Getting Started Guide

PTC Windchill Quality Solutions™ 10.2

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1

Introduction to PTC Windchill Quality Solutions

Thank you for your interest in PTC Windchill Quality Solutions®. This comprehensive toolset represents the next generation in QLM (quality lifecycle management) software.

With PTC 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, and perform a wide array of additional analysis functions.

This guide assumes that you are operating the PTC Windchill Quality Solutions Tryout version. However, you can also use this guide with a licensed version of PTC Windchill Quality Solutions.

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

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

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

- First, review the sections Getting Started on page 9 and Common Features on page 23. These sections introduce you to the basic concepts of PTC Windchill Quality Solutions. Once you have reviewed these sections, you can 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.
- The PTC Windchill Quality Solutions Tryout version is based on the Team Edition. You can use this guide with the Enterprise Edition as well. Although there are differences between these two Editions, the majority of the features and functionality described in the guide are the same. One significant difference is that in the Enterprise Edition, you are required to log in using a PTC Windchill Quality Solutions user name and password. It is also possible that in the Enterprise Edition, some functions described in the guide might be unavailable to you, depending on permissions set by your system administrator
- You can open a PDF version of this guide by selecting **Help ▸ Getting Started Guide**. Or, from the **Start Page** window, you can click the **Getting Started Guide: A Step-by-Step Tutorial** link in the **Links** section. You can print this file if you prefer a hard copy of the guide.

We hope that you find this guide helpful as an introduction to PTC 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, which provides comprehensive information about all aspects of PTC Windchill Quality Solutions.

Welcome!

2

Getting Started

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This section of the *PTC 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 PTC Windchill Quality Solutions. You also learn 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 might not look like the ones shown in this guide.

Starting PTC Windchill Quality Solutions

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

- Double-click the shortcut to **PTC Windchill Quality Solutions 10.2 Tryout** on your Windows desktop.
- From the Windows Start menu, select **[All] Programs** ▸ **PTC Windchill Quality Solutions 10.2 Tryout** ▸ **PTC Windchill Quality Solutions 10.2 Tryout**.

Note

If you are running a licensed version, “Tryout” is not included in the program name.

Selecting the Modules to Evaluate

Once PTC Windchill Quality Solutions is started, the **Modules Selection** window opens, listing all modules available for your use. In the Tryout version, no modules are selected by default, and you must select at least one module to continue. Clicking a module button alternates between selecting a module and clearing the selection. The button background color for all selected modules is gold.

1. Click **Prediction**. Make sure that this button is the only one selected.

   Note

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

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

Exiting PTC Windchill Quality Solutions

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

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

Start Page Window

The **Start Page** window is the startup center for PTC Windchill Quality Solutions. You see this window when you first start the Tryout version or Team Edition. In the Enterprise Edition, you see this window after you enter valid login account information.

The appearance of the page that you see can vary. Additionally, the number of pages that you see can vary. For example, you might see a global page that your system administrator has assigned to your user group, the default page, and any number of custom personal pages that you have created. The following sections provide all of the information you need to put the many advanced features of the **Start** page to immediate use:

- Start Page Controls on page 11
- Start Page Additional Features on page 14

Start Page Controls

A **Start** page can contain several controls that can help you use PTC Windchill Quality Solutions more efficiently. Provided below are descriptions of the controls that are shown on the default **Start** page that is supplied with PTC Windchill Quality Solutions.

Note

On a global **Start** page that is assigned to you by your system administrator, you are likely to see different controls than those described in this section. In the help or guide for this application, you can find information about customizing **Start** pages.

Recent Files

The **Recent Files** control lists as many as the last 10 files you viewed. When file names are shown in this control, you can click the name to open the file. In the Tryout version and Team Edition, the title bar of this control contains a **New Project** link. Clicking it opens the **Create Project** window, allowing you to create a new Project right from the **Start** page.

Announcements

The **Announcements** control displays announcements posted by users, providing a great mechanism for team communication. Each announcement includes a title, the name of the person who posted the announcement, and the announcement itself. Announcements marked as “High Priority” have a title that appears in red.

To insert an announcement:

1. Do one of the following to open the **Add New Announcement** window:
   - In the Tryout version or Team Edition, click **New** on the right side of the title bar.
   - In the Enterprise Edition, select **Options** ▸ **New** from the menu on the right side of the title bar.

   The **Add New Announcement** window opens.
2. For **Title**, enter `A New Announcement`.
3. For **Message**, enter `I've posted my first announcement`.
4. For **Expiration**, use the date control for this field to select tomorrow's date. Do not select the **High priority** checkbox for this announcement.
5. When finished, click **OK** to insert your announcement.

To delete an announcement:

1. Right-click the announcement you just inserted and select **Delete**. A confirmation window opens.
2. Click **OK** to delete the announcement.

To modify an existing announcement, you right-click it and select **Edit**. In the **Edit Announcement** window that opens, you modify the announcement and then click **OK** to save your changes.

Links

The **Links** control displays links for quick and easy access to Internet resources. For example, if you have a website that you visit frequently, you can set up a link to it. When you click the link, your browser starts and opens the specified web address in a new window.

Several important links are already listed for you, including:

- **Getting Started Guide: A Step-by-Step Tutorial** — Opens a PDF version of this guide. You cannot delete or modify this link.
- **PTC Website** — Opens the PTC Windchill Quality Solutions page on the PTC website.
- **PTC Technical Support** — Opens the Technical Support page on the PTC website, where you must have a PTC customer account to use the many support tools provided.

To insert a link:

1. Do one of the following to open the **Add New Link** window:
   - In the Tryout version or Team Edition, click **New** on the right side of the title bar.
   - In the Enterprise Edition, select **Options** ▸ **New** from the menu on the right side of the 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 insert the link to the Google® website. If you have Internet access, you can click this link to open this web page in a new window.

To delete a link:

1. Right-click the Google link that you just inserted and select **Delete**. A confirmation window opens.
2. Click **OK** to delete the link.

To modify an existing link, you right-click it and select **Edit**. In the **Edit Link** window that opens, you modify the link and then click **OK** to save your changes.

Note

If you are using the Enterprise Edition, two additional controls 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 using the Workflow feature, you can effectively manage your processes to keep your analysis activities on track.

The **Workflow** control displays all outstanding workflow items that are assigned to you. When you click an item, the email message associated with the item opens. When you click the icon for the associated table type, the corresponding System file opens, and the corresponding record is selected.

Alerts

The Alert application automatically notifies users when specified events occur. By monitoring your Project data, this application detects the occurrence of key events and automatically sends out email alerts.

Similar to the **Workflow** control, the **Alerts** control displays all alerts that have been sent to you. When you click an alert, the email message associated with the alert opens. When you click the icon for the associated table type, the corresponding System file opens, and the associated data is shown.

Start Page Additional Features

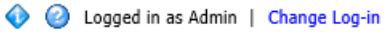
The **Start** page offers several additional features.

Expand/Collapse

In the title bar of a control, an arrow button is available for either collapsing or expanding the control. In the Tryout version and Team Edition, the arrow button is on the right. In the Enterprise Edition, the arrow button is on the left. To switch between collapsing and expanding a control, you click the arrow button.

Menu Bar

The menu bar appears in the upper right corner of the **Start Page** window. The following figure displays the menu bar for the Enterprise Edition because it provides additional options.



- Clicking the about icon opens the **About PTC Windchill Quality Solutions** window, where you can see copyright information, authorized options (if licensed), file versions, and data directories. Clicking **OK** closes this window.
- Clicking the help icon opens the help for PTC Windchill Quality Solutions in a new browser window.
- The **Logged in as** status, which is available only in the Enterprise Edition, indicates the user name that you used when you logged in to this session.
- Clicking **Change Login**, which is available only in the Enterprise Edition, allows you to change your login to a different user without having to restart PTC Windchill Quality Solutions.

Customize

In only the Enterprise Edition, a **Customize** link is shown in the upper right corner of the page if you have the permissions necessary to insert and customize **Start** pages. When you click this link, **Content** and **Layout** tabs are shown so you can set up controls and lay them out on the page.

To put some of these menu features to use:

1. Click the about icon . The **About PTC Windchill Quality Solutions** window opens.

   A navigation pane appears on the left side of this window. You click a page name to display this property page in the right pane.

   a. On the **Copyright** page, view the copyright notice for PTC Windchill Quality Solutions.
   b. On the **Authorized Options** page, view all the licensed modules and prediction calculation models that you can activate. In an unlicensed version, the status for these modules and models is blank.
   c. On the **File Versions** page, view the versions of the PTC Windchill Quality Solutions files in use.
   d. On the **My Data Directories** page, view the locations where your local Project files, Predication Parts library files, and personal user options are stored.
   e. Click **OK** to close this window.
2. Click the help icon . The help for the desktop application opens in a new window.

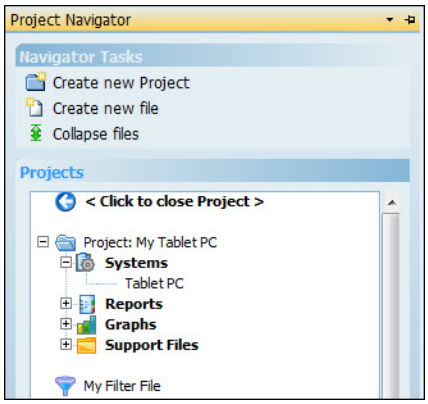
   You can use the navigation pane on the left to browse or search help topics. When you are finished, close this window.

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

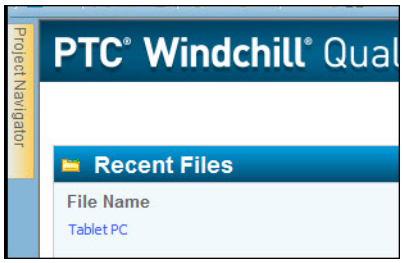
Project Navigator

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

The **Project Navigator** allows you to easily open and create Projects and files, generate reports and graphs, create files, and perform many other functions from a single location.



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**, or any auto-hide window operating in the auto-hide mode, the window slides out of view. Thus, you can easily show the **Project Navigator** when you need to use it and hide it when you do not.

You can dock, or pin, an auto-hide window so that it is always available to you. When you place the mouse cursor over the pushpin icon to pin or unpin it, the background color of the icon is blue.

To take the **Project Navigator** 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 horizontally-oriented pushpin icon in the upper right corner of the window.

The pushpin icon changes to a vertical orientation to indicate 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 of an auto-hide window is shown vertically-oriented, the window is pinned into place.

3. To unpin the window and put it back into auto-hide mode, click the vertically-oriented pushpin icon .

   The pushpin icon changes to a horizontal orientation to indicate 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. This guide assumes that the **Project Navigator** is operating in the auto-hide mode.

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 analysis tasks.

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

We begin by creating a Project.

Note

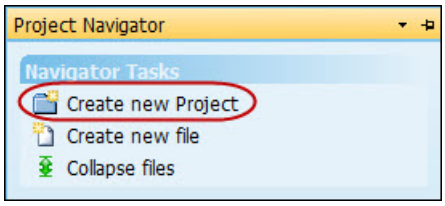
If someone has previously run through this guide, the Project **My Tablet PC** might be listed in the **Project Navigator** and/or in the **Recent Files** control on the **Start** page. Before running through the rest of this guide, delete this Project by right-clicking on the Project name in the **Project Navigator** and selecting **Delete File**. When the confirmation window opens, click **Yes**. In the Enterprise Edition, only system administrators can create and delete Projects. If you are not a system administrator, obtain the name of a Project and System file you can open from your administrator and see Opening a Project and System File on page 20.

Creating a Project from Scratch

Creating a Project from scratch is easy. The following procedure assumes that you are using the Tryout version and that the Project name that you enter is unique. For information about all types of Project creation scenarios, see “Creating a Project” in the guide or help for this application.

To create a Project from scratch:

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



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

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

   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 checkboxes. Repeatedly clicking a checkbox switches between selecting and clearing it.

6. Click **Select All** and then click **Next**. The **Set Project Properties** page appears.
7. For this Project, accept the default values and click **Next**. The **Select Common Library Files** page appears.

   This page lists all files in the Common Library, which is a special Project where you keep files that you want to use with Projects that you create. All supplied Report Design, Report Binder, and Graph Template files are included in the Common Library by default.

8. Accept the default values and click **Next**. The **Specify FMEA Setup** page appears.
9. Accept the default selection of **Set up FMEA now** and click **Next**. The **Select FMEA Worksheet Type** page appears.

   On this page, you select from a list of supplied standard layouts for performing FMEA (failure mode and effects analysis) tasks

10. Accept the default selection of **FMEA Standard Template** and click **Next**. The **Select FMEA Modes Library** page appears.

    On this page, you select from a list of supplied FMEA Modes Library files for performing component FMEAs.

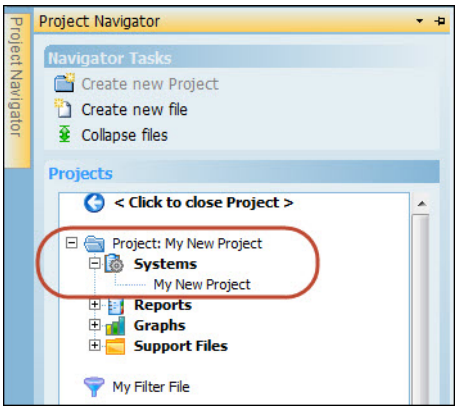
11. Accept the default selection of **FMD97 Modes - Tryout** and click **Next**. The **Set FMEA Options** page appears.

    On this page, you specify whether any local effects that you enter in a FMEA are to automatically roll up as failure modes at the next level of your FMEA hierarchy. You also indicate whether to turn on the tables for control plans and DVPs (design verification plans) in this Project's default System file.

12. Make sure all checkboxes are cleared so that modes are not rolled up and tables for control plans and DVP are not turned on. Then, click **Next**. The **Wizard Complete** page appears.

13. Click **Finish**. Progress indicators appear as the Project is created. Once the process is completed, the Project's 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 **Project:** heading designated by the open folder icon: **My New Project**.



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

    The first heading, **Systems**, refers to the main files that contain the data to analyze. In this case, one System file is listed: `My New Project`. You can create additional System file in a Project if desired. In this case, we use only one.

The other files in your Project are used to either set up the Project or support your analysis tasks.

15. Slide the **Project Navigator** out of view. Because the newly created System file is empty, no data is displayed in it.

Closing a Project and System File

To close the `My New Project` Project and System file:

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 special Common Library Project as well as the new Project that you just created.

Opening a Project and System File

To open the `My New Project` Project and System file:

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` is now listed in the **Recent Files** control on the **Start** page.

> **Tip**
>
> Clicking a file name in the **Recent Files** control is another way to open a Project's System files.

Creating a Project from an Existing Project

In some cases, you might want to create a Project from an existing Project. The existing Project can be one you set up yourself, or it can be a supplied template or sample Project. PTC Windchill Quality Solutions includes several templates and one sample Project that you can use as a starting point for creating a Project. You might find that a template creates a Project that is close to what you need, requiring only minor modifications.

This topic describes how to create a Project based on the `Tablet PC Sample` Project. The Project that you create here is then used throughout the remainder of this guide.

Note

As mentioned earlier, in the Enterprise Edition, only system administrators can create Projects. If you are a system administrator, create a Project from the `Tablet PC Sample` Project and then tell users of this application how they can open this System file to use it for the remainder of this guide.

1. In the **Project Navigator**, click **Create new Project**. The **Create Tryout Project** window opens.
2. For **Name**, 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 **Create from a Sample Project** and click **Next**. The **Select Project** page appears.
6. Select **Tablet PC Sample** and click **Next**. The **Wizard Complete** page appears.
7. Click **Finish**.

Progress indicators appear as the Project is created. Once this process is complete, the newly created **Tablet PC** System file in the **My Tablet PC** Project opens.

Module Selections Toolbar

In the procedures in this guide, we make use of the **Module Selections** toolbar. This toolbar appears by default 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 so that only the panes associated with the module we are using are shown.

If you clicked only the **Prediction** button in the **Modules Selection** window when you first started PTC Windchill Quality Solutions, only the panes for this module are shown. In the **Module Selections** toolbar, buttons for all selected modules are highlighted.

1. Click the FTA button in the toolbar to enable PTC Windchill FTA along with PTC Windchill Prediction. Tabbed panes for both of these modules are shown.
2. Click the Prediction button to remove the PTC Windchill Prediction panes.

   You can also hide and show the panes 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 this button .
4. In the window, do the following to show only PTC Windchill Prediction panes:
   a. Click **Clear All**.
   b. Click **Prediction**.
   c. Click **OK**.

Moving On

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

3

Common Features

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PTC 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, to avoid the constant repetition of these common tasks. Instead, this section usesPTC Windchill Prediction as a starting place for reviewing this functionality.

Note

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

Getting Started

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

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

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill Prediction

In the **Module Selections** toolbar, make sure the Prediction button λ is selected and all other module buttons are deselected.

Tour of the Interface

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

When you are only viewing the panes for the Prediction module, the top window contains two tabs:

- **System Tree Items** — Displays the hierarchical breakdown of your system and is shared with several other modules.
- **Problems** — Displays a list of problems and is shared with several other modules.

The tabs shown in the bottom pane depend on whether an assembly or part is selected in the **System Tree Items** table. When an assembly is selected, the following tabs are shown:

- **Parts Table** — Displays all parts for the active assembly in the **System Tree Items** table.
- **General Data** — Displays general properties for the assembly.
- **Calculation Data** — Displays calculation properties for the assembly.
- **Problems Form** — Displays a sample form for entering data for the active problem in the **Problems** table.

