Description
	Availability is a function of both reliability (how quickly a system fails) and of maintainability (how quickly the system can be repaired).
Capacity	The average throughput, profit, or reward of the system per unit time at a specified point in time.
MTBF (Mean Time Between Failures)	The MTBF represents the number of hours a unit operates between failures.
MTTFF (Mean Time to First Failure)	The average time until the first failure of the system. Frequently, it is simply called MTTF.
Reliability	The probability that a system remains operational until a specified time. Reliability is a time-based probability value, so it is always a metric between 0 and 1. A reliability of 0 means that a system is infinitely unreliable, or never functioning. A reliability value of 1 indicates that a system is infinitely reliable, or always operating.
Unavailability	The probability that, at a given time, the system would not function, due to either a failure or a repair.
Unreliability	The probability that a failure would occur during a given time period.

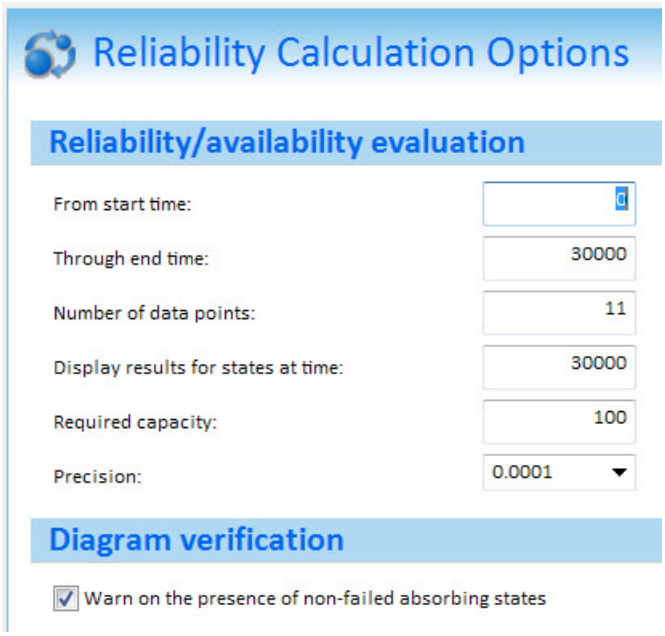
Running Calculations

To perform Windchill Markov calculations:

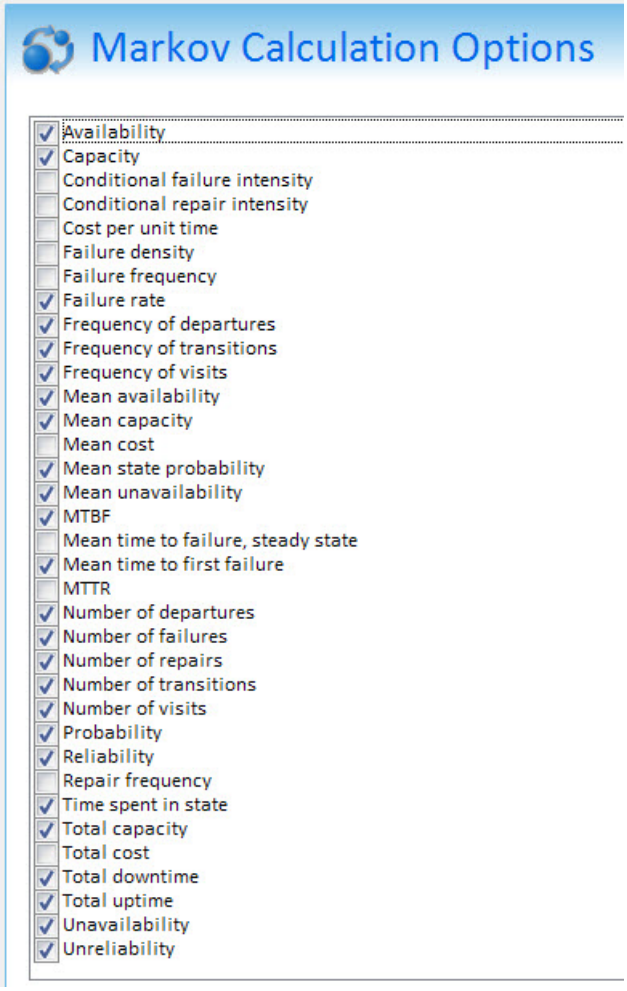
1. Select **System** ▸ **Calculate**, or click the calculate  icon on the **Standard** toolbar. The **Calculate** window opens.
2. In the left pane, select the **Calculation Selection** page (if necessary).
3. In the right pane, click **Clear All** and select **Markov** to perform calculations only for the Markov module.
4. In the left pane, under **Markov**, select the **Reliability Calculation** page.

