

Training Guide



ReliaSoft[®]



Tucson ● São Paulo ● Warsaw ● Chennai ● Singapore

RCM++ 4 Training Guide
Part Identification: RRC4S-TG-01

ReliaSoft Corporation
Worldwide Headquarters
1450 South Eastside Loop
Tucson, Arizona 85710-6703, USA
Sales and Information: 1.888.886.0410
ReliaSoft@ReliaSoft.com
<http://www.Reliasoft.com>

© 2005-2009 ReliaSoft Corporation, ALL RIGHTS RESERVED.

Notice of Rights

No part of this document may be reproduced or transmitted, in any form or by any means, for any purpose, without the express written permission of ReliaSoft Corporation, Tucson, AZ, USA.

Disclaimer

Information in this document is subject to change without notice and does not represent a commitment on the part of ReliaSoft Corporation.

Companies, names and data used herein are fictitious unless otherwise noted.

Use of the software and this document are subject to the terms and conditions set forth in the accompanying License Agreement.

This software and documentation were developed at private expense; no portion was developed with government funds.

Trademarks

ReliaSoft, RCM++, Xfmea, Weibull++, ALTA, BlockSim and MPC 3 are trademarks of ReliaSoft Corporation.

Product names and services identified in this document are trademarks of their respective trademark holders, and are used for illustration purposes. Their use in no way conveys endorsement or other affiliation with ReliaSoft Corporation.

10 9 8 7 6 5 4 3

RCM++ Training Guide

1

1.1 About this Training Guide

This training guide is intended to provide you with many examples to demonstrate the use of RCM++. It begins with step-by-step examples and then proceeds into more advanced examples. At any time during the training, please feel free to ask the instructor(s) any questions you might have.

Some of the examples in this training guide require you to access files that have been shipped with the RCM++ application. These files are located in the Training and Examples folders in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training or C:\Program Files\ReliaSoft\RCM4\Examples). The Examples folder is also accessible by clicking the **Open Examples Folder...** link in the What do you want to do? window or by selecting **Open Examples Folder...** from the **Help** menu.

1.2 RCM++ Documentation

Like all of ReliaSoft's standard software products, RCM++ is shipped with detailed printed documentation on the product (*RCM++ User's Guide*). This training guide is intended to be a supplement to that reference.



1.3 Contacting ReliaSoft

ReliaSoft can be reached at:

ReliaSoft Corporation
Worldwide Headquarters
1450 South Eastside Loop
Tucson, AZ 85710-6703 USA
Phone: +1.520.886.0366
Fax: +1.520.886.0399
E-mail: Support@ReliaSoft.com

For up-to-date product information, visit our Web site at:
<http://RCM.Reliasoft.com>

Features Summary

2

The examples in this training guide have been designed to introduce you to the features available in RCM++. This section presents a brief summary of these features. If you are already familiar with RCM++'s capabilities, you can proceed to Chapter 3, First Steps.

ReliaSoft's RCM++ facilitates analysis, data management and reporting for Reliability Centered Maintenance (RCM) analysis and also provides integrated support for failure modes and effects analysis (FMEA) and failure modes, effects and criticality analysis (FMECA).

2.1 Support for Major Industry Guidelines plus Extensive Customization Options

RCM++ supports all of the major industry guidelines for RCM and FMEA/FMECA. This includes SAE JA1011, SAE JA1012, ATA MSG-3, NAVAIR 00-25-403 and other references for RCM as well as SAE J1739, SAE ARP5580, AIAG FMEA-3 and MIL-STD-1629A for Design FMEA (DFMEA), Process FMEA (PFMEA), Machinery FMEA (MFMEA) and Criticality Analysis (FMECA).

In addition to providing pre-defined profiles for the major industry standard reporting formats, the software provides extensive capabilities to customize the interface and the reports. This includes the ability to rename fields, hide/display fields, customize the RCM decision logic and/or RPN rating criteria and other options to allow you to determine the configuration for analysis and reporting.

2.2 Intuitive Interface, Easy Data Entry, Time-Saving Shortcuts

RCM++ provides two complementary views to facilitate data entry. The worksheet view displays the analysis in a tabular format. The intuitive hierarchical view displays the system configurations at-a-glance along with the related functions, failures, effects, causes, controls, actions and tasks defined in your analysis.

For consistency and to save effort, the software allows you to re-use descriptions from any existing analysis or to select phrases from pre-defined phrase libraries. The software also provides:

- Integration with ReliaSoft's Xfmea, Weibull++, ALTA and BlockSim, as well as the capability to import data from ReliaSoft's MPC 3 and Microsoft Excel.
- Ability to link or attach other files to the analysis, such as process flow charts, design drawings, etc.
- Ability to copy/paste and import/export sections among different analyses.

2.3 RCM Decision Support

In order to focus resources where they can provide the greatest benefit, RCM++ supports two methods for selecting the equipment that will be analyzed with RCM techniques: Selection Questions (yes/no) and Criticality Factors (rating scales). The software comes with pre-defined selection questions based on the

major industry guidelines and also allows you to customize the questions and criticality factors to meet your organization's particular analysis requirements.

In order to prioritize issues and select applicable and effective maintenance tasks, RCM++ supports the Failure Effect Categorization (FEC) and Maintenance Task Selection logic diagrams in the major industry RCM standards. These logic diagrams can also be customized to meet specific application needs.

2.4 Optimum Maintenance Interval, Cost Comparisons and Task Packaging

For analysts who rely on cost comparison in addition to, or instead of, decision logic diagrams, RCM++ goes beyond calculations based on MTBFs and the often-inappropriate assumption of an exponential failure distribution. Now, you can use the Weibull, exponential, normal, lognormal or mixed Weibull distributions to describe the equipment's failure behavior and then use the same powerful calculation and simulation engines that are available in ReliaSoft's BlockSim software to estimate the optimum maintenance interval and to compare the operational costs of various maintenance strategies.

In addition, RCM++ makes it easy to group individual tasks into packages based on interval, labor crew, etc. Both manual and automated packaging options are available.

2.5 Risk Assessment

RCM++ supports the Risk Priority Number (RPN) ranking method as well as Criticality Analysis. This includes automatic RPN calculation for both initial and revised RPNs, as well as optional "roll-up" capability to calculate RPNs for other analysis levels (such as Item or Failure) based on the RPNs for the potential causes of failure.

The software is shipped with an extensive array of pre-defined rating scales for Severity, Occurrence and Detection and also allows you to create and manage your own rating scales. In addition, RCM++ supports both quantitative and qualitative criticality analysis methods. The software automatically calculates Mode and Item Criticalities and generates charts and reports of the criticality analysis.

2.6 Actions Management

RCM++ allows you to fully define and manage the recommended actions identified by the analysis in order to close the loop on corrective actions. Action management options include automated notifications via e-mail as well as useful reports and charts for progress tracking. Detailed reports on current controls are also available.

2.7 Simultaneous Access by Multiple Users

The software has been designed to allow multiple users to work cooperatively on the analysis and provides flexible techniques to share portions of an analysis with other users as well as revision tracking mechanisms, the ability to limit access to authorized users, and more.

If you are working with a secure database, more than one user can have read/write permission to access the database at the same time. This means that multiple users can simultaneously edit different portions of the analysis in the database. If other users are editing a section in a database when you log in to it, then those sections of the database that are currently being edited by the other users will be marked as "read-only" for you and the section that you are currently editing will be marked as "read-only" for the other users.

2.8 Revision Tracking

In addition to the option to restrict database access to authorized users via password protection, RCM++ provides several levels of revision tracking functionality to protect the integrity of your analysis. The last

update user and date/time stamp is clearly displayed for each record. The software also maintains a database login history, with the user and date/time for every login to the database. You can also create baseline versions of the database with the ability to “roll back” to previous versions if necessary. In addition, the software provides a Change Log feature, which allows authorized users to control the revision of a particular analysis and provides a record of all modifications since the log was activated.

2.9 Check Analysis Utility

RCM++ allows you to check a particular analysis and identify any possible discrepancies and/or omissions via the Check Analysis utility. The utility will list the potential issues and you can make the decision of whether to address them. You will not be prevented from generating plots or reports even if issues are identified via the data check.

2.10 Query Utility

The Query Utility allows you to query the current RCM++ project for the records that meet your specific query criteria. The results of the query are returned in spreadsheets that can then be exported to Microsoft Excel. You can also use the Query Utility to perform queries at the database level.

2.11 Automated Reporting and Charts

RCM++ provides a comprehensive set of print-ready reports for your analysis. This includes equipment selection, functional failure analysis, failure effect categorization, maintenance task selection and other reports for RCM analyses as well as FMEA and FMECA spreadsheets in the standard industry formats. You can choose to generate each report in Microsoft Word or Excel, which provides maximum flexibility for customization and generation of HTML and PDF versions of the reports, as desired.

You can also generate a variety of graphical charts for the analysis.

2.12 Control Plans, DVP&Rs, DRBFMs and Flow Diagrams

RCM++ provides several ways to integrate your FMEA with the requirements of the Advanced Product Quality Planning (APQP) guidelines. This includes the ability to generate a new Process FMEA (PFMEA) based on an existing Design FMEA (DFMEA) and also to create integrated Design Verification Plan and Report (DVP&R), Control Plan, Design Review Based on Failure Mode (DRBFM), Process Flow Diagram and/or Functional Block Diagram analyses.

2.13 Administrative Options and Database Tools

RCM++ provides utilities that allow you to manage and maintain the databases that you create. The administrative options and database tools include:

- The Administrative Options window, which allows the database administrator to perform administrative options, such as change the administrator information and manage the database users.
- The Database Tools window, which gives you access to database maintenance options, such as compacting and repairing the current database, creating a backup of the database and restoring the backup of the database.

First Steps

3

In addition to providing information on starting RCM++ and a brief overview of the software's main interface, this section allows you to experiment with the data management, analysis and reporting features of the software using a pre-defined analysis based on sample data. Working through this example will help you to become familiar with the software quickly and easily.

3.1 Starting RCM++

RCM++ is a 32-bit application that has been designed to work with Windows NT, 2000 and XP. The RCM++ internal screens and commands are identical regardless of which operating system you are using, and this training guide is equally applicable. To start RCM++, from **Start** select **Programs, ReliaSoft Office** and then **RCM++ 4**.

3.2 Multiple Document Interface

RCM++'s Multiple Document Interface (MDI) is the workspace within which you can create, edit and manage your RCM and FMEA/FMECA analyses. You can open one database at a time in the MDI and as many projects from that database as necessary. The MDI remains open until you close the program and closing the MDI terminates the program.

The next figure displays the RCM++ MDI and its components. The appearance of the MDI will vary depending on the window(s) currently open.



The internal area of the MDI contains the active RCM++ windows, which can include the Project Explorer and the open Project window(s). The status bar that appears at the bottom of the MDI displays the path and

filename of the database, whether Login Security is enabled for the database, whether the user has read and/or write access to the database and the current date.

3.3 Getting Help in the RCM++ Environment

ReliaSoft's RCM++ includes complete on-line help documentation. This help can be obtained at any time by pressing **F1** or by selecting **Contents** from the **Help** menu.

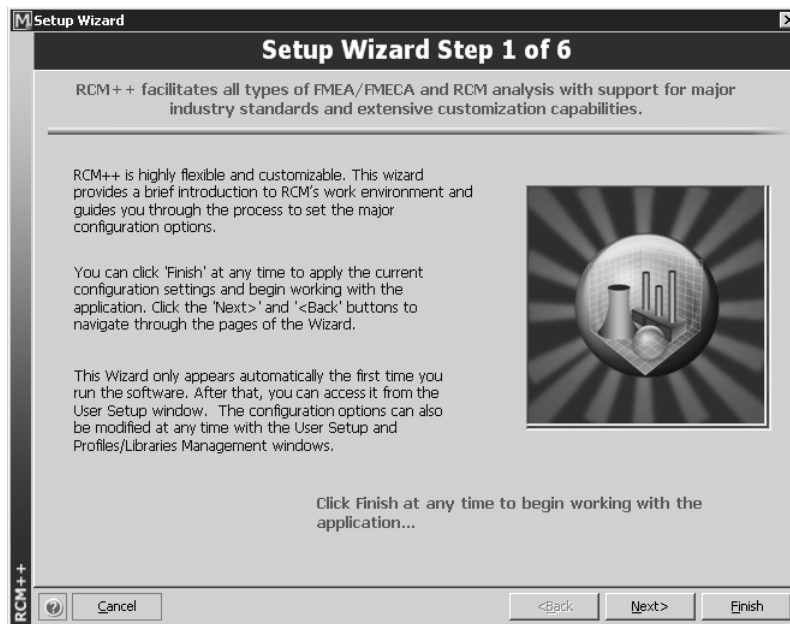
3.4 First Steps Example 1

This example allows you to experiment with the data management, analysis and reporting features of the software. For this example, you will work with a sample database that has been prepared by ReliaSoft, which contains sample data related to imaginary equipment. *Sample data sets are not intended to be realistic.*

At this time, we assume that you have started the application and, if this is the first time you have run RCM++, that you are looking at the Setup Wizard.

3.4.1 Complete the Setup Wizard

The Setup Wizard will be displayed the first time that you run the software. The purpose of the wizard is to introduce you to the RCM++ working environment while guiding you through the process to configure the software to fit the specific way that you work.



- If you have not already completed the Setup Wizard, then you can do so now before proceeding with the examples. If you would prefer to begin the examples immediately, simply click **Finish** to accept RCM++'s default configuration settings and close the window. If you would like to run the wizard again at a later time, click **Run User Setup Wizard** in the User Setup window, which is available from the **File** menu.

3.4.2 Open an Existing Database

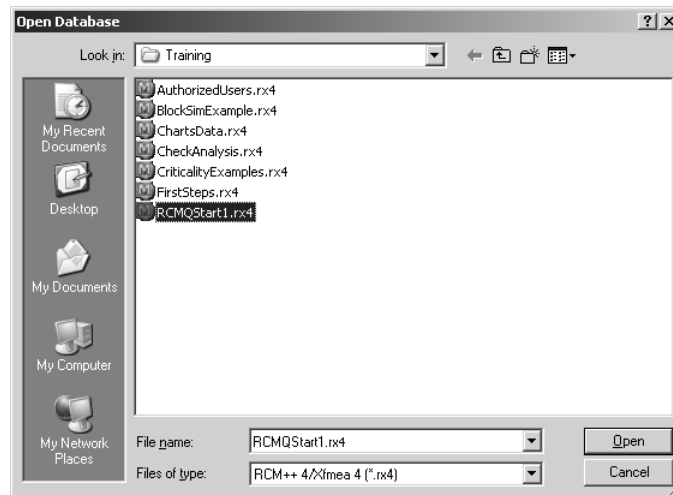
RCM++ databases can be created with or without Login Security. If Login Security is enabled for a database, then each user must log in with an authorized username and password in order to gain access to the information in the database. If Login Security is not enabled for a database, then any user who has read/write

permission to access the location where the database file is stored can view and edit the information contained in the database. By default, Login Security is not enabled for new databases. However, you can enable Login Security via the Settings (1) page of the User Setup. The database that you will access in this example is non-secure.

When you launch RCM++ (or after you have completed the Setup Wizard if this is the first time that you have started the software), the What do you want to do? window will be displayed. This window provides a quick way to create a new database or open an existing database.



- For this example, click **Open Database** to open an existing database file.
- In the Open Database window, select the file called **RCMQStart1.rx4** from the Training folder in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training), as shown next.



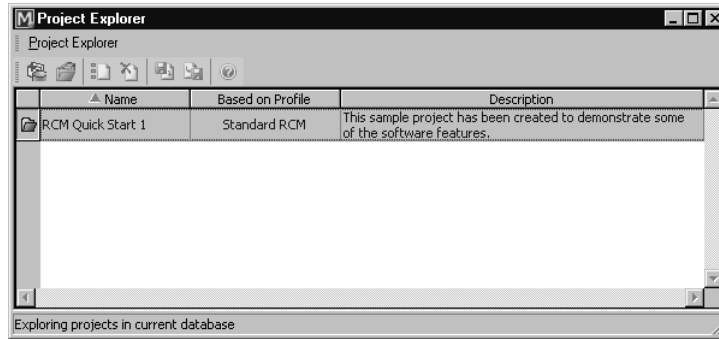
- Click **Open** to continue.

3.4.3 Open a Project

Projects give you additional flexibility for managing your analyses to fit the particular needs of your organization. You can have one or many projects in the same database. Every analysis within a given project will have the same characteristics, including the fields that are enabled/disabled in the interface and reports, the RCM decision logic, rating scales and the menu options that are available for codified information, such as Action Categories, Task Statuses, etc. These properties can be set automatically based on pre-defined profiles and libraries and are fully customizable.

- After you have opened the existing database, the Project Explorer will appear, which allows you to create, edit, delete, import or export projects within the current database. You can also duplicate and

transfer projects. The Project Explorer is shown next with the RCM Quick Start 1 project, which we will be working with in this example.

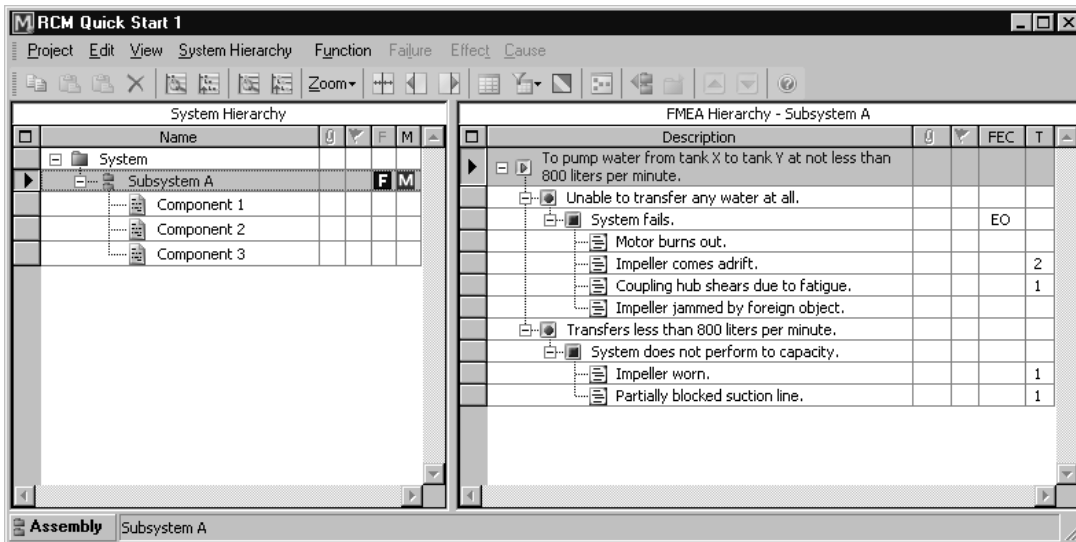


As can be seen in the Project Explorer, the RCM Quick Start 1 project is based on the Standard RCM profile. A profile is a pre-defined set of project properties, which includes selections for interface styles, rating scales, menu sets and RCM analysis logic. The Standard RCM profile enables/displays a basic set of properties that are applicable to a typical RCM analysis.

- From the Project Explorer, open the RCM Quick Start 1 project by double-clicking it, by selecting **Open Project** from the **Project Explorer** menu or by clicking the **Open Selected Project** icon.



The Project window will appear. The Project window is the main window that you will use to perform your analyses. It presents all of the items, functions, failures, effects, causes, controls, actions, tasks and related properties that you have defined within a particular project and provides all the tools required to add and edit these records. Notice that the project name, RCM Quick Start 1, appears in the caption bar at the top of the window. The Project window with Subsystem A selected is shown next.



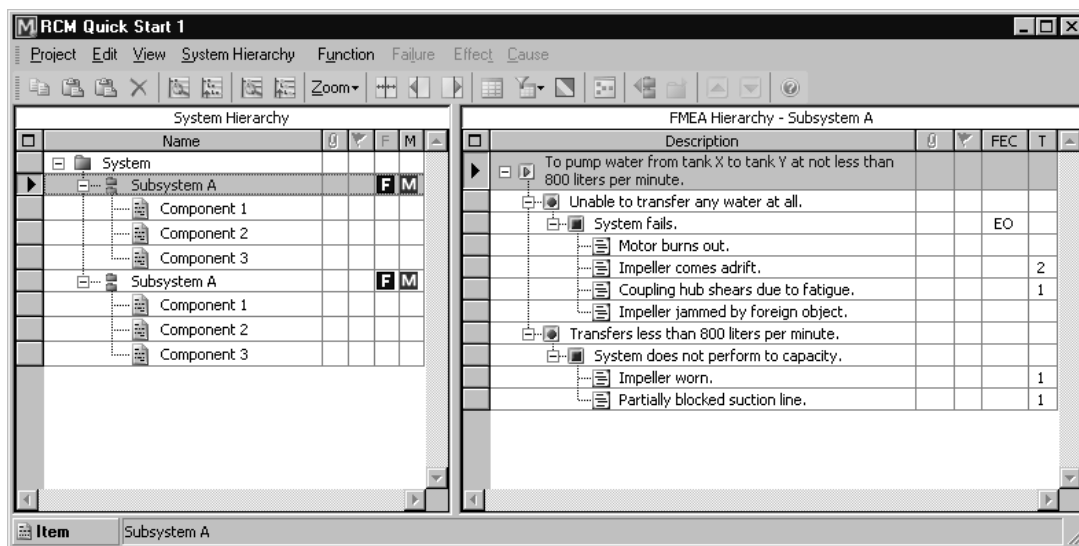
The Project window is divided into two panels. The panel on the left displays the System Hierarchy, which includes all items that have been defined in the project and also provides access to linked/attached documents and other related information. The panel on the right displays the functions, failures, effects, causes, controls, actions and tasks associated with the item that is currently selected in the System Hierarchy panel. The columns that are displayed in both panels can be configured via the Hierarchies page of the User Setup.

- You can now take a moment to get familiar with the Project window by going through the menus and their commands. You can also view the properties windows for the records by double-clicking the record name. For example, to view the Item Properties window for Subsystem A, double-click the name that appears in the Name column in the System Hierarchy panel. To view the Function Properties window for the first function, double-click the name that appears in the Description column in the FMEA Hierarchy panel, and so on.¹

3.4.3.1 Copy and Paste Items

You can copy items, functions, failures, effects or causes within a project and paste the record(s) to the same project or to another project within the same database. (Please note that if you want to share items between different databases, you must use the import/export functionality.)

- Copy Subsystem A by selecting it in the System Hierarchy panel and selecting **Copy** from the **Edit** menu or pressing **Ctrl+C**. When an item is copied, all next level items, functions, failures, effects, causes, controls, actions and tasks will also be copied, along with any attachments.
- Next, paste Subsystem A by selecting the **System** item and then selecting **Paste as Next Level Item** from the **Edit** menu or pressing **Ctrl+V**. Subsystem A will be pasted into the specified position in the hierarchy, along with its related sub-items, as shown next.²



- When you copy and paste items, they retain their original names and numbers. If you have not changed the default settings on RCM++, the item numbers will not be visible, but they are used by the software to sort the items. Renumber the items by selecting **Renumber items** from the **Project** menu so that the copied subsystem and the original subsystem no longer share an item number.
- Rename the second subsystem in the hierarchy by double-clicking its name in the System Hierarchy panel. The Item Properties window will appear.

¹ Please note that this example is meant to give you a quick overview of the software. Subsequent examples in this training guide will take you through the steps of adding records to a project using the properties windows and will provide more explanation of the fields that appear in these windows.

² When an item is copied, you can also use the **Paste as System** command in the **Edit** menu or press **Ctrl+Shift+V** to paste (add) the copied item to the System Hierarchy panel as a top level item (system).

- Edit the Item Name by typing **Subsystem B** in the corresponding field, as shown next.

The screenshot shows the 'Edit Item' dialog box with the following fields and values:

- Parent System: 1 - System
- Next Higher Assembly: N/A
- Item Name: Subsystem B
- Part Number: (empty)
- Alternate Part Number: (empty)
- Item Description: (empty)
- Remarks: (empty)
- Qty per System: (empty)
- Qty per NHLA: (empty)
- Item RPN: Initial (empty), Revised (empty)

The dialog also includes buttons for Reliability..., Analysis..., Analysis Plan..., Equipment Selection..., OK, and Cancel. The status bar at the bottom indicates 'Last Update Date: 4/11/2005'.

- Click **OK**. Notice that the name has changed in the System Hierarchy panel.

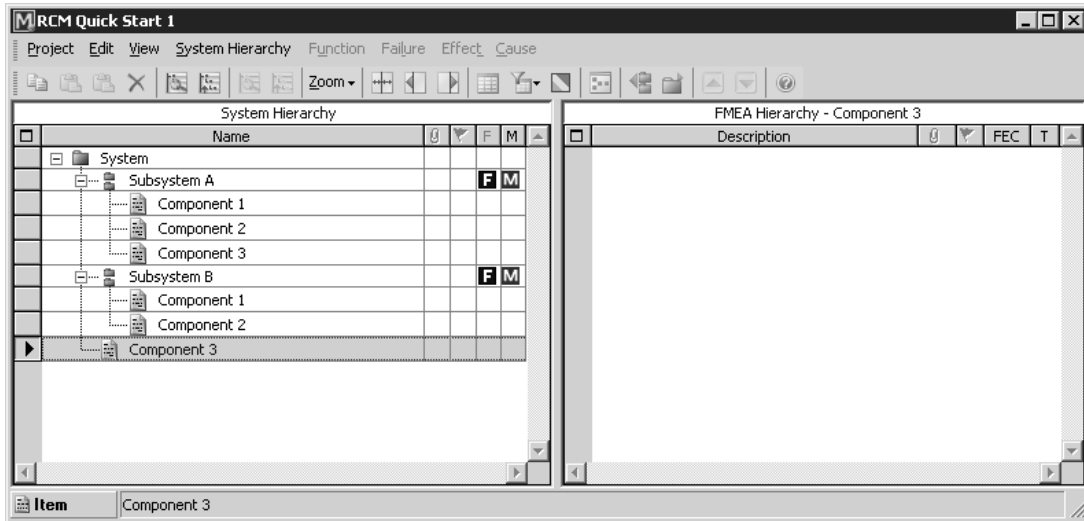
3.4.3.2 Promote and Demote Items

You can promote and demote the items within the System Hierarchy using the Promote and Demote commands available from the System Hierarchy menu or the Project toolbar. For example, if you have a system, subsystem and subsystem and you promote the subsystem up one position in the hierarchy, it will be on the same level as the subsystem. When an item is promoted or demoted, all associated next level items, functions, failures, effects, causes, controls, actions, tasks and attachments will also be moved. An item can only be demoted if there is another item on the same level and above the selected item that it can be demoted under.

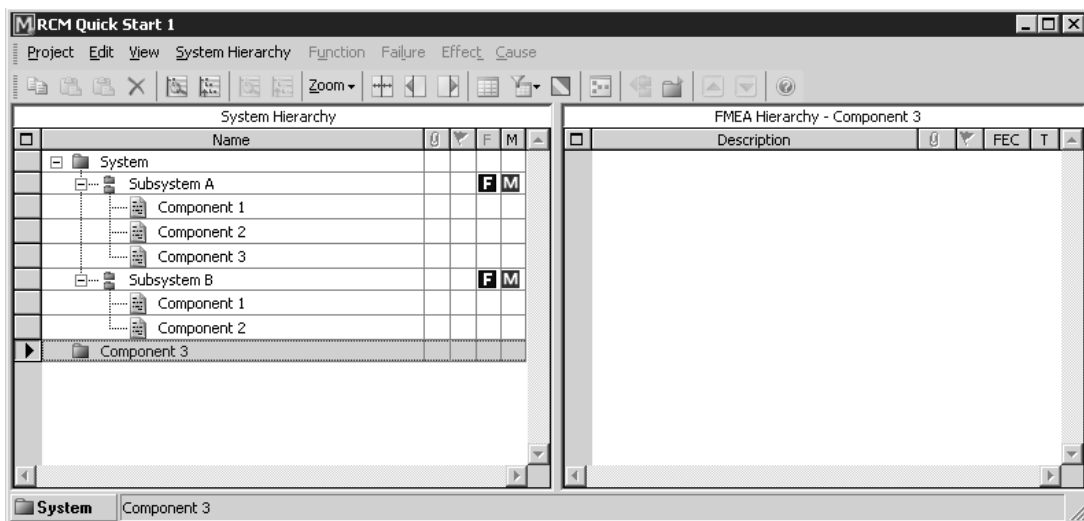
- Promote the Component 3 item that appears under Subsystem B to the next higher level in the System Hierarchy panel by selecting it and then selecting **Promote Item** from the **System Hierarchy** menu or by clicking the **Promote Item** icon on the Project toolbar.