When a part is selected, the following tabs are shown:

- **Parts Table** — Displays all parts for the active assembly in the **System Tree Items** table.
- **Prediction Data** — Displays the parameters required for calculating a predicted failure rate for the part.
- **General Data** — Displays general properties for the part as well as inherited properties from the parent assembly that you can override.
- **Problems Form** — Displays a sample form for entering data for the active problem in the **Problems** table.

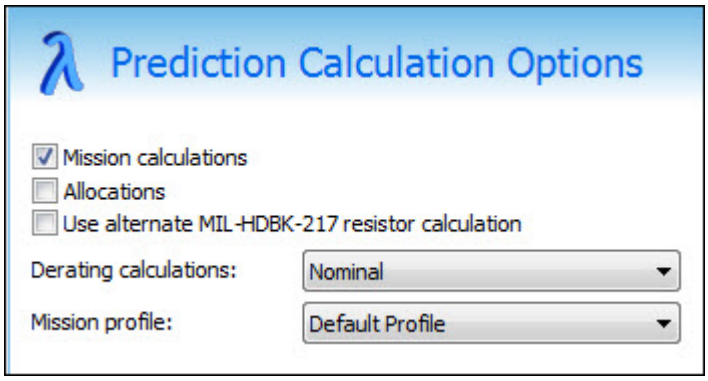
Reviewing Data

1. In the **System Tree Items** table, select the **Motherboard** assembly.
2. If necessary, select **Parts Table** in the lower pane to make this table active. The list of parts that make up the Motherboard assembly is shown.
3. In this table, click **Static RAM**. The part number for this part is SRAM031.
4. Review the fields available in this table. You can see that this part is a memory device. There are four of these parts on the Motherboard. They 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.

Running Calculations

To run calculations:

1. Select **System** ▸ **Calculate**, or click the calculate button on the **Standard** toolbar. The **Calculate** window opens.
2. In the left pane, select **Calculation Selection** if it is not already selected.
3. In the right pane, click **Clear All** and then select **Prediction** to run calculations only for the Prediction module.
4. In the left pane, select **Prediction**.
5. Leave the default values.



6. Click **OK** to run the calculations. The auto-hide **Calculation Progress** window 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**.

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

To display the results again at any time, you would select **System** ▸ **View Calculation Results**. If you have only one module enabled, the results shown are only for this module. If multiple modules are enabled, a navigation pane is shown so that you can select the pages for the results you want to view.

Generating Reports

The reporting capabilities within PTC Windchill Quality Solutions are extensive. They include the ability to view reports, print reports, generate reports to files, and create custom reports. We begin by viewing a supplied report.

Viewing a Report

1. In the **Project Navigator**, under **Reports > Prediction Reports**, select **(Common) Prediction (Summary)**.

   The **Generating Report** window opens, displaying progress. Once the report is generated, it opens in a preview window. You can use the toolbar in this window to print your report, move through its page, switch between a two-page and one-page view, zoom in and out, and close this window.

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

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

Alternatively, you can view a report by selecting **File ▸ Print Preview**. In the **Select Report to Preview** window that opens, you select the report you want to view and click **OK** to generate the report and open it in a preview window.

If you want to override the default properties for a report, when you select the report, also select the **Override report properties** checkbox. Before report generation begins, the **Report Properties** window opens so that you can specify custom values for the report.

Tip

On the standard toolbar, selecting the button for previewing a report also opens the **Select Report to Preview** window.

Printing a Report to a Printer

Any time you are viewing a report in a preview window, you can print it by clicking the print button in this window's toolbar.

However, if you want to bypass viewing the report, you can send it directly to a printer:

1. From the System file, select **File ▸ Print**. The **Select Report to Print** window opens.
2. Select the report and click **OK**. The **Print** window opens.
3. Select the printer, supply print properties, and then click **OK** to print the report.

Tip

On the standard toolbar, selecting the button for printing a report also opens the **Select Report to Print** window. If you select the **Override report properties** checkbox, before report generations beings, the **Report Properties** window opens so that you can custom specify values for the report.

Printing a Report to a File

You can also print a report to a file, which is useful if you want to email reports to colleagues or save them for later viewing. PTC Windchill Quality Solutions supports several file formats to which you can save 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 button ... to open the **Print to File** window.
4. For **File name**, enter `My Reliability Prediction`.
5. 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 haveMicrosoft Word® installed, you can select **Microsoft Word Document (*.doc)**. If you are unsure, select **Rich Text Format (*.rtf)**.
6. Ensure that the **Open file in editor after printing** checkbox is selected.

Note

If you do not know if you have any of the applications needed for viewing the supported file types, you can clear the **Open file in editor after printing** checkbox. If this checkbox is selected and the appropriate viewing application is not installed, the file is created, but it cannot be opened.

7. Click **Create**. The **Select Report to Print** window becomes active again, with **Print to file** now completed appropriately.
8. Click **OK** to generate the report and open the saved file in the associated application.
9. When you have finished viewing the file, exit the application.

Creating Custom Reports

The **Report Wizard** enables you to easily create custom reports. This wizard provides a step-by-step process for walking you through the report creation. Once you have created a report, you can save it to a Report Design file for later use.

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

   Because the **Parts Table** is active, **Prediction Parts** is the default selection for **Table type**. To make report creation easier, all fields shown in the active table or form for the report are automatically selected.
3. To remove **Part Classification (Prediction Parts)** from the **Selected fields** list, select it and then click **Remove**.
4. In the same, also remove the following fields: **Calculation Model (Prediction Parts)**, **Tagged Part? (Prediction Parts)**, and **Failure Rate, Percentage (Prediction Parts)**.
5. 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)**.
6. Click **Next**. The **Select Filter** page appears.
7. Accept the default of **– No Filter –** and click **Next**. The **Specify Data Grouping** page appears. Here you can group records into categories.

   For example, if you wanted to group records based on **Category (Prediction Parts)**, your report would show all integrated circuits together in a section, all resistors together in a section, and so on. For this example, you do not want to group records in any way.
8. Leave **Selected fields** list empty and click **Next**. The **Specify Sort** page appears.
9. In the first selection box, select **Failure Rate, Predicted (Prediction Parts)**. Clear the **Ascending** checkbox so that the failure rate data is sorted in descending order; then, click **Next**. The **Select Layout** page appears.
10. For **Layout**, select **Horizontal**.

11. For **Orientation**, select **Landscape**; then, click **Next**. The **Report Style** page appears.
12. Select **Corporate** and click **Next**. The **Report Title** page appears.
13. For **Title**, enter `My Prediction Report`; then, click **Next**. The **Wizard Complete** page appears.
14. Click **Finish**. The report is generated and opens in a preview window. The report lists all parts in order of descending failure rate.

    You might 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 might want to change the width of these columns. The **Report Wizard** creates a base Report Design file that you can then modify to suit your needs. Although you can use the **Report Designer** to place data fields directly into a blank Report Design file that you create, using the **Report Wizard** to create the base file is far more efficient. You then only need to make minor adjustments to the resulting file.
15. Select **Preview** ▸ **Close** to close the window. The Report Design file remains open in the **Report Designer**.

    In the design view, you can see the layout used to generate the report. You can now modify the Report Design file by adding new data fields, deleting fields, changing column widths, renaming column labels, and changing the report heading. You can also change colors, fonts, and other visual properties. Additionally, you can use more advanced features such as sorting, grouping, and filtering data. You can even define formulas and insert them in reports. The **Report Designer** is extremely powerful, enabling you to completely customize reports to suit your needs.

    At this point, you can choose to save the Report Design file. Let's assume that you want to save it.
16. Do the following to save the file:
    a. Select **File** ▸ **Save As**. The **Save File As** window opens.
    b. For **Name**, enter `My Prediction Report`; then, click **OK**.
17. Select **File** ▸ **Close**. 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 generate this report at any time, you would click the report name.

If you want to generate multiple reports at one time, you can insert Report Design files in Report Binders files. For more information about all reporting features and functions, see the PTC Windchill Quality Solutions help or guide.

Generating Graphs

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

Viewing a Predefined Graph

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

   This graph displays 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 graph window.

Alternatively, you can view a predefined graph by selecting **Tools** ▸ **Graph**. In the **Select Graph Template** window that opens, you select the graph to view and then click **OK** to generate the graph.

Tip

On the standard toolbar, selecting the graph button also opens the **Select Graph Template** window.

Creating a Custom Graph

The **Graph Wizard** enables you to easily create custom graphs of your System data. This wizard walks you through a series of questions about the graph you want to create. You can save graph settings to a Graph Template file so that you can quickly recreate this 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 the **Pareto** checkbox. Leave all other checkboxes 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 that the **Create corresponding Report Design file** checkbox 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. From this graph, you can see which assemblies contribute the most to overall system failure rate.

Modifying the Graph

You can modify the properties of any graph that has been generated.

1. In the window containing the graph, select **View ▸ Properties**. The **Graph Properties** window opens.
2. In the navigation pane on the left, select the various pages available to view the many properties that you can modify.
3. When finished, click **Cancel** to close the window.
4. Select **File ▸ Close**.
5. If you are asked if you want to save your changes, click **No**.

Filtering Data

When viewing your System data, you might want to view a subset of items in your Project. With large quantities of data, filtering techniques enable you to display only those items that are of interest to you. Filters can be applied not only for viewing purposes but also prior to running calculations and generating reports and graphs.

Filters 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.

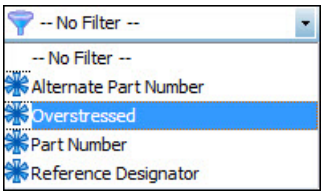
PTC Windchill Quality Solutions supports both fixed-value filters and parameterized filters. When you create a parameterized filter, you must supply a parameter value when the filter is applied. You can also build filters with multiple parameters. When building a parameterized filter, be aware that the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

Using Predefined Filters

PTC Windchill Quality Solutions includes a number of predefined filters that you can apply.

1. In the **System Tree Items** table, select **Motherboard**.
2. Select the **Parts Table**. The list of parts in the Motherboard assembly are shown.
3. In the toolbar, use the filter selection box to select **Reference Designator**.

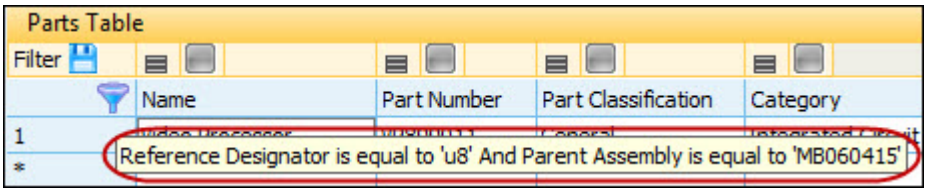
> **Tip**
>
> If you do not see **Reference Designator** in the filter list, ensure that you have the **Parts Table** selected. The filters available in the list depend on the active pane or window.



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

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

   Only the item with the matching reference designator is now shown in the **Parts Table**. If you place the mouse cursor over the filter icon in the upper left corner of the **Parts Table**, parameters for the filter are shown as a tooltip.



5. In the filter selection box, select **– No Filter –** to remove the applied filter.

Creating Custom Filters

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

1. Select the **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 for 'Temperature Rise (Prediction Parts)' here**, enter `20` as the temperature rise value 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 might be creating a filter that is for your own use. In that case, it is best to save it to your My Filter file. In other cases, if you are creating a filter you know would be helpful to all team members, you would want to save it to the Project Filter file so others can use it.
13. Click **Next**. The **Wizard Complete** page appears.
14. Click **Finish**.

    If this is the first time you have saved a personal filter, PTC Windchill Quality Solutions asks if you want to create a My Filter file in which to store your newly constructed filter. In the **Create Support File** window, click **Yes** to create this file.

If you have previously created a My Filter file, this message does not appear. If a message appears asking if you want to overwrite or use the existing file, select **Use Existing**.

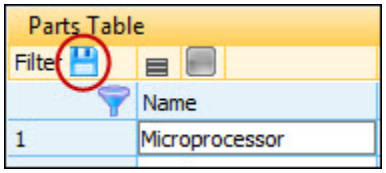
The filter is applied to your data so that all parts with a temperature rise of 20 degrees Celsius or higher are shown. Your new filter is shown in the filter selection box.

In the list for this selection box, your new filter, **Prediction - High Temperature Parts**, is preceded with a person icon instead of an asterisk icon. This indicates that the filter is stored in your My Filter file and not in the Project Filter file. All Project filters are preceded with a folder icon.

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

You can also view and modify filters in Filter files. Open the Project Filter file by selecting **Filter** under **Support Files > Setup** in the **Project Navigator**. You can insert new filters directly in this file. Similarly, **Support Files > Setup** in the **Project Navigator**, you can click **My Filter file** to open your personal Filter file to view, modify, and insert personal filters in it.

Lastly, you can use the filter bar to quickly build filters. The filter bar is located above the column headers if a table supports it. 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 in the top left corner 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 fields shown in tables.

For this example, you modify the layout of the **Parts Table**.

1. Right-click the **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 as columns. If the checkbox is cleared, the field is not shown.
2. Select the **217 Quality** checkbox. The **Parts Table** is updated to include this field as the last column. 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**.

The **Format Builder** inserts fields at the end of the table. However, you can click and drag a column to where you want it.

Importing Data

The **Import Wizard** enables you to easily import data into your System file by asking you a series of questions about the data you want to copy in to it. You can save the settings for performing an import in an Import/Export Template file so that you can quickly perform this same import later.

For this example, you 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. For **File type**, select **System**. For **Name**, enter `My Imported Data`. Make sure the **Run Create File Wizard** checkbox 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**, select **Microsoft Excel**.
7. Navigate to the `My Tablet PC` folder in your `My PTC Windchill Quality Solutions Files` directory.

> **Note**
>
> If you are using the Enterprise Edition, you must navigate to the `Samples` directory on the application server and then open the folder for your installed language. You then open the `Tablet PC Sample` folder, where the file referenced in the next step resides.

8. Select **ReliabilityPredictionImport** and click **Open**.

   You are returned to the **Select Source File** page, where the path to the selected file is shown.
9. Click **Next**. The **Specify Worksheet Format** page appears.

10. Leave **First row of cells has column names** selected and click **Next**. The **Select Data Type** page appears.
11. Select **Parts only** and click **Next.** The **Select Import Type** page appears.
12. Select **I want to add records** and click **Next**. The **Select Field Assignments** page appears.

    On this page, you map the data to import into PTC Windchill Quality Solutions fields. The first column is selected by default.
13. Map the columns for the data to import:
    a. For **Data field**, which appears near the bottom of the page, select **Part Number**.

       The column heading of the first column changes to **Part Number**.

       To map a column to a field, you can either select from the **Data field** list or type letters for the field name until the correct match is located.
    b. Click the second column and, for **Data field**, select **Quantity**.
    c. Click the third column and, for **Data field**, select **Reference Designator**.
    d. Click the fourth column and, for **Data field**, select **Name**.
14. Now that all four columns are mapped, click **Next**. The **Save Template** page appears.

    For this example, you do not need to save your import settings to an Import/Export Template file.
15. Click **Next**. The **Wizard Complete** page appears.
16. Click **Finish**. Importing begins and the **Parent Assembly Selection** window opens.
17. 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 the parent assembly with which to associate imported parts.
18. 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 click **View Log** to see them. In this case, there are no errors or warnings, and all parts are imported successfully.
19. Click **Close** to dismiss the **Import/Export** window. You can see the newly imported parts in the **Parts Table** and **System Tree Items** table.
20. When you are finished reviewing your new data, select **File** ▸ **Close**.

    For this example, you are going to delete the newly created System file.

21. In the **Project Navigator**, right-click the System file named **My Imported Data** and select **Delete**.
22. When the confirmation window opens, click **Yes** to delete the file.

Moving On

While the introductory sections introduced you to some basic features, PTC Windchill Quality Solutions offers an extensive array of additional capabilities. With the foundation you now have, you can move forward to explore specific analysis modules. All module-specific sections assume that you have successfully completed the introductory sections and are comfortable with the features they describe.

At any time during operation, help is available. To access the help, 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

PTC Windchill Prediction

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

Note

Because Projects can be fully customized, your screens might 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 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 PTC Windchill Prediction to perform this work can dramatically increase the efficiency and accuracy of 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 “Ordering Reliability Standards” in the help.

Getting Started with PTC Windchill Prediction

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

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

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill Prediction

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

The System file displays only PTC Windchill Prediction panes

Using PTC Windchill Prediction

In the top pane, the **System Tree Items** table displays the hierarchical breakdown of your system. In the bottom pane, the **Parts Table** displays all components in the assembly selected in the system tree. In the bottom pane, the additional tabbed panes shown depend on whether an assembly or part is active.

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

Viewing Prediction Data

1. In the **System Tree Items** table, select the **Motherboard** assembly.
2. In the **Parts Table**, which now shows the parts that make up the Motherboard assembly, click **Static RAM**.

   This part has a part number of SRAM031.
3. Review the fields available in this table.

   You can see that this is a memory device. There are four of these parts on the Motherboard.
4. In the **Prediction Data** pane, view the parameters associated with this part.
5. Click **Pi Factors** to open the **Pi Factors** window.

   In this window, you can see the factors used in the equation for computing the failure rate for this part. 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, see the help.
6. 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 **Hard Disk Assembly** .
2. Select **Insert** ▸ **Sibling Assembly**. A new assembly is inserted at the same level as the selected assembly.