   The **Reliability Calculation** page allows you to specify information for reliability and availability evaluation.
5. For **Through end time**, enter `30000`.
6. For **Display results for states at time**, enter `30000`.

7. Leave the rest of the defaults. The page should appear as follows:



8. In the left pane, select the **Calculation Options** page. Leave the default values:



9. Click **OK** to perform the calculations. The **Calculation Progress** pane displays status information. When the calculations are complete, the **View Calculation Results** window opens.

Tip

*You can print your calculation results by clicking **Print** in the **View Calculation Results** window. You can also save them to a Microsoft Excel spreadsheet by clicking **Excel**.*

10. Click **Close** when you have finished reviewing results.

To redisplay the results at any time, select **System ▸ View Calculation Results**. If you have only one module enabled, the results are displayed for that module. If you have more than one module enabled, select the appropriate page to view the results. When finished, click **Close**.

Once results have been calculated for a Markov diagram, the results calculated for a state appear on the **Results** page in its **Calculation Properties** window and the results calculated for a transition appear on the **Results** page in its **Calculation Properties** window.

Viewing a Report

1. In the **Project Navigator**, under **Reports > Markov Reports**, select **(Common) Markov (Summary)**. The **Select Markov Diagram** window opens.
2. Select **Memory Analysis**, make sure **Print all diagrams** is cleared, and click **OK** to generate the report in the **Preview** window.

   This report outputs data related to a Markov analysis in the System file, and includes the calculation results, state summary, and diagram.

   You can use the various toolbar buttons in the **Preview** window to page through your report, zoom in and out, and print the report.
3. When finished viewing the report, do one of the following to close the **Preview** window:
   - Select **Preview ▸ Close**.
   - Click the red **Close** button on the toolbar.

Graphing Data

1. In the **Project Navigator**, under **Graphs > Markov Graphs**, select **(Common) Markov Availability v Time** to generate this graph. The **Select Markov Diagram** window opens.
2. Select **Memory Analysis** and click **OK** to generate the graph.

   This graph displays system availability at the points in time specified in the **Calculate** window for Markov calculations.
3. When finished viewing the graph, select **File ▸ Close**.

Windchill Markov Additional Features

Windchill Markov includes a number of additional features and functions. A brief listing of other topics of interest is shown below. For more information on these features, see the help or guide for Windchill Quality Solutions.

- You can specify the cost to be associated with each state and transition. The cost can be a gain or loss per unit time for a state or for a transition. Mean and total capacity and cost values can then be calculated for the system.
- You can change the visual properties of a state or transition by right-clicking the object and selecting **VisualProperties**.
- You can use a graphic file in your diagram by right-clicking a state, selecting **Visual Properties**, and selecting an image file on the Graphic tab.
- You can add descriptive text labels to any state diagram. Select **Insert ▸ Label**, and choose the label style. You can then place the label in the diagram and enter the desired text.

13

Windchill LCC

This section of the *Windchill Quality Solutions Getting Started Guide* provides basic information about LCC (life cycle cost) analyses and how to perform them using Windchill LCC.

In this section, you enter a fixed cost item in Windchill LCC , review other cost equation functions, and learn about using cost variables. Next, you perform calculations and view standard reports and graphs on the life cycle cost data.

Note

Because Projects can be fully customized, your screens may not look like the ones shown in this guide.

LCC Analysis Overview

LCC (life cycle cost) analysis is used to compute the cost of a product or system over its lifetime. By including all costs such as design, production, warranty, repair, and disposal, LCC analyses provide an accurate assessment of total system cost.

During the system design phase, LCC analysis is valuable for determining the most cost-effective solutions before substantial costs are incurred; it is also an excellent method by which you can compare the costs of different alternatives, such as redesigning an existing system versus designing a completely new system.

LCC analysis considers factors such as inflation and the time value of money to make realistic cost computations; such analyses can also be used to perform sensitivity analysis so that you can pinpoint variables which have the most influence on system cost.