- Notice that the Component 3 item now appears on the same level as Subsystem A and Subsystem B, as shown next.



- Promote Component 3 again up to the system level, as shown next.



- Now return Component 3 back to its original position as an item below Subsystem B by selecting it and then selecting **Demote Item** from the System Hierarchy menu or by clicking the icon.



You will need to select the **Demote Item** command two times to return the item to its original position.

- Next, delete Subsystem B from the hierarchy by selecting it and then selecting **Delete** from the **Edit** menu or pressing **Delete**. A window will appear to confirm that you want to delete the selected item. Click **Yes**.

Subsystem B will be deleted, along with its associated next level items. The Project window will now appear as it did when you first opened it.

3.4.4 Perform Equipment Selection

In order to focus resources where they can provide the greatest benefit, RCM++ supports two configurable methods for selecting the equipment that will be analyzed with Reliability Centered Maintenance (RCM) techniques: Selection Questions and Criticality Factors. To view the Selection Questions analysis that has been performed for this example, double-click the **M** icon to the right of the Subsystem A item. The Equipment Selection window for this item will be displayed, as shown next.

1 - Subsystem A: Equipment Selection		
Parent System	1 - System	
Next Higher Assembly	N/A	
Current Item	1 - Subsystem A	
Selection Questions Criticality Factors		
Safety	Could failure affect safety or have other hazardous consequences?	No
Detectability	Could failure be undetectable or not likely to be detected during normal operation?	No
Operational	Could failure have significant operational impact?	Yes
Economic	Could failure have significant economic impact?	No
Remarks Remarks related to the equipment selection decision.		
<input type="checkbox"/> Analyze for RCM (Manual Override)		
Last Update Date: 4/6/2005		

- Click the cell in the bottom right corner of the table to change the answer to the last question to **Yes**. You will notice that the “Economic” label changes from green to red, indicating that the failure of the item could have significant economic impact (and the item should be considered for RCM analysis).

1 - Subsystem A: Equipment Selection		
Parent System	1 - System	
Next Higher Assembly	N/A	
Current Item	1 - Subsystem A	
Selection Questions Criticality Factors		
Safety	Could failure affect safety or have other hazardous consequences?	No
Detectability	Could failure be undetectable or not likely to be detected during normal operation?	No
Operational	Could failure have significant operational impact?	Yes
Economic	Could failure have significant economic impact?	Yes
Remarks Remarks related to the equipment selection decision.		
<input type="checkbox"/> Analyze for RCM (Manual Override)		
Last Update Date: 4/6/2005		

- Click **OK** to save the change and close the window.

3.4.5 View the Analysis in the Worksheet View

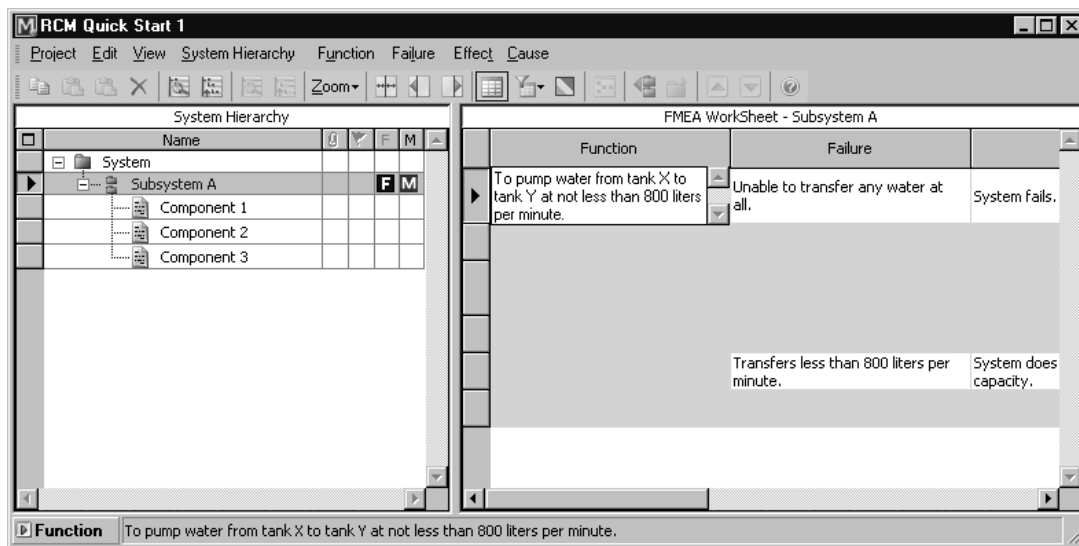
RCM++ provides two complementary views to facilitate data entry for the functional failure analysis (often called FMEA). The worksheet view displays the analysis in a horizontal, tabular format while the hierarchical view displays the information at-a-glance in a hierarchical tree structure.

You have been looking at the hierarchical view, but you can easily switch to view the analysis in the worksheet view.

- To do this, make sure that the **Subsystem A** item is selected in the System Hierarchy and select **Worksheet View** from the **View** menu, press **Ctrl+W** or click the **Toggle worksheet/tree view** icon.



You can see that the panel on the right side of the Project window now displays the information in a tabular format, as shown next.



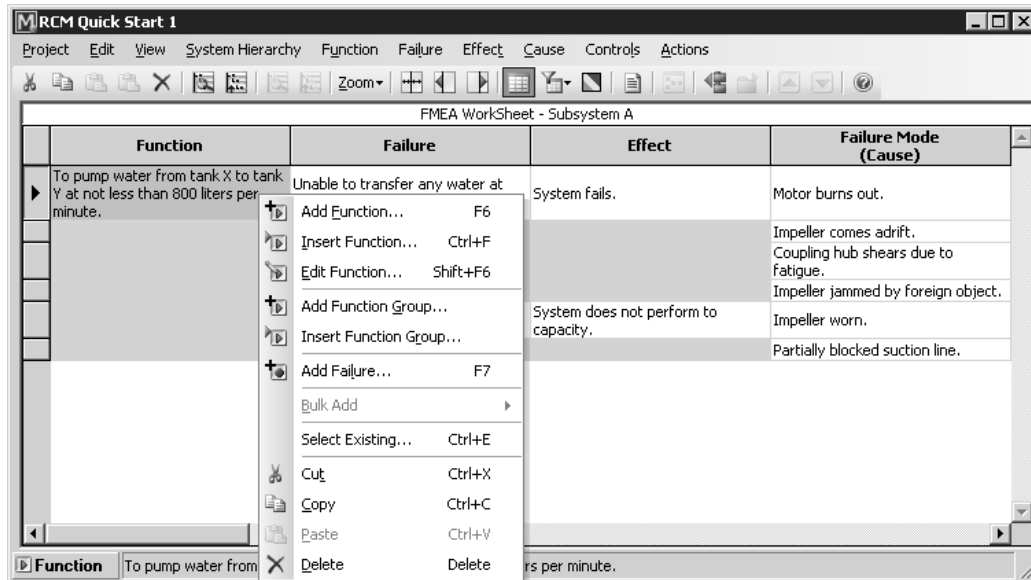
- When you display the worksheet, you may be in Edit mode (*i.e.* a cursor blinks in the currently selected cell). To exit Edit mode, press **Esc**.
- To display more of the worksheet within the window, click the **Hide System Hierarchy** icon.



The cells in the Worksheet view are color-coded according to their purpose/functionality. Cells that are white (or blue when selected) contain record properties (*e.g.* function description), green cells contain values that are automatically calculated by the application (*e.g.* RPN_i, if applicable) and grey cells are nonfunctional due to the layout of the analysis in this view.

- You can add and edit records by typing directly within the cells of the worksheet and/or by using the menus and shortcut menus to open the appropriate properties windows. For example, to open the

Function Properties window, right-click the cell that contains the function description, as shown next, and select **Edit Function** from the shortcut menu or press **Shift+F6**.³

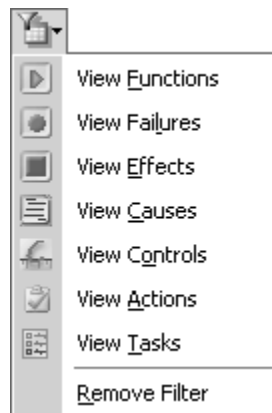


- Now return to the hierarchical view by selecting **Worksheet View** from the **View** menu.

3.4.6 View the Records by Type

When working in the Project window, you can filter the information displayed in the panel on the right to show all functions, all failures, all effects, all causes, all controls, all actions or all tasks and specific related properties in a tabular view.

- To filter the information associated with the selected item, select **View Records by Type** from the **View** menu or click the **Filter** icon. A submenu will appear, as shown next.



³ Please note that the FMEA Worksheet view is not intended to have the same functionality as a Spreadsheet application such as Microsoft Excel. The data entry and editing capabilities in the Worksheet view are limited and you may want to use the Properties window for the corresponding record when performing extensive data entry and/or editing.

- Select **View Tasks**. The panel will change to display only the maintenance task records and specific related properties, as shown next. (Please note that you may have to scroll and/or resize the window to view all the tasks and their properties.)

#	Task Name	Status	Type	Assigned Int...	Labor (Crew Name)	Duration per Incident	Total Cost per Incide...	Cost per Uptime	Average Availab... (%)
1	On condition task to inspect impeller for wear and initiate preventive maintenance if necessary.	Assigned	OC	3 Month	The labor requi...	0.25 Hour	\$12.50	0.695 / Hour	99.52
2	On condition task to inspect suction line for obstruction and initiate preventive maintenance if necessary.	Assigned	OC	3 Month	The labor requi...	0.5 Hour	\$25.00	0.343 / Hour	99.65
3	On condition task to inspect impeller for conditions that indicate it will come off.	Rejected	OC	1 Month	The labor requi...	0.25 Hour	\$25.00		
4	Re-design the equipment to reduce the likelihood that the impeller will come off.	Assigned	OT				\$10,000.00		
5	A scheduled replacement for the coupling hub.	Assigned	RR	748.698 Hour	The labor requi...	2 Hour	\$210.00		

- You can sort the records that appear in this filtered view. Sort the task records by their Total Cost per Incident by clicking the corresponding column header. Notice that the records are now sorted by their Total Cost per Incident from lowest to highest. Click the column header again to sort the data from highest to lowest Total Cost per Incident.
- Now return to the hierarchical view by selecting **Remove Filter** from the **View Records by Type** sub-menu or icon. Restore the two-panel display by clicking the **Restore/Split Screen** icon twice.



The first time you select this command, it restores the display to its previous state. The second time, the two panels will be evenly split within the Project window.

- With Subsystem A selected, the window will look like the figure shown next.

Description	FEC	T
Unable to transfer any water at all.		
System fails.	EO	
Motor burns out.		
Impeller comes adrift.		2
Coupling hub shears due to fatigue.		1
Impeller jammed by foreign object.		
Transfers less than 800 liters per minute.		
System does not perform to capacity.		
Impeller worn.		1
Partially blocked suction line.		1

3.4.7 Perform Failure Effect Categorization

As you can see, the functions, functional failures, effects and causes (failure modes) for Subsystem A have already been defined for this data set. In addition, the effect of the first failure (unable to transfer any water at all) has already been analyzed and categorized as **EO - Evident Operational**.

- To analyze the effect of the second failure, double-click inside the **FEC** column to the right of the effect with the description “System does not perform to capacity.” The Failure Effect Categorization window for this effect will be displayed, as shown next.

Failure Effect Categorization

Current Item	1 - Subsystem A
Function	1 - To pump water from tank X to tank Y at not less than 800 liters per minute.
Failure	2 - Transfers less than 800 liters per minute.
Effect	1 - System does not perform to capacity.

Question 1
Is the occurrence of a functional failure evident to the operator during the performance of normal duties?
 Yes No

Question 2
Does the functional failure or secondary damage resulting from the functional failure have a direct adverse effect on operating safety or other hazardous results?
 Yes No

Question 3
Does the hidden functional failure or secondary damage resulting from the functional failure have a direct adverse effect on operating safety or other hazardous results?
 Yes No

Question 4
Does the functional failure have a direct adverse effect on operating capability?
 Yes No

Question 5
Does the hidden functional failure have a direct adverse effect on operating capability?
 Yes No

ES Evident Safety EO Evident Operational EE Evident Economic HS Hidden Safety HO Hidden Operational HE Hidden Economic

Last Update Date: 4/9/2005

- Answer **Yes** to Question 1, **No** to Question 2 and **No** to Question 4 to categorize the effect as **EE - Evident Economic**.

- If desired, you can also provide an explanation for your answer to each question and/or general remarks associated with the FEC analysis for this effect in the text boxes on the right side of the window.

Failure Effect Categorization

Current Item	1 - Subsystem A
Function	1 - To pump water from tank X to tank Y at not less than 800 liters per minute.
Failure	2 - Transfers less than 800 liters per minute.
Effect	1 - System does not perform to capacity.

Question 1
Is the occurrence of a functional failure evident to the operator during the performance of normal duties?
 Yes No

Question 2
Does the functional failure or secondary damage resulting from the functional failure have a direct adverse effect on operating safety or other hazardous results?
 Yes No

Question 3
Does the hidden functional failure or secondary damage resulting from the functional failure have a direct adverse effect on operating safety or other hazardous results?
 Yes No

Question 4
Does the functional failure have a direct adverse effect on operating capability?
 Yes No

Question 5
Does the hidden functional failure have a direct adverse effect on operating capability?
 Yes No

ES Evident Safety EO Evident Operational **EE Evident Economic** HS Hidden Safety HO Hidden Operational HE Hidden Economic

Answer 1
Explanation of answer 1.

Answer 2
Explanation of answer 2.

Answer 3

Answer 4
Explanation of answer 4.

Answer 5

Remarks
Remarks relating to FEC analysis.

Category
EE - Evident Economic

OK Cancel

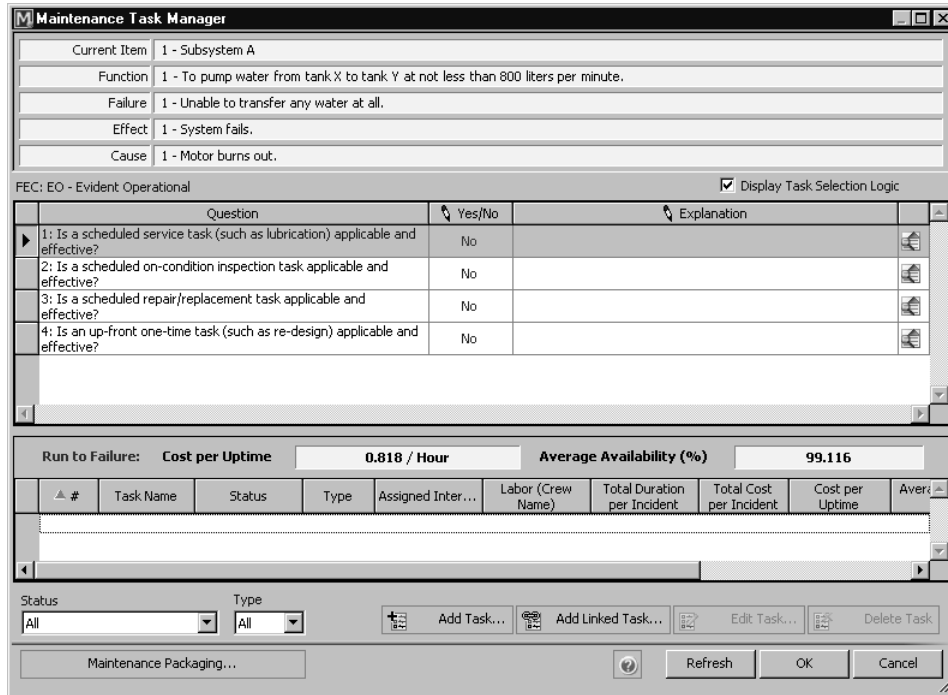
Last Update Date: 4/9/2005

- Click **OK** to save the changes and close the window.

3.4.8 Perform Maintenance Task Selection

RCM++ provides full support for the Task Selection logic in the major industry guidelines for RCM along with the ability to compare the operational costs of potential maintenance strategies.

- To perform the task selection for the first potential cause of failure, double-click inside the **T** column to the right of the cause with the description “Motor burns out.” The Maintenance Task Manager window for this cause will be displayed, as shown next.



The applicable task selection questions (based on the logic that has been defined for the project and the FEC for the associated effect) are displayed in the middle of the window. The Cost per Uptime and Average Availability percentage that has been calculated for a run-to-failure maintenance strategy (*i.e.* no preventive maintenance tasks) is displayed below that. The tasks that have been considered to address this issue are displayed at the bottom of the window.

- Click the **Yes/No** column to the right of the third question to change the answer to **Yes**, indicating that a scheduled repair/replacement task is applicable and effective to address this issue. If desired, you can type some additional comments in the text box to the right.

Maintenance Task Manager

Current Item 1 - Subsystem A

Function 1 - To pump water from tank X to tank Y at not less than 800 liters per minute.

Failure 1 - Unable to transfer any water at all.

Effect 1 - System Fails.

Cause 1 - Motor burns out.

FEC: EO - Evident Operational Display Task Selection Logic

Question	Yes/No	Explanation
1: Is a scheduled service task (such as lubrication) applicable and effective?	No	
2: Is a scheduled on-condition inspection task applicable and effective?	No	
3: Is a scheduled repair/replacement task applicable and effective?	Yes	Comments regarding efficacy of repair/replacement task.
4: Is an up-front one-time task (such as re-design) applicable and effective?	No	

Run to Failure: **Cost per Uptime** 0.818 / Hour **Average Availability (%)** 99.116

#	Task Name	Status	Type	Assigned Inter...	Labor (Crew Name)	Total Duration per Incident	Total Cost per Incident	Cost per Uptime	Average Availability (%)

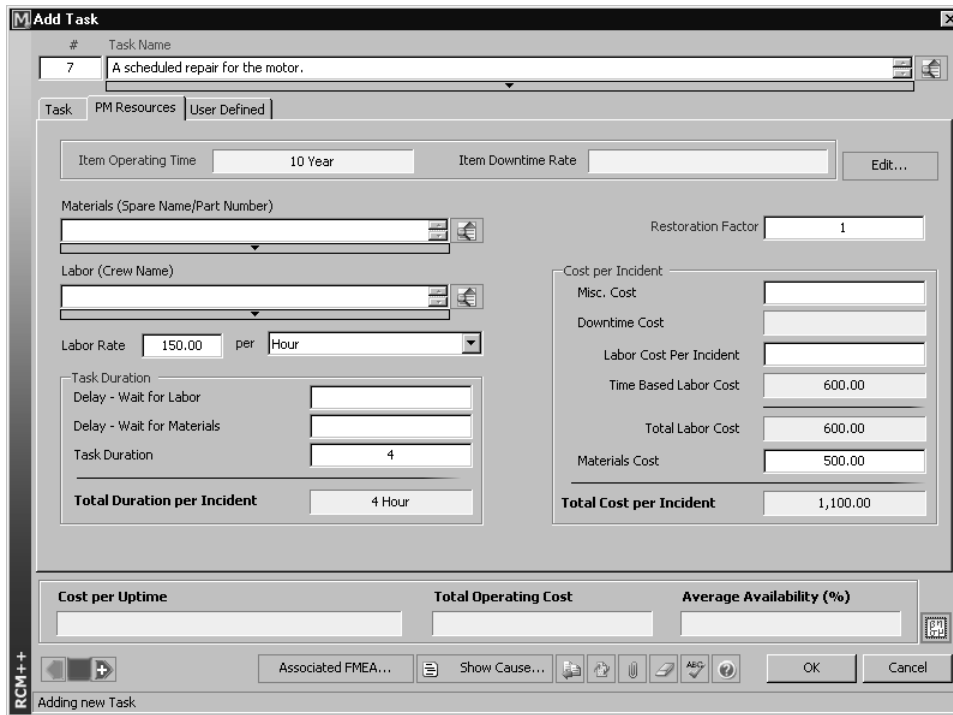
Status: All Type: All

Buttons: Add Task..., Add Linked Task..., Edit Task..., Delete Task

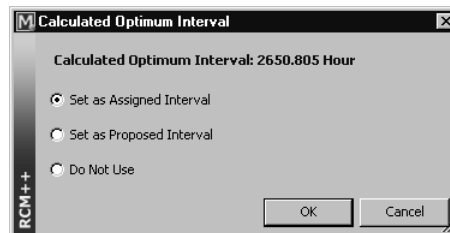
Buttons: Refresh, OK, Cancel

- Click the **Add Task** button to open the Task Properties window. Enter the following information on the Task page:
 - Task #:** Accept the default number.
 - Task Name:** Type “A scheduled repair for the motor.”
 - Type:** Select “Repair/Replace (RR)” from the menu.
 - Status:** Select “Assigned” from the menu.
- Click the **PM Resources** tab to describe the resources required to perform the scheduled repair. Enter the following information:
 - Labor Rate:** Enter 150 per Hour.
 - Task Duration:** Enter 4 Hours.
 - Restoration Factor:** Enter 1 to indicate that the motor will be restored 100% by the repair (*i.e.* as good as new).

- **Materials Cost:** Enter \$500



- Return to the Task page to define the maintenance interval. Click **Calculate Optimum** to allow the software to determine this interval based on the cost of corrective repair, the cost of preventive repair and the probability of failure. Accept the calculated value, **2650.805 Hours⁴** and **Set as Assigned Interval**.



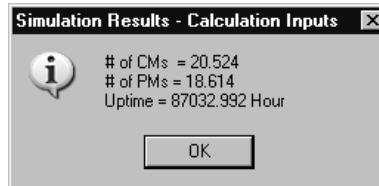
Note that the Optimum Interval utility assumes a Restoration Factor of 1 for both Corrective Maintenance and Preventive Maintenance.

- Click the **Calculate** icon to simulate the operation of the equipment and estimate the Cost per Uptime, Total Operating Cost and Average Availability for this maintenance strategy.



⁴. To change the number of decimal places displayed in your results, select **User Setup** from the **File** menu, and click the **Other** tab. Change the **Displayed Math Precision** field to the desired number of decimal places, then click **OK**.

A blue progress bar will appear at the bottom of the Task Properties window as RCM++ runs the simulations. If you have not changed the default user settings, when the progress is 100% complete, the simulation results will be displayed, as shown next.



- Click **OK**. The Task Properties window will look like the figure shown next.

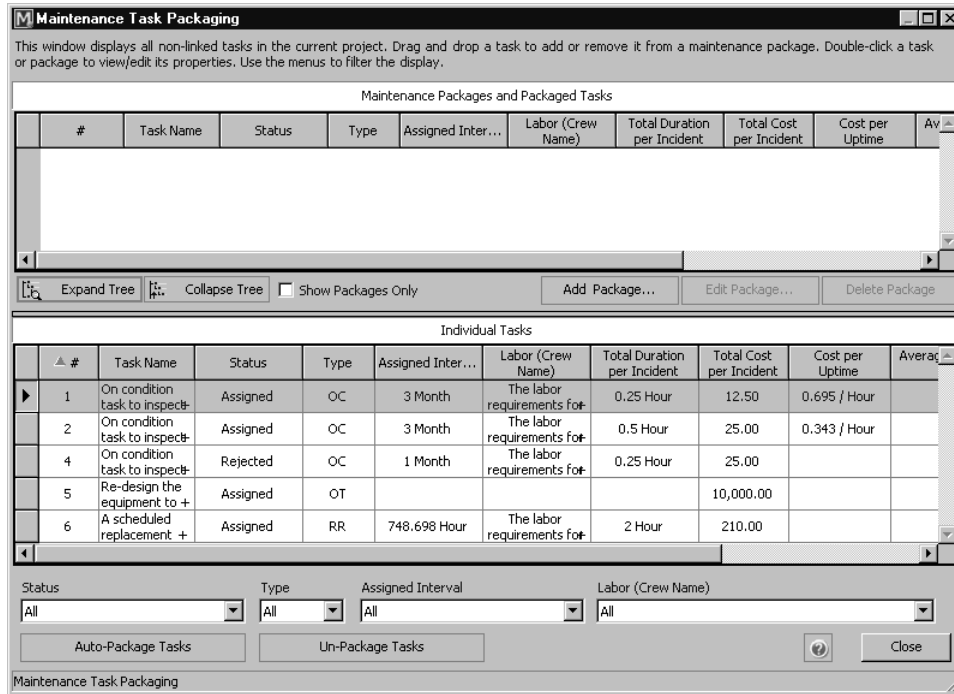
The image shows the "Add Task" dialog box in RCM++. The "Task Name" field contains "7 A scheduled repair for the motor.". The "Task" tab is selected, showing "Type" as "Repair/Replace (RR)" and "Status" as "Assigned". The "Assigned Interval" is set to "2650.805" with "Units" as "Hour". The "Based on" radio buttons are set to "Item Age". The "Cost per Uptime" is "0.754 / Hour", "Total Operating Cost" is "65,628.20", and "Average Availability (%)" is "99.35". The "OK" button is highlighted.

- Click **OK** to save the changes and close the Task Properties window then click **OK** again to close the Maintenance Task Manager.

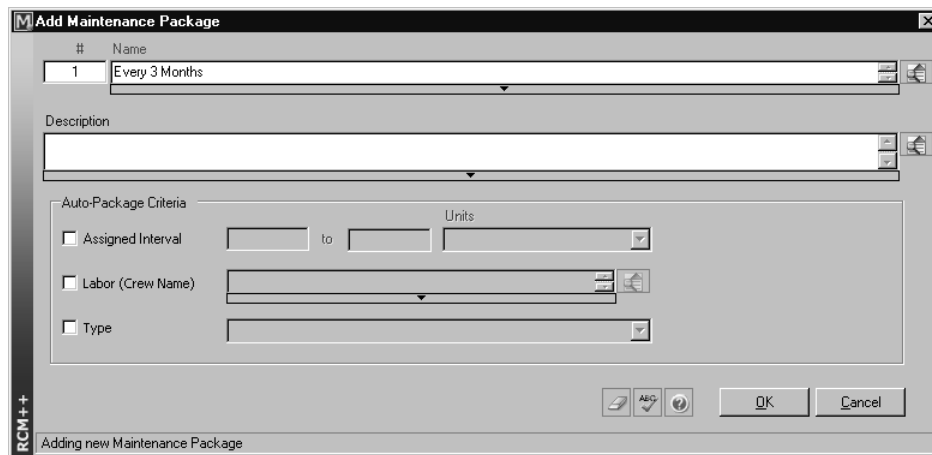
3.4.9 Package the Maintenance Tasks

RCM++'s Maintenance Task Packaging utility allows you to group individual tasks together based on interval, labor requirements, etc. to achieve the most efficient maintenance plan that is possible.

- Select **Maintenance Packaging** from the **Project** menu to open the Maintenance Task Packaging window for this project, as shown next.