   If you had inserted a child assembly, it would have been inserted one level lower than the selected assembly.
3. For **Name**, enter `My Demo Assembly` for the new assembly.
4. In the **Parts Table**, which currently shows no parts for this newly inserted assembly, do the following in the blank row:

   a. For **Name**, leave it blank.

   b. For **Part Number**, enter `ABC` and press **Tab**.

      The first time that you enter a part number, all enabled Prediction Parts Libraries are initialized for searching. If you are using a licensed version, this might take a moment or so.

   c. If not already selected, for **Part Classification**, select **General**.

   d. For **Category**, select **Integrated Circuit**.

   e. For **Subcategory**, select **Logic, CGA or ASIC**.

f. For **Reference Designator**, enter `U27`.

5. Select the **Prediction Data** pane.

   All part parameters are blank or show one or more number signs (#). To compute a failure rate, default values are stored for required parameters.

6. Click **Defaults**.

   A number of parameters are now filled in with values. These values represent average values for these parameters. The calculation engine uses these average values if you do not enter specific data values.

   Because PTC Windchill Prediction uses average values for the part to produce a preliminary failure rate estimate, using these default values is a good way to start your analysis. As data becomes available, you can go back and enter it in the **Prediction Data** pane.

7. Click **Defaults** again to hide the default values from view.

   The **Defaults** button is there only for informational purposes. During calculations, PTC Windchill Prediction automatically uses the default values for parameters in which you do not enter values. You do not need to click **Defaults** to have this occur.

8. Click **Pi Factors** to see the computed failure rate of your newly inserted part.
9. Click **Close** to close the **Pi Factors** window.

Using 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 the **Parts Table**.
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 fills in the appropriate part data.

3. Select the **Prediction Data** tab to view the data that has been automatically entered for this library part.

   You can see that almost all of the parameters have been filled in.

A few fields, such as **Initial Temp Rise**, are dependent on the operating conditions of your system. You must enter these types of values.

Viewing Parts in Parts Library Files

In some cases, you might not know an exact part number. In these cases, you can browse the parts in Prediction Parts Library files to select the part to insert.

1. Select the **Parts Table**.
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.
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.
7. In the menu for the **Results** table, click the **+ Insert** button to insert the part in the **Parts Table**, which is visible on the right.

> **Tip**
>
> You can also drag and drop parts from the **Library Browse** window to insert them in the **Parts Table**. Click the desired part's row in the **Results** table and, while still holding down the left mouse button, drag the part to insert it at the end of the **Parts Table**.

Searching for Library 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** table lists all parts that include the text "transistor" in any part of the **Description** field. As you can see, you can perform a wide variety of searches using all types of search parameters.

Entering Parts Using the NPRD/EPRD Libraries

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

1. In the **Library Browse** window, for **Search for**, select **NPRD 2011 Parts**.
2. For **Category**, select **Battery**
3. For **Subcategory**, select **General.**
4. Click **Search**. The **Results** table displays the matches for a general battery in the NPRD 2011 library.
5. Click **NPRD-611** to select it.
6. In the menu for the **Results** table, click **+ Insert** to insert the part in the **Parts Table**.
7. Close the **Library Browse** window by clicking the **x** in the upper right corner of the window.

Understanding Prediction Calculations

PTC Windchill Prediction 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 that represents the number of failures likely to occur over a time period, usually defined in units of FPMH (failure per million hours) or FITS (failures per billion hours). 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.
MTBF	The MTBF (mean time between failures) represents the number of hours a unit operates between failures. For non-repairable units, which cannot be repaired once a failure occurs, the MTBF is equivalent to MTTF (mean time to first failure). Therefore, the terms MTBF and MTTF are sometimes used interchangeably, although doing this is not theoretically accurate. In PTC Windchill Prediction, 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.

Calculation	Description
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 that has an availability of 0.99999, which means that it is operational 99.999% of the time.
MTTR	MTTR (mean time to repair) 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 PTC Windchill Maintainability is used in conjunction with PTC Windchill Prediction, the computed MTTR values of components and subassemblies can be obtained from the Maintainability module. Units for MTTR values are typically hours or minutes. MTTR is also referred to as MCT (mean corrective time).

PTC Windchill Prediction can also compute the above measures using mission phases. To perform mission calculations, you define a mission profile, which describes the phases of a mission your system experiences. For example, the mission of an airplane might consist of three phases: take-off, flight, and landing. Each one of these phases occurs in different environments and conditions. You can also define a phase as dormant or active 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 results for the entire mission as well as for individual phases.

PTC 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.

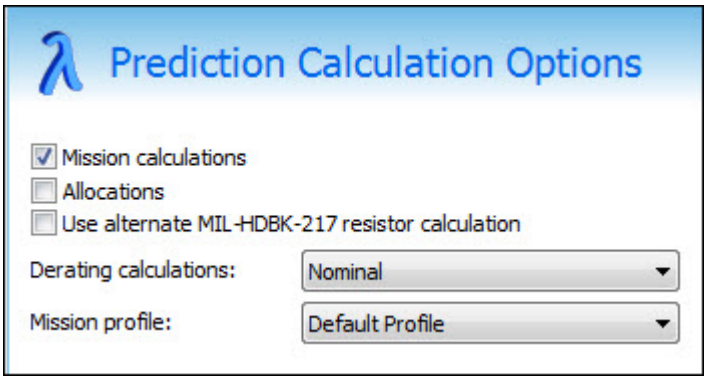
The Prediction module also supports a variety of reliability allocation methodologies. When using these methods, you allot MTBF values across the subassemblies and/or components of your system, and then, based on specified weighting factors, calculate the projected failure rate of the components and/or subassemblies in the system.

Reliability allocations are useful when you have reliability goals that 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 assign one highly complex subsystem an MTBF of 5,000 hours, and split up the remaining 5,000 hours over all other subsystems. In this way, you can apportion MTBF goals to ensure that your overall objectives are met.

Running Prediction Calculations

To compute the predicted failure rate of your system:

1. Select **System** ▸ **Calculate**, or click the calculate button 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 **Prediction** to run only calculations for the Prediction module.
4. In the left pane, select the **Prediction** page.
5. Leave the default selections.



6. Click **OK** to run the calculations. The **Calculation Progress** window opens, displaying 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**.

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

To display the results again at any time, you would select **System ▸ View Calculation Results**. If you have only one module enabled, the results shown are only for this module. If multiple modules are enabled, a navigation pane is shown so that you can select the pages for the results you want to view.

Viewing a Prediction Report

1. In the **Project Navigator**, under **Reports > Prediction Reports**, select **(Common) Prediction (Summary)** to generate this report and open it in a preview window

   This report includes assembly names, part numbers, reference designators, quantities, and calculation results for failure rate and MTBF.

   You can use the toolbar in this window to print your report, move through its page, switch between a two-page and one-page view, zoom in and out, and close this window.
2. When finished viewing the report, do one of the following to close the window:
   - Select **Preview ▸ Close**.
   - Click the close button on the toolbar.

Alternatively, you can view a report by selecting **File ▸ Print Preview**. In the **Select Report to Preview** window that opens, you select the report to view.

Tip

On the standard toolbar, selecting the button for previewing a report also opens the **Select Report to Preview** window.

Graphing Prediction Data

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

   This graph displays 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 can view a predefined graph by selecting **Tools** ▸ **Graph**. In the **Select Graph Template** window that opens, you select the graph to view and then click **OK** to generate the graph.

Tip

On the standard toolbar, selecting the button for generating a graph also opens the **Select Graph Template** window.

Additional Prediction Features

Many more features and functions are available within PTC Windchill Prediction. A brief listing of other topics of interest is shown below. To learn more about these features, see the help.

- You can perform reliability predictions using 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.
- You can combine models within a Project and apply MTBF adjustment techniques such as PRISM Process Grades and Telcordia calculation methods for high-powered analyses.
- You can use Prediction Derating files to store minimum and maximum derating criteria for part types.
- You can use Prediction Defaults files to store part parameter values for part types.
- You can use Prediction Values Library files to store your own user-defined environments and quality levels.
- You can use Mission Profile files to store data associated with various mission phases, including dormancy information and the total mission time.
- You can use Prediction Parts Library files to store part data for custom parts, thereby supplementing the supplied Prediction Parts Library files.
- You can use Prediction Correlation Library files to search library components based on in-house part numbers rather than manufacturer part numbers.
- You can use Prediction Process Grade files to store scoring profiles, which translate total scores into quantitative Pi-factor multipliers that impact predicted failure rates.
- You can use Prediction Bayesian files to store test and field data that you want to use to modify predicted failure rates for more real-world predicted values.

5

PTC Windchill FMEA

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This section of the *PTC 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 PTC Windchill FMEA. In this section, you enter FMEA data, run calculations, and view reports and graphs.

Note

Because Projects can be fully customized, your screens might 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, they are 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 FMEA guidelines. The most common FMEA standards include MIL-STD-1629, various automotive 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 this item. The next step is to establish, based on system knowledge, what the resulting effects of failure modes are. Along with each end effect, the analyst might determine the severity of this effect, its probability of occurrence, and how it 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 FMEAs and FMECAs 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 PTC Windchill FMEA

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

If you are already using PTC Windchill Quality Solutions and the **Tablet PC** System file is open, you can get started by activating the FMEA module. For more information, see Activating PTC Windchill FMEA on page 53.

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Activating PTC Windchill FMEA

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

The System file displays only PTC Windchill FMEA panes.

Using PTC Windchill FMEA

The top window contains the following tabbed panes:

- **System Tree Items** — Displays the hierarchical breakdown of your system and is shared with several other modules.
- **Problems** — Displays a list of problems and is shared with several other modules.
- **FMEA Table** — Displays a list of all your FMEAs.
- **FMEA Tree Items** — Displays the hierarchical breakdown of your FMEA structure. By default, the name of the **FMEA Tree Items** table is followed by a hyphen and **Functional**, **Process**, or **Component** to indicate the type of FMEA selected in the **FMEA Table**.

The bottom window contains the following tabbed panes:

- **Problems Form** — Displays a sample form for entering data about the active problem in the **Problems** table.
- **FMEA Worksheet** — Displays the failure item, mode, cause, and effect data that is entered for the active **FMEA Tree Items** record.
- **FMEA Control Plans** — Displays the control plans inserted in this System file and **FMEA Worksheet** causes and **FMEA Tree Items** records with which they are associated.
- **FMEA DVPs** — Displays the DVPs (design verification plans) inserted in this System file and the **FMEA Tree Items** records and **FMEA Worksheet** causes with which they are associated.
- **FMEA** — Displays a sample form for entering item, mode, cause, and effect data for the active **FMEA Tree Items** record.

In PTC Windchill FMEA, FMEAs can be extensively customized. 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 a result, your FMEAs might not look exactly like the ones in this guide.

Additionally, you can perform FMEA activities on the web using PTC Windchill Quality Solutions Web Access.

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 PTC 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 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 three types of FMEAs:

1. In the **FMEA Table**, select **System Functional FMEA**.
2. In the **FMEA Tree Items - Functional** table, select **Processing Section**.
3. In the **FMEA Worksheet** table, view the functional FMEA for the processing section of the tablet PC.
4. In the **FMEA Tree Items - Functional** table, select **Touchpanel**.
5. In the **FMEA Worksheet** table, view the functional FMEA for the touchpanel section of the tablet PC.
6. In the **FMEA Table**, select **Battery Process FMEA**.
7. In the **FMEA Tree Items - Process** table, expand **Battery** if necessary and then select **Solder**.

8. In the **FMEA Worksheet** table, view the process FMEA for soldering the battery for the tablet PC.
9. In the **FMEA Tree Items - Process** table, select **Assembly**.
10. In the **FMEA Worksheet** table, view the process FMEA for assembling the battery of the tablet PC.
11. In the **FMEA Table**, select **Tablet PC Component FMEA**.
12. In the **FMEA Tree Items - System** pane, expand **Industrial Tablet PC** if necessary and then select **Motherboard**.
13. In the **FMEA Worksheet** table, view the component FMEA for the motherboard of the tablet PC.

Entering FMEA Data

To enter data in a FMEA:

1. In the **FMEA Table**, select **System Functional FMEA**.
2. In the **FMEA Tree Items - Functional** table, select **Processing Section**.
3. In the **FMEA Worksheet** table, in the **Function / Process** column, select **Transfer data and provide computing functions**.
4. Do the following to insert and complete a new record:
   a. Select **Insert** ▸ **Insert Mode** to insert a new failure mode.
   b. For **Failure Mode**, enter `Hard drive failure`.
   c. For **Mode Percentage**, enter `25`.
   d. For the other three failure modes for this function, change **Mode Percentage** to `25`.

   Note

   If the entire column is not visible, you can resize the column.

   Failure mode percentages of all failure modes for a single item should add up to 100 percent. For this example, you are going to assume that all four modes have an equal likelihood of occurring.

   In real-world situations, some modes are more likely to occur than others. You would reflect this by designating the appropriate percentages for each mode.

   e. For **Local Effect** for your newly inserted failure mode, 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 this effect again because you could select it from the list.

f. Click **Yes** to add the new effect to the list.

g. For **End Effect**, select **Tablet PC not functional**.

h. For **Sev**, which is a custom prompt assigned to the **Severity** field, select **9** to indicate a high severity.

i. For **Class**, leave it blank.

j. For **Cause of Failure**, enter `Bad sector on hard drive`.

k. For **Occ**, which is a custom prompt assigned to the **Occurrence** field, select **2** to indicate a low probability of occurrence.

l. For **Current Controls**, enter `Test hard drive on bootup`.

m. For **Det**, which is a custom prompt assigned to the **Detection** field, select **6** to indicate a moderate detection mechanism is in place. Then, press **Tab** to move to the next field.

   PTC Windchill FMEA automatically computes the RPN (risk priority number) for this failure mode.

   Depending on your system and your requirements, you might 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 to eliminate or mitigate the risk of their occurrence.

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

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

p. For **Target Date**, click in the field to make the calendar icon available. Then, click this icon to display the calendar control.

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

Once the recommended actions have been put into place, you would complete the remaining fields: **Actions Taken**, **Sev Res**, **Occ Res**, and **Det Res**. These last three fields all have custom prompts assigned to fields for assigning result values for severity, occurrence, and detection.

You have now completed entering data for a new failure mode. Entry of additional FMEA data is accomplished in the same manner. You can enter any number of data levels (items, modes, causes, and effects) by using commands on the **Insert** menu and on the right-click menu. You can also enable the **Insert FMEA Items** toolbar to insert FMEA data using toolbar buttons.

FMEA data structures can be customized, which means you can vary the hierarchical relationship of your FMEA data as well as the data to collect.

Working with List Library Files

List Library files allow you to define list items that are used throughout your System file, which ensures that your 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 command is not available, click **Collapse files** and then click **Expand files**.

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

As you saw while editing the System file in the `My Tablet PC` Project, in the **Local Effect** column in the **FMEA Worksheet** table, you can select a choice from a list. You can also type an entirely new local effect directly in the cell. In this case, a window opens, asking 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.

Understanding FMEA 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 following table describes the results calculated by the FMEA module. Once calculations run, you can view these results in the **FMEA Worksheet** table.

Calculation	Description
RPN	The overall risk of a particular failure mode occurring in your system. The RPN (risk priority number) 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 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 severity, occurrence, and detection values, they are computed again when you perform FMEA calculations to ensure that all RPN values are current.
RPN result	An RPN value 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	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	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 FPMH (failures per million hours) or FITS (failures per billion hours).
Mode failure rate	The number of occurrences of a specific failure mode over a time period, usually defined in units of FPMH (failures per million hours) or FITS (failures per billion hours).

Calculation	Description
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: • 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 or detectable failures per billion hours.
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 or isolation failures per billion hours.

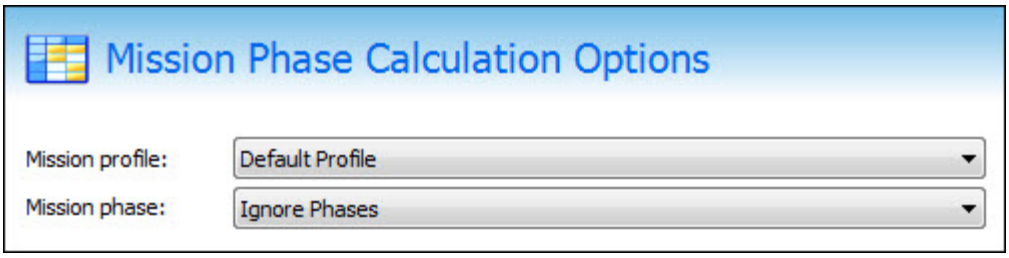
Running FMEA Calculations

To compute FMEA results:

1. Select **System** ▸ **Calculate**, or click the calculate button on the standard toolbar. The **Calculate** window appears.
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 **FMEA** to run calculations only for the FMEA module.

4. In the left pane, expand the **FMEA** folder if necessary and select the **Mission Phase** page.

   On this page, you supply mission profile and mission phase options for mission calculations. For this example, you do not need to consider mission phases. Leave the default values.



5. In the left pane, select the **Risk** page.

   On this page, you indicate whether to calculate initial and resulting risk levels. For this example, select both checkboxes.

6. Click **OK** to run the calculations. The **Calculation Progress** window opens, displaying status information. When the calculations are complete, a window opens, indicating this.
7. Click **OK** to close this window.