If you are unfamiliar with LCC analysis and would like to study this topic in more detail, the following text reference is an excellent resource:

- Life-Cycle Cost and Economic Analysis by Wolter J. Fabrycky and Benjamin S. Blanchard (1991)

Getting Started with Windchill LCC

If Windchill Quality Solutions is started and the Tablet PC System file is open

If you are already using Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Windchill LCC module; for more information, see Starting Windchill LCC on page 147.

If Windchill Quality Solutions is not started

If Windchill Quality Solutions is not started, please start it. For more information, see Starting Windchill Quality Solutions on page 10.

If your copy of the Tablet PC System file is not open

The **Tablet PC** System file in your **My Tablet PC** Project is used to demonstrate module features in this guide. If this System file is not open, open it by doing one of the following:

- If the **Recent Files** list of the **Start Page** shows a link for the **Tablet PC** System file in the **My Tablet PC** Project, click it to open the file.
- If the **Project Navigator** shows a listing of your Projects and Systems (you see a **Click a file to open** link), click **Tablet PC** under **My Tablet PC** to open the System file.
- If the **Project Navigator** has a Project other than My Tablet PC open (you see a name other than **My Tablet PC** after the **Project**: label):
  1. Close all open files by clicking **<Click to close Project>**.
  2. Under **My Tablet PC**, click **Tablet PC** to open the System file.
- If the **Project Navigator** has the My Tablet PC Project open (you see **Project: My Tablet PC** in the **Project Navigator**), click **Tablet PC** under the **Systems** heading to open this System file.

Starting Windchill LCC

On the **Module Selections** toolbar, select the LCC button  and deselect all other module buttons.

The panes for Windchill LCC are shown in your System file.

Using Windchill LCC

The **LCC** table at the top shows the cost breakdown structure as defined for the system. The cost breakdown structure can be as detailed as you wish. Windchill LCC also supplies some cost breakdown templates that you can use as a starting point for LCC studies.

The lower pane, **LCC - Equation Editor**, displays the cost equation associated with the selected item in the cost breakdown tree. All equations are completely user-customizable.

You now enter a fixed cost item, review other cost equation functions, and learn how to insert cost variables.

Entering a Fixed Cost Item

1. Select the **LCC** table.
2. Select **Maintenance Cost** and review the associated cost equation. In this case, the cost is linked to data related to repair and failure metrics found in other modules.
3. Select **Insert** ▸ **Sibling** to insert a new cost item.
4. Enter `Disposal Cost` as the name of the new item.
5. In the **LCC - Equation Editor**, for **Cost Equation**, enter `500` to indicate it costs $500 to dispose of a system.

Reviewing Other Cost Equation Functions

Many costs may not be constant, and Windchill LCC offers a number of ways for defining how cost is computed.

1. In the **LCC - Equation Editor**, click **Data Fields** to open the **Insert Field** window. In this window, you can insert fields from other modules for use in your equation.
2. Click **Cancel** to close the **Insert Field** window.
3. Another method of adding data fields is to use the **Data Fields** toolbar. Select **LCC** ▸ **Data Fields Toolbar**. The **Data Fields** toolbar, an auto-hide window, is shown. You can select from the list of available metrics and use easy drag and drop operations to put data fields into your equation.
4. Click the **X** in the upper right corner of the **Data Fields** toolbar to close it.
5. Click **Date Functions** to see the list of date-related functions available for use in cost equations.
6. Click **Math Functions** to see the list of math functions that can be used in cost equations.

Using Cost Variables

1. In the **LCC - Equation Editor**, select **Variables** to bring up the **Insert Variable** window.
2. Drop down the list of variables available for inserting into your cost equations.
3. Click **Cancel** to close the **Insert Variable** window.

The variables available are defined in the LCC Variables file. To open the sample LCC Variables file to see where these variables have been defined:

1. In the **Project Navigator**, click **Expand files** to display Support files.
2. Under **Support Files>LCC**, select **Variables** to open the LCC Variables file.

   In the LCC Variables file, you can see the list of variables that appeared in the dropdown list associated with the **Variables** button in the **LCC - Equation Editor**.