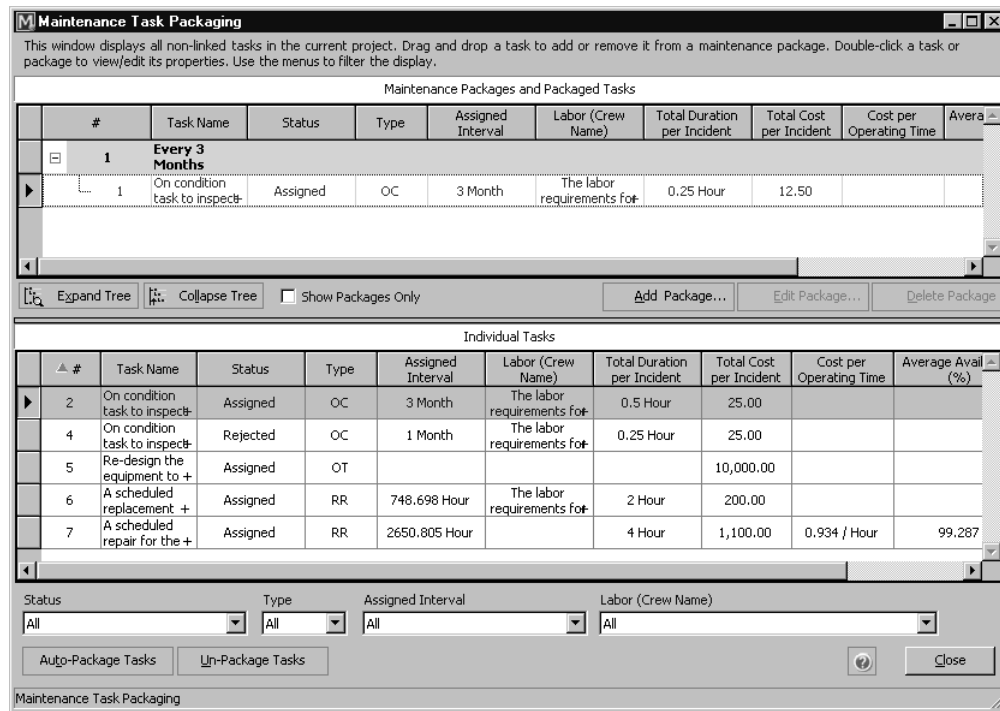


- Maintenance packages and packaged tasks are displayed at the top of the window and individual unpackage tasks are displayed at the bottom of the window. Click **Add Package** and type **Every 3 Months** for the Name, as shown next.



- Click **OK** to create the package.

- Now select the first individual unpackaged task with the description that begins “On condition task to inspect impeller for wear...” and drag/drop the task under the package that you just created. The window will now look like the figure shown next.



Other methods to assign a maintenance task to a package (*i.e.* assigning the package from the Task Properties window or using the Auto-Package Tasks feature) are described in the *RCM++ User's Guide*.

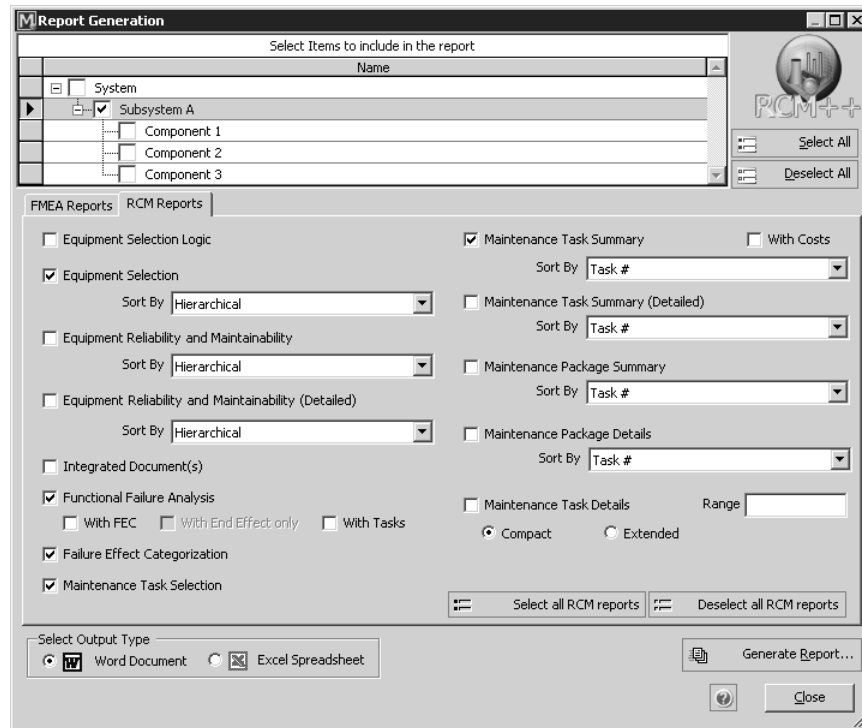
- Click **Close** to exit the utility.

3.4.10 Generate a Report of the Analysis

RCM++ provides a complete set of reports for your analysis. Reports can be generated in Microsoft Word and/or Excel, which provides maximum flexibility for customization and the ability to create HTML and PDF versions of the reports, as desired.

- To open the Report Generation window, select **Generate Reports** from the **Project** menu. The Report Generation window will appear, which allows you to specify the items and forms you want to include in the report and whether you want to create the report in Microsoft Word or Microsoft Excel.
- Select the **Subsystem A** item in the area at the top of the window. Do not select components.
- On the FMEA Reports page, click **Deselect all FMEA reports** to clear all selections and then select only the **Report Summary** form.
- Go to the RCM Reports page and click **Deselect all RCM reports**. Select the following report forms:
 - Equipment Selection**
 - Functional Failure Analysis**
 - Failure Effect Categorization**
 - Maintenance Task Selection**
 - Maintenance Task Summary**

- You will notice that some of the report forms allow you to select which field (column) to sort by. Accept the default selections for this example.
- In the Select Output Type area of the window, select **Word Document**. The window will now look like the one shown next.



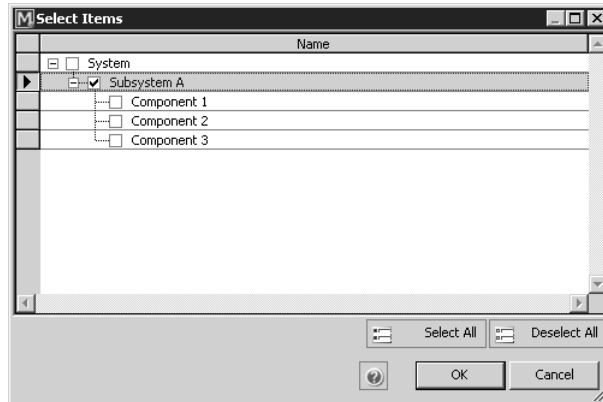
- Click **Generate Report**. The Save Report As window will appear, which allows you to specify the name and location for the report. Specify to save the report as **RCM Quick Start 1**. When you click **Save**, a blue progress bar will appear at the bottom of the MDI. When the progress is 100% complete, the report will automatically open in Microsoft Word.
- Once you have finished viewing the report, leave it open. Return to RCM++ and close the Report Generation window by clicking the **Close** button.

3.4.11 Generate Charts Based on the Analysis

RCM++ also provides a complete array of plots and charts for graphical presentation of your analysis.

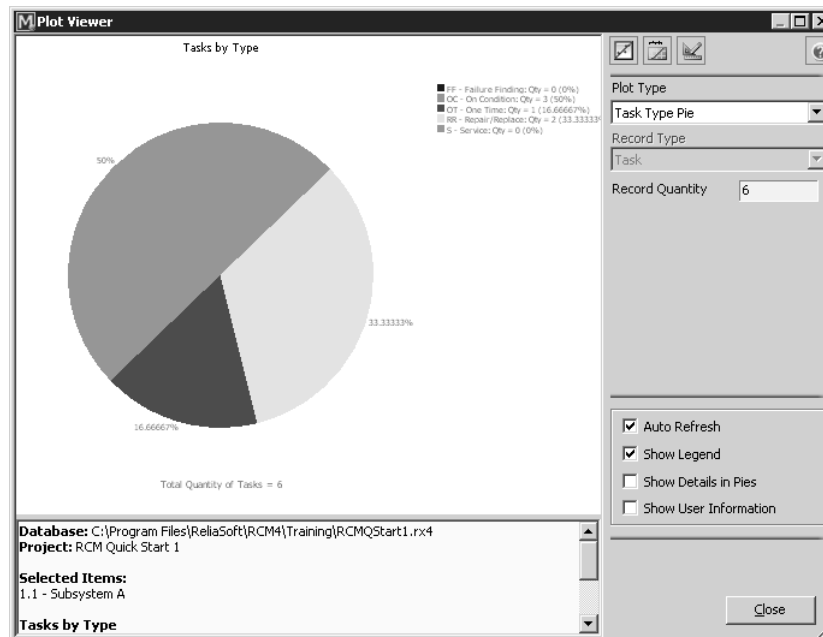
- To create plots and charts, select **Plot Viewer** from the **Project** menu.

- In the Select Items window that appears, select to include data associated with Subsystem A, as shown next. Do not select any of the components.



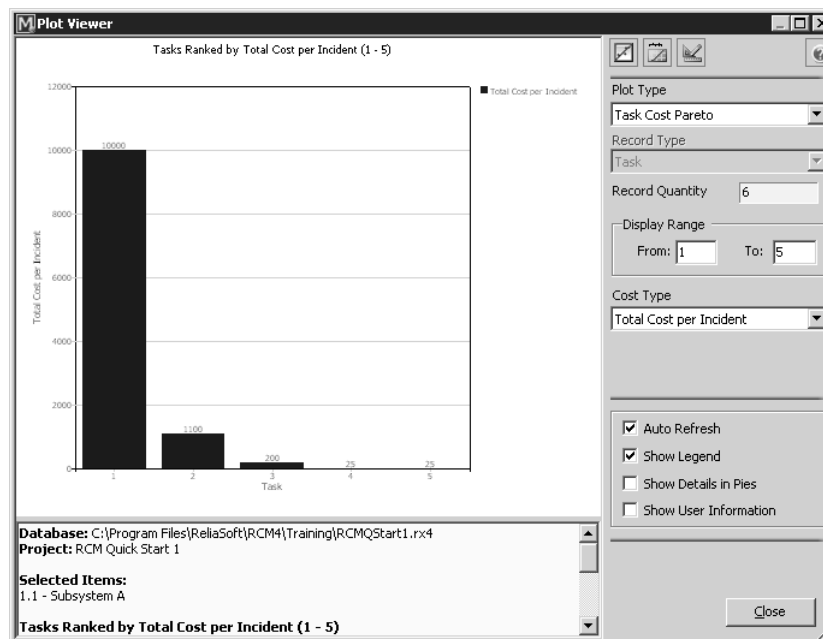
- Click **OK**.
- The Plot Viewer utility will appear. Select **Task Type Pie** from the Plot Type drop-down menu in the Control Panel on the right side of the window. Make the following selections:
 - **Auto Refresh** = Selected
 - **Show Legend on Plot** = Selected
 - **Show Details in Pie** = Not Selected
 - **Show User Information** = Not Selected

The plot, which displays the percentage of tasks in the data set that have been assigned to each of the available task types, will look like the one shown next.



- Next, select **Task Cost Pareto** from the **Plot Type** menu. Since **Auto Refresh** is selected on the Control Panel, the Plot Viewer will be updated automatically to display the plot type you have selected. Make the following selections:
 - **Display Range:** 1 to 5
 - **Cost Type** = Total Cost per Incident
 - **Auto Refresh** = Selected
 - **Show Legend on Plot** = Selected
 - **Show Details in Pie** = N/A
 - **Show User Information** = Not Selected

The plot, which displays the top five maintenance tasks ranked by Total Cost per Incident (highest to lowest), will look like the one shown next.



3.4.11.1 Copy Plot Graphic and Legend

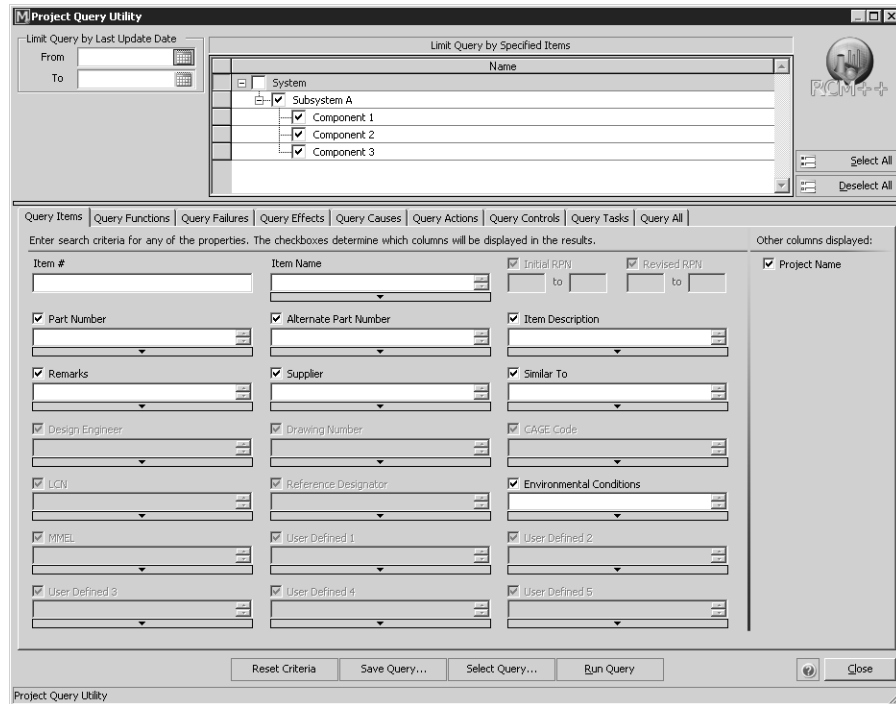
RCM++ allows you to add the plot graphic and legend to other documents, such as the print-ready report of your analysis.

- To do this, right-click inside the plot area and select **Copy Plot Graphic** from the shortcut menu that appears.
- Next, go to the report that you created in Microsoft Word for this example and paste the graphic into the document.
- Now return to the Plot Viewer and right-click inside the plot area again or inside the legend panel. This time, select **Copy Text Legend** from the shortcut menu and return to the report.
- Place the cursor below the plot graphic and paste the contents of the Clipboard into the report.
- You can save the changes you have made to the report, if desired, and then close Microsoft Word.
- Close the Plot Viewer by clicking **Close**.

3.4.12 User-Defined Queries

The Query Utility allows you to query the current project for the records that meet your specific query criteria. The results of the query are returned in tabular grids that can then be exported to Microsoft Excel, if desired.⁵

- To access the Query Utility, select **Query Utility** from the **Project** menu. The utility will appear, as shown next.

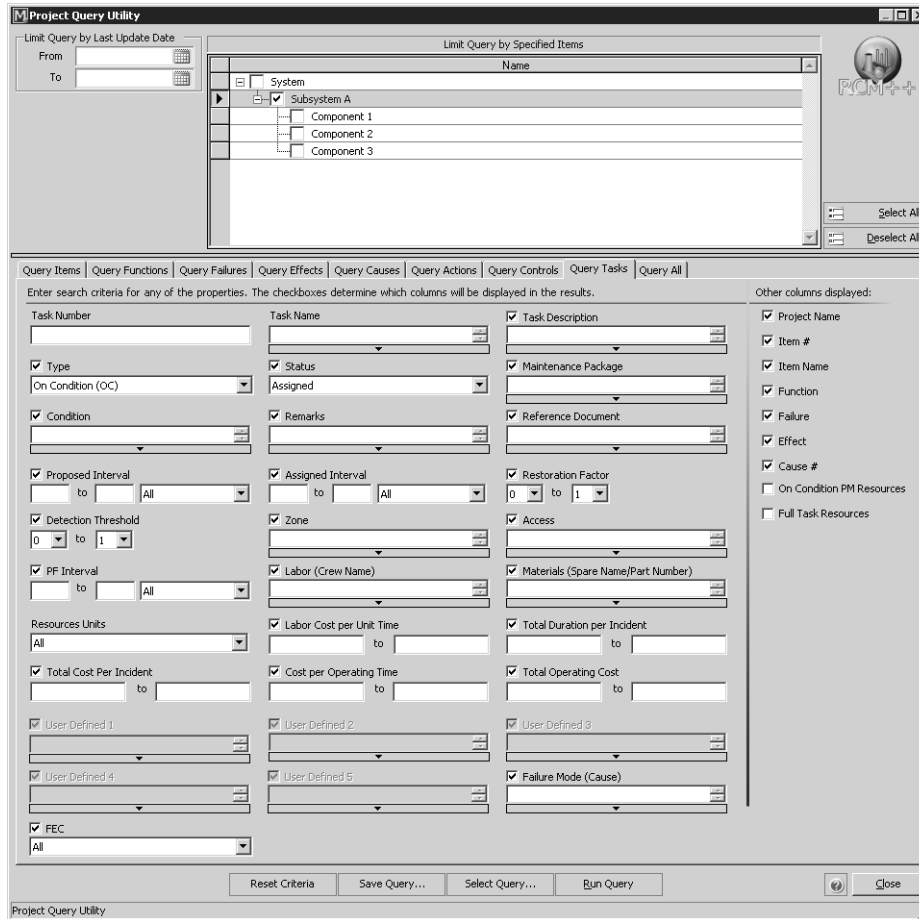


- Select **Subsystem A**, as before, in the area at the top of the window to specify that query results will only include data associated with this item.
- Click the **Query Tasks** tab to specify the criteria to find specific maintenance tasks in the current project.
- For Type, select **On Condition (OC)** from the drop-down menu. For Status, select **Assigned** from the drop-down menu.

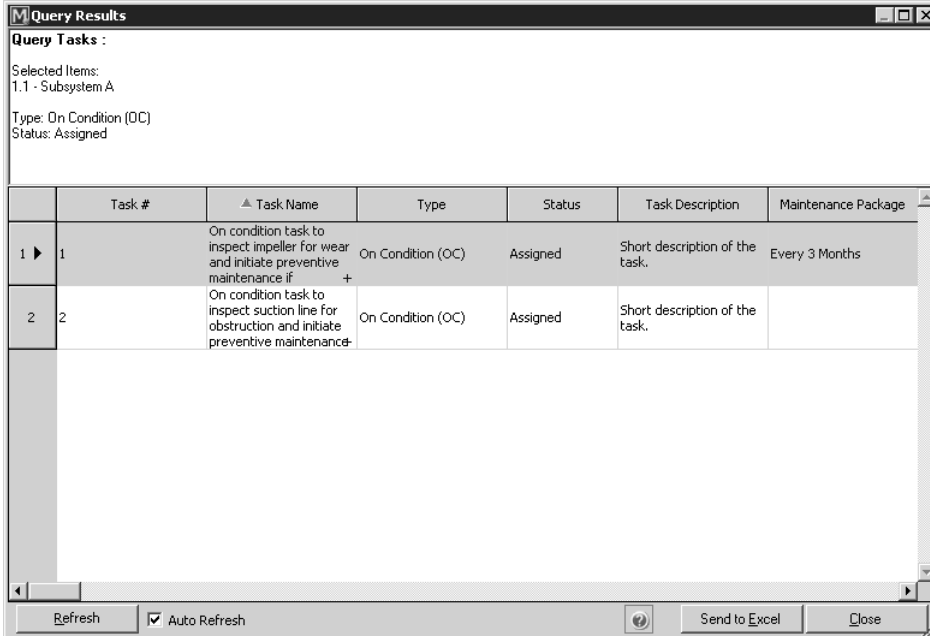
⁵. You can also use the Query Utility for database level queries by selecting **Query Database** from the **Tools** menu in the MDI.

3 First Steps

- You can specify which columns you want to appear in the query results by setting the checkboxes at the left of each property. For this example, accept the default selections. The window will look like the one shown next.



- Click **Run Query**. The query results will appear in the Query Results window, as shown next.





Query Results

Query Tasks :

Selected Items:
1.1 - Subsystem A

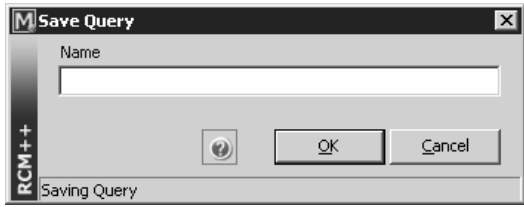
Type: On Condition (OC)
Status: Assigned

	Task #	Task Name	Type	Status	Task Description	Maintenance Package
1 ▶	1	On condition task to inspect impeller for wear and initiate preventive maintenance if +	On Condition (OC)	Assigned	Short description of the task.	Every 3 Months
2	2	On condition task to inspect suction line for obstruction and initiate preventive maintenance	On Condition (OC)	Assigned	Short description of the task.	

Refresh Auto Refresh  Send to Excel  Close


The criteria you specified for the query will appear at the top of the window. The results of the query will appear at the bottom of the window. These results will vary depending on the type of record and on the criteria you selected to include in the query, including the columns you selected to be displayed. You can click the column header to sort the results by any of the columns.

- Click **Send to Excel** to send the query results to a spreadsheet in Microsoft Excel.
- A window will appear that allows you to specify the name and location to save the results to. Enter **RCM First Steps Query**. When you click **Save**, a blue progress bar will appear at the bottom of the Query Results window. When the progress is 100% complete, the query results will automatically open in Microsoft Excel.
- Close Excel then close the Query Results window.
- From the Query Utility, you can save the query criteria as a custom query by clicking the **Save Query** button. The Save Query window will appear, as shown next.



Save Query

Name

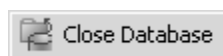


RCM++ Saving Query

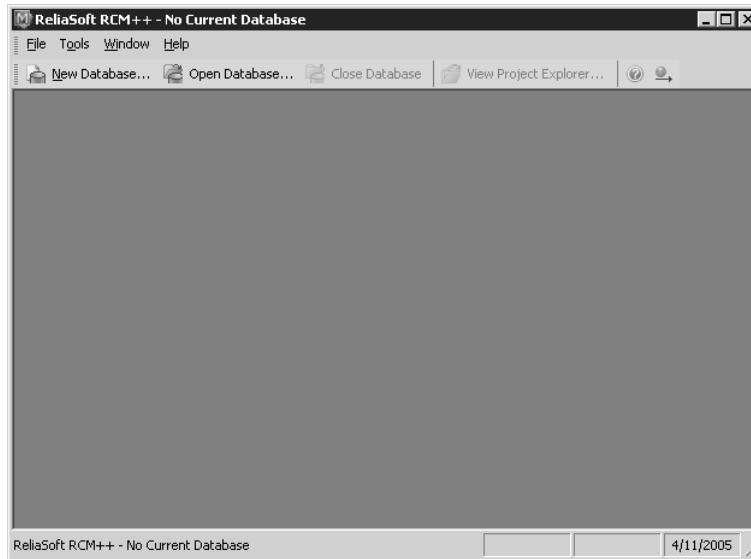
- Type **RCM First Steps Query** for the query name and save it as a custom query by clicking **OK**.
- Close the Query Utility.

3.4.13 Close the Database

- To close the database, select **Close Database** from the **File** menu or click the **Close Database** icon.



- Notice that “No Current Database” appears in the caption bar and status bar at the top and bottom of the MDI, indicating that a database is not currently open.⁶



⁶ If you do not close the database, it will be closed automatically when you create a new database for the next example or open an existing database.

Step-by-Step Examples

4

4.1 List of Examples

This chapter provides the following step-by-step examples, designed to introduce you to the features of the RCM++ software:

- Example 1 - Simple MSG-3 Analysis for Aircraft Subsystem - page 33
- Example 2 - Add Authorized Users to Secure Database - page 47
- Example 3 - Maintenance Task Intervals, Costs and Packaging - page 50
- Example 4 - Excel Import/Export for Items and/or FMEAs - page 59
- Example 5 - Using the Plot Viewer Utility - page 62
- Example 6 - RCM Analysis for Conveyor Belt - page 70
- Example 7 - RCM Analysis for Dust Filter - page 74
- Example 8 - Cost and Availability Comparisons - page 78
- Example 9 - Integration with BlockSim via XML - page 85
- Example 10 - Using the Check Analysis Utility - page 89
- Example 11 - Using Profiles/Libraries for Customization - page 94
- Example 12 - Advanced Techniques for Profiles/Libraries - page 101
- Example 13 - Using Revision Tracking Features - page 107
- Example 14 - Using Change Logs - page 112
- Example 15 - Perform Your Own RCM Analysis - page 119

4.2 Example 1 - Simple MSG-3 Analysis for Aircraft Subsystem

This example guides you through the process of performing an RCM analysis for an aircraft subsystem following the MSG-3 guidelines.

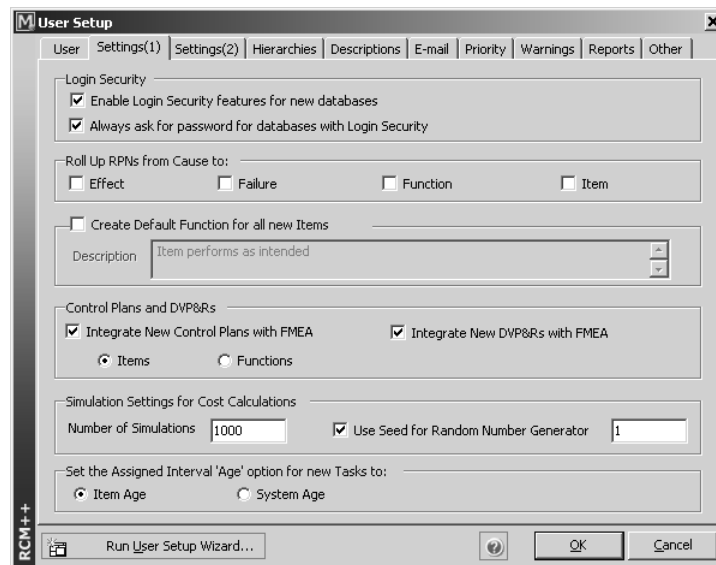
For this example, you will work with sample data provided for demonstration purposes. *This information is not intended to be realistic.*

4.2.1 Enable Login Security

The first step for this example is to configure the software so that the new databases that you create will require a username and password to access the database.

- To do this, select **User Setup** from the **File** menu and click the **Settings (1)** tab.

- Select the **Enable Login Security features for new databases** option, as shown next.



- Click **OK** to close the User Setup.

4.2.2 Create a New Database

- Create a new database by selecting **New Database** from the **File** menu or by clicking the **New Database** icon.



- In the Create New Database window, type the name **AircraftExample** and click **Save** to continue.

The Database Creation Wizard will be displayed, which guides you through three simple steps required to create a secure database in RCM++.

- In Step 1 of the Database Creation Wizard, type **username** in the Username input box and type **password** in the Password input box. This will be the username and password that you will use to log in to the database. Type the password again in the Confirm input box to confirm it. Type the rest of the

required information in the Creator/Administrator Information area (indicated with red text), as shown next with sample information.

Database Creation Wizard
C:\Program Files\ReliaSoft\RCM4\Files\AircraftExample.r4

Wizard Step 1 of 3

Creator/Administrator Login

Please enter your username and password for this new database. Future access to this database will be based on this username and password.

Username: username
Password: *****
Confirm: *****

Creator/Administrator Information

Contact information for the database creator (administrator)

First Name: First
Last Name: Last
E-mail: first.last@company.com
Title: Creator Title
Company: Company Name
Phone: Phone Number

RCM++

Cancel <Back Next>

- Click **Next** to continue.

Step 2 of the Database Creation Wizard allows you to add authorized users to the database.

Database Creation Wizard
C:\Program Files\ReliaSoft\RCM4\Files\AircraftExample.r4

Wizard Step 2 of 3

Would you like to add other authorized users to this database?

Yes, I would like to add other users now.
 No, I may do so at a later time.

RCM++

Cancel <Back Next>

- For this example, we will not add authorized users so select **No, I may do so at a later time**. Click **Next**.