Viewing a FMEA Report

To view a supplied FMEA report:

1. In the **Project Navigator**, under **Reports > FMEA Reports**, select **(Common) FMEA Standard Design**. Because a record selection is required for report generation, the **Report Properties** window opens
2. Under the **Record selection** heading, select **System Functional FMEA**.
3. Click OK to generate the report and open it in a preview window. You can use the toolbar in this window to print your report, move through its page, switch between a two-page and one-page view, zoom in and out, and close this window.
4. When finished viewing the report, do one of the following to close the window:
   - Select **Preview ▸ Close**.
   - Click the close button on the toolbar.

Graphing FMEA Data

The FMEA module has several supplied graphs and supports the creation of custom graphs. During the installation of PTC Windchill Quality Solutions, Graph Template files for all supplied graphs are copied into the Common Library so that they are available for immediate use with all your Projects. You can generate a graph using any Graph Template file in the Project or in the Common Library. All Graph Template files in the Common Library have a **(Common)** prefix in their names.

To generate a supplied FMEA graph:

1. In the **Project Navigator**, under **Graphs > FMEA Graphs**, select **(Common) FMEA Top 10 RPN**. 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 you are finished viewing the graph, select **File ▸ Close**. If a window opens, asking whether you want to save changes, click **No**.

Additional FMEA Features

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

- You can use PTC Windchill Quality Solutions Web Access to perform component, functional, and process FMEAs 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. PTC Windchill Quality Solutions Web Access provides significant advantages for enabling FMEAs to be performed in a collaborative environment through its global accessibility.
- You can use the unique “Roll Up” and “Build” features to construct FMEAs more effectively. You can either roll up local effects as failure modes for the next higher data level in the worksheet or build a FMEA by progressing down through data levels to fill in end effects, next effects, severities, and failure effect probabilities.
- You can compute any number of custom FMEA calculations and even override built-in RPN calculations with custom equations.
- You can customize your FMEA data hierarchy in the Project’s FMEA Design file, which provides ultimate flexibility to ensure your FMEA process needs are met.

- You can use FMEA Modes Library files to automatically add failure modes for specific part types to component FMEAs.
- You can use the Project's FMEA Fault Equivalence file to ensure consistency and efficiency in FMEA construction. By grouping failure consequences based on failure modes, this file reduces the level of effort needed to complete a component FMEA by automatically pulling in consequence data for duplicated failure modes. PTC Windchill FMEA supplies a number of standard FMEA Modes Library files.
- You can use control plans to create a structured plan for designing, selecting, and implementing controls for the system, thereby ensuring that the process remains in a state of control throughout the product life cycle.
- You can use DVPs (design verification plans) to track the tests that ensure product designs are meeting customer specifications and that product development is correctly focused.
- You can copy PTC Windchill global attributes and PTC Creo quality-critical characteristics for PTC Windchill parts into the Global Attributes table. In this special System Tree Items subtable, you can associate attributes with FMEA control plans and DVPs.

6

PTC Windchill FTA

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

Note

Because Projects can be fully customized, your screens might 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. It offers a simple and powerful approach for reliability and safety analysis. FTA 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 that can lead to the occurrence of this event.

FTA is based on a simple set of rules and logic symbols (such as AND gates, OR gates, and many others) from probability theory and Boolean algebra. It 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 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 FTA and would like to learn morel, 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 PTC Windchill FTA

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

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

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill FTA

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

The System file displays only PTC Windchill FTA panes.

Using PTC Windchill FTA

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

The top pane contains the following information:

- **Problems** — Displays a list of problems and is shared with several other modules.
- **FTA Table** — Displays an hierarchical table with columns of data. It provides an expandable/collapsible view of the fault tree data contained in the graphical view in the lower pane.

The bottom pane contains the following information:

- **Problems Form** — Displays a sample form for entering data about the active problem in the **Problems** table.
- **FTA Diagram** — Displays a graphical view of the fault tree, which is the most common view for developing and modifying fault trees. The top figure in the diagram 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, you can right-click it and select **Properties**. To review these properties:

1. In the **FTA Diagram**, double-click **TS-1**, which is a basic event with a description of **Temperature Sensor Failure**. The **Properties** window opens.
2. In the left pane, click the following pages to review properties on the various pages.
   - **General** — Displays the event type and identifying text.
   - **Calculation Data** — Displays information about the event's quantitative properties that is used during fault tree calculations.
   - **Library Event** — Displays information about the library associated with this event. In this case, no information is shown as this event was not inserted from a library.
   - **Graphic** — Enables you to associate a graphic image of your choosing with the event.
   - **User Properties** — Provides extra data fields you can use for any purpose you desire.
   - **Remarks** — Allows you to enter a lengthy notation about this particular event.
3. Click **Cancel** to close the **Properties** window.
4. Double-click **BAT-FIRE**, which is an OR gate with a description of **Battery catches on fire**. This gate is the fault tree's top gate. The **Properties** window opens.

   Gates have four additional property pages: **Inputs**, **Cut Sets**, **Reliability Importance Measures**, and **FTA Results**.

   The **Inputs** page provides a table view of all the events and gates that are inputs to this gate. The last three pages display calculation results. If calculations have not yet been run, no data appears on these pages.
5. 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 the 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 open the **Properties** window.
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 that you just inserted.
2. Right-click this gate 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. Do the following to define this gate's properties:
   a. Double-click the gate to open the **Properties** window.
   b. Select the **General** page.
   c. For **Identifier**, enter `Mech Fault`.
   d. For **Description**, enter `Mechanical failure` .
   e. Click **OK** to close the **Properties** window.
5. Select the **HD Failure** OR gate again.
6. Right-click this gate and select **Insert Input**; then, insert another OR gate.
7. Do the following to define this gate's properties:
   a. Double-click the gate to open the **Properties** window.
   b. Select the **General** page.
   c. For **Identifier**, enter `Elec/SW Fault`.
   d. For **Description**, enter `Electrical or software failure` .
   e. Click **OK** to close the **Properties** window.
8. Select the **HD Failure** OR gate again.
9. Right-click this gate and select **Insert Input**; then, insert yet another OR gate.
   a. Double-click the gate to open the **Properties** window.
   b. Select the **General** page.

c. For **Identifier**, enter `Ext Fault`.

d. For **Description**, enter `External failure` .

e. Click **OK** to close the **Properties** window.

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. Also shown is a plug icon.

   - When a red warning symbol appears over the plug icon, you cannot insert the event in the current location.

   - When no warning symbol appears over the plug icon, you can insert the event in the current location.

4. Move the cursor so that the circle shape is over the gate labeled **Mech Fault**. Because you can insert the basic event in this location, the warning symbol does not appear over the plug.
5. Click to insert the basic event. The cursor retains the shape of the basic event so you can continue to insert basic events.
6. Click to insert one more basic event under the **Mech Fault** OR gate.
7. Move the mouse over to the **Elec/SW Fault** OR 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 might need to change an event to a gate or a gate to an event. For this example, assume that rather than completing the logic for the **Ext Fault** OR gate at this time, you want to change it to an undeveloped event, indicating that you will come back later and more fully analyze this particular failure path. This

type of failure can be caused by such events as the tablet PC being dropped, or someone spilling coffee on it. For now, however, you want to leave this branch open-ended and return to develop it later, when you have more information.

1. In the **FTA Diagram**, double-click the **Ext Fault** Gate. The **Properties** window for this gate open.
2. For **Gate/Event 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 menu. To view these properties:

1. In the **FTA Diagram**, beneath the **Mech Fault** OR gate, double-click the left event you inserted to open the **Event Properties** window.
2. On the **General** page, do the following:
   a. For **Identifier**, enter `Bearing Fault`.
   b. For **Description,** enter `Mechanical bearing failure`.
3. On the **Calculation Data** page, do the following:
   a. For **Input Type** , leave it set to **Constant probability**.
   b. For **Probability**, enter `0.0015`.
4. Click **OK** to close the **Event Properties** window.
5. In the **FTA Diagram**, beneath the **Mech Fault** OR gate, double-click the second event you inserted to open the **Event Properties** window.
6. On the **General** page, do the following:
   a. For **Identifier**, enter `Media Fault`.
   b. For **Description,** enter `Hard drive media failure`.
7. On the **Calculation Data** page, do the following.
   a. For **Input Type**, select **Failure rate/MTBF**.
   b. For **Failure rate**, enter `0.0001`.
8. Click **OK** to close the **Event Properties** window.
9. In the **FTA Diagram**, beneath the **Elec/SW Fault** OR gate, double-click the event you inserted to open the **Event Properties** window.
10. On the **General** page, do the following:

a. For **Identifier**, enter `Controller Fault`.

b. For **Description**, enter `Hard drive controller failure`.

11. On the **Calculation Data** page, do the following:

    a. For **Input Type** , leave it set to **Constant probability**.

    b. For **Probability**, enter `0.0125`.

12. Click **OK** to close the **Event Properties** window.

13. In the **FTA Diagram**, double-click the **External Fault** undeveloped event to open the **Event Properties** window.

14. On the **Calculation Data** page, do the following:

    a. For **Input Type** , leave it set to **Constant probability**.

    b. For **Probability**, enter `0.0002`.

15. Click **OK** to close the **Event Properties** window.

Using Transfer Gates

Fault trees can become quite large and complex, containing many gates and events. In these cases, for ease of analysis, it might be helpful to break the single fault tree up into smaller fault trees that are all linked together. Additionally, you might 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 or to handle repeated logic.

1. In the **FTA Diagram**, select the **Mech Fault** OR gate.

2. Right-click the gate and select **Break into Transfer**.

   A new fault tree is inserted. The **Mech Fault** OR 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 this fault tree, right-click the **Mech Fault** OR gate and select **Collapse Transfer** to return the fault tree to the original diagram.

You can also insert new Transfer gates directly into your fault trees just like any other gate.

Understanding FTA Calculations

PTC Windchill FTA includes both qualitative and quantitative calculations. Qualitative calculations analyze the unwanted event (the top gate in the fault tree) and determine the minimum combination of events that cause this 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 brief descriptions are provided. For more information, see the help or guide for PTC 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 occur.
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.

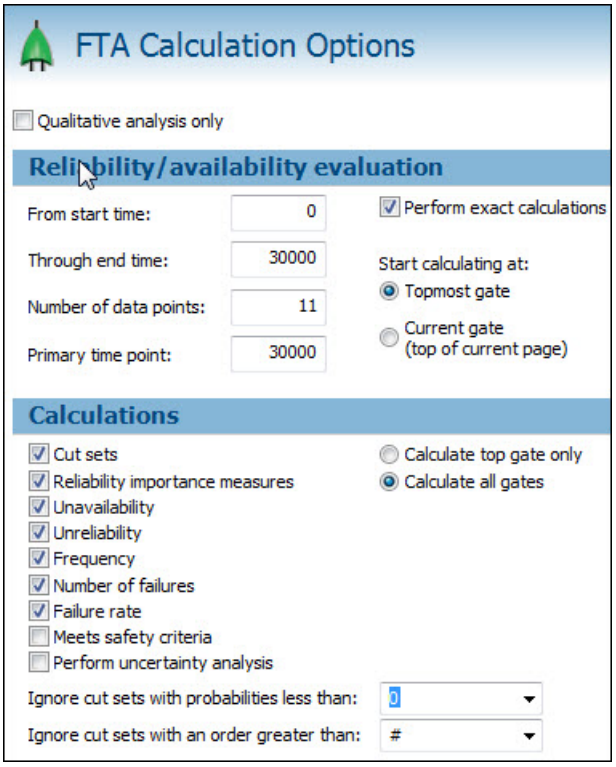
Running FTA Calculations

To compute fault tree results:

1. In the **FTA Table**, select **BAT-FIRE**.
2. Select **System** ▸ **Calculate**, or click the calculate button on the standard toolbar. The **Calculate** window opens.
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 **FTA** to run calculations only for the FTA module.
5. In the left pane, expand the **FTA** folder if necessary and select the **General** page.

   Both this page and the **Advanced** page contain a number of calculation options. The options shown depend on the FTA calculation type selected for the System file. This file is for a time dependent tree.
6. Under **Reliability/availability evaluation**:
   a. For **Through end time**, enter `30000`.
   b. For **Number of data points**, enter `11`.
   c. For **Primary time point**, enter `30000`.
   d. Select **Perform exact calculations**.
7. Under **Calculations**:
   a. Leave **Cut sets** selected.
   b. Select the following calculations as well:
      - Reliability importance measures
      - Unavailability
      - Unreliability
      - Frequency
      - Number of failures
      - Failure rate
   c. Select **Calculate all gates**.

   Your page should now match the one in the following figure.



8. In the left pane, select the **Advanced** page.
9. For **Calculation method**, select **Exact**.

   For more information about all options for all tree types, click **Help** to open the help.
10. Click **OK** to run the calculations. 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**.

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

To display the results again at any time, you would select **System** ▸ **View Calculation Results**. If you have only one module enabled, the results shown are only for this module. If multiple modules are enabled, a navigation pane is shown so that you can select the pages for the results you want to view.

Viewing Cut Sets

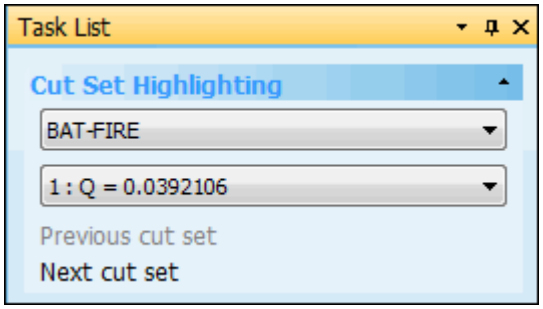
A cut set is a set of events that together cause the top event to occur. A minimal cut set (MCS) is the smallest set of events, which, if they all occur, cause the top event to occur.

During calculations, cut sets are calculated if you selected this option in the FTA calculation properties. You can view cut sets, cycling through them one at a time.

To view cut sets:

1. In the **FTA Diagram** pane, select the top **BAT-FIRE** OR gate.
2. Select **FTA** ▸ **Highlight Cut Sets**.

   The **Task List** window opens. In the **Cut Set Highlighting** area, the first cut set is selected by default. In the **FTA Diagram** pane, the gates and events that make up this cut set are highlighted in blue.



> **Note**
>
> If you have the **Project Navigator** pinned into view, you might want to unpin it and slide it out of view while you are viewing cut sets.

3. In the **Task List** window, click **Next cut set** to view the next cut set for the **BAT-FIRE** OR gate. You can continue clicking this command until it becomes unavailable, indicating that you are viewing the last cut set. To go back, click **Previous cut set**.

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

4. On the **FTA** menu, select **Highlight Cut Sets** again to turn off cut set highlighting and close the **Task List** window.

Viewing an FTA Report

To view an FTA report:

1. In the **Project Navigator**, under **Reports > FTA Reports**, select **(Common) FTA (Summary)**. Because the three reports in this Report Binder file require input data, the **Report Properties** window opens.
2. For the top report, do the following:
   a. Under the **Record Selection** heading, select **Print selected gate**.
   b. If **BAT-FIRE** is not already selected, click ... to select it.
   c. Verify that the **Apply this selection to all reports** checkbox is selected.

   For the other reports, you can use the default values.
3. Click **OK** to generate the report and open it in a preview window. This report outputs data related to a fault tree (top gate) in the System file. It includes calculation data, gate and event details, and the fault tree diagram.

   You can use the toolbar in this window to print your report, move through its pages, switch between a two-page and one-page view, zoom in and out, and close this window.
4. When finished viewing the report, do one of the following to close the window:
   - Select **Preview ▸ Close**.
   - Click the close button on the toolbar.

Graphing FTA Data

1. In the **Project Navigator**, under **Graphs > FTA Graphs**, select **(Common) FTA Unavailability v Time**. The **Select the Gate to Graph** window opens.
2. Select **BAT-FIRE**, which is the top gate, and click **OK** to generate the graph for the entire FMEA.

   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**.

Additional FTA Features

PTC 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 PTC Windchill Quality Solutions.

- You can use Fault Tree CCF Groups files to store CCFs (common cause failures) to copy them into any fault tree. A CCF is an event or mechanism that can cause two or more failures (basic events) to occur simultaneously.
- You can use repeated events, which are basic events that you insert in more than one place in the fault tree. When a repeated event occurs, it occurs simultaneously everywhere you have inserted it.
- You can use Fault Tree Event Library files to store commonly used events so that these events, and their failure and repair parameters, can easily be copied into any fault tree.
- You can run exact calculations. Or, you can run cut set approximations to expedite the analysis of large trees.
- You can customize the appearance of gates and events, including colors, fonts, images, and sizing.
- You can 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 fault tree events to other modules. If the linked data changes, these changes are automatically reflected within the fault tree. You can link FTA events to data in the following modules: FMEA, Markov, and Prediction.
- You can use PTC Windchill FTA automatic paging to better manage large fault trees.
- In addition to standard time dependent fault trees, you can build and evaluate lambda tau and SAE ARP4754A and ARP4761 fault trees. You can also import CAFTA files into PTC Windchill FTA.
- You can use PTC Windchill Event Tree when you have a PTC Windchill FTA license. The Event Tree module provides full event tree analysis capabilities. This means that you can analyze the consequences that result from a sequence of events occurring in your system.

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PTC Windchill RBD

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This section of the *PTC Windchill Quality Solutions Getting Started Guide* provides basic information about building and evaluating RBDs (reliability block diagrams) using PTC 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 might 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. Therefore, designing redundancy into a system can often lead to increased reliability and availability.