   LCC Variables can be defined as:

   - Constant: the variable value is fixed
   - Varies over Time Intervals: meaning the variable changes based on the defined time interval, which could be by month or by year for example
   - Varies over Alternatives: the variable value changes based on alternative system designs that you define, which could be a redesign and a new design
   - Varies over Alternatives and Time Intervals: the variable varies based on both time intervals and alternatives
3. Select **File ▸ Close** to close the Variables file.
4. In the **Project Navigator**, click **Collapse files** to hide the Support files.

Performing Calculations

Windchill LCC enables you to compute costs based on the entire product lifecycle, from inception to product disposal. One of the significant benefits of Windchill LCC is that it enables you to factor reliability metrics into lifecycle cost – an often hidden, but significant, factor in overall product lifetime cost. By accounting for component failures and repairs along with related labor costs and maintenance activity costs, you can obtain a thorough analysis of true product cost.

Windchill LCC encompasses a variety of cost calculations:

Calculation	Description
Total System Cost	The most basic of cost computations, total system cost reflects the cost of your system over its entire lifecycle by using a cost breakdown structure (CBS) of your system.
Line Item Costs	Windchill LCC computes the cost of each of the line items in your CBS. Depending upon the granularity of your CBS, you can see the costs associated with the various parts of your product lifecycle: design costs, R&D expenses, maintenance costs, labor fees, etc.
NPV (net present value)	With the time intervals functionality of Windchill LCC, you can take into account inflation rates over the specified time interval you want to assess. Windchill LCC then projects the

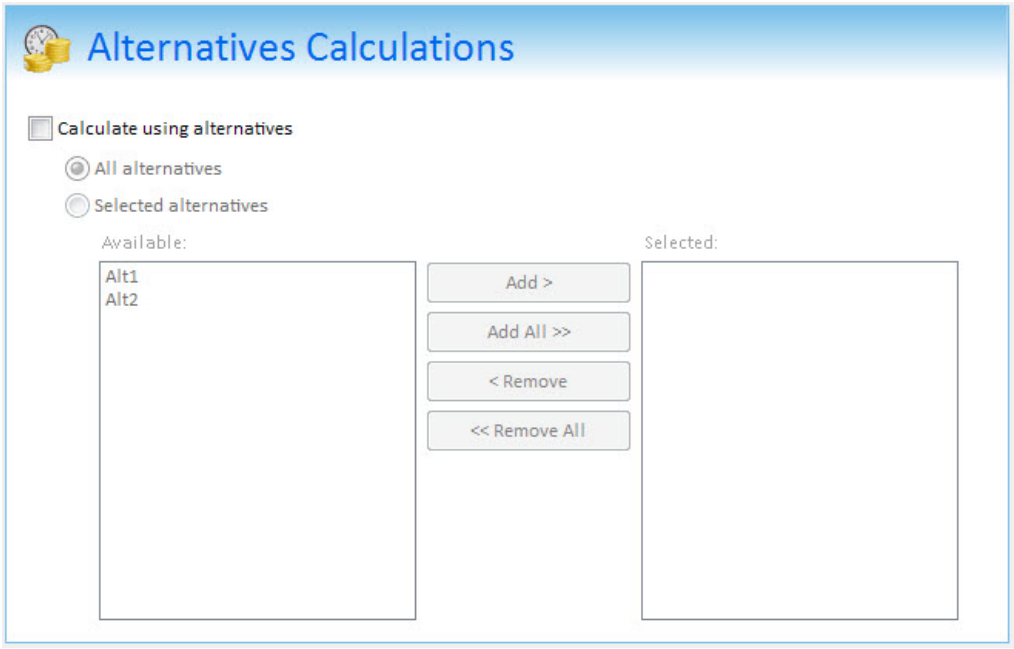
Calculation	Description
	NPV of your system, i.e. the cost of your system in today's dollars based on inflation rates.
Costs Based on Design Alternatives	With the alternatives feature of Windchill LCC cost, you can compare the cost of various design alternatives. For example, to fix a known issue, you could look at the cost of retrofitting a current design with a corrective action solution versus the cost of a redesign.
Costs Based on Design Alternatives and Inflation Rates	Using a combination of the time intervals and alternatives features, you can factor in inflation rates to analyze the cost of design alternatives.
Sensitivity Analyses	Windchill LCC supports sensitivity analyses, which enable you to see which variables have the most impact on your system cost. By varying different cost items over a range of fluctuations, you can see which variables have the most significant influence on total cost. Ensuring highly sensitive variables remain stable enables you to more easily keep costs in check.