Step 3 of the Database Creation Wizard allows you to create a project for the database.



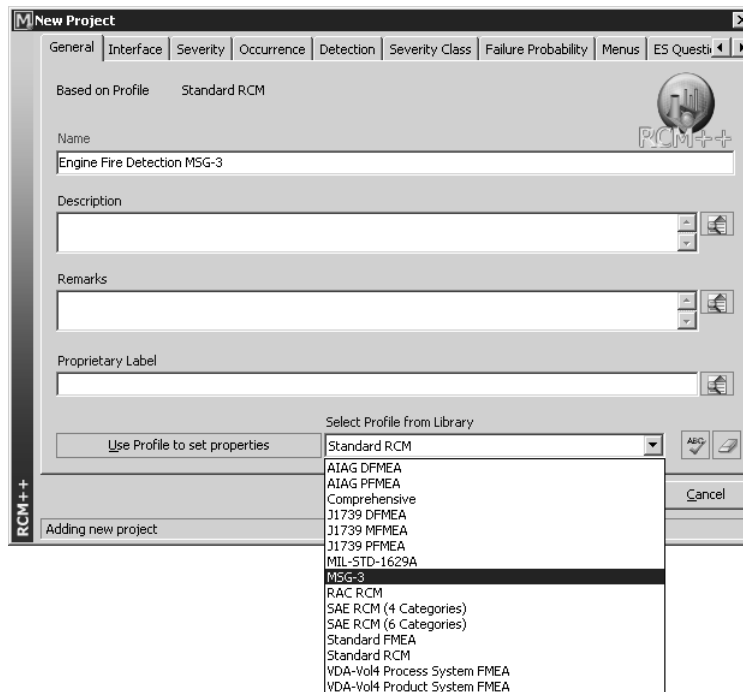
- Select **Yes, I would like to create a project now** and click **Finish**.

4.2.3 Create a New Project

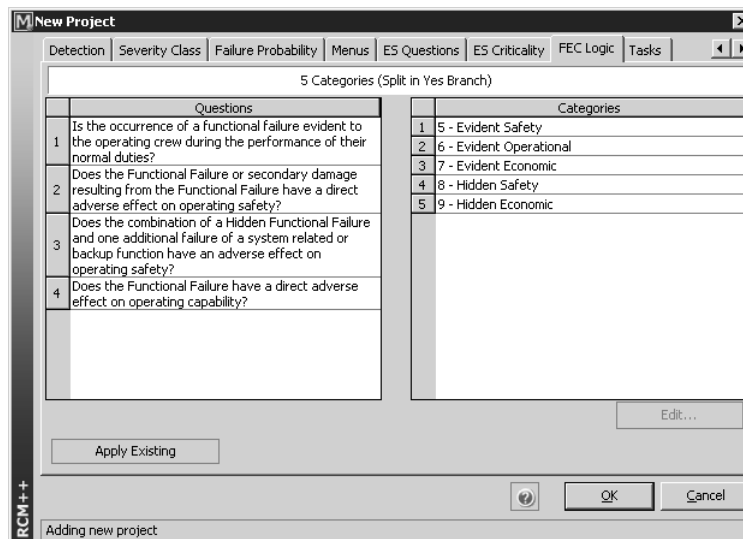
After you have created the new database, the next step is to create a project within the new database. The New Project window allows you to set the properties that apply to all of the analyses within the given project. This includes:

- **Interface Style:** which determines which data fields will be enabled/displayed for the analysis (and what they will be called). This includes user-defined fields.
- **Severity, Occurrence and Detection Rating Scales:** which allow you to rate the relative severity of the failure effects and the relative likelihood of occurrence and detection for the failure causes, if you are using the Risk Priority Number (RPN) risk assessment methodology that is commonly employed in FMEA analyses.
- **Menus:** which set the available options for menus throughout the analysis, such as Action Categories, Task Statuses, etc.
- **ES Questions:** which determines the questions and categories that will be used for the Selection Questions method of RCM equipment selection.
- **ES Criticality:** which determines the categories, factors and ratings for the Criticality Factors method of RCM equipment selection.
- **FEC Logic:** which determines the questions and categories that will be used for the RCM failure effect categorization.
- **Tasks:** which determines the questions and task types that will be used for the RCM task selection.

- In the New Project window, type **Engine Fire Detection MSG-3** for the project name. At the bottom of the window, click the **Use Profile to set properties** button and select the **MSG-3** profile from the drop-down menu, as shown next.

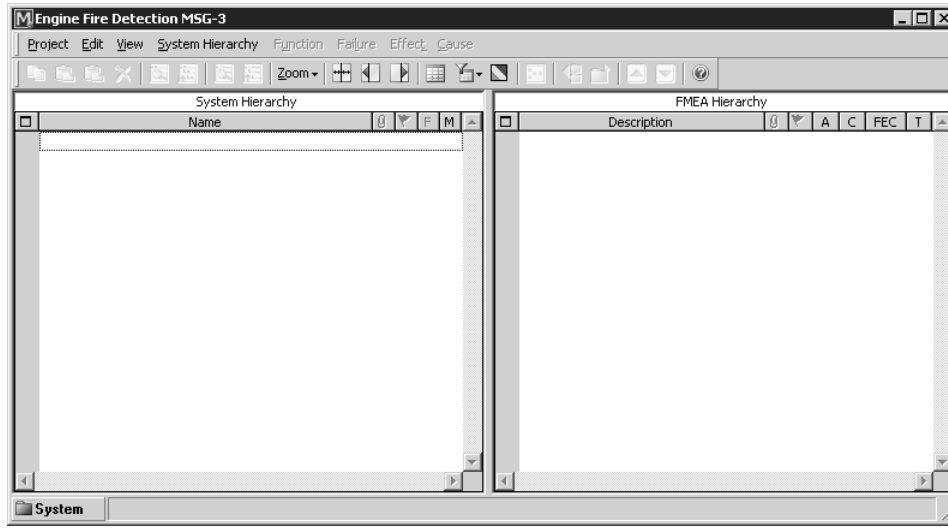


- You can then click each of the tabs in the Project Properties window to view the properties that have been set automatically by selecting the MSG-3 profile. Note that these properties cannot be edited until you have saved the project for the first time. The FEC Logic page for the MSG-3 profile is shown next.



- Click **OK**. The Project window will appear. The Project window is the main window that you will use to perform your analyses. It presents all of the items, functions, failures, effects, causes, controls, actions, tasks and related properties that you have defined within a particular project and provides all the tools

required to add and edit these records. Notice that the project name, Engine Fire Detection MSG-3, appears in the caption bar at the top of the window.



The Project window is divided into two panels. The panel on the left displays the System Hierarchy, which includes all items that have been defined in the project. The panel on the right displays the functions, failures, effects, causes, controls, actions and tasks associated with the item that is currently selected in the System Hierarchy panel. For this example, we will use the hierarchical view of this information.

4.2.4 Define the System Configuration

The analysis will be performed on the Engine Fire Detection subsystem, which has two components: Zone 1 Sensor and Zone 2 Sensor, as shown next.

Engine Fire Detection

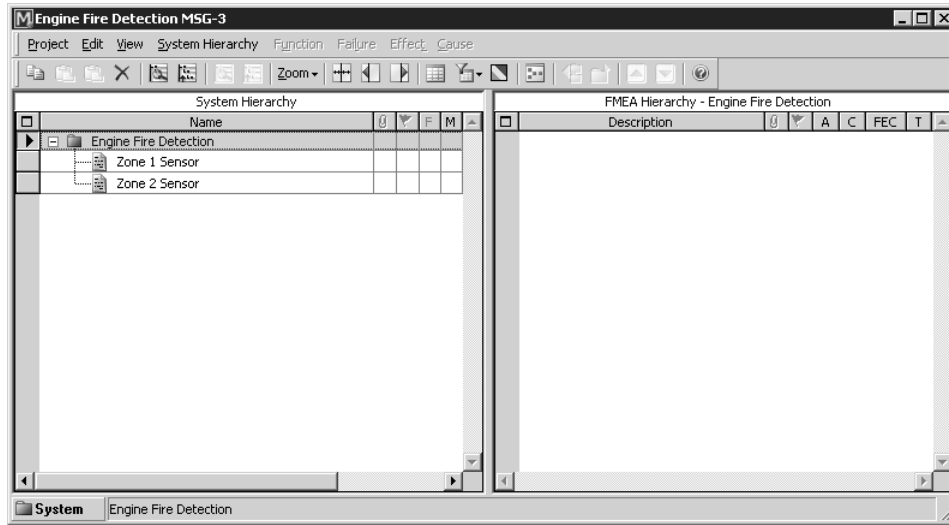
- Zone 1 Sensor
- Zone 2 Sensor
- To define this configuration and the specific properties of the item that is currently undergoing analysis, select **Add System** from the **System Hierarchy** menu to open the Add System window.
- In the Add System window, accept the default item number, **1**, that appears in the # input box.¹

¹. The item # will automatically be set for you if the **Autonumber new Items** option is selected on the Settings (2) page of the User Setup. If it is not automatically set, type **1** in the # input box.

- Type **Engine Fire Detection** in the Item Name input box. The Add System window will look like the one shown next.

- Click **OK** to add the top level item to the system hierarchy.
- Next, add the Zone 1 Sensor component to the system configuration by selecting the system, **Engine Fire Detection**, and then selecting **Add Next Level Item** from the **System Hierarchy** menu.
- In the Add Item window that appears, accept the default item number, **2**, and type **Zone 1 Sensor** in the Item Name input box. In addition, enter the following item properties on the General and Other pages of the window:
 - **Part Number:** AC2611G201
 - **Qty per System:** 16
 - **Qty per NHLA:** 4
 - **Supplier:** VORTOS Inc.
 - **Similar To:** Various
- Click **OK** to add the item to the configuration.
- With the **Zone 1 Sensor** item selected, select **Add Same Level Item** from the **System Hierarchy** menu and enter the following item properties:
 - #: 3
 - **Name:** Zone 2 Sensor
 - **Part Number:** AC2611G202
 - **Qty per System:** 8
 - **Qty per NHLA:** 2
 - **Supplier:** VORTOS Inc.
 - **Similar To:** Various
- Click **OK** to save the changes and close the window.

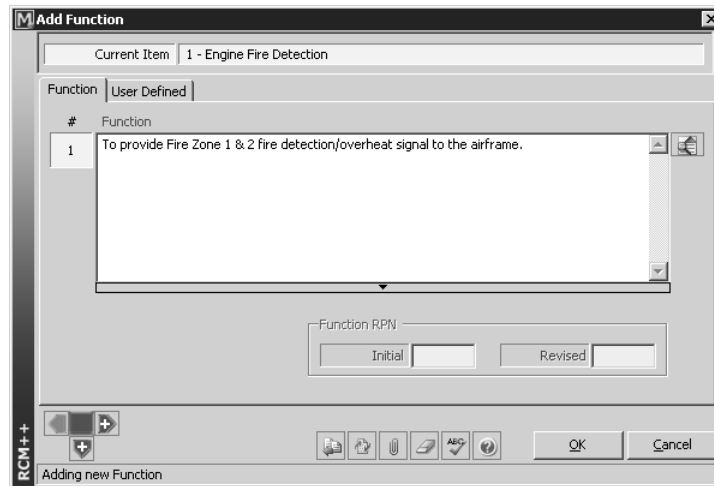
Once all three items have been added to the system hierarchy, your Project window will look like the one shown next.



4.2.5 Define the Functions

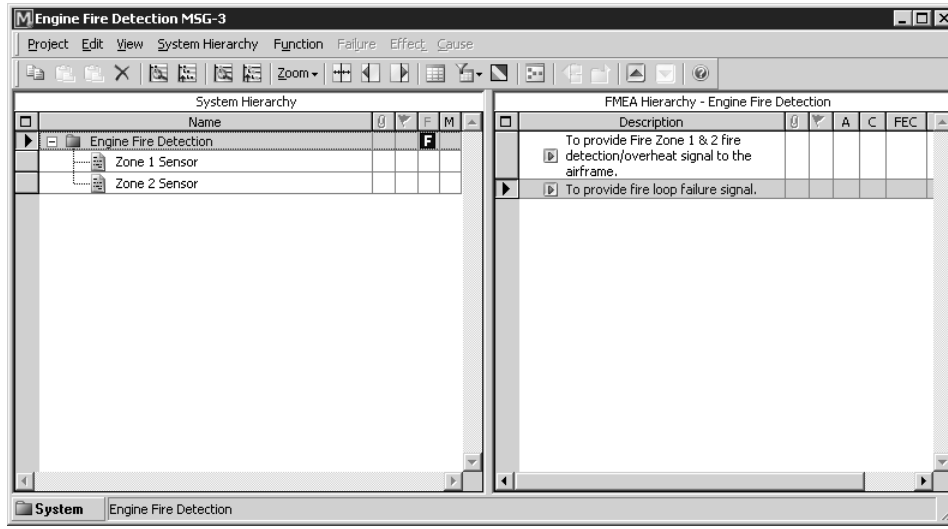
The following functions have been identified for the system in this example:

- To provide Fire Zone 1 & 2 fire detection/overheat signal to the airframe.
- To provide fire loop failure signal.
- To define a function, select the item it pertains to in the system hierarchy (in this case, **Engine Fire Detection**) and select **Function** then **Add Function** from the **System Hierarchy** menu or press **F6**. You can also right-click the item and select **Function** then **Add Function** from the shortcut menu. The Add Function window will appear.
- Type the description for the first function, **To provide Fire Zone 1 & 2 fire detection/overheat signal to the airframe**, in the Function input box, as shown next.



- Click **OK**. The function will appear in the panel on the right side of the Project window.

- Add the second function to the system in the same way. When you have added both functions, the Project window will look like the one shown next.



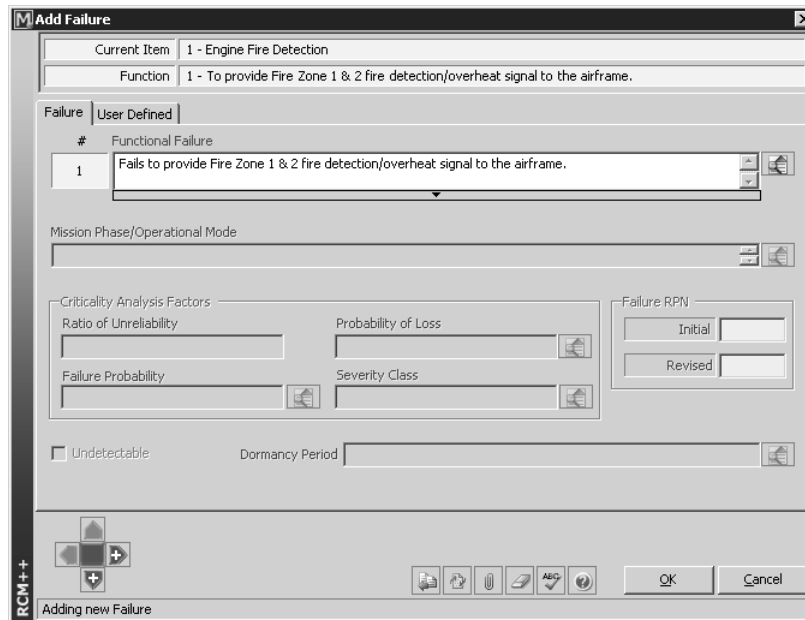
4.2.6 Define the Potential Failures

Two potential failures have been identified for the first function in this example.

Fails to provide Fire Zone 1 & 2 fire detection/overheat signal to the airframe.

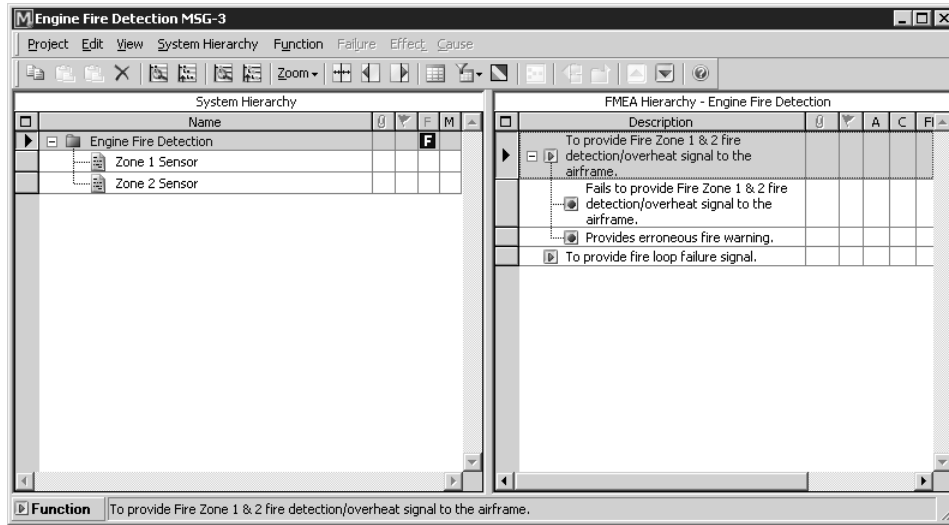
Provides erroneous fire warning.

- To define a failure, select the function and select **Add Failure** from the **Function** menu or press **F7**. You can also right-click the function and select **Add Failure** from the shortcut menu. The Add Failure window will appear.
- Type the description of the potential failure into the Functional Failure input box, as shown next.



- Click **OK**. The failure will appear in the panel on the right side of the Project window.

- Add the second failure in the same way. When you have added both failures, the Project window will look like the one shown next.

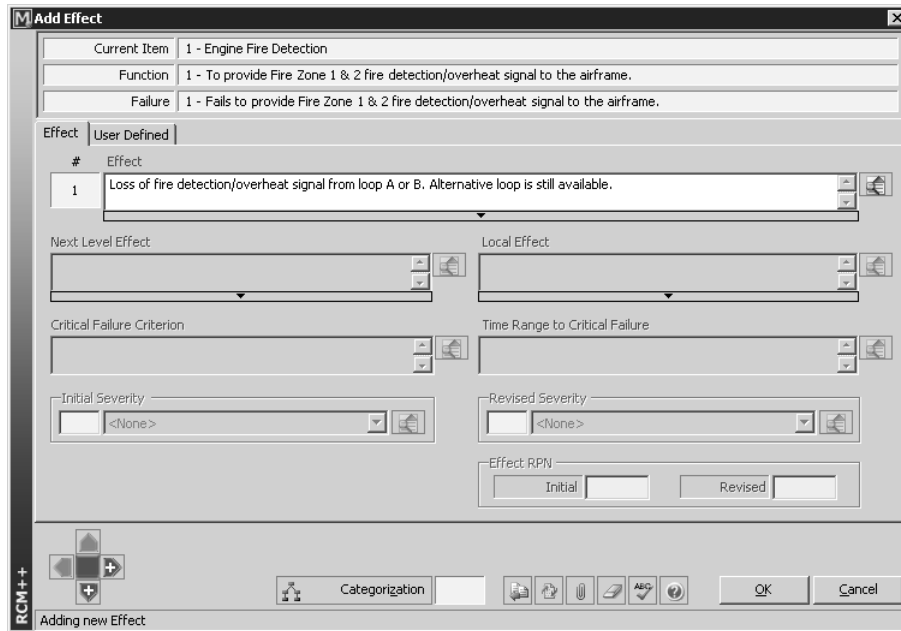


4.2.7 Define the Potential Effects of Failure

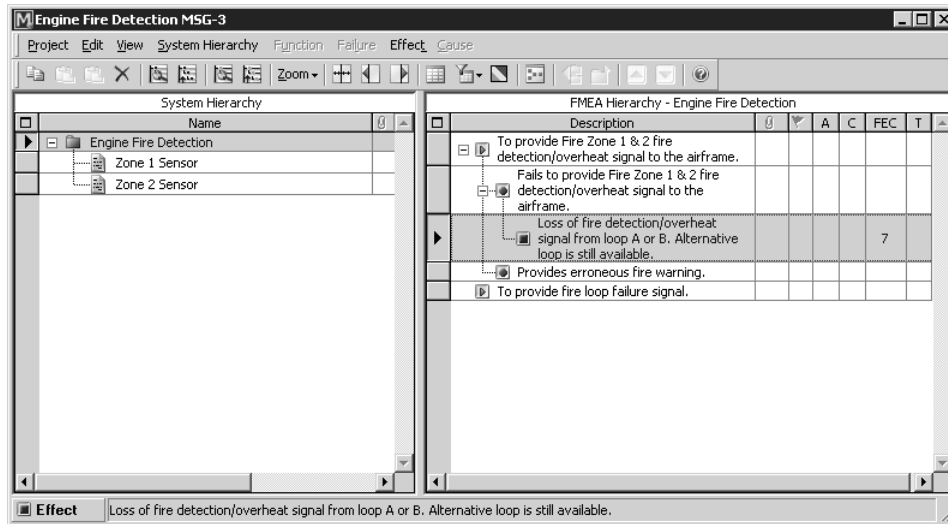
One potential effect of failure has been identified for the first potential failure in this example:

Loss of fire detection/overheat signal from loop A or B. Alternative loop is still available.

- To define an effect, select the failure and select **Add Effect** from the **Failure** menu or press **F8**. You can also right-click the failure and select **Add Effect** from the shortcut menu. The Add Effect window will appear.
- Type the description of the potential effect of failure into the Effect input box, as shown next.



- Click the **Categorization** button to display the Failure Effect Categorization (FEC) logic for this analysis. Answer **Yes** to Question 1, **No** to Question 2 and **No** to Question 4 to categorize the effect as **7 - Evident Economic**.
- Click **OK** to close the (FEC) window and then click **OK** to close the Effect window.
- The effect will appear in the panel on the right side of the Project window, with the categorization displayed in the FEC column, as shown next.

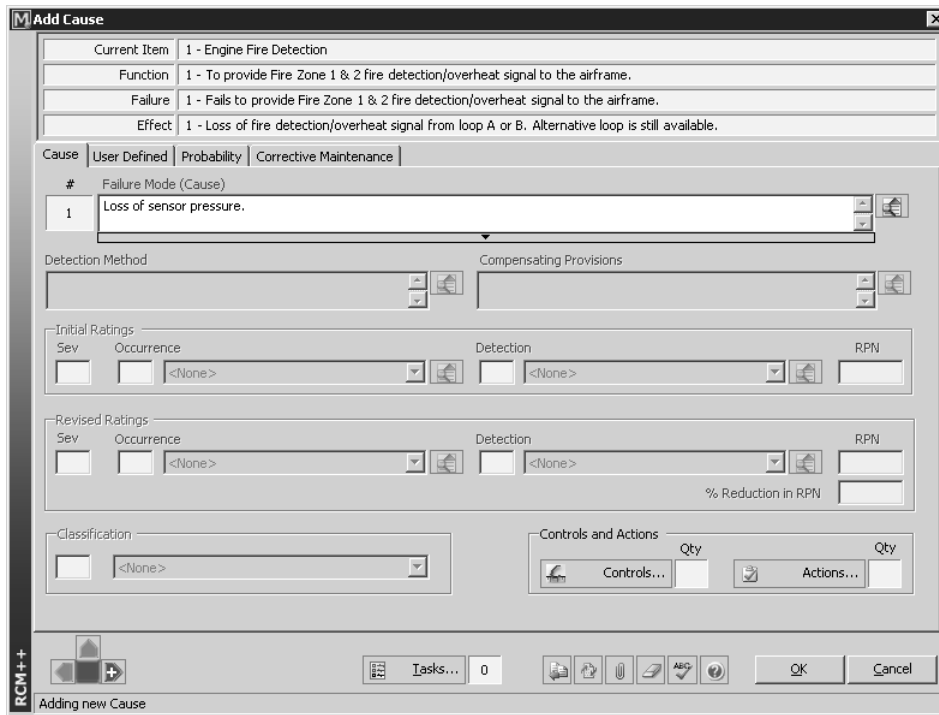


4.2.8 Define the Potential Causes of Failure

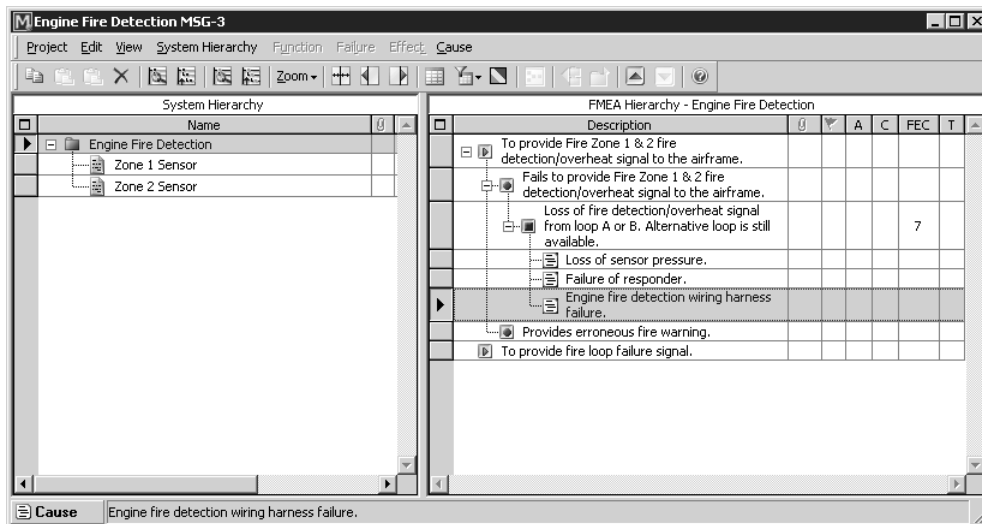
Three potential causes of failure (also called failure modes) have been identified for the first failure in this example:

- Loss of sensor pressure.
- Failure of responder.
- Engine fire detection wiring harness failure.
- To define a cause, select the effect and select **Add Cause** from the **Effect** menu or press **F9**. You can also right-click the effect and select **Add Cause** from the shortcut menu. The Add Cause window will appear.

- Type **Loss of sensor pressure** into the Failure Mode (Cause) input box, as shown next.



- Click the right-plus navigation arrow in the bottom left corner of the window to save the first cause and add the next one. Repeat for the third cause and then click **OK** to close the window.
- The causes will appear in the panel on the right side of the Project window, as shown next.



4.2.9 Select and Define a Maintenance Task

One maintenance task has been selected to address the first cause of failure.

Detailed inspection of engine fire detection loops.

- Double-click inside the **T** column to the right of the “Loss of sensor pressure” cause to open the Maintenance Task Manager.

The FEC for the effect of this failure is displayed in the middle of the window, along with the Task Selection Questions from the MSG-3 analysis guidelines that are applicable for Evident Economic effects.

- Click the **Yes/No** column to the right of the second question to change the answer to **Yes**, indicating that a scheduled inspection task is applicable and effective to address this issue. If desired, you can type some additional comments in the text box to the right.

Question	Yes/No	Explanation
7A: Is a lubrication or servicing task applicable and effective?	No	
7B: Is an inspection or functional check to detect degradation of function applicable and effective?	Yes	Comments regarding applicability of inspection task.
7C: Is a restoration task to reduce failure rate applicable and effective?	No	
7D: Is a discard task to avoid failures or to reduce the failure rate applicable and effective?	No	

#	Task Name	Status	Type	Assigned Interval	Labor (Crew Name)	Total Duration per Incident	Total Cost per Incident	Cost per Uptime	Average Availability (%)
1	Undetermined								

- Click **Add Task** to define the task. Enter the following information:
 - #:** Accept the default, 1.
 - Task Name:** Detailed inspection of engine fire detection loops.
 - Type:** Inspection (IN)
 - Status:** Assigned
 - Assigned Interval:** 2000 Hour
 - Remarks:** Inspect for condition and security.
 - Zone:** 400

The window will look like the figure shown next.

- Click **OK** to save the changes and close the window.
- Click **OK** to exit the Maintenance Task Manger.