Different types of redundancy, such as parallel operating and standby non-operating, exist. When items are in a parallel operating configuration, all are not necessarily needed to be operational for the system to operate. For example, in a simple system, two batteries might be 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 become even more complex when you consider factors such as the switch delay encountered in standby situations when the backup unit must be switched on. You might also need to account for the fact that a parallel operating unit has a higher failure rate than a standby unit because it is always powered. You can envision how analyzing the reliability and availability 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 about maintenance activities, spare parts, and repair resources.

PTC Windchill RBD provides optimization and simulation tools so you can 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 PTC Windchill RBD

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

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

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill RBD

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

The System file displays only PTC Windchill RBD panes.

Using PTC Windchill RBD

The top window contains three tabbed panes:

- **Problems** — Displays a list of problems and is shared with several other modules.
- **RBD Table** — Displays all diagrams in the 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 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 the tablet PC during various phases of the mission.
- **RBD Blocks** — Displays a table view of the selected diagram.

The bottom window contains two tabbed panes:

- **Problems Form** — Displays a sample form for entering data about the active problem in the **Problems** table.
- **RBD** — Displays a graphical view of the selected diagram. For ease of viewing, you can resize this pane using the splitter control, which appears when you place 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** folder.
2. Select **Insert** ▸ **New Block Diagram**. A new block diagram is inserted and, in the **RBD Diagram** pane below, only start and end nodes are 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. To insert data about the diagram in the **RBD Table**, do the following:
   a. For **Identifier**, enter `Memory Board`; then, press the **Tab** key
   b. For **Description**, enter `Block Diagram for the Memory Board Assembly`. Do not press the **Tab** key as this would cause the **Phase Diagrams** folder to be selected.

Inserting Blocks into a Block Diagram

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

Connecting Blocks in a Block Diagram

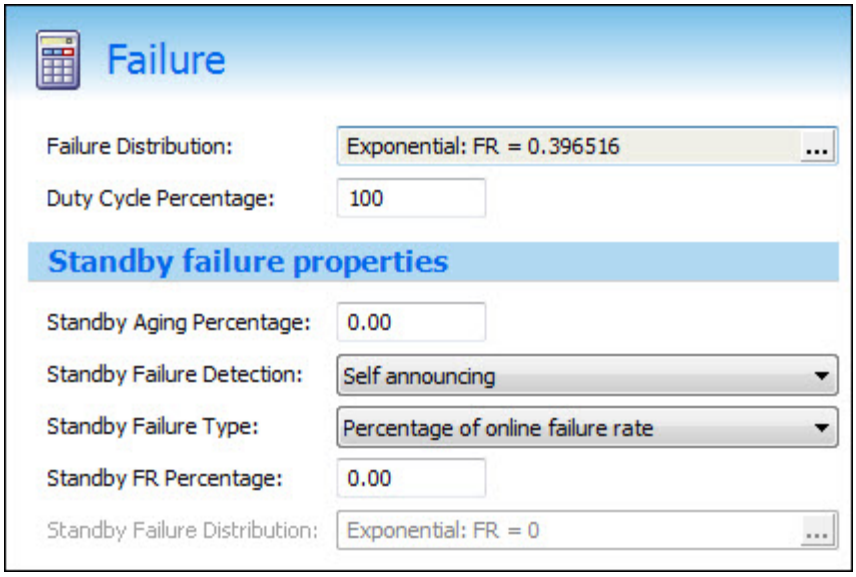
1. Place the mouse cursor over the triangle connection point on the right side of the start node, until the cursor changes shape to a long arrow.
2. Click the triangle connection point on the right side of the start node and then click the first block. The start node is now connected to the first block.
3. Click the triangle connection point on the right side of the first block and then click the second block. The first block is now connected to the second block.

> **Tip**
>
> You can also select **RBD** ▸ **Auto Connect Blocks** to automatically connect blocks based on the order in which they were inserted.

Assigning Block Calculation Properties

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

1. Double-click the left block to open 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 open the **Distribution** window.
6. Leave **Distribution** set to **Exponential**.
7. Leave **Failure rate** selected. Then, to the right, enter `0.396516` for the failure rate.
8. Click **OK** to close the **Distribution** window. The **Calculation Properties** window now displays the specified exponential failure rate for **Failure Distribution**.
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** set to `1` and **Switch Probability of Success** set to `1.000000`.
14. Click **OK**. In the block diagram, the first block shows the redundancy. You might need to drag the right-most block further to the right to adjust the space between the blocks.

Linking Blocks to Other Modules

If the block diagram you are creating includes assemblies from your system tree, you can efficiently access this data using links. When you link blocks in a block diagram to items in other modules, PTC Windchill RBD pulls in information from these other modules.

Not only does linking the data reduce data entry, but it also has the additional advantage of keeping the linked data updated. When you make changes to your assemblies and recalculate failure rates, these new values are automatically used in your block diagram.

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

1. In the **RBD Diagram** pane, 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 an assembly in this module.

   This System file has only one configuration. If it had multiple configurations, **Configuration** would be the next field shown. In it, you would select the configuration with the assembly to which you want to link.
3. Click the arrow next to the **System Tree Item** list to open a selection window.
4. Expand the memory assembly **MEM061789** and select the **DRAMC7001** assembly.
5. Click **OK** to close the **Link Data** window.

In the block diagram, the block shows data for the linked **DRAMC7001** assembly. A link icon appears near the upper right corner of the block to visually indicate that the block is linked to data in another module.

Tip

If you enabled both PTC Windchill RBD and PTC Windchill Prediction, you would be able to drag assemblies from the **System Tree Items** table in the upper window and drop them into the **RBD Diagram** pane in the lower window to create linked blocks.

Understanding RBD Calculations

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

Calculation	Description
MTBF	The mean number of hours between two consecutive system failures in a long run. MTBF (mean time between failures) includes both operational and downtime hours between two consecutive failures, and it is the average distance in hours between two failures in a long run. On the **Advanced** page in the RBD calculation properties, you specify the run length for **Number of system failures to reach steady state**.
MTTF	The expected or average time to failure in hours. For repairable systems, MTTF (mean time to failure) is the average time to reach the first system failure. Hence, it is also called MTTFF (mean time to first failure). If you select **Account for repair in reliability** on the **General** page in the RBD calculation properties, reliability is calculated using the failure and repair information supplied in the calculation properties for blocks, and this reliability value is then used to calculate MTTF.
MTTR	MTTR (mean time to repair) 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. MTTR can be calculated by considering the frequency of each failure scenario and its respective average repair times.
Optimal number of spares	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 numbers of spares. The optimal number of spares corresponds to the minimum value of the total cost.
Optimal maintenance intervals	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

Calculation	Description
	maintenance interval corresponding to the minimum total cost. Optimal maintenance intervals are calculated using optimization algorithms integrated within the simulation engine.
Optimal repair resources	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. 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. If you select **Account for repair in reliability** on the **General** page in the RBD calculation properties, reliability is calculated using the failure and repair information supplied in the calculation properties for blocks, and this reliability value is then used to calculate MTTF.
Unreliability	The probability that a failure occurs during a given time period.
Failure Rate	The chance 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. If you select **Account for repair in reliability** on the **General** page in the RBD calculation properties, reliability is calculated using the failure and repair information supplied in

Calculation	Description
	the calculation properties for blocks, and this reliability value is then 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. PTC 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). A common term, "five nines", refers to a system which has an availability of 0.99999, which means that it is operational 99.999% of the time.
Mean availability	The average availability over a specified time interval. Mean availability is the ratio of the mean total uptime to the total time over a specified interval.
Steady state availability	The availability in a long run, or as time tends to infinity. Steady state availability is the ratio of the total uptime to total time in a long run. On the **Advanced** page in the RBD calculation properties, you specify the run length for **Number of system failures to reach steady state**.
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 RBD Calculations

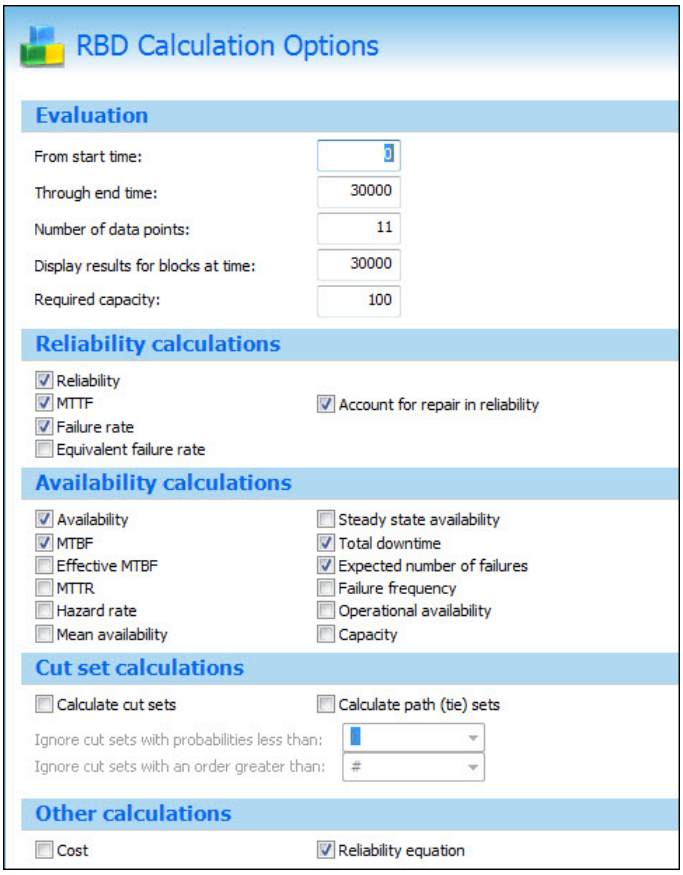
To calculate RBD results:

1. In the **RBD Table**, select **Tablet PC**.
2. Select **System** ▸ **Calculate**, or click the calculate button on the standard toolbar. The **Calculate** window opens.
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 run calculations only for the RBD module.

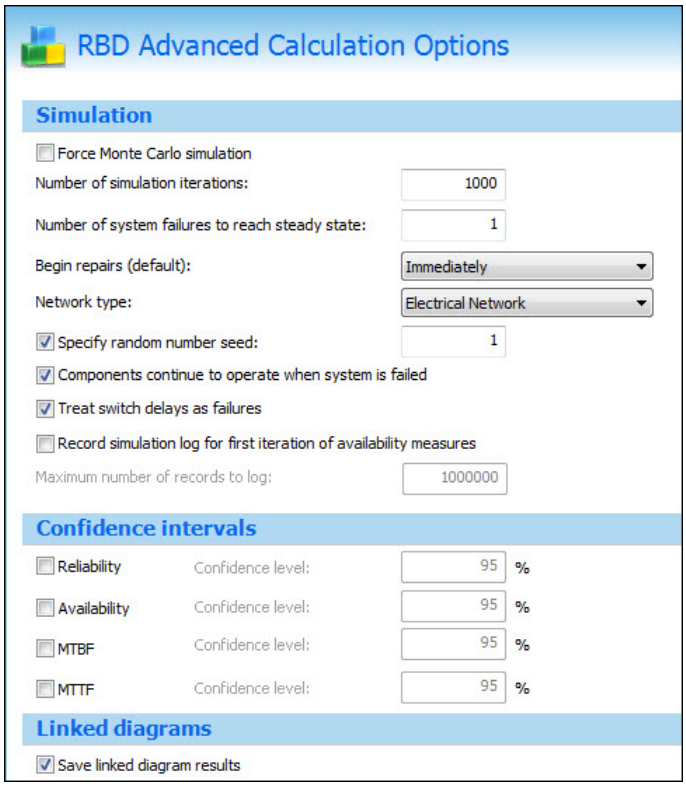
5. In the left pane, expand the **RBD** folder if necessary and select the **General** page.

   Both this page and the **Advanced** page contain a number of calculation options.

6. On the **General** page, leave all default values.



7. In the left pane, select the **Advanced** page.
8. On this page, also leave all default values.



9. Click **OK** to run the calculations. When completed, the **View Calculation Results** opens.
10. In the left pane, expand the **RBD Results** folder if necessary and select the **General** page.

> **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 display the results again at any time, you would select **System ▸ View Calculation Results**. If you have only one module enabled, the results shown are only for this module. If multiple modules are enabled, a navigation pane is shown so that you can select the pages for the results you want to view.

Viewing the Reliability Equation

When PTC Windchill RBD analytically computes diagram results, you can view the equation that was used to calculate reliability. However, to do this, **Reliability equation** must have been selected under **Other calculations** on the **General** page for RBD calculation properties prior to calculating.

To view the reliability equation:

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

$$R_{Tablet\ PC} = R_{\text{Motherboard}} \cdot R_{\text{Touchpanel}} \cdot R_{\text{Memory Board}} \cdot R_{\text{Hard Disk Assembly}} \cdot R_{\text{Battery}}$$

5. Click **Close** to close the **View Calculation Results** window.

Viewing an RBD Report

To view an RBD report:

1. In the **Project Navigator**, under **Reports > RBD Reports**, select **(Common) RBD (Summary) Portrait**. Because the three reports in this Report Binder file require input data, the **Report Properties** window opens.
2. For the top report, do the following:
   a. Under the **Record selection** heading, select **Print selected diagram**.
   b. If **Tablet PC** is not already selected, click ... to select it.
   c. Verify that the **Apply this selection to all reports** checkbox is selected.

   For the other reports, you can use the default values.
3. Click **OK** to generate the report and open it in a preview window.

   You can use the toolbar in this window to print your report, move through its pages, switch between a two-page and one-page view, zoom in and out, and close this window.
4. When finished viewing the report, do one of the following to close the window:

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

Graphing RBD Data

1. In the **Project Navigator**, under **Graphs > RBD Graphs**, select **(Common) RBD Reliability v Time** 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**.

Additional RBD Features

PTC 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 PTC Windchill Quality Solutions.

- You can model a wide array of system complexities including limited repair resources, fixed and variable costs, switching mechanisms, imperfect repairs, switch delays, transportation delays, and logistic delays.
- You can use advanced simulation and optimization features to evaluate optimal maintenance intervals, repair resources, and spares.
- You can model hot, cold, and warm spares.
- You can use junctions to model redundant configurations of non-identical components.
- You can compute confidence intervals for various reliability metrics.
- You can use diagram links to link one block diagram to another, thereby creating a parent/child relationship.
- You can select from a large number of distributions, including exponential, lognormal, normal, Rayleigh, time independent, Weibull, uniform, and constant time.
- You can model both electrical and flow type networks.
- You can create phase diagrams, which take into account operation on all of the various phases that the system experiences during a mission.
- You can specify not only calculation properties but also visual properties for a block or connector. If you want, you can even show a custom image for a block.

8

PTC Windchill FRACAS

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This section of the *PTC 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 PTC 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 might 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.

PTC Windchill FRACAS allows you to create a completely customized FRACAS 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 PTC Windchill FRACAS

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

If you are already using PTC Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can get started by activating the FRACAS module. For more information, see Activating PTC Windchill FRACAS on page 95.

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Activating PTC Windchill FRACAS

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

The System file displays only PTC Windchill FRACAS panes.

Using PTC Windchill FRACAS

The top window contains two tabbed panes:

- **System Tree Items** — Displays the hierarchical breakdown of your system and is shared with several other modules.
- **Problems** — Displays a list of problems and is shared with several other modules.

The bottom window also contains two tabbed panes:

- **Problems Form** — Displays a sample form for entering data about the active problem in the **Problems** table.
- **FRACAS Incidents** — Displays the incidents entered for the active **System Tree Items** record.
- **FRACAS Incident Form** — Displays a sample form for entering incident data for the active **System Tree Items** record.

A FRACAS in PTC Windchill FRACAS can be extensively customized. You can select which data fields appear and give them custom names. As a result, the FRACAS that you use might not look exactly like the one in this guide.

Additionally, in the Enterprise EditionPTC Windchill Quality Solutions supports performing FRACAS activities on the Web using PTC Windchill Quality Solutions Web Access.

Entering Incidents

The main data element of your FRACAS is an incident or a failure report of some type. For this example, you enter an incident in the **Tablet PC** System file in your **My Tablet PC** Project. In any Project, you can customize the tables and forms in which you enter incident data.

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

   Note that the newly entered incident appears in red. By default, all open incidents appear in red to highlight them. This is a setting that you can customize.
3. For **Location**, select **Austin.**
4. For **Technician**, select **Arnold Palmer.**
5. For **Serial Number**, enter `42661`.
6. For **Occurrence Date**, click in the field to make the calendar icon available. Then, click this icon to display the calendar control.
7. Select today's date.
8. For **Incident Description**, enter `Customer reports that the touchpanel is non-responsive in a certain area`.
9. Leave the **Closed?** checkbox cleared. You select this checkbox only after the incident has been analyzed and corrective action implemented.
10. 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 is often easier to enter and modify your FRACAS data on a form. A form allows you to view the data for one record at a time in a larger format for easier entry. In your FRACAS implementations, you can decide whether to use a table and/or a form. When both views are available, you can use which ever you find most comfortable.

To view and enter incident data on a form:

1. Select **FRACAS Incident Form**.
2. In the **Incident Analysis** area, 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 touchpanel. Contacted customer who reported that original shipping container had arrived slightly damaged.`
5. For **Failure Mode**, select **Cracked, Fractured**.
6. Select the **FRACAS Incidents** table to return to this table.

Filtering FRACAS Data

Due to the large number of incidents that can be accumulated over time, PTC Windchill FRACAS supports data filtering to allow you to view a subset of incidents 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.