Running Calculations

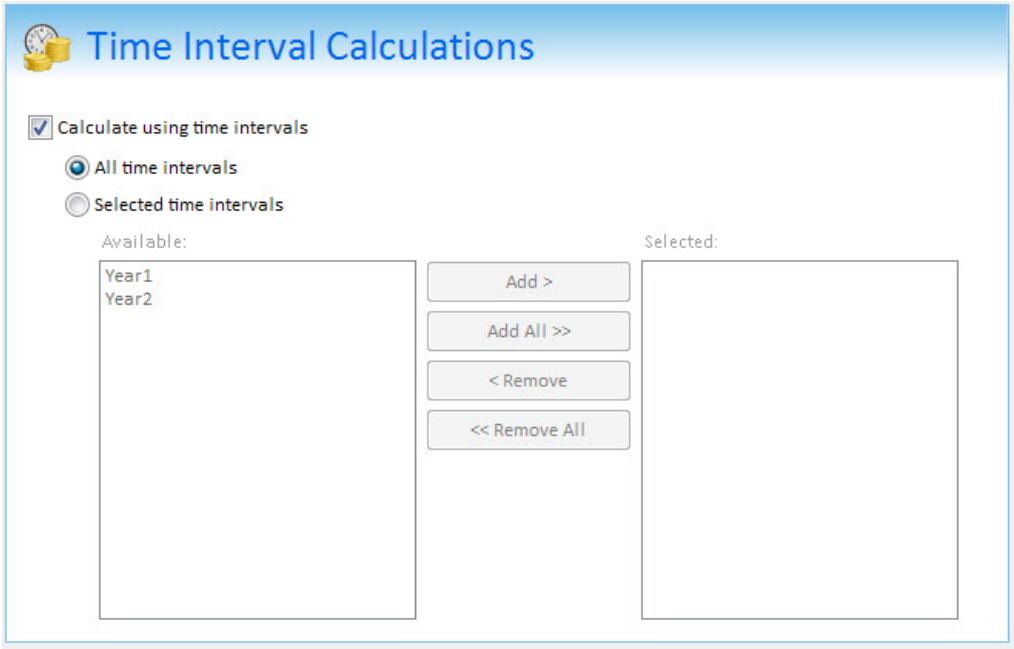
To perform a Windchill LCC calculation:

1. Select **System** ▸ **Calculate**, or click the calculate  icon on the **Standard** toolbar. The **Calculate** window opens.
2. In the left pane, select the **Calculation Selection** page if necessary.
3. In the right pane, click **Clear All** and select **LCC** to perform calculations only for the LCC module.
4. In the left pane, under **LCC**, select the **Alternatives** page.

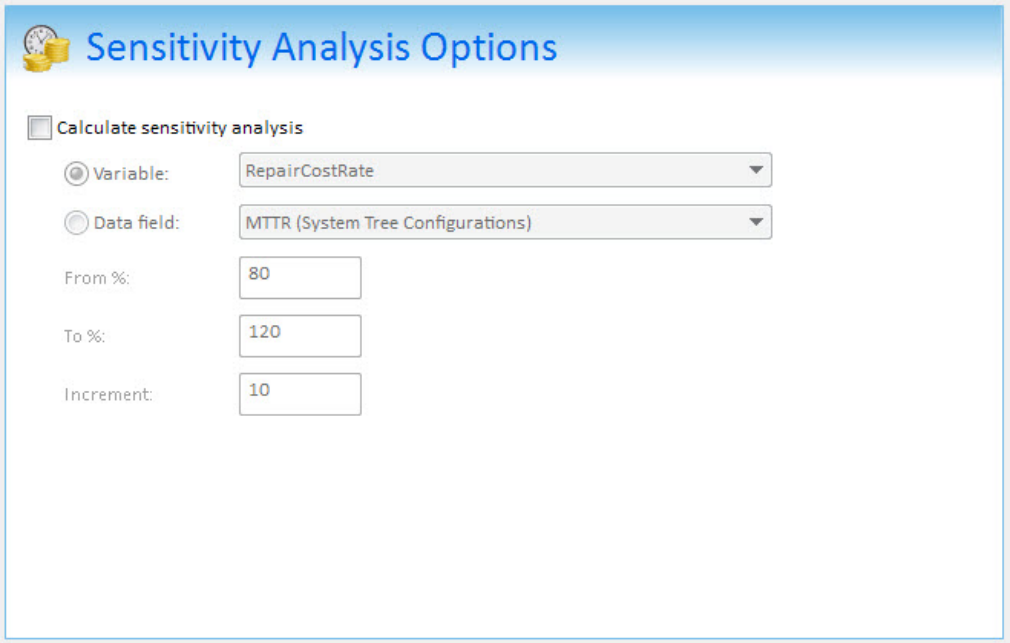
5. Use the default settings.