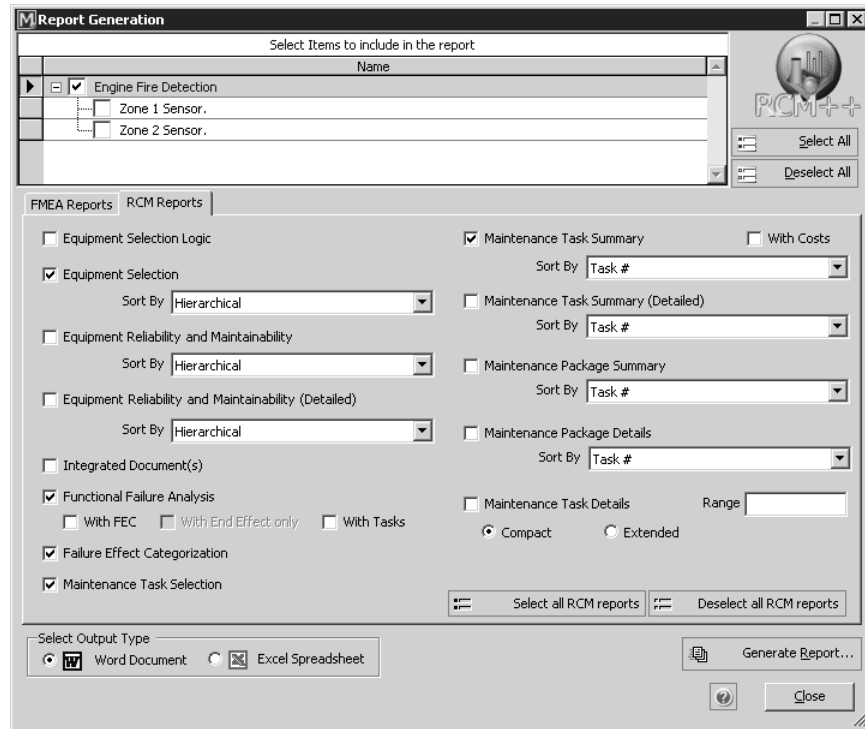
The remaining analysis for this subsystem will not be entered during this example. The full analysis is available for review (if desired) in the “8 – Aircraft RCM (MSG-3)” project in the Demonstration.rx4 database that is installed in the Examples folder of the RCM++ application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Examples).

4.2.10 Generate a Report of the Analysis

The next step is to generate a print-ready report for the analysis.

- Select **Generate Reports** from the **Project** menu. The Report Generation window will appear, which allows you to specify the items and forms you want to include in the report and whether you want to create the report in Microsoft Word or Microsoft Excel.
- Select the **Engine Fire Detection** item in the area at the top of the window.
- On the FMEA Reports page, click **Deselect all FMEA reports** to clear all selections and then select only the **Report Summary** form.
- Go to the RCM Reports page and click **Deselect all RCM** reports. Select the following report forms on this page:
 - **Equipment Selection**
 - **Functional Failure Analysis**
 - **Failure Effect Categorization**
 - **Maintenance Task Selection**
 - **Maintenance Task Summary**

- In the Select Output Type area at the bottom of the window, select **Word Document**.
- The window will now look like the one shown next.



- Click **Generate Report**. The Save File As window will appear, which allows you to specify the name and location for the report. Specify to save the report as **Aircraft MSG-3 Report**.
- Click **Save**. The report will be created and will automatically open in Microsoft Word.
- After you have finished reviewing the report, close Microsoft Word and then close the Report Generation window.
- Leave the database open and proceed to the next example.

4.3 Example 2 - Add Authorized Users to Secure Database

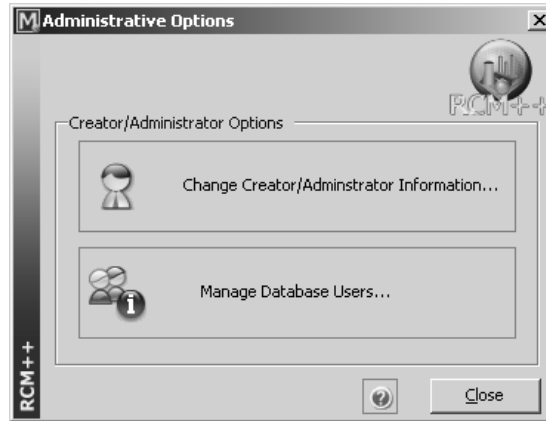
This example will guide you through the process to add authorized users to the AircraftExample.rx4 database that you created in the previous example. When you are working with databases that have Login Security enabled, keep in mind that the following special functions and considerations apply:

- Access to the database is restricted to individuals who have an authorized user account for the database.
- The database can be accessed simultaneously by more than one authorized user. These users will have read-only permission to access to any portion of the database that is currently being edited by another user and will have read-write permission to access to the rest of the database.
- Each record properties window will display the date/time and the name of the user who last edited the record.
- The application will maintain a list of every login to the database, which includes the name of the user and the date/time of the login.
- Users will have the ability to “lock” entire projects in the database or specific sections of the analysis. This prevents other users from editing the material while the lock is in place.

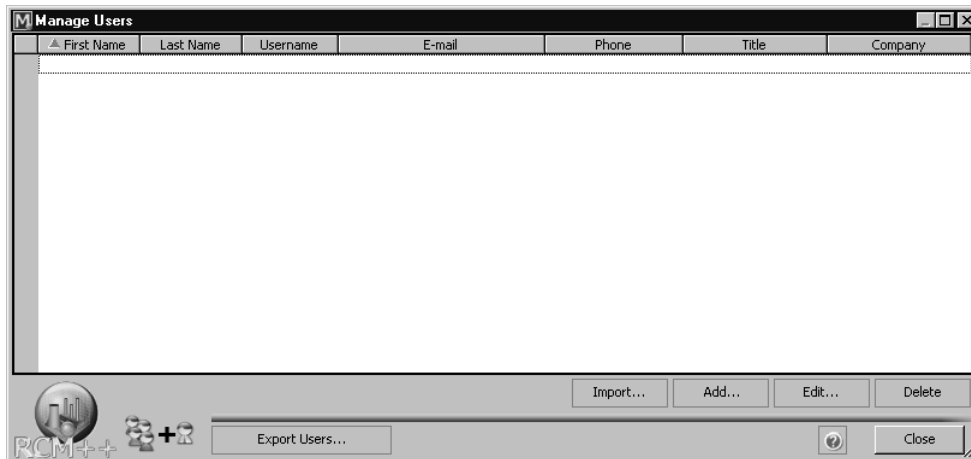
The next sections will guide you through the steps to add an authorized user to a database and import an existing user account from another database.

4.3.1 Add a User to the Database

- With the AircraftExample.rx4 database open, select **Administrative Options** from the **Tools** menu. In the Administrative Options window that appears, enter the administrative username and password that you established when you first created the database and click **Login**. If you followed the instructions in Section 4.2.2, this will be “**username**” and “**password.**”
- After you have entered a valid administrative password, the Administrative Options window will change to display two buttons, as shown next.



- Click **Manage Database Users** to open the Manage Users window. This window displays a list of all user accounts (except the administrative account) that have been defined for the current database.



These users are authorized to view and edit the material contained in the database but they do not have the ability to add, edit or delete the authorized user accounts that have been established for the database.

- To add a new user, click **Add**.

- In the User Login and Contact Information window, enter the required fields to create a new user account. Enter the following information:
 - **First Name:** Jane
 - **Last Name:** User
 - **Username:** janeuser
 - **Password:** password²
 - **Confirm:** password
 - **E-Mail:** RCM@ReliaSoft.com

Your screen will look like the figure shown next.

- Click **OK** to create the account.

You can see that the new user account has been added to the list of authorized users. *Note:* In addition to the ability to add new users, you can use the **Edit** and **Delete** buttons in the Manage Users window to manage existing user accounts.

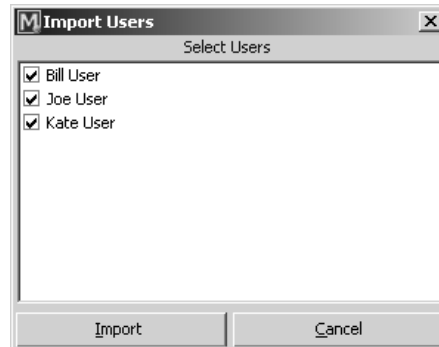
4.3.2 Import a User Account from Another Database

You can also import user accounts from another database with Login Security enabled.

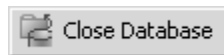
- To try this, click the **Import** button in the Manage Users window. You will be prompted to select the database that you want to import user accounts from.

² Note that RCM++ prevents multiple users from having the same username but it does not require the passwords to be unique.

- Select **AuthorizedUsers.rx4** from the Training folder in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training) and click **Open**. A list of the user accounts that have been defined in the selected database will now be displayed in the Import Users window, as shown next.³



- By default, all users will be selected for import. Accept this selection and click **Import** to add the user accounts to the current database. These users are now authorized to view and edit the material in the current database.
- When you are finished investigating RCM++'s capabilities to manage authorized database users, close the Manage Users window and then close the Administrative Options window. If desired, you can close the database before proceeding to the next example by selecting **Close Database** from the **File** menu or by clicking the **Close Database** icon.



If you do not close the database, it will be closed automatically when you create a new database for the next example.

4.4 Example 3 - Maintenance Task Intervals, Costs and Packaging

This example will guide you through the steps required to calculate the optimum interval for a repair/replacement maintenance task, to estimate operational costs that can be used to compare maintenance strategies and to create maintenance packages.

For this example, you will work with sample data provided for demonstration purposes. *This information is not intended to be realistic.*

4.4.1 Create a New Database without Login Security Enabled

The first step is to configure the software so that the new databases that you create will not require a username and password to access the database.

- To do this, select **User Setup** from the **File** menu and click the **Settings (1)** tab.
- De-select the **Enable Login Security features for new databases** option and click **OK** to close the User Setup.
- Next, select **New Database** from the **File** menu or click the **New Database** icon.



³. Note that if a user account in the source database already exists in the destination database, it will not be listed in the Import Users window.

- Type **TaskExample.rx4** for the filename and click **Save** to create the database.

4.4.2 Create a New Project

Because you created a database without Login Security enabled, the Database Creation Wizard was not displayed. Instead, RCM++ takes you immediately to the New Project window, which allows you to create a project for your new database.

- Type **Maintenance Tasks** for the Name, make sure that the **Standard RCM** profile has been selected to set the project properties and click **OK** to create the project.

4.4.3 Create an Item and Define the Reliability/Maintainability

- Select **Add System** from the **System Hierarchy** menu to create an item.
- Accept the default #, **1**, type **Equipment A** for the Item Name and, if desired, define some additional properties, such as Part Number, Supplier, Environmental Conditions, etc.
- Click **Reliability** to open the Item Reliability and Maintainability window. Go to the **Maintainability** tab to define the operating time and units. This is the total amount of time that the equipment is expected to operate for the scope of your analysis and this information will be used for the cost calculations that will be performed later. Enter the following:
 - **Operating Time** = 10
 - **Units** = Year⁴

⁴ Note that the Units menu for this and other cost calculation inputs within the software allows you to enter time-based values in different units, which will be converted to the common “Base Unit” for calculation purposes. The available units and the necessary conversion factors are set via the Menus page in the Project Properties window.

- In addition, specify an **Item Downtime Rate** of **\$100 per Hour** to indicate that for each hour that the equipment is down due to failure or maintenance, it will cost the organization \$100 in terms of lost production, scrap, etc. The window will look like the figure shown next.⁵

Parent System	N/A
Next Higher Assembly	N/A
Current Item	1 - Equipment A

Reliability | Maintainability

Operating Time: 10 Units: Year

Item Downtime Rate: 100.00 per Hour

RCM++ Last Update Date: 6/19/2007

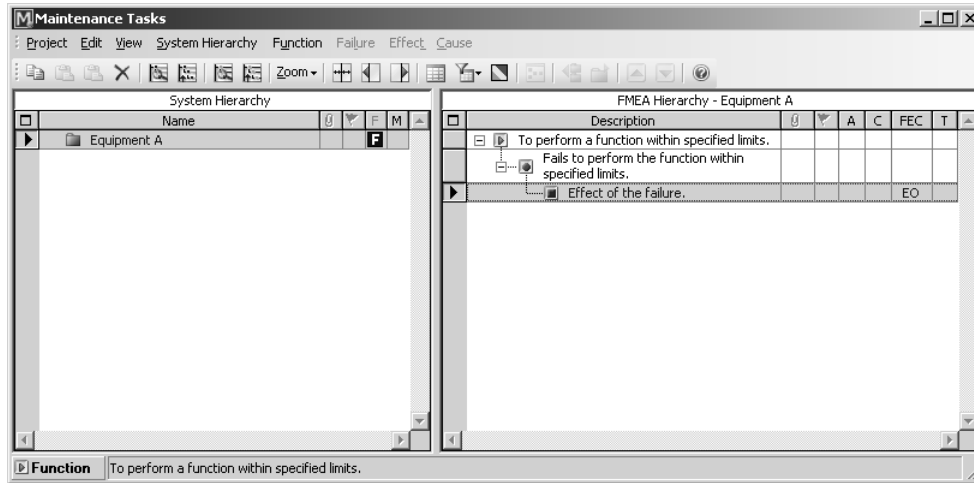
Click **OK** to close Item Reliability and Maintainability, then **OK** to close Edit Item.

4.4.4 Create a Function, Failure and Effect

- With the Equipment A item selected, select **Function** then **Add Function** from the **System Hierarchy** menu or shortcut menu to open the Add Function window. Type the following function description:
 - To perform a function within specified limits.
- Click the down-plus navigation arrow in the bottom left corner of the window to save the function and open the Add Failure window. Type the following failure description:
 - Fails to perform the function within specified limits.
- Click the down-plus arrow to save the failure and open the Add Effect window. Type the following effect description:
 - Effect of the failure.
- Click the **Categorization** button to open the Failure Effect Categorization window. Answer **Yes** to Question 1, **No** to Question 2 and **Yes** to Question 4 or select **EO - Evident Operational** from the **Category** menu.

⁵. Note that the default currency symbol for RCM++ is U.S. dollars (\$) but this can be changed from the Other page of the User Setup.

- Click **OK** to save the categorization and then click **OK** again to save the effect. The Project window will look like the figure shown next.



4.4.5 Define the Cause, Probability and Corrective Maintenance Properties

- With the effect selected, select **Add Cause** from the **Effect** menu or shortcut menu to open the Add Cause window. Type the following cause description:
 - Actionable cause of failure.
- Click the **Probability** tab so that you can define the probability density function (*pdf*) for this particular failure cause. Select **Define the probability of occurrence for this Cause** to enable the rest of the cause probability settings and specify the following:
 - **Data Source:** Field data for a similar component.
 - **Distribution Units:** Hour
 - **Distribution:** Weibull
 - **Beta:** 1.5
 - **Eta:** 2500
 - **Gamma:** 0

The window will look like the figure shown next.

The screenshot shows the 'Add Cause' dialog box in RCM++ software. The dialog is titled 'Add Cause' and has a close button (X) in the top right corner. It contains several fields and tabs:

- Current Item:** 1 - Equipment A
- Function:** 1 - To perform a function within specified limits.
- Failure:** 1 - Fails to perform the function within specified limits.
- Effect:** 1 - Effect of the failure.

Below these fields are four tabs: **Cause**, **User Defined**, **Probability**, and **Corrective Maintenance**. The **Probability** tab is selected.

Inside the **Probability** tab, there is a checkbox labeled 'Define the probability of occurrence for this Cause.' which is checked. Below this is a 'Data Source' field containing the text 'Field data for a similar component.'

The main area is divided into two sections:

- Distribution and Parameters:** This section has a 'Distribution Units' dropdown menu set to 'Hour'. To the right are three icons: a triangle, a 'W!' icon, and a square with a diagonal line. Below this is a list of distribution types: Weibull, Exponential, Normal, Lognormal, Mixed Weibull - 2, Mixed Weibull - 3, and Mixed Weibull - 4. The 'Weibull' option is selected. To the right of this list are three input fields: 'Beta' (value: 1.5), 'Eta' (value: 2500), and 'Gamma' (value: 0).
- Calculate Probability:** This section has two input fields: 'Time' and 'Probability'. Below these is a 'Calculate' button with a 'W!' icon.

At the bottom of the dialog, there is a status bar with 'RCM++' on the left, a 'Tasks...' field with '0', and several icons. On the right side of the status bar are 'OK' and 'Cancel' buttons.

If desired, you can enter a time value and click the **Calculate** icon to estimate the probability of failure due to this failure cause at the specified time.

- Click the **Corrective Maintenance** tab so that you can specify the time and resources required to restore the equipment if this failure cause occurs. You can see that the operating time and downtime rate that you specified for the equipment is displayed for your reference at the top of the page. In addition, specify the following:
 - **Restoration Factor:** Enter **1** to indicate that the equipment will be fully restored (*i.e.* “as good as new”) after the corrective maintenance.
 - **Labor Rate:** Enter **\$150 per Hour**. Note that the units that you specify for labor will also be applied to the task duration times that you enter next.
 - **Task Duration:** Enter **24** hours for the **Delay - Wait for Labor** and **6** hours for the **Task Duration**. Therefore, the Total Duration per Incident will also be 30 hours.
 - **Cost per Incident:** Enter **\$200** for **Materials Cost**. You can see that the Downtime Cost and Time Based Labor Cost are entered automatically based on the downtime and labor rates that have already been entered and the task duration. Therefore, the Total Cost per Incident will be \$4,100.

The window will look like the figure shown next.

- Click the **Calculate** icon to start the simulation that will be used to estimate the operational cost and availability that can be expected if no preventive maintenance is performed for this failure cause (*i.e.* a run-to-failure maintenance strategy). When the process completes, a window will display the number of corrective maintenance actions and the amount of uptime projected by the simulation. These are inputs to the Cost per Uptime, Total Operating Cost and Average Availability calculations. Click **OK** to return to the Add Cause window, which displays the calculated results:
 - **Cost per Uptime** = 1.813 / Hour
 - **Total Operating Cost** = \$156,747.10
 - **Average Availability** = 98.691%

The specific calculation methods for these estimates are presented in detail in the *RCM++ User's Guide*.

4.4.6 Define a Repair/Replacement Maintenance Task

- Click the **Tasks** button to open the Maintenance Task Manager for this cause.

You can see that the FEC for the associated effect and the applicable maintenance task selection questions (based on the RCM logic that has been pre-defined for the project) are displayed in the middle of the window. The Cost per Uptime calculated for a run-to-failure maintenance strategy (corrective maintenance only) is also displayed for your reference. The table at the bottom of the window displays the tasks that have been assigned or are under consideration to address this particular failure cause.

- Click **Add Task** to open the Add Task window. Accept the default #, **1**, and type the following task name:
 - Scheduled repair/replacement.

- Select **Repair/Replacement (RR)** for **Type** and **Proposed** for **Status**. The task type determines the options that will be available in the Task Properties window and the calculation method that will be used for the Cost per Uptime, Total Operating Cost and Average Availability calculations.⁶
- Click the **PM Resources** tab so that you can specify the time and resources required for each scheduled repair/replacement maintenance action. Specify the following:
 - **Restoration Factor:** .9
 - **Labor Rate:** \$75 per Hour
 - **Task Duration:** 2 Hour
 - **Materials Cost:** \$100

The window will look like the figure shown next.

⁶. The available Task Types are based on the settings that have been defined on the Tasks page of the Project Properties window.

4.4.6.1 Calculate the Optimum Interval

RCM++ provides a utility that can be used to calculate the optimum interval for a repair/replacement task based on the cost of corrective maintenance, the cost of preventive maintenance and the probability of failure. To use this utility:

- Return to the **Task** page and click the **Calculate Optimum** button. The optimum interval will be entered automatically in the **Assigned Interval** field, as shown next.

The screenshot shows the 'Add Task' dialog box with the following fields and values:

- #**: 1
- Task Name**: Scheduled repair/replacement.
- Task**: PM Resources | User Defined
- Type**: Repair/Replace (RR)
- Status**: Proposed
- Maintenance Package**: (empty)
- Reference Document**: (empty)
- Proposed Interval**: (empty)
- Assigned Interval**: 1016.664
- Units**: Hour
- Calculate Optimum...** button is present.
- Based on:** Item Age System Age
- Condition**: (empty)
- Remarks**: (empty)
- Zone**: (empty)
- Access**: (empty)
- Cost per Uptime**: (empty)
- Total Operating Cost**: (empty)
- Average Availability (%)**: (empty)

- Change the **Assigned Interval** to **2 Month**, which is close to the optimum and more practical for incorporating the task into the overall maintenance plan.

4.4.6.2 Calculate the Operational Costs

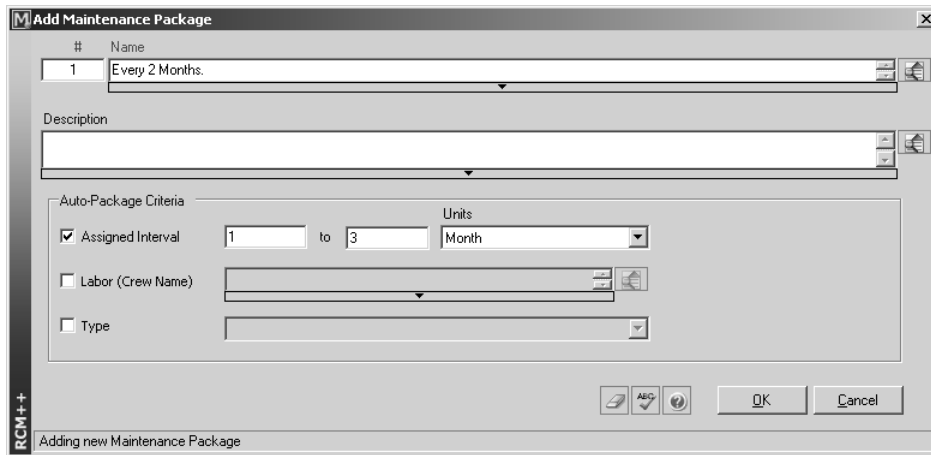
- Once you have made all of the required inputs for the maintenance task cost calculations, click the **Calculate** icon to start the simulation. When the process completes, a window will display the number of corrective maintenance actions, the number of preventive maintenance actions and the amount of uptime projected by the simulation. Click **OK** to return to the Add Task window, which displays the calculated results:
 - Cost per Uptime** = 1.501 / Hour
 - Total Operating Cost** = \$130,193.95
 - Average Availability** = 98.997%
- Click **OK** to save the changes and close the window.

4.4.7 Perform Maintenance Packaging

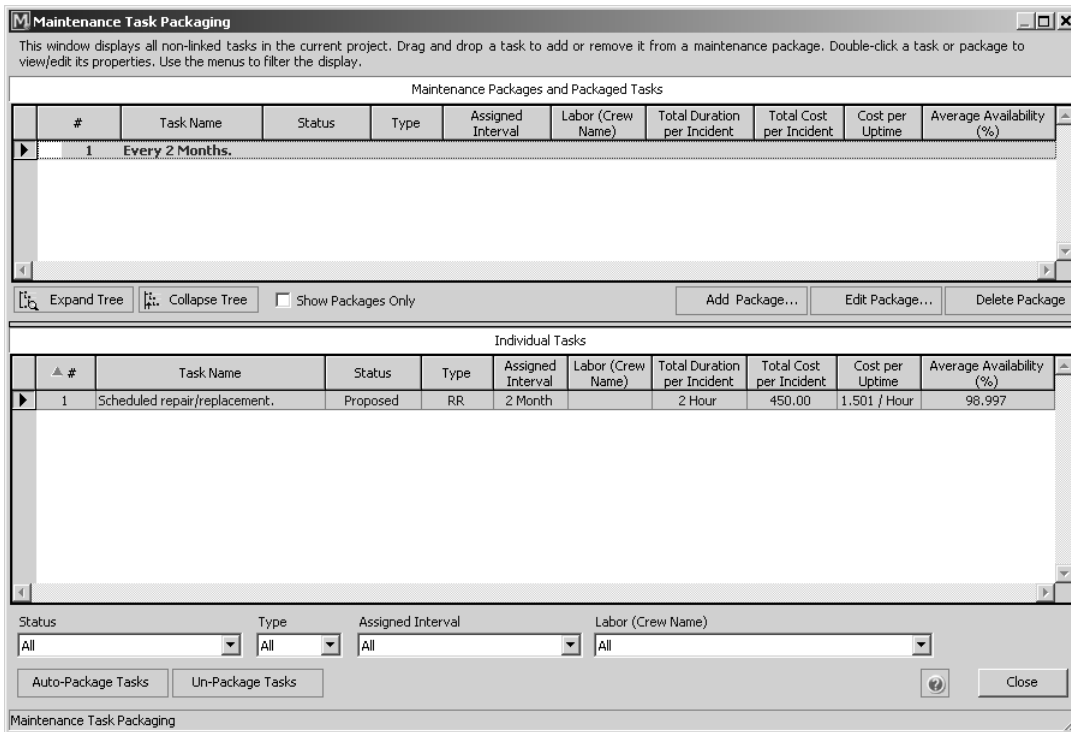
RCM++'s Maintenance Task Packaging utility allows you to group tasks together into packages based on interval, resource requirements, etc.

- From within the Maintenance Task Manager, click the **Maintenance Packaging** button to open the Maintenance Task Packaging window.

- Click **Add Package** to open the Add Maintenance Package window. Accept the default #, **1**, and type the following maintenance package name:
 - **Every 2 Months.**
- Select the **Assigned Interval** option for auto-packaging criteria and enter **1 to 3 Month**, as shown next.

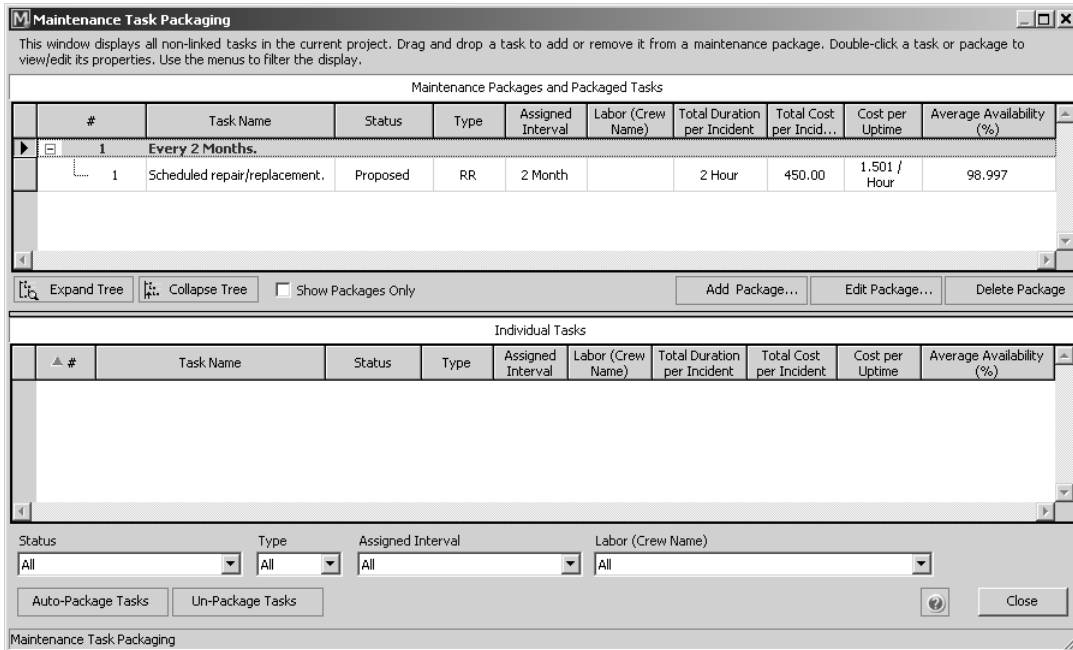


- Click **OK** to create the package, which will be displayed in the top panel of the Maintenance Task Packaging window, as shown next.