PTC Windchill FRACAS supports both fixed-value filters and parameterized filters for all of its tables. 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 FRACAS Filters

A number of predefined filters are supplied with the FRACAS module. For example, you can apply a filter to limit **FRACAS Incidents** records to only open incidents.

1. Select the **FRACAS Incidents** table.
2. In the filter selection box in the standard toolbar, select **Open Incidents**. Only incidents that are not marked as closed are shown in the table.
3. In the filter selection box, select **– No Filter –** to remove this filter.

Creating Custom FRACAS Filters

You can use the Filter Wizard to create any number of custom filters.

To create a custom FRACAS filter:

1. Select **Filter** ▸ **Filter Wizard** or click the Filter Wizard button in the standard toolbar. 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 **Select the table type**, select **FRACAS Incidents**.
4. From the list of fields, select **Technician**; then, 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 for 'Technician' here**, click the browse button. A selection window opens.
8. Select the checkbox for **Hugh Downs** and click **OK**, which closes the selection window.
9. Click **Next**. The **Review Filter** page appears.

   Ensure that **I want to add more conditions to the filter** is cleared to indicate that the filter is complete; then, click **Next**. The **Save Filter** page appears.
10. Select **I want to save my filter for later use**.
11. For **Filter name**, enter `Technician Hugh Downs`.
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 might be creating a filter that is for your own use. In that case, it is best to save it to your My Filter file. In other cases, if you are creating a filter you know would be helpful to all team members, you would want to save it to the Project Filter file so others can use it.
13. Click **Next**. The **Wizard Complete** appears.
14. Click **Finish**.

    If this is the first time you have saved a personal filter, PTC Windchill Quality Solutions asks if you want to create a My Filter file in which to store your

newly constructed filter. In the **Create Support File** window, click **Yes** to create this file.

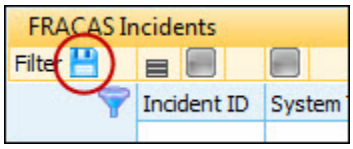
If you have previously created a My Filter file, this message does not appear. If a message appears asking if you want to overwrite or use the existing file, select **Use Existing**.

The filter is applied to your data so that only incidents assigned to technician Hugh Downs are shown. Your new filter is shown in the filter selection box. In the list for this selection box, your new filter, **Technician Hugh Downs**, is preceded with a person icon instead of a PTC Windchill Quality Solutions icon. This indicates that the filter is stored in your My Filter file and not in the Project Filter file. All Project filters are preceded with a folder icon.

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

You can view and modify your personal filters by clicking **My Filter File** in the **Project Navigator** to open your My Filter file. You can insert new filters directly in this file.

Additionally, you can quickly build filters using the filter bar, which is located above the column headers of the tables that support it. Using the filter bar, you can sort and/or select the records to show in the table. You can also save filters created using the filter bar by clicking the save icon in the left corner of the filter bar.



You can create the same custom filter from the previous exercise using the filter bar.

To use the filter bar:

1. Select the **FRACAS Incidents** table.
2. In the filter bar, for **Technician**, click the icon for selecting a filtering condition.

3. Select **is equal to** for the condition.
4. Click in the area to the right of the condition A selection window opens.
5. Select the checkbox for **Hugh Downs**.

6. Click **OK**. The selection window closes and the **FRACAS Incidents** table is updated to show only incidents assigned to technician Hugh Downs.
7. To return to the original data view, in the filter bar, click the icon for selecting a filtering condition for **Technician** and select **(not filtered)**.

Viewing a FRACAS Report

To view a supplied FRACAS report:

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

   This report outputs data on all incidents by part number. For each part number, this 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 toolbar in this window to print your report, move through its pages, switch between a two-page and one-page view, zoom in and out, and close this window.
2. When finished viewing the report, do one of the following to close the window:
   - Select **Preview ▸ Close**.
   - Click the close button on the toolbar.

Graphing FRACAS Data

The FRACAS module has several supplied graphs and supports the creation of custom graphs. During the installation of PTC Windchill Quality Solutions, Graph Template files for all supplied graphs are copied into the Common Library so that they are available for immediate use with all your Projects. You can generate a graph using any Graph Template file in the Project or in the Common Library. All Graph Template files in the Common Library have **(Common)** as a prefix.

To generate a supplied FRACAS graph:

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 you are finished viewing the graph, select **File ▸ Close**.

Additional FRACAS Features

PTC 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 PTC Windchill Quality Solutions.

- You can use PTC Windchill Quality Solutions Web Access to perform FRACAS tasks via the Web. This zero-client, web-based application 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.
- You can run MTBF calculations using your actual incident data. If you track the operational time of your system, the FRACAS module can run a wide variety of MTBF calculations, which you can customize even further by applying filters.
- You can use the “on-the-fly” Format Builder to modify FRACAS tables with a simple right-click.
- You can import FRACAS data using the Import Wizard. This feature enables you to directly populate your FRACAS data with incident data collected from other sources.
- In the Enterprise Edition, you can also:
  - Use a customized workflow process so that when an incident moves from one process state to another an email message is automatically sent to the appropriate personnel, notifying them of the update.
  - Use the Alerts application to send customized notifications to system users based on criteria you define.

    Use the Audit Trail application to track data modifications for audit requirements.
  - Create Projects from PTC Windchill PDMLink/MPMLink products, where you can visually distinguish hardware and software elements in the system tree.
  - Associate a FRACAS incident with an existing PTC WindchillCAPA or change management object or manually create and delete associations.

9

PTC Windchill Weibull

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

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

Note

Because Projects can be fully customized, your screens might 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 analysis, also called life data analysis and failure data analysis, is used a wide variety of applications. For example, you can use Weibull analysis to evaluate field failures or test failures. The idea is to determine a best fit distribution for the collected sample data so that you can uncover or predict trends.

To perform a Weibull analysis, the first and most important step is to gather sound life data. You must identify the failure usage scale, which are the units for the age of the component or system being tested. Age might be measured in units of operating hours, miles, or cycles. 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 results, and predict future trends.

If you are unfamiliar with and would like to study this topic in more detail, the following 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 PTC Windchill Weibull

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

If you are already using PTC Windchill Quality Solutions and your Project with the **Tablet PC** System file is open, you can enable the Weibull module. For more information, see Enabling PTC Windchill Weibull on page 105.

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill Weibull

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

The System file displays only PTC Windchill Weibull panes. For both this module and the ALT module, a three-window interface is used. The upper left window displays the **LDA Navigator**, which you use to select an analysis type and manage data sets.

LDA Navigator

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

Data sets are organized by analysis types. Under **Analysis type**, you click the type of data sets you want to view.

For the Weibull module, three analysis types are available:

- **Life Data** — Consists of parametric life data sets, non-parametric life data sets, and reliability growth data sets. You can also insert data sets for plotting multiple data sets concurrently on a plot.
- **Warranty Analysis** — Consists of warranty data sets, which contain data about when a failed 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.

- **Degradation Analysis** — Consists of degradation analysis sets, which use 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 will fail 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 data sets you no longer need. You can also further organize the data sets for any analysis type by creating subfolders.

Weibull Parameters

The window beneath the **LDA Navigator** contains a number of tabbed panes, depending on the selected analysis type.

- When **Life Data** is selected, this window contains either two or three panes: **Parameters**, **Advanced** (when applicable), and **Plot Options**.
- When **Warranty Analysis** is selected, the previous three panes are available as well two additional panes: **Warranty** and **Forecast Parameters**.
- When **Degradation Analysis** is selected, only two panes are available: **Parameters** and **Plot Options**.

The two panes common to all life data sets display analysis parameters and plot options.

- **Parameters** — Specifies parameters for analyzing the selected data set.
- **Plot Options** — Specifies the number and type of plots to display in the **Weibull Plot** pane in the window on the right.

When the **Advanced** pane is applicable, it specifies the estimation method and any needed distribution parameters.

When a life data set is calculated, results display at the bottom of panes in which you enter parameter, in the **Calculation results** area. Here, you can specify a fixed value for a particular calculated value if you want. The results shown depend on the distribution selected.

All panes in the lower right window display toolbar buttons on the right side of the title bar. Buttons are available only when they are applicable to the active data set.

You can click these toolbar buttons to perform common tasks, including:

- Calculating the active data set
- Showing the plot for the active data set
- Opening the Summary Calculator window to perform additional calculations
- Running best fit distribution analysis

Weibull Data Points

When a life data set is selected in the **LDA Navigator**, the window to the right contains three tabbed panes:

- **Problems Form** — Displays a sample form for entering data about the active problem in the **Problems** table.
- **Weibull Data Points** — Displays the data you want to analyze. The column headings in this table vary, depending on the type of life data set.
- **Weibull Plot** — Displays a plot for the data set and the one or more distributions applied to it. The parameters, distribution, and number of plots shown depend on selections made on the panes in the lower left window.

Tip

You can modify the column heading in the **Weibull Data Points** table to suit your process needs. Simply double-click the column heading and then specify the desired name in the **Change Column Name** window that opens.

Using PTC Windchill Weibull

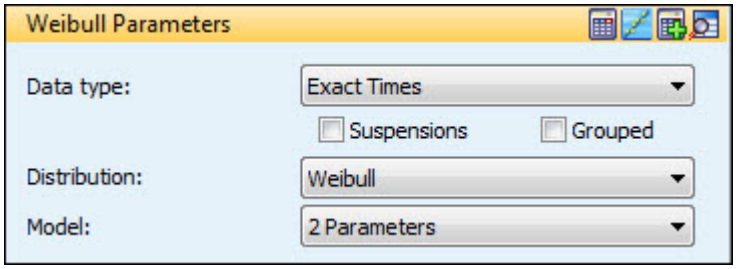
You now create a data set, enter data points, and find the distribution that best fits your data points. After viewing and modifying the plot, you generate a report.

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 life data sets.
2. In **Data Sets**, select the **Life Data** folder.
3. Select **Insert** ▸ **LDA Data Set**. A new life data set named *LDA Data Set* is inserted in the folder. It is already selected.
4. Enter `My Weibull Data Set` as the name of this data set.

5. Select the **Parameters** pane in the lower left window.
6. Leave the default values.



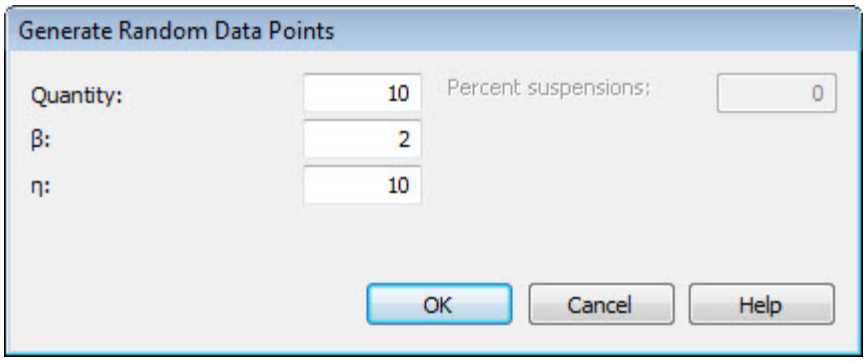
Entering Data Points

Once the analysis parameters are specified, you 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 point generator to 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 sample data generation.

1. Select the **Weibull Data Points** pane.
2. Select **LDA ▸ Generate Random Data Points**. The **Generate Random Data Points** window opens.

   Percent suspensions is unavailable because the **Suspensions** checkbox was not selected in the **Weibull Parameters** pane.
3. Leave the default values.



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. PTC Windchill Weibull and PTC Windchill ALT include a tool for finding the distribution that best fits the data for the selected data set.

1. Select **LDA ▸ Find Best Fit Distribution**. The **Best Fit Distribution** window opens and shows all available failure distributions on the **Analysis** page. You can select which distributions you want to check against the data set. In this case, leave all distributions selected.
2. Click **Analyze**. A ranking for each distribution appears in the **Rank** column.

   Depending on your data set, the recommended distribution might not be the distribution currently selected for the data set. For example, the current distribution is Weibull (2 Parameters), and the recommended distribution for this randomly generated data set might be Weibull (3 Parameters). If this is the case, the **Change** button is shown at the bottom of the window, along with a prompt asking whether you want to change the current distribution setting to the recommended distribution.

   For this example, if the **Change** button is shown, ignore it so that the this Weibull (2 Parameters) distribution remains in use.
3. Click **Close**.

Understanding Weibull Calculations

Calculations, which in PTC Windchill Weibull are performed dynamically for life data sets, are based on the distribution specified. In the case of the Weibull distribution, the Weibull module calculates the following results:

- β — The Beta value is the slope of the line.
- η — The Eta value is the characteristic life, which is the point at which 63.2% of the items in the data set have failed.
- ρ — The Rho value is a value between -1 and 1 that expresses how well the data fits the probability line.
- ρ^2 — The Rho-squared value is the 10th percentile of the correlation coefficient.

In the lower left window, you can view these calculated values in the **Calculation results** area in panes in which you specify analysis parameters.

Viewing Weibull Plots

When you analyze life data sets, PTC Windchill Weibull automatically generates and displays the resulting Weibull plots in the **Weibull Plot** pane on the right. These plots are updated dynamically as you make changes. So, for example, if you change the distribution, the plot is updated to display the newly selected distribution.

To view the resulting Weibull plot:

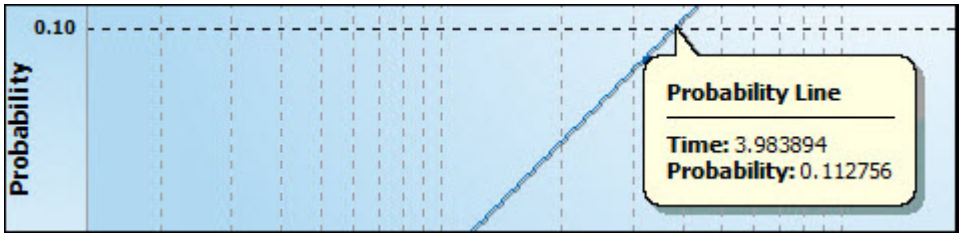
1. In the window on the right, select the **Weibull Plot** pane.

   You can learn many things by examining a Weibull plot. For example, if points are concentrated in one particular area, a batch problem might 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, might indicate multiple competing failure sources. For example, many components have a high infant mortality due to production and quality problems, and then they have another group of failures later in life when they begin to wear out. In this case, you might want a separate Weibull plot for each failure mode, treating the data points for other failure modes as suspensions. As noted earlier, Weibull analysis is most effective when each data set concentrates on one failure mode.

   You can also use the plot to determine if the distribution selected fits your data well. For example, if the failure data points curve in comparison to the best fit line, then the selected distribution probably was not the best fit for the data. To determine a distribution with the best fit, you can perform best fit distribution analysis.

2. Determine the B10 life, which is the time at which 10% of the items in the data set have failed. To do so, place your cursor at the point where the plot line intersects the horizontal line at 0.10 Probability. A tooltip indicates the probability value at a specified time. Your time varies, depending on the random data points that were 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 Plots

Weibull plots are very easy to customize. When a plot is active, you can open the **Plot Properties** window and change the plot colors, labels, and fonts to suit your needs.

1. Select the **Weibull Plot** pane.
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. Leave the default values.
6. In the left pane, select the **Color** page.
7. Under **Style**, for **Quickstyle**, select **Light Line**. This property applies a predefined set of colors to the plot and its background.

   If you select **Default** or **No Style**, you can specify color preferences for some or all properties under **Color** using color controls.
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** page and then the **Font Size** page.

   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** to update your plot.

    The title is now *My Weibull Plot*, the color palette has changed, and the legend is in the top left corner rather than in the center right. Because you specified that the legend was to be moveable, you can drag it wherever you like.
11. Place your mouse pointer over the legend until the cursor changes to a hand. Select the legend and drag it to the bottom right of your plot.

Viewing Plots for Multiple Data Sets

When you select the **Multiple Data Sets** folder in the **LDA Navigator**, you can plot data 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, such as circuit board test-to-failure data at both 50 degrees C and 60 degrees C
- Data sets of similar products, such as failure data for bearings from different suppliers
- Data sets from different time frames, such as those from the past five calendar years
- 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. Under **Analysis type**, ensure **Life Data** is selected.
3. Under **Data sets**, select **Multiple Data Set Plots**.
4. Select **Insert ▸ Multiple Data Set Plot**. A new data set row appears in this folder.

   This new data set, which is named *Multiple Data Set Plot* by default, is automatically selected.
5. Enter `My Weibull Multiple Data Set Plot`.
6. In the **Weibull Plot Options** pane, click **Select All** to select the two revisions listed for the hard disk.

The plot in the **Weibull Plot** pane plots both data sets. If you select only some of data sets available in the **Weibull Plot Options** pane, you can always go back and select them to add them to the plot.

Viewing a Weibull Report

To view a Weibull report:

1. In the **Project Navigator**, under **Reports > Weibull Reports**, select **(Common) Weibull Life Data**. Because the two reports in this Report Binder file require input data, the **Report Properties** window opens.
2. For the top report, do the following:
   a. Under the **Record selection** heading, if **Hard Disk Revision A** is not already selected for **Weibull Data Set**, click ... to select it.
   b. Verify that the **Apply this selection to all reports** checkbox is selected.

   For the other report, you can use the default values.
3. Click **OK** to generate the report and open it in a preview window.

   You can use the toolbar in this window to print your report, move through its pages, switch between a two-page and one-page view, zoom in and out, and close this window.
4. When finished viewing the report, do one of the following to close the window:
   - Select **Preview ▸ Close**.
   - Click the close button on the toolbar.