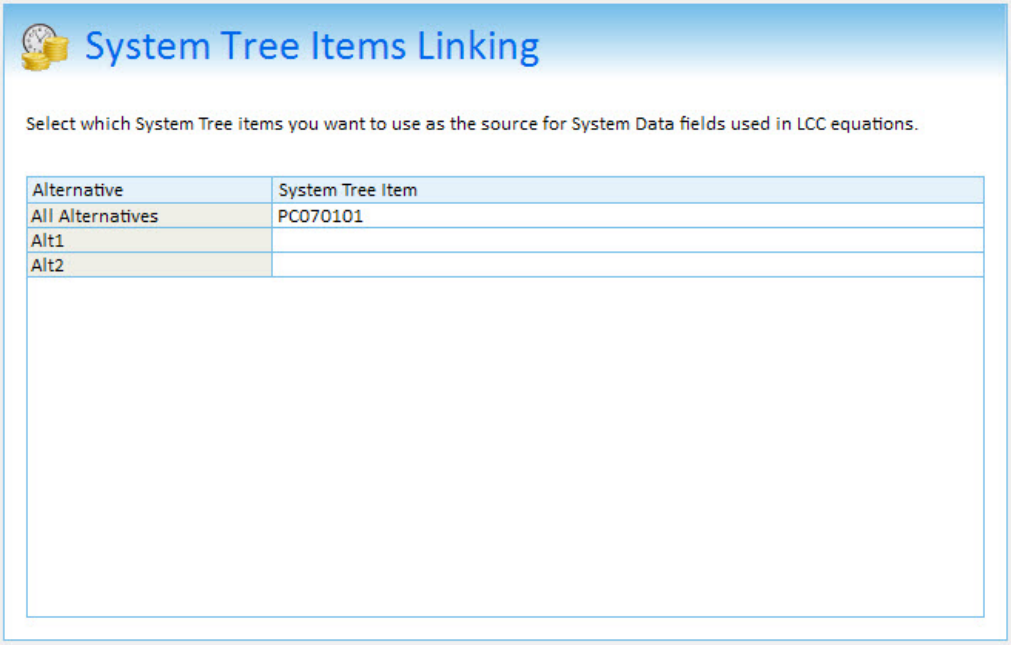
6. In the left pane, select the **Time Intervals** page.
7. Use the default settings.



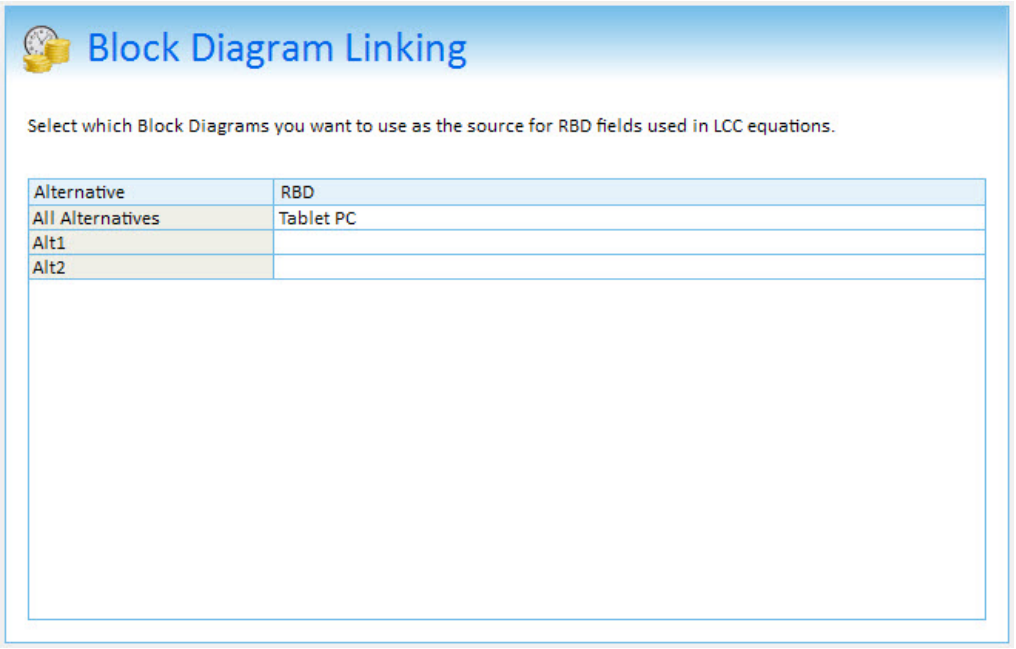
8. In the left pane, select the **Sensitivity Analysis** page.
9. Use the default settings.