The individual, unpackaged tasks in the current project are displayed in the bottom panel. You can assign a task to a maintenance package by dragging and dropping it under the selected package or by opening the Task Properties window and selecting the appropriate package from the Maintenance Package menu. In addition, if you have specified auto-package criteria, the software can automatically assign individual tasks to a package with matching criteria.

- Click the **Auto-Package Tasks** button to start the process. When it completes, click the **Expand Tree** button to display all of the information in the top panel, as shown next.



As you can see, the individual task created for this example has been automatically assigned to the “Every 2 Months” maintenance package because the task interval, 2 Months, matches the range specified in the auto-package criteria for the package.

- Click **Close** to close the Maintenance Task Packaging window, then **OK** to close the Maintenance Task Manager then **OK** to close the Cause Properties window.

4.4.8 Make Login Security Selection for New Databases

After completing the examples up to this point, you will have worked with both secure and non-secure RCM++ databases. For the rest of the examples in this training guide, unless otherwise specified, you can decide whether or not you want to enable Login Security for the new databases that you create.

- If you prefer to work with databases that require login with an authorized username and password, then select the **Enable (activate) Login Security features for new databases** option on the Settings (1) page of the User Setup. If not, leave the setting as it currently is.
- You can now close the project and database before proceeding to the next example.

4.5 Example 4 - Excel Import/Export for Items and/or FMEAs

This example guides you through the process to import/export system configuration data and functional failure analysis (FMEA) data from Excel files that meet RCM++’s required format for import.

4.5.1 Export a System Configuration to Excel

- Open the **Export to XML** project in the BlockSimExample.rx4 database that is found in the Training folder in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training).
- Select **Export Items** then **To Excel Spreadsheet** from the **Project** menu.

- Type **System Configuration** for the name of the new Excel file and then click **Save** to start the export process.

The progress bar at the bottom of the MDI indicates that all of the items in the project's System Hierarchy panel are being exported to an Excel spreadsheet. Any information in the Item Properties window and on the Reliability page of the Item Reliability and Maintainability window will also be exported. When the process completes, the Excel file will open automatically.

- After you have reviewed the export file, close Excel and return to RCM++.

4.5.2 Create a New Database and Project

- Create a new database called **ExcelExample.rx4** and a new project called **Import and Export**. Use the **Standard RCM** profile to set the properties for the new project.

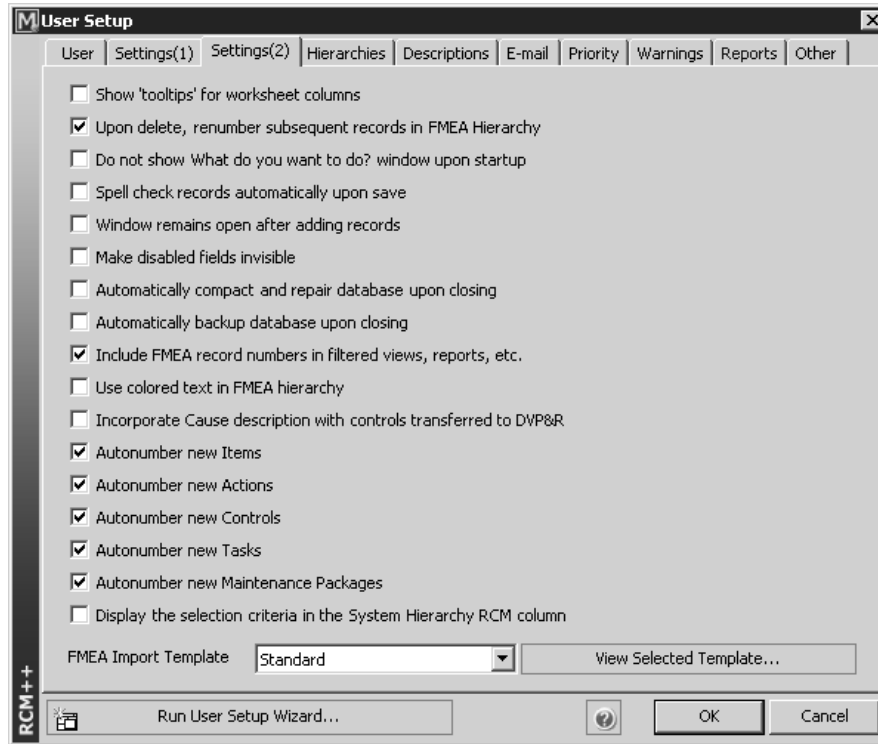
4.5.3 Import the System Configuration from Excel

- In the new project, select **Import Items** then **From Excel Spreadsheet** then **Import as Systems** from the **Project** menu.
- Navigate to the System Configuration.xls file that you just created. (*Note:* It will be in the C:\Program Files\ReliaSoft\RCM4\Reports folder if you have not changed any of the defaults for the software.)
- Click **Open** to start the import process.
- When you are asked to select a sheet for import, accept the default choice of **Item Import Template** and click **OK**.
- When the progress bar at the bottom of the MDI completes, a message will indicate that the process was completed successfully. Click **OK**. You will see that the system configuration information from the Excel spreadsheet has been imported into the current project.

4.5.4 Import Item's Functional Failure Analysis (FMEA) from an Excel File

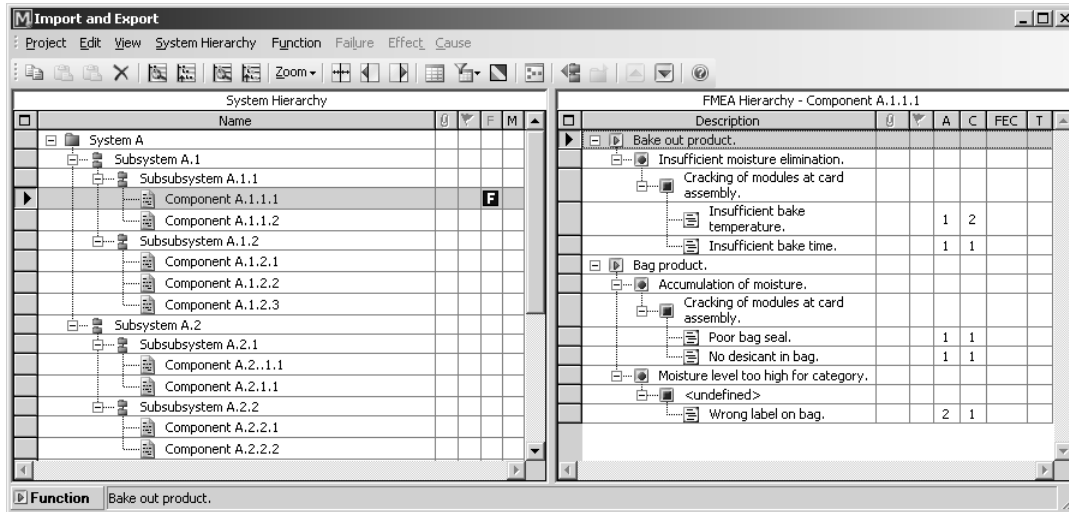
When importing functional failure analysis (FMEA) data from Excel, you can choose from two import templates that are installed in the Examples folder of the application directory (*e.g.* C:\Program Files\ReliaSoft\RCM4\Examples). The basic template (called "ImportSpreadsheet.xls") allows you to import functions, failures, effects, causes, controls and actions along with a few additional properties of those records. The comprehensive template (called "ImportSpreadsheetComprehensive.xls") allows you to import all of the properties for these records. For this example, we will be using a sample data file that follows the basic template.

- First, make sure that the software is configured to use the basic import template. To do this, select **User Setup** from the **File** menu and go to the **Settings (2)** page of the User Setup, as shown next.



- Make sure **Standard** is selected in the FMEA Import Template field at the bottom of the window and click **OK**.
- Right-click the item called “Component A.1.1.1” in the project’s System Hierarchy and select **Import/Export Item’s FMEA** and then **Import from Excel** from the shortcut menu.
- Navigate to the “Import from Excel Data.xls” file located in the Training folder in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training) and click **Open**. During the import, a progress bar will be displayed at the bottom of the MDI.
- When you are asked to select a sheet for import, accept the default choice of **FMEA - System** and **Append** and click **OK**.
- When the process is 100% complete, a message will be displayed to indicate that the information has been imported. Click **OK** to continue.

- You can see that the functions, failures, effects, causes, controls and actions defined in the Excel spreadsheet have been automatically added to the analysis in RCM++, as shown next.



4.5.5 Export Item's Functional Failure Analysis (FMEA) to an Excel File

You can also export the functional failure analysis from any RCM++ project to Microsoft Excel.

- To export the analysis in the current project, right-click **Component A.1.1.1** and select **Import/Export Item's FMEA** and then **Export to Excel** from the shortcut menu.
- Type **Excel Export** for the filename and click **Save** to start the process. The progress bar will once again be displayed at the bottom of the MDI. When the export is complete, the new spreadsheet will be opened automatically in Microsoft Excel.

This exported file fits the basic template format required for automatic import into RCM++. You can see that each unique entry is displayed in a separate column and specific types of data must always exist in a specific column. For example, the function description must be in the first column, the initial Occurrence rating must be in the twelfth column, etc.

- When you have finished investigating RCM++'s import/export functionality with Microsoft Excel, close the Excel spreadsheet, the project and the database before proceeding to the next example.

4.6 Example 5 - Using the Plot Viewer Utility

This example allows you to experiment with RCM++'s Plot Viewer Utility, which provides a variety of charts for graphical presentation of your analysis. This example will also provide some practice with RCM++'s import/export functionality.

For this example, you will work with a sample database that has been prepared by ReliaSoft, which contains sample data related to imaginary products. *Sample data sets are not intended to be realistic.*

4.6.1 Create a New Database and Project

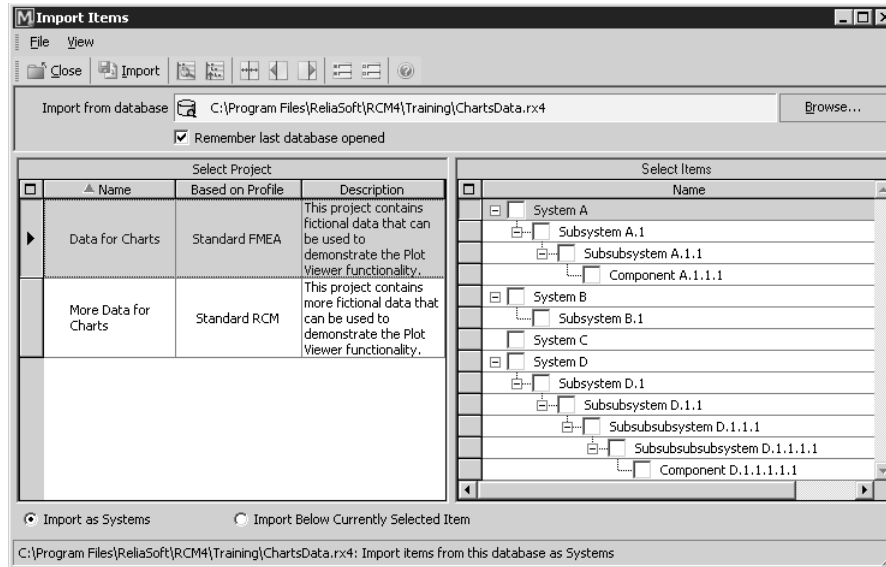
- Create a new database called **PlotsExample.rx4**.
- Create a new project called **Data for Charts**. Select the **Comprehensive** profile to set the project properties.

4.6.2 Import Items to Obtain Data

In order to save time, you will obtain the data for this example from projects that have already been created in another database.

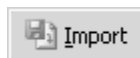
- To do this, select **Import Items** and then **From Database** from the **Project** menu. Select the database called “ChartsData.rx4” in the Training folder in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training) and click **Open**.

The Import Items window will be displayed, with the projects contained in the ChartsData.rx4 database displayed in the panel on the left and the items associated with the selected project in the panel on the right, as shown next.



The source database contains two projects and each project contains one or more items with functions, failures, effects, causes, controls, actions and tasks defined.

- To import the data from a project in the ChartsData.rx4 database to the new project that you have created, simply select one of the projects in the panel on the left and then choose **Select All** from the **File** menu. Select **Import** from the **File** menu or click the **Import Selected Items** icon.

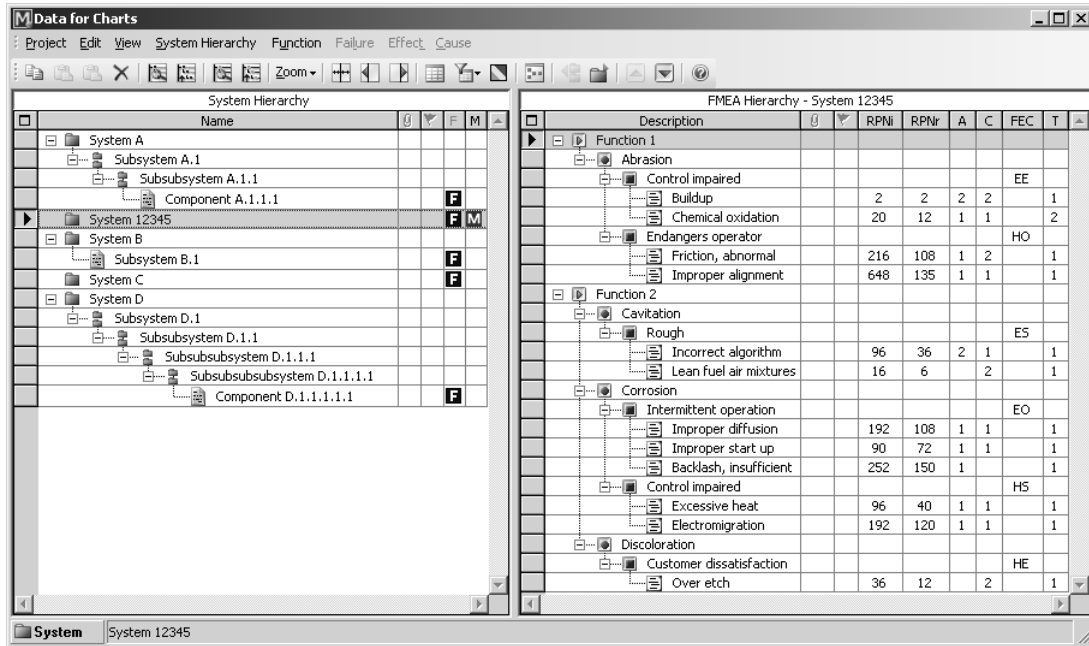


A blue progress bar will appear at the bottom of the Import Items window to show you the progress of the import action. When the import is 100% complete and the blue bar disappears, a message will appear to notify you that the selected items have been successfully imported.

- Click **OK** to continue.
- The Import Items window will remain open to allow you to import additional items. Select the other project in the ChartsData.rx4 database and repeat the process to import all of the items associated with the second project.
- When the import is complete, select **Close** from the **File** menu or click the **Close** icon in the top right corner of the window to exit the Import Items window and return to the Project window.

You can now see that all of the items from the ChartsData.rx4 database have been added to the System Hierarchy for the current project. In addition, all functions, failures, effect, causes, controls, actions, tasks

and related information associated with those items were also imported. With System 12345 selected, the Project window will now look like the figure shown next.



You can now use this fictional data to experiment with RCM++'s Plot Viewer.

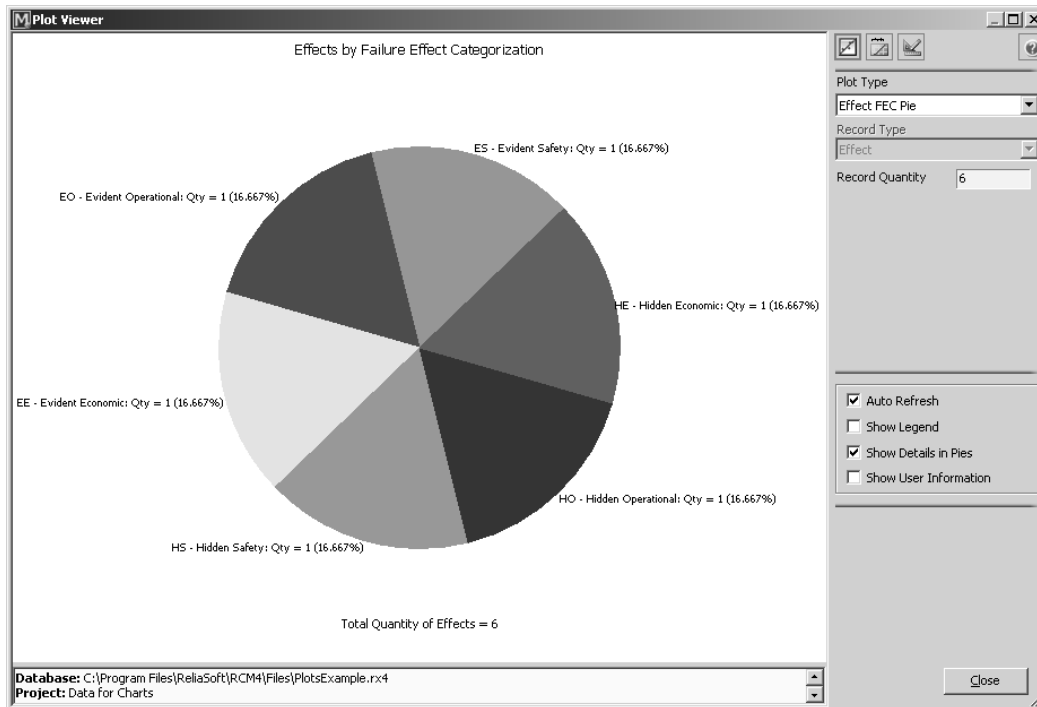
4.6.3 Generate Pie Charts

- To begin, select **Plot Viewer** from the **Project** menu or press **Ctrl+Shift+P**. The Select Items window displays all of the items that have been created in the System Hierarchy for this project and allows you to select one or more items to be included in the plots/charts that you create.
- Since the item called “System 12345” was selected in the Project window, it will also be selected in the Select Items window. With this item selected, click **OK** to open the Plot Viewer.

The Plot Viewer provides 22 different plot types to choose from and all of these plot types provide additional options to allow you to select the information to be displayed in the plot. When you first open the Plot Viewer, it will automatically create a chart based on the current data and the plot type and options for the last plot that you created.

- Select **Effect FEC Pie** from the **Plot Type** menu. The appearance of the Control Panel will change to display the options available for pie charts. Make the following selections:
 - **Auto Refresh** = Selected
 - **Show Legend** = Not Selected
 - **Show Details in Pies** = Selected
 - **Show User Information** = Not Selected

The Plot Viewer window will now look like the figure shown next.



You can see that the plot area has been updated to display a pie chart, with the segments representing the percentage of effects that have been assigned to each Failure Effect Category (FEC). In addition, the legend panel at the bottom of the Plot Viewer window has been updated with the details associated with the current chart. This includes the pathname/filename for the database, the project name, the numbers and names of the items included in the chart and the FEC percentage information.

You may wish to take some time now to experiment with the options available in RCM++'s pie charts. For example, you can hide the details on the pie chart and display them in a legend instead. Notice that if you change the size of the window or the information that is displayed in the chart, the pie graphic may change from a circle to an elliptical shape. To restore the circular shape for the pie, simply click the **Redraw/Refresh Plot** icon to re-draw the chart.

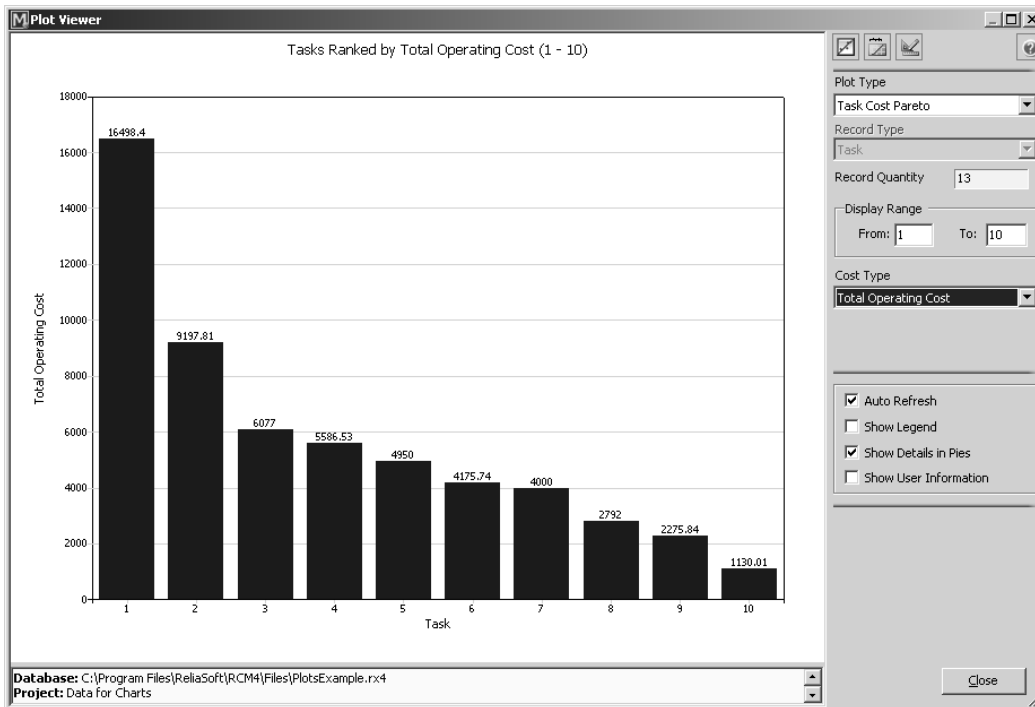


As you experiment with the plot types and Control Panel options, please be aware that if the **Auto Refresh** option is not selected, you will need to click the **Redraw/Refresh Plot** icon to update the plot area to reflect the new selections.

4.6.4 Generate Pareto (Bar) Charts

- Next, select **Task Cost Pareto** from the **Plot Type** menu and make the following selections:
 - **Display Range** = 1 to 10
 - **Cost Type** = Total Operating Cost
 - **Auto Refresh** = Selected
 - **Show Legend** = Not Selected
 - **Show Details in Pies** = Selected
 - **Show User Information** = Not Selected

The Plot Viewer will now look like the figure shown next.



You can see that the plot area has been updated to display the top ten tasks (based on Total Operating Cost) that are associated with the selected item. If desired, you can change the options in the Control Panel to display other variations of the Task Costs chart. For example, you can change the Display Range to 1 to 5 or change the Cost Type to Cost per Uptime or Total Cost per Incident. Other combinations are also available.

- You can take some time now to experiment with the other bar charts by selecting the chart from the Plot Type menu and then making the appropriate selections in the Control Panel. When you are finished, return to the Tasks Ranked by Total Operating Cost (1 - 10) chart and proceed with the example.

4.6.5 Edit Plot Setup

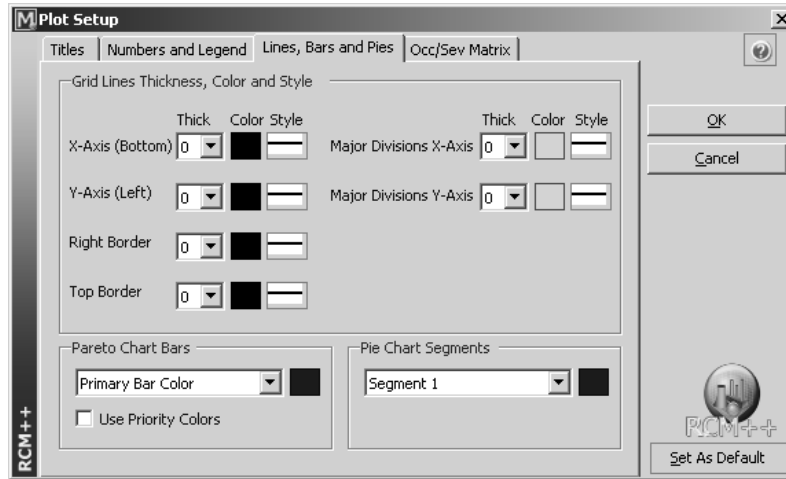
You can use the Plot Setup window to customize the appearance of the charts that you create in RCM++.

- To access this utility, right-click inside the plot area or legend panel and select **Plot Setup** from the shortcut menu or click the **Plot Setup** icon.

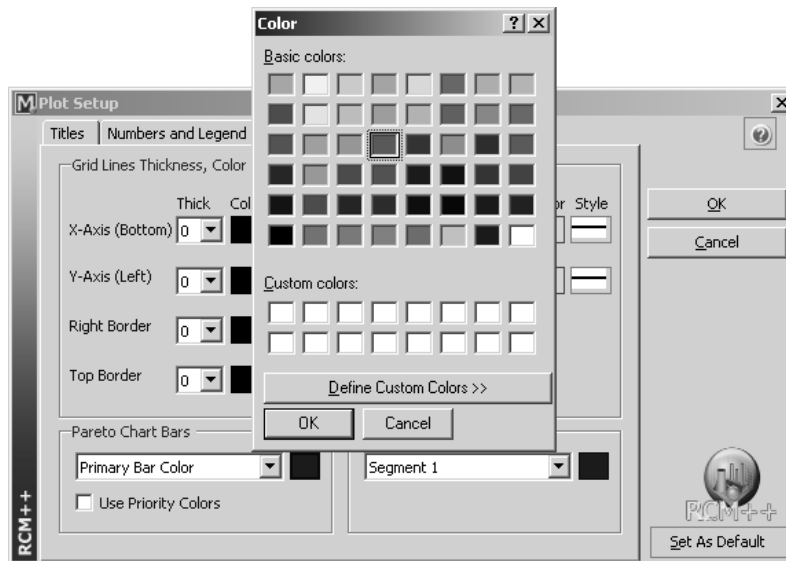


The Plot Setup provides many customization options, which are described in detail in the *RCM++ User's Guide*. For this example, you will make a change to the settings for pareto (bar) charts.

- To do this, click the **Lines, Bars and Pies** tab to display a page like the one shown next. This page presents all of the customization options for grid lines, pareto chart bars and pie chart segments.



- To change the color of the bars in the pareto chart, click the box to the right of the **Primary Bar Color** menu in the bottom left corner of the window and select a new color from the Color Palette, as shown next.



- Click **OK** to close the Color Palette and then click **OK** again to close the Plot Setup and return to the Plot Viewer window. If the new bar color is not applied automatically, click **Redraw/Refresh Plot** to update the display.

This change to the plot settings will be in effect for all pareto (bar) charts generated during this session in the Plot Viewer. If you close and re-open the window, the default settings will return. If you want a plot settings change to persist after the current session, click the **Set as Default** button in the bottom right corner of the Plot Setup window.