Additional Weibull Features

PTC Windchill Weibull includes a number of additional 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 PTC Windchill Quality Solutions.

- You can specify a threshold parameter, which is also known as a location parameter or minimum life parameter, to set 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, a threshold parameter straightens a plot of data values if the data shows a pronounced curve compared to the failure distribution line.
- You can perform reliability growth analysis, which tracks the increase in the reliability of a product over time. By tracking reliability, mean life, or failure rate over time, you can predict future reliability values based on the current rate of growth of the measurement of interest. Weibull module uses the Duane/Crow-AMSAA model to perform reliability growth analysis.
- You can analyze data without specifying an underlying distribution using non-parametric life data analysis. The Weibull module supports the Kaplan-Meier and standard actuarial methods.

- You can perform degradation analysis, which forecasts future failures based on measurements of degradation or performance over time. The Weibull module supports six degradation models, including Linear, Exponential, and Power.
- You can use the General Statistics Calculator to run 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.
- You can use the Test Planning Calculator 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.
- You can use the Summary Calculator to perform additional calculations on data sets that are analyzed based on parametric distributions. This applies to all but non-parametric life data sets. These additional calculations include Standard Probability, Conditional Probability, Failure Rate, Warranty Time, Time to Failure, and more.
- You can use the Optimal Replacement Wizard to optimize your component replacement strategy based on minimizing system downtime or the overall cost of the system over the long term.
- You can link Weibull data to items inPTC Windchill Prediction and PTC Windchill RBD to make the results calculated for reliability predictions and block diagrams more accurate.

10

PTC Windchill ALT

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

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

Note

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

ALT Overview

ALT (accelerated life testing) is a technique for speeding up product testing so that you can find the reliability characteristics of a product more quickly. To apply ALT techniques, you test products in high-stress situations that typically shorten product life or hasten degradation of product performance. With such tests, “stress” refers to any accelerating variable.

By statistically fitting an acceleration model to the test data and extrapolating the fitted model, you can 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 stress levels encountered during normal use, products with high reliability last so long, or degrade so little, that their performance and lifetime are very difficult to estimate. 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 component is tested at specific combinations of stress levels. You enter the failure and suspended times corresponding to the stress levels in the software.

If the stresses on the component are constant with respect to time, the tests are known as constant stress tests. In some cases, the stresses are increased with time so that the test can be completed within a predetermined time with some failures. You record variations in the stresses in stress profiles.

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 PTC Windchill ALT

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

If you are already using PTC Windchill Quality Solutionsand your Project with the **Tablet PC** System file is open, you can enable the ALT module. For more information, see Enabling PTC Windchill ALT on page 117.

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill ALT

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

The System file displays only PTC Windchill ALT panes. For both this module and the Weibull module, a three-window interface is used. The upper left window displays the **LDA Navigator**, which you use to select an analysis type and manage data sets.

LDA Navigator

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

Data sets are organized by analysis types. Under **Analysis type**, you click the type of data sets you want to view.

For the ALT module, two analysis types are available:

- **Accelerated Life Testing** — Consists of parametric life data sets, non-parametric life data sets, and reliability growth data sets. You can also insert data sets for plotting multiple data sets concurrently on a plot.
- **Accelerated Degradation** — Consists of degradation analysis sets, which use 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 will fail 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 data sets you no longer need. You can also further organize the data sets for any analysis type by creating subfolders.

ALT Parameters

The window beneath the **LDA Navigator** contains one or more panes, depending on the selected analysis type.

- When **Accelerated Life Testing** is selected, this window contains different panes, depending on the folder selected under **Data Sets**. When the **Life Data** folder is selected, two panes are available: **Parameters** and **Plot Options**
- When **Accelerated Degradation** is selected, the same two panes are available.

These two panes display analysis parameters and plot options.

- **Parameters** — Specifies parameters for analyzing the selected data set.
- **Plot Options** — Specifies the number and type of plots to display in the **ALT Plot** pane in the window on the right.

When a life data set is calculated, results display at the bottom of the **Parameters** pane, in this **Calculation results** area. Here, you can specify a fixed value for a particular calculated value if you want. The results shown depend on the distribution selected.

All panes in the lower right window display toolbar buttons on the right side of the title bar. Buttons are available only when they are applicable to the active data set.

You can click these toolbar buttons to perform common tasks, including:

- Calculating the active data set
- Showing the plot for the active data set
- Opening the Summary Calculator window to perform additional calculations
- Running best fit distribution analysis

ALT Data Points

When a life data set is selected in the **LDA Navigator**, the window to the right contains three tabbed panes: **ALT Data Points**, **ALT Results**, and **ALT Plot**.

- **ALT Data Points** — Displays the data you want to analyze.
- **ALT Results** — Displays results once the data set is calculated. The results shown depend on the selections made on the panes in the lower left window.
- **ALT Plot** — Displays a plot for the data set and the one or more distributions applied to it. The parameters, distribution, and number of plots shown depend on selections made on the panes in the lower left window.

Tip

You can modify the column heading in the **ALT Data Points** table to suit your process needs. Simply double-click the column heading and then specify the desired name in the **Change Column Name** window that opens.

Using PTC Windchill ALT

You now create a data set, enter data points, and find the distribution that best fits your data points. After viewing and modifying the plot, you generate a report.

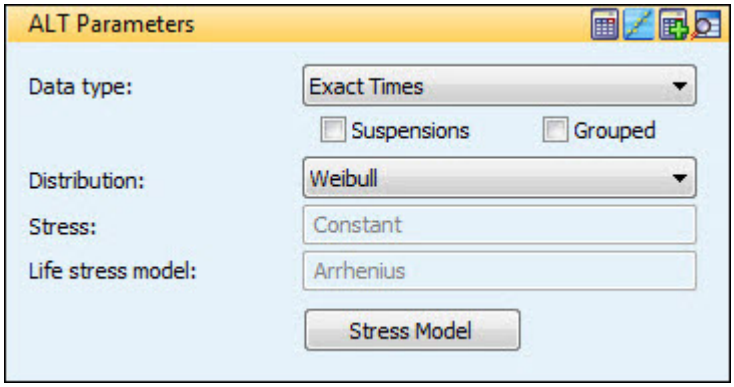
Creating a New Data Set

In this section, you create a random data set and then specify a stress model and stresses. The stress levels that you use for testing should accelerate the failure modes under consideration, but they should do not introduce failure modes that would never occur under normal use conditions. Generally, stress levels fall outside the product specification limits but inside the design limits. If you do not

know what stresses or limits to use, you can perform multiple tests with small sample sizes to ascertain those that are appropriate. In this case, you specify only one stress, which is operating temperature.

To create a new data set:

1. In the **LDA Navigator**, under **Analysis type**, click **Accelerated Life Testing** to ensure you are viewing data sets for this type of analysis.
2. Under **Data sets**, select the **Life Data** folder.
3. Select **Insert** ▸ **ALT Data Set**. A new data set named *ALT Data Set* is inserted in the folder. It is already selected.
4. Enter `My ALT Data Set` as the name of this data set.
5. Select the **Parameters** pane in the lower left window.
6. Leave the default values.



7. Click **Stress Model**. The **Stress Model** window opens.
8. In the first row of the table, select the *Stress 1* value for **Name** and enter `Temperature`.
9. For **Usage Stress**, enter `310`.
10. For **Default Value**, enter `350`.
11. Click **OK** to close the **Stress Model** window.

Entering Data Points

Once the analysis parameters are specified, you enter data points in the **ALT 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 point generator to 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 sample data generation.

1. Select the **ALT Data Points** pane.
2. Select **LDA ▸ Generate Random Data Points**. The **Generate Random Data Points** window opens.
3. For **β**, enter `6`.
4. For **B**, enter `17000`.
5. For **C**, enter `3.0e-12`.
6. In the table on the right, click **< Click here to insert a stress level >**.
7. For **Quantity**, enter `2`.
8. For **Temperature**, enter `493`.
9. Repeat steps 6 through 8 to insert the following stress records.

Quantity	Temperature
4	513
5	533

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

Running Calculations in PTC Windchill ALT

Calculations determine the parameters for the selected life stress model. The parameters to calculate depend on the distribution specified. Because automatic data set calculation is turned off for the ALT module by default, you must manually run these calculations.

To calculate ALT results:

1. Select **System ▸ Calculate**, or click the calculate button 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 run 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.

   These same results are also shown on the ALT Results pane. In the right pane, select this pane so that you can see the same results.

Viewing ALT Plots

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

To view the resulting ALT plot:

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

   This plots displays the acceleration factor with respect to the defined temperature stress. If you had added other stresses, they would have been considered fixed at the usage stress levels.

> **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**.

Viewing an ALT Report

1. In the **Project Navigator**, under **Reports > ALT Reports**, select **(Common) Accelerated Life Testing**. Because the two reports in this Report Binder file require input data, the **Report Properties** window opens.
2. For the top report, under the **Record selection** heading, if **Hard Disk Revision D** is not already selected for **ALT Data Set**, click ... to select it.

   For the other report, you can use the default values.
3. Click **OK** to generate the report and open it in a preview window.
4. You can use the toolbar in this window to print your report, move through its page, switch between a two-page and one-page view, zoom in and out, and close this window.
5. When finished viewing the report, do one of the following to close the window:
   - Select **Preview ▸ Close**.
   - Click the close button on the toolbar.

Additional ALT Features

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

- You can perform analysis based on both constant and time-varying stresses using the Weibull, lognormal, and exponential distributions.
- You can use all common accelerated life testing models, including Arrhenius, Eyring, Inverse Power Law, Temperature-Humidity, Temperature-NonThermal, Generalized Eyring, Proportional Hazards, and General Log-Linear.
- You can perform accelerated degradation analysis, which forecasts future failures based on measurements of degradation or performance over time. The ALT module supports six degradation models, including Linear, Exponential, and Power.
- You can generate many different plot types and also even compare and contrast multiple plots. Additionally, you can perform best fit distribution analysis and use the Summary Calculator to perform additional calculations on parametric life data sets.

11

PTC Windchill Maintainability

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

In this section, you review and enter data in the Maintainability module, run calculations on that data, and view a report.

Note

Because Projects can be fully customized, your screens might 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 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 various maintainability analysis procedures compute in different ways. 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 might justify a change in design and/or repair procedures.

To complete a maintainability prediction, you must have 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 predictions and would like to study this topic in more detail, refer to MIL-HDBK-472.

Getting Started with PTC Windchill Maintainability

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

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

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill Maintainability

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

The System file displays only PTC Windchill Maintainability panes.

Using PTC Windchill Maintainability

The top window contains two tabbed panes:

- **System Tree Items** — Displays the hierarchical breakdown of your system and is shared with several modules.
- **Problems** — Displays a list of problems and is shared with several other modules.

The bottom window also contains two tabbed panes:

- **Problems Form** — Displays a sample form for entering data for the active problem in the **Problems** table.
- **Maintainability Data** — Displays all maintainability specific data for the assembly or part selected in the system tree.

For this example, you begin by reviewing and entering maintainability data. You then learn about Maintainability Task Library files.

Reviewing and Entering Maintainability Data

In the **System Tree Items** table, you select an assembly or part so you that you can view and modify the repair data and repair tasks entered for this item in the **Maintainability Data** pane below.

1. In the **System Tree Items** table, select the following assemblies and review the data shown in the **Maintainability Data** pane:
   - Motherboard
   - Touchpanel
   - Memory Board
2. Now select **Hard Disk Assembly**. Currently, no data is present in the **Maintainability Data** pane.
3. In the **Repair tasks** table, click **< Click here to insert a new record >** to insert the first task.
4. For **Task Code**, select **Remove HD Assy**.
5. To insert a second task, click **< Click here to insert a new record >** again and for **Task Code**, select **R/R Hard Disk**.

> **Note**
>
> R/R stands for “Remove and Replace.”

6. To insert the third and final task, click**< Click here to insert a new record >** again and for **Task Code**, select **Replace HD Assy**.

On the upper right side of the pane, the following display-only fields are updated: **Totals**, **Number of items**, **Total time (Mct)**, and **Manminutes**. PTC Windchill Maintainability pulls in the times for performing the three repair tasks that you inserted from Maintainability Task Library files.

Maintainability Task Library Files

You can retrieve repair data from either Maintainability Task Library files or Maintainability FD&I Output files. For this example, the repair data was retrieved from a Maintainability Task Library file.

To view the Maintainability Task Library file for this sample Project:

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

> **Note**
> If this command is not available, click **Collapse files** and then click **Expand files**.

2. Under **Support Files > Maintainability > Task Library**, select **Maintainability Task Library**. This file opens.
3. In the **Tasks** pane on the left, select various tasks to see the repair data for these tasks in the pane on the right.
4. When finished, select **File ▸ Close** to close this file.
5. In the **Project Navigator**, click **Collapse files** to hide all support files.

Understanding Maintainability Calculations

PTC 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 brief descriptions are provided.

> **Note**
> Some of these calculations reference preventive maintenance and/or corrective maintenance. Corrective maintenance restores a failed system to operational status by repairing or replacing failed components. Preventive maintenance is the practice of replacing components or subsystems before they fail to promote continuous system operation.

For more information about these calculations, see the guide or help for PTC 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. 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 (mean active maintenance time) calculation.
MTTR	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 (mean time to repair) is calculated by rolling up the average repair times for lower-level components to compute subassembly and system repair values. Units for MTTR values are typically hours or minutes. MTTR is also referred to as MCT (mean corrective time). **Tip** If you use this module in conjunction with PTC Windchill Prediction, you can use the Maintainability-computed MTTR values for components in your reliability prediction.
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. The MCMT is the average time required to restore a failed system to operational status by repairing or replacing failed components.
Mean active maintenance time (MAMT)	The average time required to perform all corrective and preventive maintenance actions. 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,

Calculation	Description
	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. The MPMT is the average time required to replace components or subsystems before they fail to promote continuous system operation. The calculation is taken from MIL-HDBK-472 Procedure 2.
Percent isolation to a single replaceable item	The percentage of faults detected that can be isolated to a single replaceable item.
Percent isolation to a group of replaceable items	The percentage of faults detected that can be isolated to *n* or fewer replaceable items, where *n* is a specified quantity.

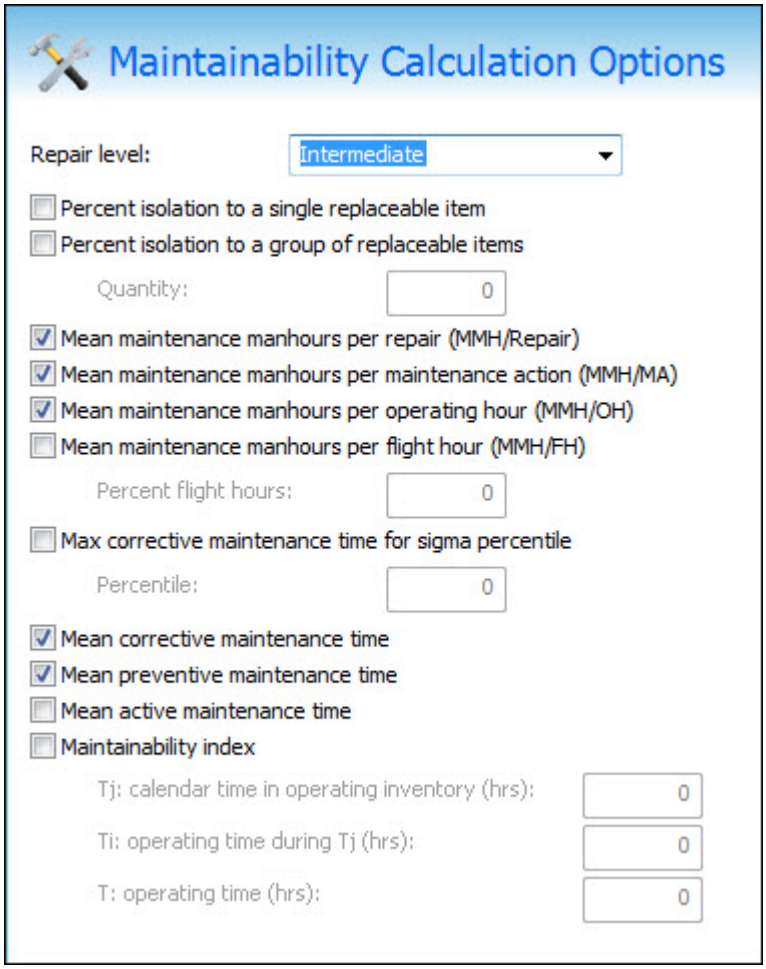
Running Maintainability Calculations

To calculate Maintainability results:

1. Select **System** ▸ **Calculate**, or click the calculate button 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 **Maintainability** to run 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 run the calculations. When the calculations are complete, the **View Calculation Results** window opens.

   Values that are not calculated display a value of #.#. These are calculations you did not select on the **Maintainability** page in 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 display the results again at any time, you would select **System ▸ View Calculation Results**. If you have only one module enabled, the results shown are only for this module. If multiple modules are enabled, a navigation pane is shown so that you can select the results you want to view.

Viewing Maintainability Reports

1. In the **Project Navigator**, under **Reports > Maintainability Reports,** select **(Common) Maintainability Standard** to generate this report and open it in a 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 (mean maintenance manhours per operating hour), and MTTR (mean time to repair).

   You can use the toolbar in this window to print your report, move through its page, switch between a two-page and one-page view, zoom in and out, and close this window.