10. In the left pane, select the **Link to System Tree Items** page.
11. Use the default settings.



12. In the left pane, select the **Link to Block Diagram** page.
13. Use the default settings.



14. Click **OK** to perform the calculations. The **Calculation Progress** pane displays status information. When the calculations are complete, the **View Calculation Results** window opens.

    When LCC calculations are finished running, cost and NPV results can be viewed in the **View Calculation Results** window.

    Tip

    *You can print your calculation results by clicking **Print** in the **View Calculation Results** window. You can also save them to an Excel spreadsheet by clicking **Excel**.*

15. Click **Close** when you have finished reviewing results.

To redisplay the results at any time, select **System ▸ View Calculation Results**. If you have only one module enabled, the results are displayed for that module. If you have more than one module enabled, select the appropriate page to view the results. When finished, click **Close**.

Viewing a Report

1. In the **Project Navigator**, under **Reports > LCC Reports**, select **(Common) LCC** to generate this report in the **Preview** window.

   This report outputs the life cycle cost data from the System file, including the cost breakdown structure (CBS) item names, equations, time intervals, and calculated costs and net present values (NPVs).

You can use the various toolbar buttons in the **Preview** window to page through your report, zoom in and out, and print the report.

2. When finished viewing the report, do one of the following to close the **Preview** window:
   - Select **Preview** ▸ **Close**.
   - Click the red **Close** button on the toolbar.

Graphing Data

1. In the **Project Navigator**, under **Graphs > LCC Graphs,** select **(Common) LCC Cost per Time Interval and Alternative** to generate the graph.

   This graph displays the cost calculation results by time interval for all alternatives in a cylinder bar graph.

2. When finished viewing the graph, select **File** ▸ **Close**.

Windchill LCC Additional Features

Windchill LCC includes a number of features and functions. A brief listing of other topics of interest is shown below. For more information on these features, see the guide or help for Windchill Quality Solutions.

- Windchill LCC can perform a sensitivity analysis which is used to determine how much of an effect a particular variable has on overall system cost. When performing a sensitivity analysis, you specify a variable to modify and a percentage range over which to modify the variable. You can then view how the cost varies with the changes to the underlying variable.
- The Equation Editor is very powerful and enables you to create both simple and complex equations. Click **Verify** at any time to verify the syntax of the entered equation.

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Conclusion

We hope that you have found this guide to be a useful demonstration of the capabilities of Windchill Quality Solutions. The information presented in this Getting Started Guide is only the beginning of what can be accomplished with the feature-rich power of Windchill Quality Solutions.

As a Windchill Quality Solutions customer, you have access to a full complement of resources, including: Windchill Quality Solutions Help; getting started tutorials; FAQs and tips; knowledgeable, experienced customer support; and an extensive library of reliability-related documents.

You can also boost your productivity by learning from the experts at PTC University. Whether you're looking for specific training courses, ways to improve the proficiency of experienced users, or a personalized corporate learning program that meets your training schedule and budget requirements, PTC University can help you boost your productivity through online courses, leadership training, consulting, and other services to optimize your business.

We welcome your feedback! Contact us at 800-477-6435 (press 5 and then 1), or email relex-doc@ptc.com. If you are evaluating Windchill Quality Solutions, email relex-eval@ptc.com, or contact your Account Manager today with suggestions, comments, or feedback of any kind. We look forward to hearing from you!