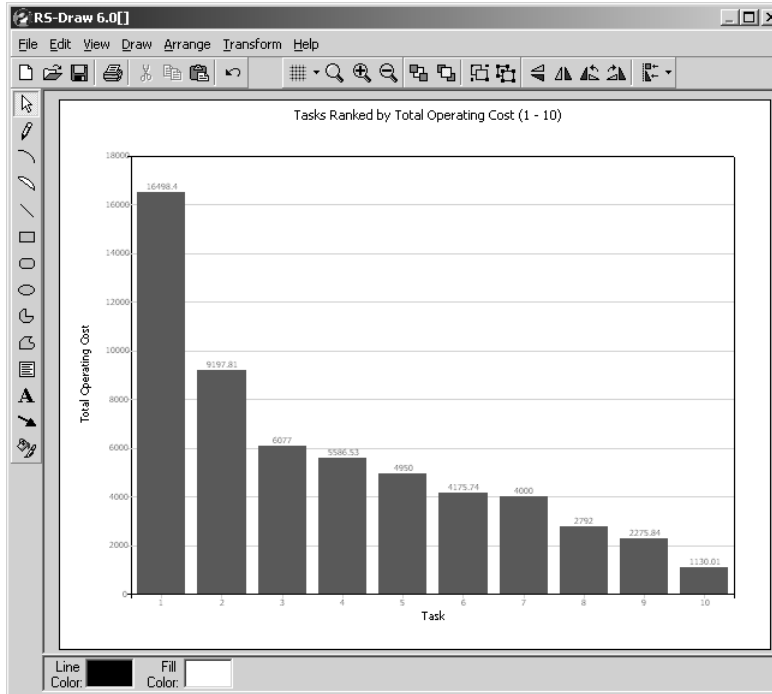
4.6.6 Send Plot to RS Draw

As in most of ReliaSoft's other software products, RCM++'s plotting utility provides integration with the RS Draw metafile (vector) graphics editor. You can use RS Draw to edit and annotate the chart graphics that you create in the Plot Viewer and also to save plot graphics as Windows metafiles (*.wmf).

- With the Tasks Ranked by Total Operating Cost chart displayed in the Plot Viewer, right-click inside the plot area or legend panel and select **Edit Plot** from the shortcut menu or click the **Edit Plot** icon.



The RS Draw utility will be opened with the current chart displayed, as shown next.



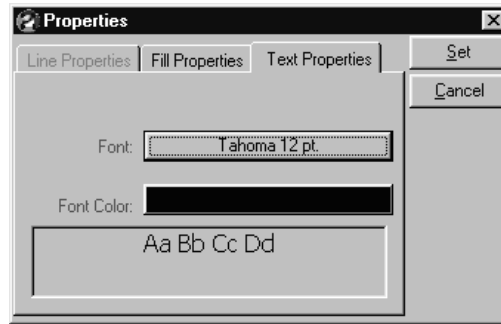
- You can expand the title for the chart to include the name of the item analysis that the chart is based on. To do this, click the **Text** tool from the toolbar on the left side of the window.



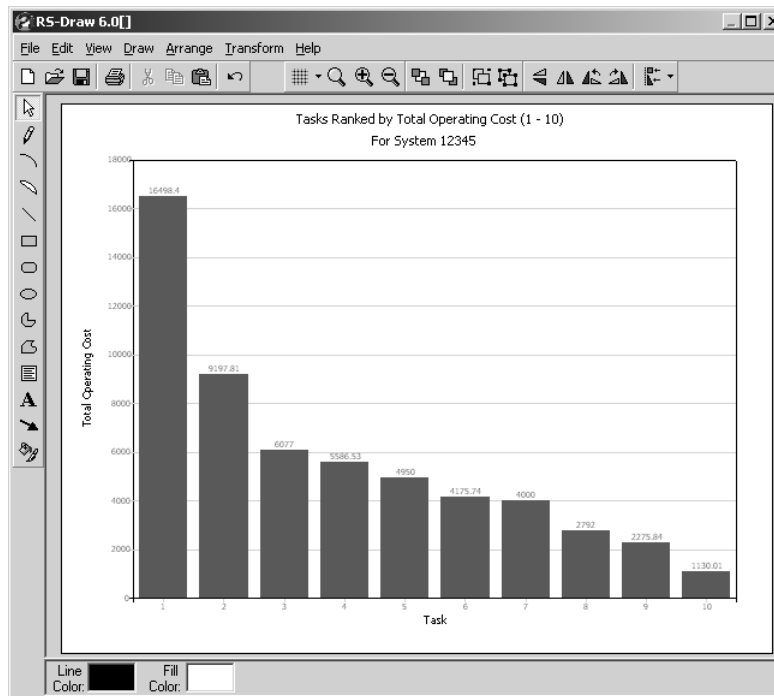
- The cursor will turn into an arrow with a T next to it. Click inside the plot in the area of the title and drag the mouse down for a short distance before releasing the left mouse button. A blinking vertical line will be placed into the graphic at the location where you placed the mouse and the length of this line will depend on how far you dragged the mouse.
- Type the following text into the plot and the press **Enter** to create the new text object.
 - For System 12345
- Click the **Select** tool and use it to right-click the new text object.



- Select **Object Properties** from the shortcut menu and use the Properties window to change the appearance of the text to match the original plot title. Change the **Font Color** to black and the **Font** to 12 point Tahoma then click **Set** to close the window and apply the properties.



- Now use the **Select** tool to drag the text object into the desired position, centered below the original plot title.⁷ Click the white background of the plot to de-select the new text object. The RS Draw window will now look like the figure shown next.



You can follow similar procedures to make other annotations to the plot graphic, if desired.

- To save the annotated plot graphic as a Windows metafile that can be inserted or edited in other applications, select **Save** from the **File** menu. Specify the name and location of the *.wmf file and click **Save**.
- Now, select **Exit** from the **File** menu or click the **X** in the top right corner of the window to close RS Draw.
- Close the Plot Viewer then close the project and database before proceeding to the next example.

⁷ If desired, you can use RS Draw's Align Objects tool to exactly center the original title and the new subtitle. Simply press **Shift** while selecting the original title and then the new subtitle. When both text objects are selected, choose **Center** from the **Align Objects** icon to center align the text objects automatically.

4.7 Example 6 - RCM Analysis for Conveyor Belt

This example guides you through the process for entering a portion of an RCM analysis for a conveyor belt. For this example, you will work with sample data provided for demonstration purposes. *This information is not intended to be realistic.*

4.7.1 Create a New Database and Project

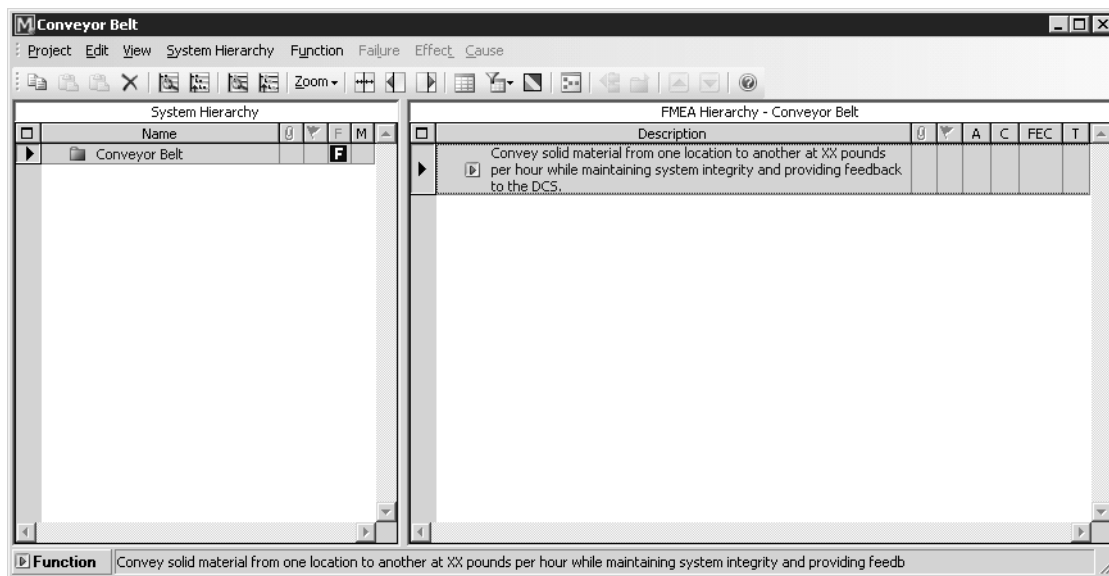
- Create a new database called **Sample RCMs**.
- Create a new project called **Conveyor Belt** and use the **Standard RCM** profile to set the project properties. This will automatically configure the software for a basic RCM analysis.

4.7.2 Define the Item and Function

For this example, the analysis will be performed on a Conveyor Belt, which has the following primary function:

Convey solid material from one location to another at XX pounds per hour while maintaining system integrity and providing feedback to the DCS.

- Define the item and function in the project, as shown next.



4.7.3 Define the Failures, Effects and Causes

The analysis team has identified the following ways that the equipment may fail to perform its intended function:

Failure: Conveys less than the required rate.

Effect: Reduction in production.

Cause: Product belt slippage due to improper alignment and/or tension.

Cause: Plugged feed and/or discharge spout due to foreign object.

Failure: Conveys no material.

Effect: Loss of production.

Cause: Belt conveyor bearing worn or seized due to improper lubrication.

Cause: Chain drive failure due to chain wear and/or damage.

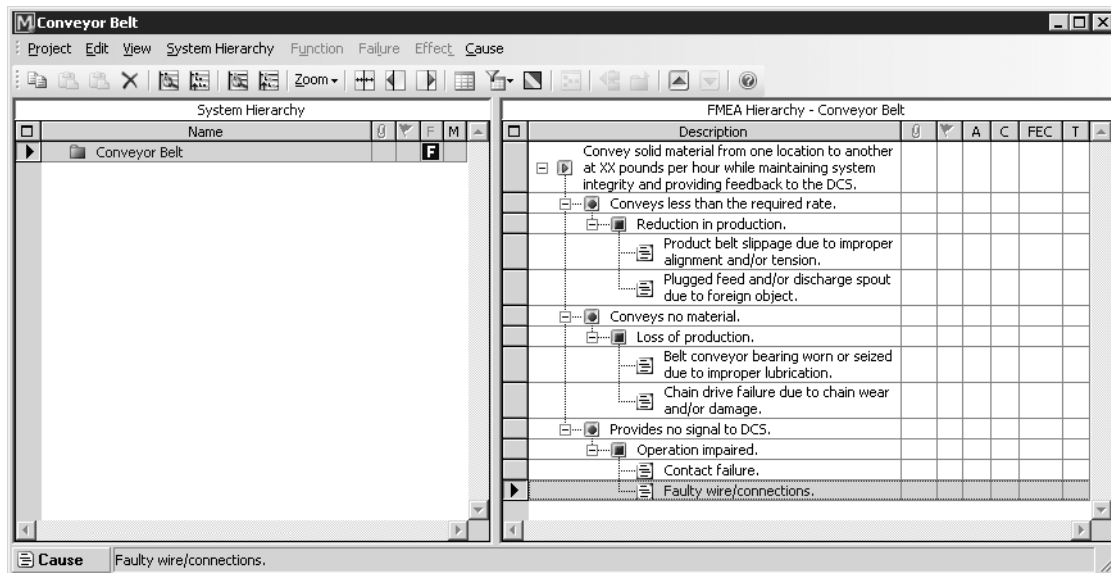
Failure: Provides no signal to DCS.

Effect: Operation impaired.

Cause: Contact failure.

Cause: Faulty wire/connections.

- Enter this portion of the analysis into the project, as shown next.



4.7.4 Perform the Failure Effect Categorization

- Double-click the **FEC** column to the right of the first effect description to display the logic diagram that will be used to categorize the failure effects. Select **Yes** to answer the first question, **No** to answer the

second question and **Yes** to answer the last question. The effect will be categorized as **EO - Evident Operational**, as shown next.

Failure Effect Categorization

Current Item	1 - Conveyor Belt
Function	1 - Convey solid material from one location to another at XX pounds per hour while maintaining system integrity and providing feed
Failure	1 - Conveys less than the required rate.
Effect	1 - Reduction in production.

Question 1: Is the occurrence of a functional failure evident to the operator during the performance of normal duties?
 Yes No

Question 2: Does the functional failure or secondary damage resulting from the functional failure have a direct adverse effect on operating safety or other hazardous results?
 Yes No

Question 3: Does the hidden functional failure or secondary damage resulting from the functional failure have a direct adverse effect on operating safety or other hazardous results?
 Yes No

Question 4: Does the functional failure have a direct adverse effect on operating capability?
 Yes No

Question 5: Does the hidden functional failure have a direct adverse effect on operating capability?
 Yes No

Answers 1-5: [Empty text boxes]

Remarks: [Empty text box]

Category: **EO - Evident Operational**

Buttons: OK, Cancel

Last Update Date: 3/14/2006

- Click **OK** to save the analysis and return to the Project window.
- Use a similar procedure to analyze the other two effects. These effects will also be categorized as **EO - Evident Operational**.

4.7.5 Select and Define the Maintenance Tasks

- Right-click the third failure cause (“Belt conveyor worn or seized...”) and select **Manage Tasks** from the shortcut menu to open the Maintenance Task Manager window.

- Select **Yes** to answer the first task selection question, as shown next.

Question	Yes/No	Explanation
1: Is a scheduled service task (such as lubrication) applicable and effective?	Yes	
2: Is a scheduled on-condition inspection task applicable and effective?	No	
3: Is a scheduled repair/replacement task applicable and effective?	No	
4: Is an up-front one-time task (such as re-design) applicable and effective?	No	

Run to Failure:	Cost per Uptime	Undetermined	Average Availability (%)	Undetermined					
▲ #	Task Name	Status	Type	Assigned Interval	Labor (Crew Name)	Total Duration per Incident	Total Cost per Incident	Cost per Uptime	Average Availability (%)

Buttons: Add Task..., Add Linked Task..., Edit Task..., Delete Task, Refresh, OK, Cancel

- Click **Add Task** to define the task. Enter the properties shown next and click **OK** to save the record.

1 Task Name: Apply proper lubrication to the conveyor bearing.

Task: PM Resources | User Defined

Type: Service (5) Task Description: [Empty]

Status: Assigned

Maintenance Package: [Empty] Reference Document: [Empty]

Proposed Interval: [Empty] Units: [Empty] Assigned Interval: 1 Week Units: [Empty] Calculate Optimum... [Empty]

Based on: Item Age System Age

Condition: [Empty]

Remarks: [Empty]

Zone: [Empty] Access: [Empty]

Cost per Uptime: [Empty] Total Operating Cost: [Empty] Average Availability (%): [Empty]

Buttons: Associated EMEA..., Show Cause..., OK, Cancel

- Close the Maintenance Task Manager for this failure cause and then open the window for the next cause (“Chain drive failure...”).

- Answer the selection questions **No, No, Yes, No** to indicate that a scheduled repair/replacement maintenance strategy will be applicable and effective for this issue.
- Add a task with the properties shown next.

- If desired, you may continue this analysis on your own, entering additional failures, effects, causes and/or tasks based on your experience.
- When you are finished, close the project but leave the database open to proceed to the next example.

4.8 Example 7 - RCM Analysis for Dust Filter

This example guides you through the process for entering a portion of an RCM analysis for a dust filter. For this example, you will work with sample data provided for demonstration purposes. *This information is not intended to be realistic.*

4.8.1 Create a New Project

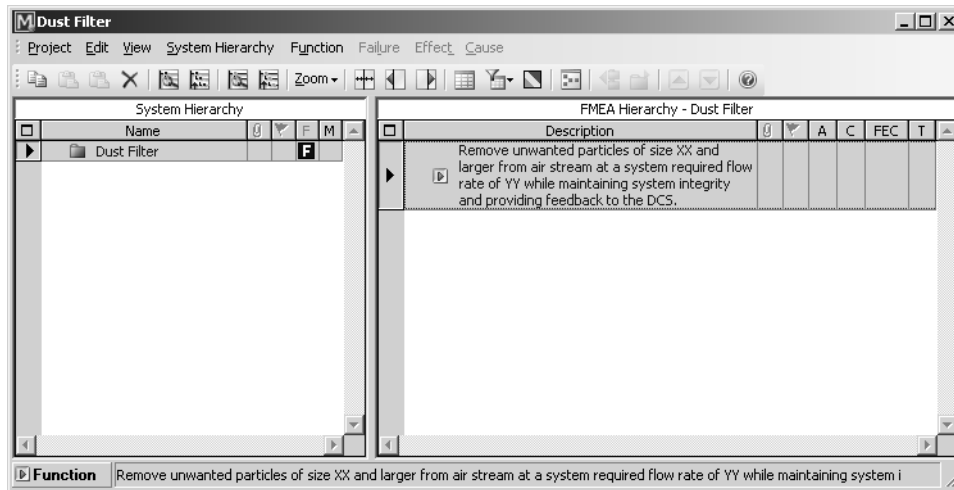
- With the database from the previous example open, create a new project called **Dust Filter** and use the **SAE RCM (6 Categories)** profile to set the project properties.

4.8.2 Define the Item and Function

For this example, the analysis will be performed on a Dust Filter, which has the following primary function:

Remove unwanted particles of size XX and larger from air stream at a system required flow rate of YY while maintaining system integrity and providing feedback to the DCS.

- Define the item and function in the project, as shown next.



4.8.3 Define the Failures, Effects and Causes

The analysis team has identified the following ways that the equipment may fail to perform its intended function:

Failure: Does not remove required particles.

Effect: Regulatory non-compliance.

Cause: Tube sock failure.

Cause: Tube cage/thimble sheet seal failure.

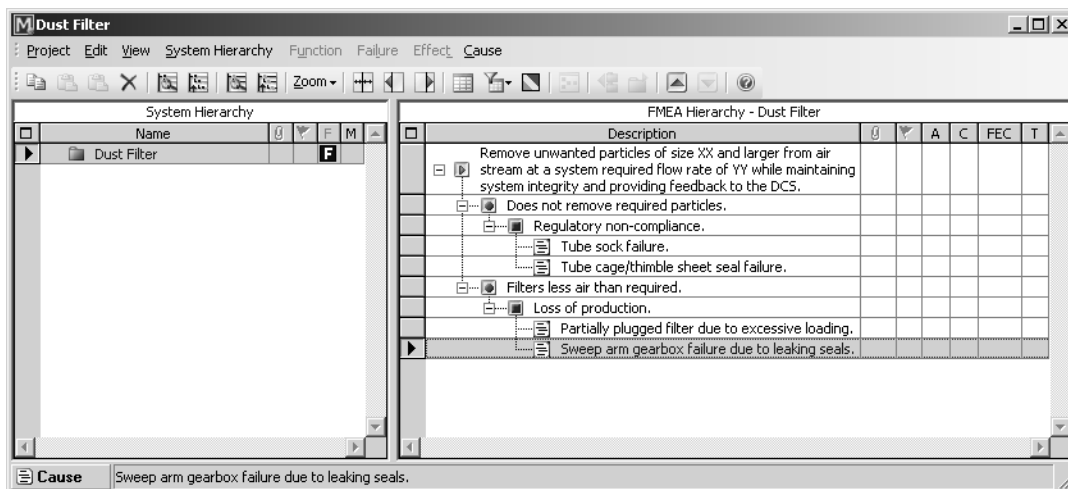
Failure: Filters less air than required.

Effect: Loss of production.

Cause: Partially plugged filter due to excessive loading.

Cause: Sweep arm gearbox failure due to leaking seals.

- Enter this portion of the analysis into the project, as shown next.



4.8.4 Perform the Failure Effect Categorization

- Double-click the **FEC** column to the right of the first effect description to display the logic diagram that will be used to categorize the failure effects. Select **Yes** to answer the first question and **Yes** to answer the second question. The effect will be categorized as **1 - Evident Safety and Environmental Consequences**, as shown next.

Failure Effect Categorization

Current Item	1 - Dust Filter
Function	1 - Remove unwanted particles of size XX and larger from air stream at a system required flow rate of YY while maintaining system
Failure	1 - Does not remove required particles.
Effect	1 - Regulatory non-compliance.

Question 1
Will the loss of function caused by this failure mode on its own become evident to the operating crew under normal circumstances?
 Yes No

Question 2
Is there an intolerable risk that the effects of this failure mode could injure or kill someone OR Is there an intolerable risk that the effects of this failure mode could breach a known environmental standard or regulation?
 Yes No

Question 3
Is there an intolerable risk that the effects of the multiple failure could injure or kill someone OR Is there an intolerable risk that the effects of the multiple failure could breach a known environmental standard or regulation?
 Yes No

Question 4
Does the failure mode have a direct adverse effect on operational capability?
 Yes No

Question 5
Does the multiple failure have a direct adverse effect on operational capability?
 Yes No

1 Evident Safety and Environmental Consequences

2 Evident Operational Consequences

3 Evident Non-Operational Consequences

4 Hidden Safety and Environmental Consequences

5 Hidden Operational Consequences

6 Hidden Non-Operational Consequences

Answer 1

Answer 2

Answer 3

Answer 4

Answer 5

Remarks

Category
1 - Evident Safety and Environmental Consequences

Performing Failure Effect Categorization

- Click **OK** to save the analysis and return to the Project window.
- Use a similar procedure to analyze the other effect. This effect will be categorized as **2 - Evident Operational Consequences**.

4.8.5 Select and Define the Maintenance Tasks

- Right-click the first failure cause (“Tube sock failure”) and select **Manage Tasks** from the shortcut menu to open the Maintenance Task Manager window.

- Answer the selection questions **No**, **No**, **Yes**, **No** to indicate that a scheduled discard (replacement) maintenance strategy will be applicable and effective for this issue, as shown next.

- Click **Add Task** to define the task. Enter the properties shown next and click **OK** to save the record.

- If desired, you may continue this analysis on your own, entering additional failures, effects, causes and/or tasks based on your experience.
- When you are finished, close the project but leave the database open to proceed to the next example.

4.9 Example 8 - Cost and Availability Comparisons

This example guides you through the process for comparing maintenance strategies based on cost and availability. For this example, you will work with sample data provided for demonstration purposes. *This information is not intended to be realistic.*

4.9.1 Mechanical Component with Wearout

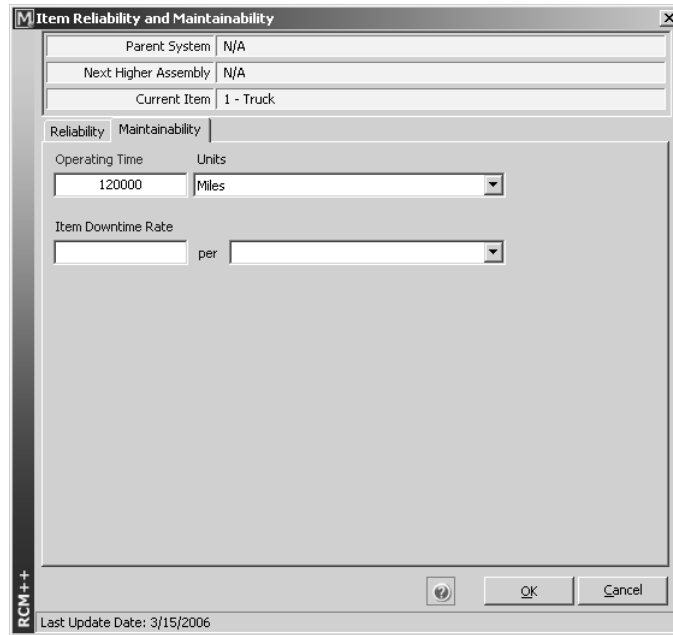
Consider an RCM analysis for a large truck that is intended to operate for 120,000 miles per year. A critical failure mode has been identified for a mechanical component and reliability analysis indicates that the failure behavior follows a Weibull distribution with $\beta = 2.3$ and $\eta = 72,000$ miles. Considering logistical factors, downtime penalties and the actual repair resources, it takes 7 work days (3,500 miles of lost “production”) and costs \$4,650 each time the component must be replaced when it fails. The component will be “as good as new” after the maintenance action. The RCM analysis team is considering whether to incorporate a scheduled preventive replacement task into the maintenance plan. Because there are no additional logistical delays/costs for a planned replacement, the PM task will take only 1 work day and cost \$2,050.

- With the database from the previous example open, create a new project called **RCM Cost Comparison** and use the **Standard RCM** profile to set the project properties.
- Select **Project Properties** from the **Project** menu and go to the **Units** tab. Click **Edit** and go to the **Units** tab. Enter **Mile** for the Base Unit and use the **Delete Row** button to delete all of the other units except **Day**. Enter **500** for the Multiplier, as shown next.

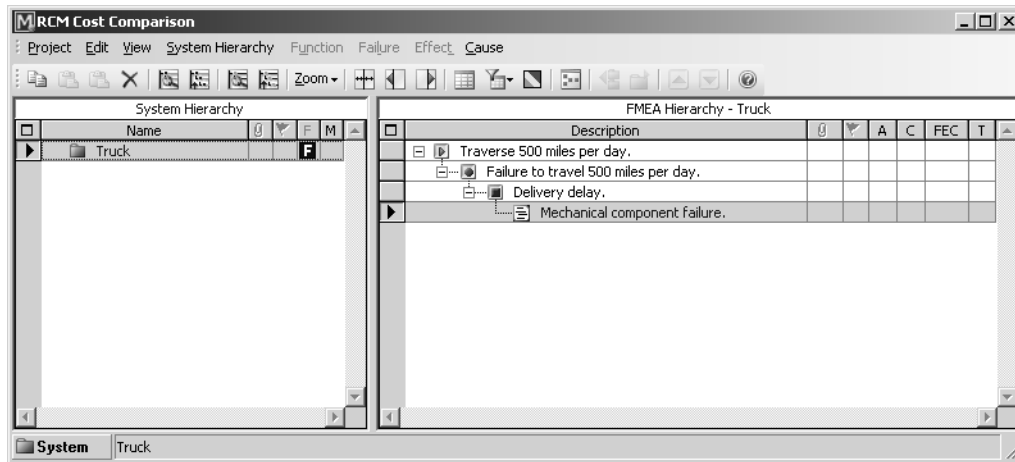
Classification	Action Priority	Action Category	Control Type	Prob of Loss	Task Status	Units
Base Unit: Mile						
Other Units						
1 ▶		Unit				Multiplier
		Day				500

- Save the changes and close the Project Properties window. With these settings, there will be two options for entering “time” values within the project, Mile or Day, where 1 day is equivalent to 500 miles.

- Add an item called “Truck” and open the Item Reliability and Maintainability window.⁸ On the Maintainability tab, enter **120,000** for the Operating Time and select **Mile** for the Units, as shown next.



- Enter a function, failure, effect and cause, as shown next.



⁸ To open the Item Reliability and Maintainability window, you can click the **Reliability** button in the Item Properties window or select **Item Reliability/Maintainability** from the **System Hierarchy** menu.

4 Step-by-Step Examples

- Open the cause (“Mechanical component failure”) and define the failure behavior on the Probability tab, as shown next.

The screenshot shows the 'Edit Cause' dialog box with the 'Probability' tab selected. The 'Current Item' is '1 - Truck', 'Function' is '1 - Traverse 500 miles per day.', 'Failure' is '1 - Failure to travel 500 miles per day.', and 'Effect' is '1 - Delivery delay.'. The 'Define the probability of occurrence for this Cause.' checkbox is checked. The 'Distribution and Parameters' section shows 'Mile' as the unit, with a list of distributions including Weibull, Exponential, Normal, Lognormal, and Mixed Weibull variants. The Weibull distribution is selected, with parameters Beta (2.3), Eta (72000), and Gamma (0). The 'Calculate Probability' section has empty fields for Time and Probability. The status bar shows 'Last Update Date: 3/15/2006'.

- Define the duration and cost for corrective maintenance on the Corrective Maintenance tab, as shown next.

The screenshot shows the 'Edit Cause' dialog box with the 'Corrective Maintenance' tab selected. The 'This failure is undetectable and will not be corrected until the next scheduled maintenance or inspection' checkbox is unchecked. 'Item Operating Time' is set to '120000 Mile' and 'Item Downtime Rate' is empty. 'Restoration Factor' is '1'. 'Materials (Spare Name/Part Number)' and 'Labor (Crew Name)' are empty. 'Labor Rate' is empty per Day. 'Task Duration' is set to '7'. 'Total Duration per Incident' is '7 Day'. 'Cost per Incident' section shows 'Misc. Cost' as '4,650.00', with 'Downtime Cost', 'Labor Cost Per Incident', 'Time Based Labor Cost', and 'Materials Cost' empty. 'Total Cost per Incident' is '4,650.00'. 'Cost per Uptime' section shows 'Total Operating Cost' and 'Average Availability (%)' empty. The status bar shows 'Last Update Date: 3/15/2006'.