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

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

Additional Maintainability Features

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

- You can use Maintainability Tasks Library files to store standard maintenance tasks and repair time so that they can easily be copied into any maintainability prediction. While a supplied Maintainability Tasks Library contains the task data from MIL-HDBK-472, you can create any number of your own files.
- You have the option of performing maintainability calculations based on MIL-HDBK-472 Procedure 2, 5A, or 5B standards.
- You can use Maintainability Groups files to perform MIL-HDBK-472 Procedure 5A calculations.
- You can link items in your maintainability prediction with items in other modules such as PTC Windchill Prediction and PTC Windchill RBD.

- You can use default repair levels or defined your own custom repair levels.
- You can export maintainability data to LSAR compatible formats.

12

PTC Windchill Markov

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

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

Note

Because Projects can be fully customized, your screens might 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 you can use to accurately model complex systems that 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 you can use other modeling methods, such as fault trees and RBDs (reliability block diagrams), to 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, you must construct a Markov diagram, which is also known as a state transition diagram. This diagram is a graphical representation of the system's operational, degraded, and failed states as well as the transitions between these states. Most commonly, transition rates are failure rates or repair rates. The Markov diagram ultimately represents the system as a set of random variables with interdependencies. The results of a Markov analysis can include 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 PTC Windchill Markov

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

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

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill Markov

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

The System file displays only PTC Windchill Markov panes.

Using PTC Windchill Markov

The top window contains the **Markov Table** pane, and the lower window contains the **Markov Diagram** pane.

- **Markov Table** — Displays all Markov diagrams in the System file.
- **Markov Diagram** — Displays the Markov diagram selected in the table.

The states of the Markov diagram are represented by colored shapes. The transitions between states are represented by the arrows connecting two states together.

For this example, you begin by reviewing state and transition properties. You then create a simple Markov diagram.

Reviewing Markov State and Transition Properties

For ease of viewing, you can resize the **Markov Diagram** pane using the splitter control, which appears when you place the mouse cursor between the two panes. If horizontal and/or vertical scroll bars are present in the **Markov Diagram** pane, you can use them to view hidden parts of the diagram.

Finally, you can zoom in and out by right-clicking in an empty area of the diagram and selecting a zoom option. Or, you can press and hold down the **Ctrl** key while rotating your mouse wheel.

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 tablet PC operates in a degraded mode. If all three SRAM SIMs fail, the tablet PC fails.

1. In the **Markov Diagram** pane, double-click **State5**. The **Calculation Properties** window for this state opens.

   On the **General** page, you set one of three conditions for the state: Good, Failed, or Degraded.

   If you want to calculate costs, you can also associate a gain or loss that occurs when the system is in this state.
2. In the left pane, select the **Results** page. This page displays the most recent calculated results for this state. If calculations are not yet available, this page is empty.
3. Click **Cancel** to close the window for the state.
4. Select **Markov ▸ View States**. The **Markov States** window opens. It displays all of the states currently in the diagram. In this window, you can edit the data for all states in one place, which is useful when you have a large Markov diagram and need to manage many states.
5. Click **Close** to close the **Markov States** window.
6. Place the mouse cursor over the left-most black arrow between **State5** and **State10** until the cursor changes to a four-sided arrow; then, double-click.

   The **Calculation Properties** window for this transition opens. On the **General** page, you see that a rate of 0.125 is set.
7. In the left pane, select the **Results** page. This page displays the most recent calculated results for this transition. If calculations are not yet available, this page is empty.
8. Click **Cancel** to close the window for the transition.
9. Select **Markov ▸ View Transitions**. The **Markov Transitions** window opens. It displays all of the transitions currently in the diagram.

In this window, you can edit the data for all transitions in one place, which is useful when you have a large Markov diagram and need to manage many transitions.

10. Click **Close** to close the **Markov Transitions** window.

Creating a Simple Markov Diagram

You have seen what a Markov diagram looks like in PTC Windchill Markov. Now you can create a simple diagram:

1. Select the **Markov 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 inserted in the diagram for you.
4. Select the **Markov Diagram** pane.
5. Select **Insert** ▸ **State**. The **Insert State** window opens.
6. Click **OK** to insert a state with the default style. When you move the mouse cursor in the diagram pane, it changes into the shape of the selected state style.
7. Move the cursor to the right of the initial state and click the mouse button to insert a state.

   The cursor remains in the shape of the state style 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 open the **Properties** window.
11. For **Rate**, enter `0.00015` to indicate a failure rate of 0.00015 failures per hour; then, click **OK**.
12. Double-click the bottom transition line to open the **Properties** window.
13. For **Rate**, enter `12.5` to indicate a repair rate of 12.5 repairs per hour; then, click **OK**.
14. Double-click the right-most state to open the **Properties** window.
15. For **State**, select **Failed**; then, click **OK**.

This simple diagram models a system that begins in an operational state. Because it has a failure rate of 0.00015 failures per hour, the system eventually reaches the failed state. With a repair, which occurs at the rate of 12.5 repairs per hour, the system returns to the operational, or good, state.

Understanding Markov Calculations

PTC Windchill Markov computes an extensive set of reliability related values. A sampling of supported calculations is outlined below and brief descriptions are provided. For more information about these calculations, see the help or guide for PTC 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 value, so it is always a value between 0 and 1. It 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	The MTBF (mean time between failures) represents the number of hours a unit operates between failures.
Mean time to first failure (MTTFF)	The average time until the first failure of the system. Frequently, MTTFF 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 value 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 Markov Calculations

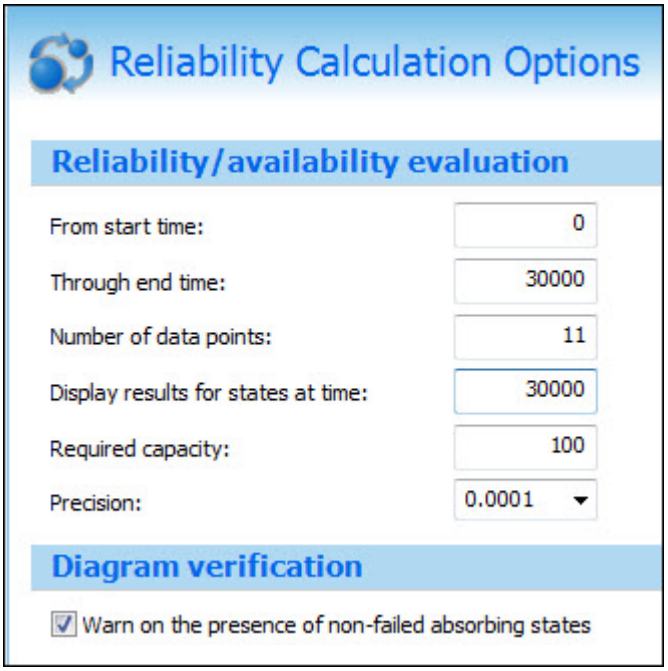
To calculate Markov results:

1. Select **System** ▸ **Calculate**, or click the calculate button 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 **Markov** to run calculations only for the Markov module.

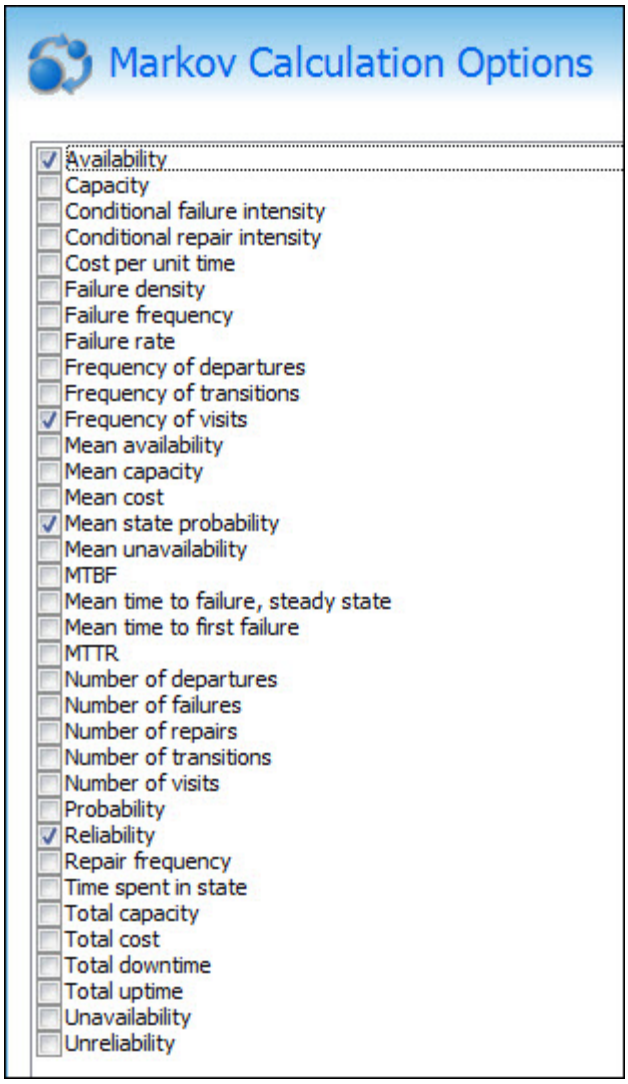
4. In the left pane, expand the **Markov** folder if necessary and select the **Reliability Calculation** page.

   On this page, you specify options for evaluating reliability and availability.

5. For **Through end time**, enter `30000`.
6. For **Display results for states at time**, enter `30000`.
7. Leave the rest of the default values.



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



9. Click **OK** to run the calculations. 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 display the results again at any time, you would select **System ▸ View Calculation Results**. If you have only one module enabled, the results shown are only for this module. If multiple modules are enabled, a navigation pane is shown so that you can select the results you want to view.

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. Likewise, the results calculated for a transition appear on the **Results** page in its **Calculation Properties** window.

Viewing a Markov Report

1. In the **Project Navigator**, under **Reports > Markov Reports**, select **(Common) Markov (Summary)**. The **Report Properties** window opens. Because the three reports in this Report Binder file require input data, the **Report Properties** window opens.
2. For the top report, do the following:
   a. Under the **Record selection** heading, select **Print selected diagram**.
   b. If **Memory Analysis** is not already selected, click ... to select it.
   c. Verify that the **Apply this selection to all reports** checkbox is selected.

   For the other reports, you can use the default values.
3. Click **OK** to generate the report and open it in a preview window.

   This report outputs data related to the selected Markov analysis. It includes calculation results, state summary, and diagram.

   You can use the toolbar in this window to print your report, move through its pages, switch between a two-page and one-page view, zoom in and out, and close this window.
4. When finished viewing the report, do one of the following to close the window:
   - Select **Preview ▸ Close**.
   - Click the close button on the toolbar.

Graphing Markov Data

1. In the **Project Navigator**, under **Graphs > Markov Graphs** , select **(Common) Markov Availability v Time** to generate this graph.

   If there are multiple Markov diagrams in the System file, the**Select Markov Diagram** window opens. However, this file has only one.

The graph displays system availability at the points in time specified in the **Calculate** window for Markov calculations. For this diagram, all reliability values are 1.0.

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

Additional Markov Features

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

- You can specify the cost to associate with each state and transition. The cost can be a gain or loss per unit time. Mean and total capacity and cost values can then be calculated for the system.
- You can specify not only calculation properties but also visual properties for a state or transition. If you want, you can even show a custom image for a state.
- You can add descriptive text labels to any state diagram. The Markov Style Library file stores custom styles for labels, states, and transitions.

13

PTC Windchill LCC

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

In this section, you enter a fixed cost item in the LCC module, review other cost equation functions, and learn about using cost variables. Next, you run calculations and view standard reports and graphs.

Note

Because Projects can be fully customized, your screens might 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 PTC Windchill LCC

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

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

If PTC Windchill Quality Solutions is not started

If PTC Windchill Quality Solutions is not started, then start it. For more information, see Starting PTC 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, then open it by doing one of the following:

- If the **Recent Files** control on the **Start Page** lists the **Tablet PC** System file in the **My Tablet PC** Project, click this file name 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** shows that a different Project is 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.

Enabling PTC Windchill LCC

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

The System file displays only PTC Windchill LCC panes.

UsingPTC Windchill LCC

The top window contains the **LCC - Cost Breakdown Structure** pane, and the lower window contains the **LCC - Equation Editor** pane.

- **LCC - Cost Breakdown Structure** — Displays the cost breakdown structure defined for the system. While PTC Windchill LCC supplies some entries that you can use as a starting point, you can customize the structure and make it as detailed as you want.
- **LCC - Equation Editor** — Displays the cost equation associated with the item selected in the cost breakdown structure. You can customize all supplied equations and create new equations.

For this example, you enter a fixed cost item, review other cost equation functions, and learn how to insert cost variables.

Entering a Fixed Cost Item

1. In the **LCC - Cost Breakdown Structure** pane, select **Maintenance Cost** .
2. In the **LCC - Equation Editor** pane, review the cost equation for this item. In this case, the cost is linked to data fields storing repair and failure results calculated by 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** pane, for **Cost equation**, enter `500` to indicate that its costs $500 to dispose of a system.

Reviewing Other Cost Equation Functions

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

1. In the **LCC - Equation Editor** pane, click **Data Fields** to open the **Insert Field** window. In this window, you can insert fields from other modules in your equation.
2. Click **Cancel** to close the **Insert Field** window.

   You can also use the **Data Fields Toolbar** to insert fields in your equation.
3. Select **LCC ▸ Data Fields Toolbar**. This toolbar, which is a fully functioning auto-hide window, opens. From here, you can drag available fields into the **LCC - Equation Editor** pane and drop them 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 you can use in cost equations.

Using Cost Variables

1. In the **LCC - Equation Editor** pane, select **Variables** to open the **Insert Variable** window.
2. Click the **Variables** list to view the variables you can insert into your cost equations.
3. Click **Cancel** to close the **Insert Variable** window.

The variables available are defined in the LCC Variables file.

You can open the sample LCC Variables file to see these variables:

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

   Note

   If this command is not available, click **Collapse files** and then click **Expand 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 list associated with the **Variables** button in the **LCC - Equation Editor**.

   You can define an LCC variable to be any of the following types:

- **Constant** — The value is fixed
- **Varies over Time Intervals** — The value changes based on time intervals that you define, which might be monthly or yearly for example
- **Varies over Alternatives** — The value changes based on alternative system designs that you define, which might be a redesign and a new design
- **Varies over Alternatives and Time Intervals** — The value varies based on both time intervals and design alternatives

3. Select **File** ▸ **Close** to close the LCC Variables file.
4. In the **Project Navigator**, click **Collapse files** to hide all support files.

Understanding LCC Calculations

PTC Windchill LCC enables you to compute costs based on the entire product lifecycle, from inception to product disposal. One of the significant benefits of PTC Windchill LCC is that it enables you to factor reliability metrics into lifecycle cost, which is 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.

PTC 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 the cost breakdown structure of your system.
Line item Costs	PTC Windchill LCC computes the cost of each of the line items in your cost breakdown structure. Depending upon structure granularity, you can see the costs associated with the various parts of your product lifecycle, such as design costs, R&D expenses, maintenance costs, labor fees, and more.
NPV (net present value)	With the time intervals functionality of PTC Windchill LCC, you can take into account inflation rates over the specified time interval you want to assess. PTC Windchill LCC then projects the NPV of your system. The NPV is the cost of your system in today's dollars based on inflation rates.
Costs based on design alternatives	With the alternatives feature of PTC Windchill LCC, you can compare the costs 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 system redesign.

Calculation	Description
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	PTC 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 LCC Calculations

To calculate LCC results:

1. Select **System** ▸ **Calculate**, or click the calculate button 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 **LCC** to run calculations only for the LCC module.
4. In the left pane, expand the **LCC** folder if necessary and select each of the pages to view the default settings. For this example, you use the default values for all pages.
5. Click **OK** to run the calculations. When the calculations are complete, the **View Calculation Results** window opens, where you can see cost and NPV results.

> **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**.

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

To display the results again at any time, you would select **System** ▸ **View Calculation Results**. If you have only one module enabled, the results shown are only for this module. If multiple modules are enabled, a navigation pane is shown so that you can select the results you want to view.

Viewing an LCC Report

1. In the **Project Navigator**, under **Reports > LCC Reports**, select **(Common) LCC** to generate this report and open it in a preview window.

   This report outputs the life cycle cost data from the System file, including the cost breakdown structure items, equations, time intervals, and calculated costs and net present values.

   You can use the toolbar in this window to print your report, move through its page, switch between a two-page and one-page view, zoom in and out, and close this window.
2. When finished viewing the report, do one of the following to close the window:
   - Select **Preview ▸ Close**.
   - Click the close button on the toolbar.

Graphing LCC 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**.

Additional LCC Features

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

- You can perform sensitivity analyses, which determine how particular variables affect 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.
- You can create very simple or complex cost equations, verifying the syntax for equations as you enter or modify them.

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Conclusion

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

PTC Windchill Quality Solutions customers have access to a full complement of resources, including: PTC Windchill Quality Solutions help, getting started guides, knowledge base articles, and experienced customer support.

You can also boost your productivity by learning from the experts at PTC University. Whether you are 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! If you are evaluating PTC Windchill Quality Solutions, you can send email messages with suggestions, comments, questions, and feedback of any kind to quality-tryout@ptc.com.

If you are a licensed user, you can send feedback about this guide or any other PTC Windchill Quality Solutions guide or help system to quality-doc@ptc.com. You can also use the many resources available for support on the Technical Support page of the PTC website. To contact PTC Technical Support by phone, licensed users can call 800-477-6435 and refer to the Support Phone Map for specific menu choices. We look forward to hearing from you!

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