- Click the **Calculate** icon to simulate the operation of the truck for one year, assuming that the mechanical component will be run to failure. The results will be as follows:
 - 1.43 CMs and Uptime = 115,114.20 miles
 - Total Operating Cost = \$6,626.25
 - Cost per Uptime = 0.058 per mile
 - Average Availability = 95.93%
- Click the **Tasks** button then click **Add Task**. Define the planned replacement maintenance strategy as shown in the next two pictures.

The screenshot shows the 'Add Task' dialog box in the RCM++ software. The dialog is titled 'Add Task' and contains the following fields and options:

- # Task Name:** 1 Preventive replacement
- Task:** PM Resources | User Defined
- Type:** Repair/Replace (RR)
- Status:** Proposed
- Maintenance Package:** [Empty]
- Reference Document:** [Empty]
- Proposed Interval:** [Empty] **Units:** [Empty]
- Assigned Interval:** 1 **Units:** Miles
- Calculate Optimum...** button
- Based on:** Item Age System Age
- Condition:** [Empty]
- Remarks:** [Empty]
- Zone:** [Empty] **Access:** [Empty]
- Cost per Uptime:** 1.43
- Total Operating Cost:** \$6,626.25
- Average Availability (%):** 95.93

At the bottom of the dialog, there are buttons for 'Associated EMEA...', 'Show Cause...', 'OK', and 'Cancel'. The RCM++ logo is visible in the bottom left corner, and the text 'Adding new Task' is displayed at the bottom of the dialog.

- Return to the Task tab and click the **Calculate Optimum** button to calculate the optimum replacement time given the reliability and cost information that you have provided.
- Replace the calculated value (60330.254 miles) with 60,000 and return to the PM Resources tab. Click the **Calculate** icon to simulate the operation of the truck for one year, assuming that the mechanical component will be replaced every 60,000 miles. The results will be as follows:
 - .98 CMs and .79 PMs and Uptime = 116,246.80 miles
 - Total Operating Cost = \$6,188.95
 - Cost per Uptime = 0.053 per mile
 - Average Availability = 96.87%

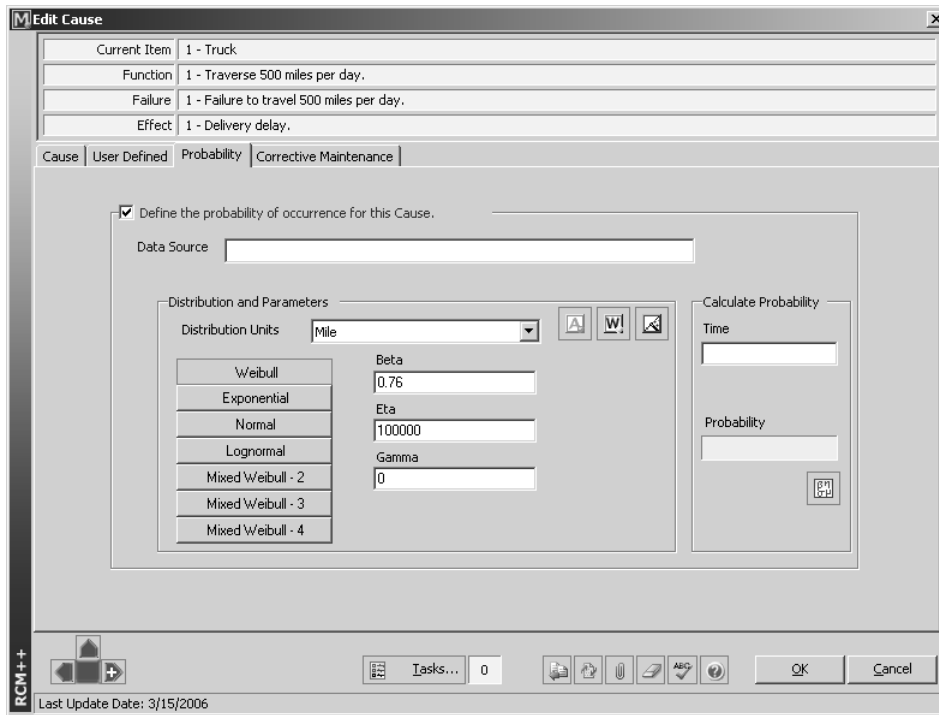
The analysis indicates that the scheduled replacement strategy provides both lower cost and better availability than run-to-failure. The differences between the two strategies will be even greater when applied to an entire fleet of trucks over multiple years of operation.

- Close the cause and task windows to return to the Project window and proceed with the rest of the example.

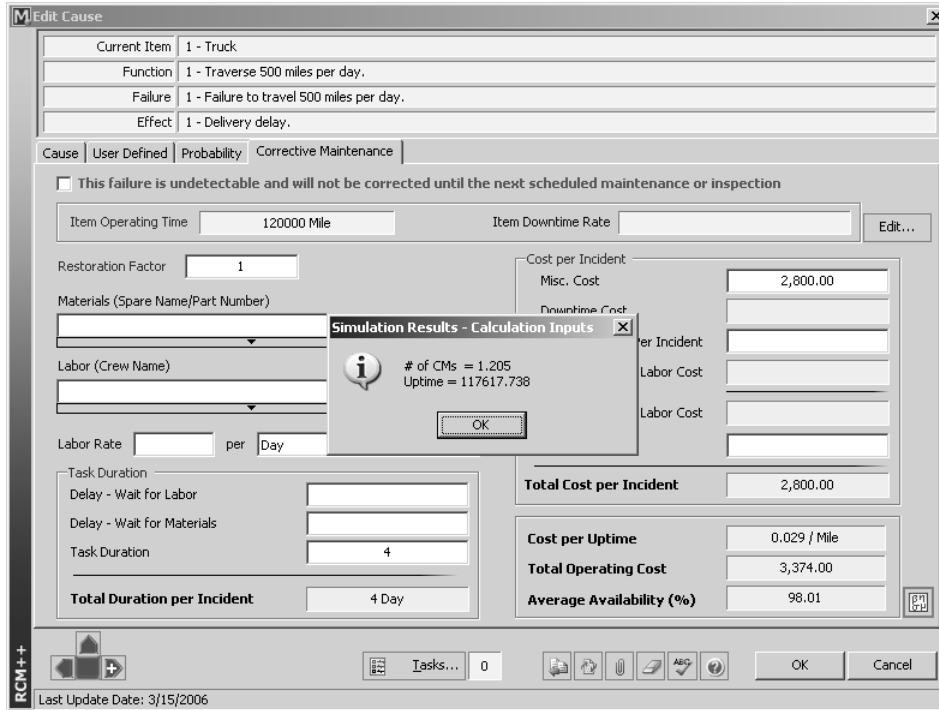
4.9.2 Electrical Component with Infant Mortality

Another critical failure mode has been identified for an electrical component of the truck. This follows a Weibull distribution with beta = .76 and eta = 100,000 miles. The analysis team is considering a planned replacement for this component at 60,000 miles to coincide with the PM for the mechanical component. For this failure mode, the CM downtime is 4 work days; the CM cost is \$2,800; the PM cost would be \$1,200 and there would be no additional PM downtime because the equipment is already down for the other maintenance task.

- Enter another cause called “Electrical component failure” and define the failure behavior as shown next.



- Define the corrective maintenance duration and cost and click the **Calculate** icon. The results will be as shown next.



4 Step-by-Step Examples

- Define the proposed preventive replacement task and calculate the results, as shown in the next two pictures.

Edit Task

Task Name
2 Preventive replacement.

Task PM Resources User Defined

Type Repair/Replace (RR) Task Description
Status Proposed

Maintenance Package Reference Document

Proposed Interval Units Assigned Interval Units
60000 Mile Calculate Optimum...

Based on: Item Age System Age

Condition
Remarks
Zone Access

Cost per Uptime **Total Operating Cost** **Average Availability (%)**

Associated EMEA... Show Cause... OK Cancel

Last Update Date: 3/15/2006

Edit Task

Task Name
2 Preventive replacement.

Task PM Resources User Defined

Item Operating Time 120000 Mile Item Downtime Rate Edit...

Materials (Spare Name/Part Number) Restoration Factor 1

Labor (Crew Name) Cost per Incident
Misc. Cost 1,200.00

Labor Rate per Cost Per Incident
Task Duration
Delay - Wait for Labor
Delay - Wait for Materials
Task Duration
Total Duration per Incident Total Cost per Incident 1,200.00

Simulation Results - Calculation Inputs
of CMs = 1.387
of PMs = 0.876
Uptime = 117252.301
OK

Cost per Uptime 0.042 / Mile **Total Operating Cost** 4,934.80 **Average Availability (%)** 97.71

Associated EMEA... Show Cause... OK Cancel

Last Update Date: 3/15/2006

In this case, the analysis indicates that a run-to-failure maintenance strategy will be more cost-effective and provide better availability than scheduled replacement. In fact, since the beta parameter of the failure distribution is less than 1, this indicates that the equipment does not experience wearout and there is no

optimum preventive replacement time. The team could repeat the analysis for other maintenance intervals and would always determine that run-to-failure is more cost-effective.

- Close the project and database then proceed to the next example.

4.10 Example 9 - Integration with BlockSim via XML

RCM++ provides integration with ReliaSoft's BlockSim system reliability, maintainability and availability analysis software. You can generate blocks and diagrams in BlockSim based on the system configuration and reliability information that you have defined in RCM++. This example guides you through the process of exporting items from an RCM++ project to an XML file that can be opened with BlockSim.

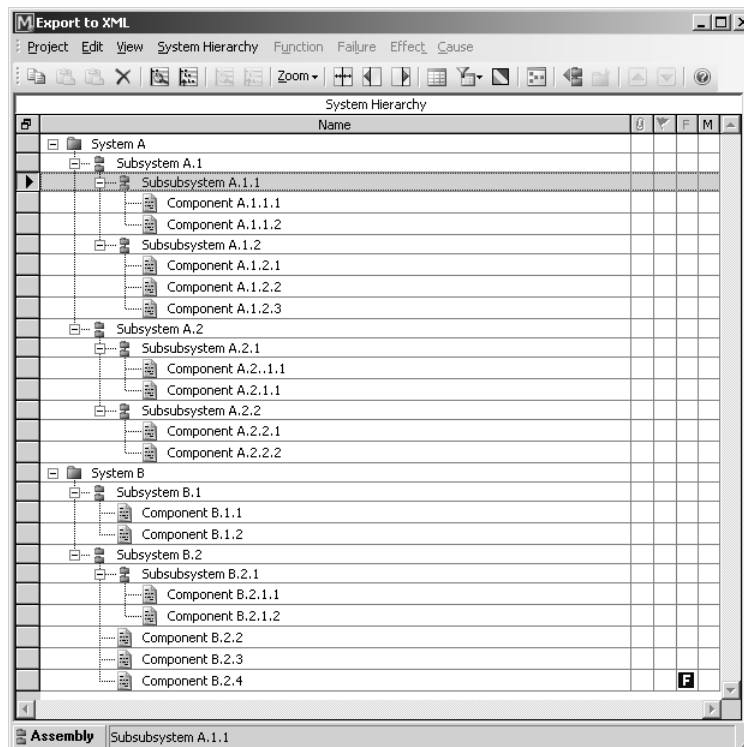
For this example, you will work with a sample database that has been prepared by ReliaSoft, which contains sample data related to imaginary products. *This information is not intended to be realistic.*

Note: BlockSim 6 or newer is required to perform this example.⁹

4.10.1 Open an Existing Database and Project

- Open the sample project called “Export to XML” that has already been created in the BlockSimExample.rx4 database file that is located in the Training folder in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training).

With the FMEA hierarchy panel hidden and the **Subsubsystem A.1.1** item selected, the Project window will look like the figure shown next.



- You can take some time now to examine the system configuration that has been defined for this project. You may want to open the properties windows (e.g. Item Properties windows and Item Reliability and Maintainability windows) for the items to view the reliability characteristics and other properties that

⁹ The example illustrated in this section was created using BlockSim 7.

have been defined for the items. You will also notice that reliability characteristics have been defined for the cause associated with the last item. This information will also be transferred to BlockSim.

- When you are finished, close the Project window so that only the Project Explorer is displayed.

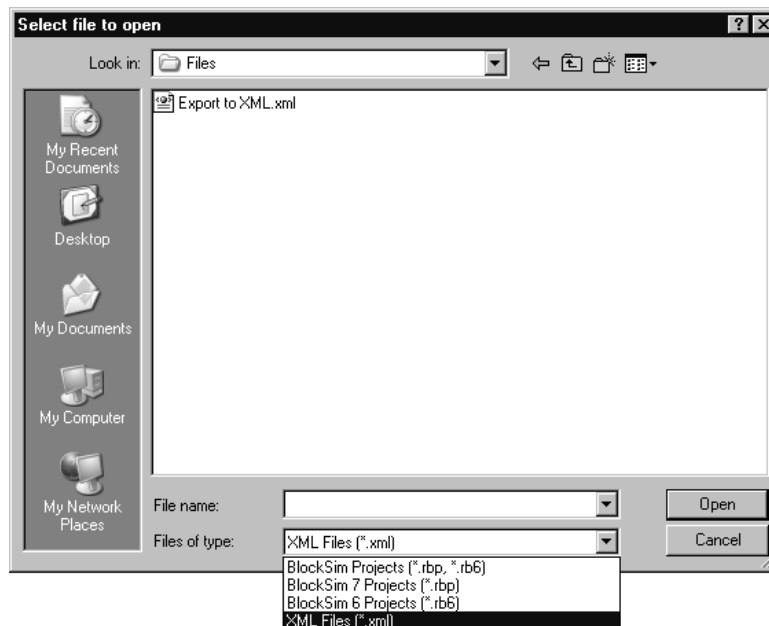
4.10.2 Export Project from RCM++

The next step is to export the system configuration that has been defined in RCM++ to an XML file (*.xml) that is accessible by the BlockSim software.

- To do this, select **Export XML Project** from the **Project Explorer** menu.
- In the window that appears, select **Export as RBD**.
- Note the location where the file will be saved, accept the default filename, “Export to XML,” and click **Save** to transfer the data to an XML file (*.xml).
- When the window appears to inform you that the XML file has been created successfully, click **OK**.

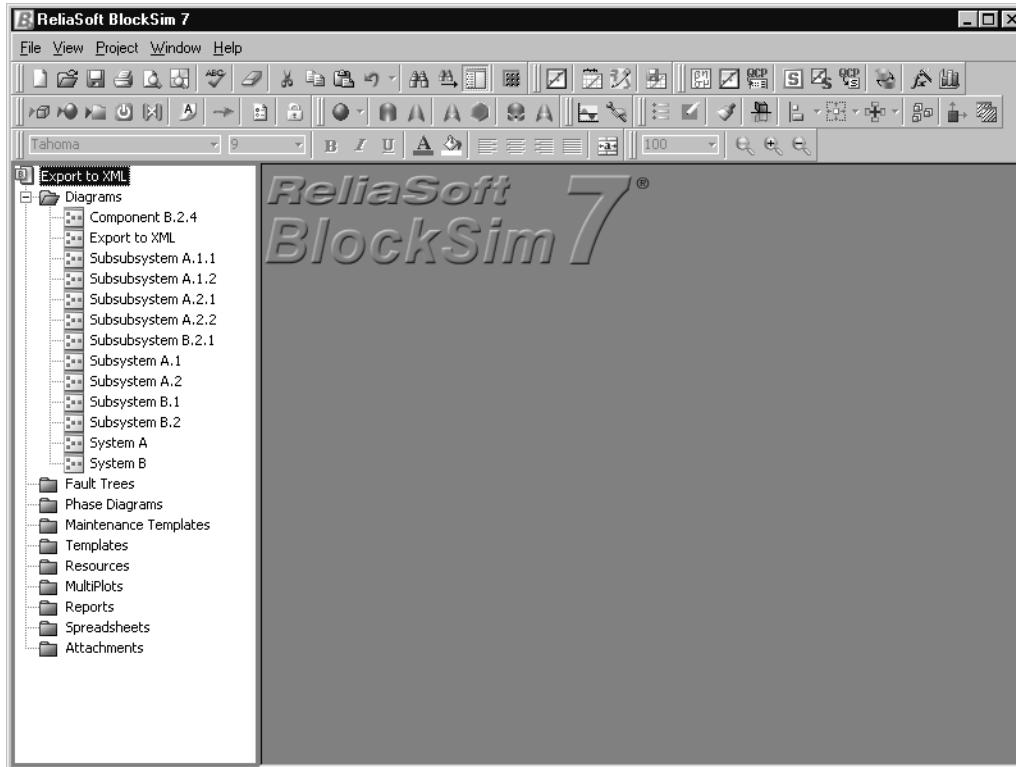
4.10.3 Open the XML File in BlockSim

- When the export to XML is complete, leave the RCM++ database open and activate the BlockSim 6 software.
- In BlockSim, choose to open an existing project. Select **XML Files (*.xml)** from the **Files of type** menu, as shown next.



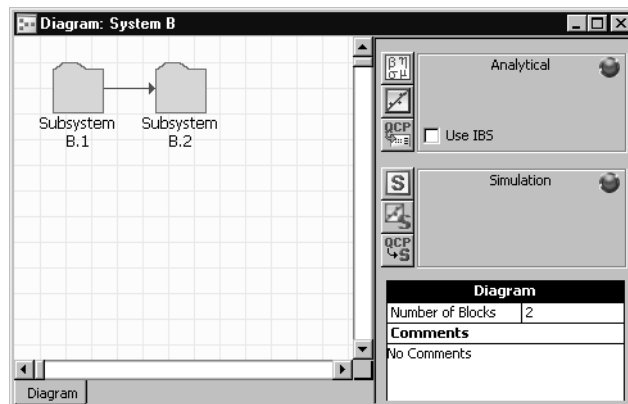
- Locate and select the XML file called “Export to XML.xml” that you just created in RCM++ and click **Open**.

- BlockSim will create a project that contains diagrams and blocks to represent the system configuration and probability data that was defined in RCM++, as shown next.



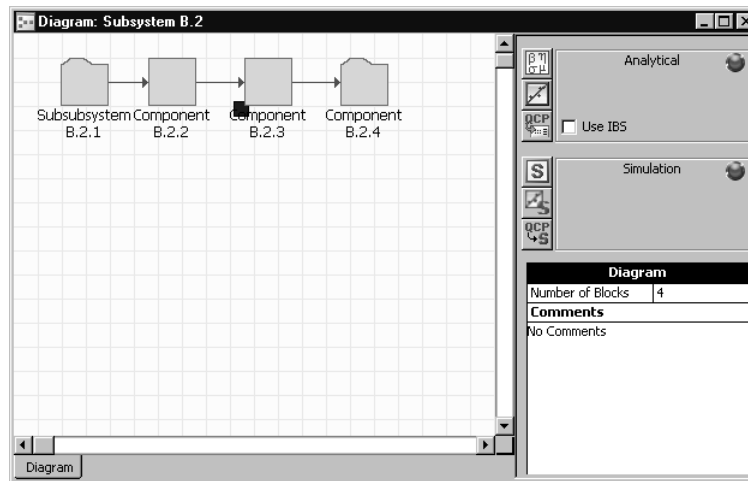
The system configuration and probability data from RCM++ is represented in BlockSim with diagrams, subdiagrams and blocks. For example, a system from RCM++ will be represented by a diagram that consists of subdiagrams or blocks for every associated sub-item and cause.¹⁰

- To demonstrate this, open the Diagram Sheet called **System B** by double-clicking its name in the Project Explorer. This Diagram Sheet represents the System B top level (system) item from the RCM++ configuration. The diagram contains two subdiagram blocks to represent the two subsystems in the next level of the configuration, Subsystem B.1 and Subsystem B.2, as shown next.

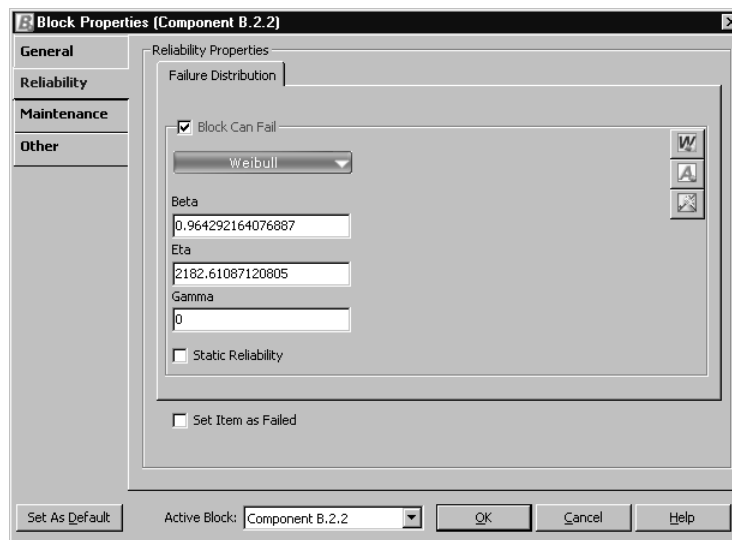


¹⁰Note that if you had selected **Export as Fault Tree** during the export process, the data would be represented in a fault tree format.

- Right-click the **Subsystem B.2** block and select **Open Subdiagram** from the shortcut menu. The Subsystem B.2 Diagram Sheet will appear, which contains a subdiagram block to represent Subsystem B.2.1, two blocks to represent the Component B.2.2 and Component B.2.3 items and a subdiagram block to represent Component B.2.4 and its associated cause, as shown next.

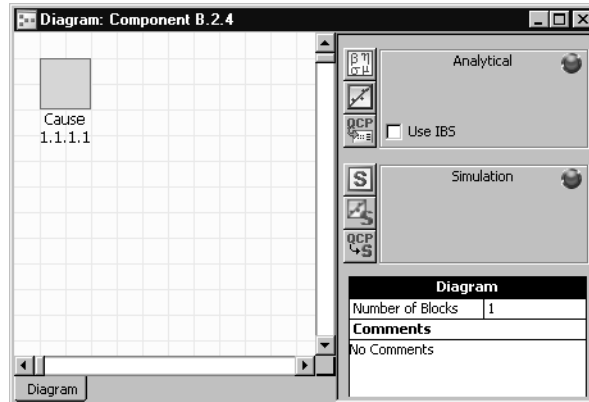


- Now double-click the **Component B.2.2** block to open the Block Properties window for that item. In the Block Properties window, click the **Reliability** tab.
- On the Failure Distribution page of the Reliability tab, you can see that the reliability properties for the block have been defined based on the information defined in RCM++, as shown next.



- In addition, the text that was entered into the Item Description field in the RCM++ Item Properties window is displayed on the Comments & Attachments page of the General tab in the Block Properties window.

- Close the Block Properties window for Component B.2.2 by clicking **OK** and open the diagram linked to the Component B.2.4 subdiagram block.



This diagram contains one block to represent the cause that has been defined for Component B.2.4 in the original RCM++ project. Please note that when Cause Probability information is transferred to BlockSim, the time-based parameters (*e.g.* eta for Weibull) are converted to the Base Unit for the project. This is necessary because BlockSim assumes that all time values have the same units.

4.10.4 Close BlockSim

- When you are finished investigating the diagrams, subdiagram blocks and blocks in BlockSim, exit the BlockSim application by selecting **Exit** from the **File** menu. If desired, you can save the BlockSim project.
- Return to the RCM++ application.

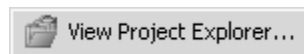
4.11 Example 10 - Using the Check Analysis Utility

This example demonstrates the capabilities of RCM++'s Check Analysis Utility, which identifies any possible discrepancies and/or omissions in each analysis. The utility lists the potential issues and you can make the decision of whether or not to address each issue.

For this example, you will work with sample data prepared by ReliaSoft. *Sample data sets are not intended to be realistic.*

4.11.1 Create a New Database and Import an Existing Project

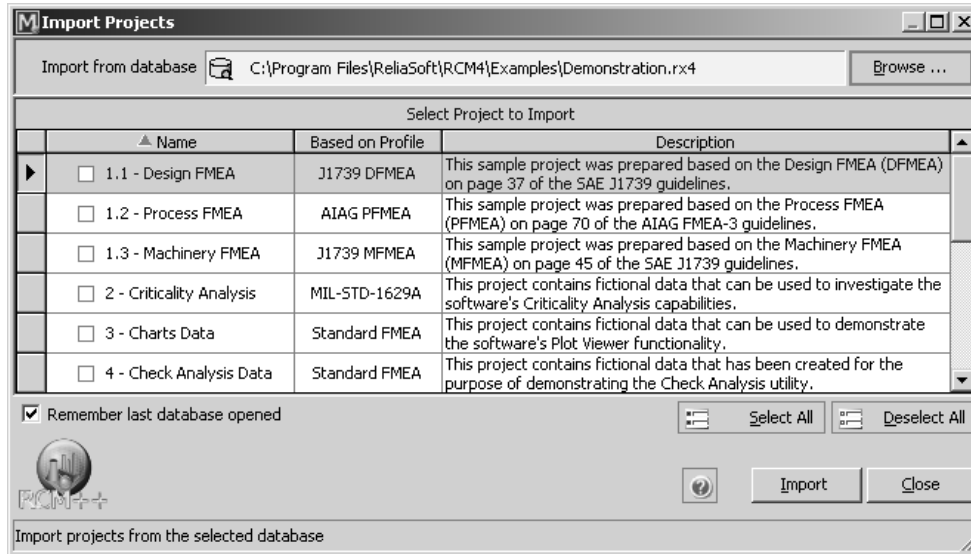
- Create a new database called **CheckAnalysis.rx4**. When prompted to create a new project, click **Cancel**.
- Select **View Project Explorer** from the **File** menu or click the **View Project Explorer** icon.



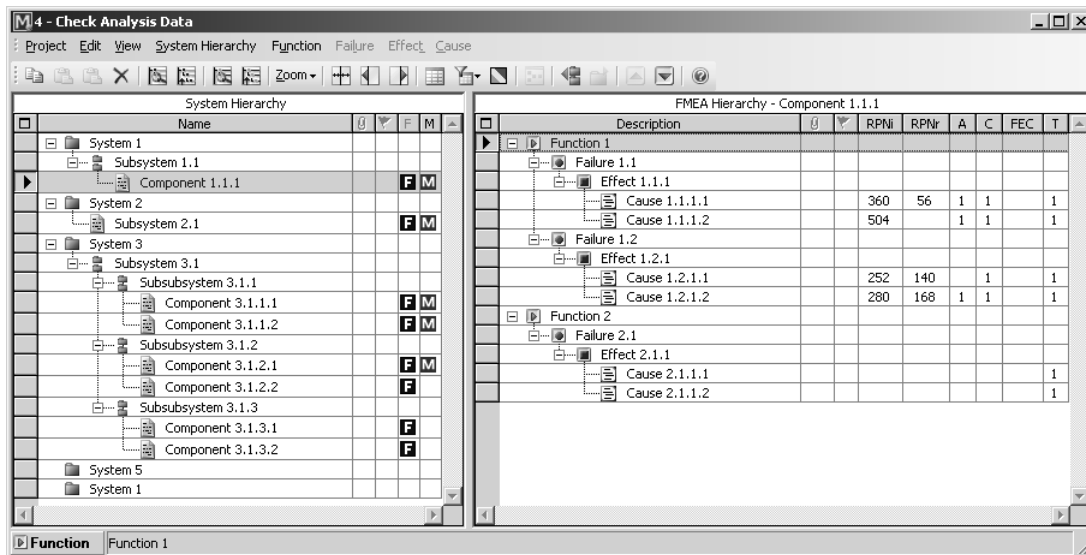
- Select **Import Projects** from the **Project Explorer** menu or click the **Import Projects** icon.



- When prompted to select a database to import from, navigate to the Examples folder in the application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Examples) and select the database called Demonstration.rx4. The Import Projects window will be displayed, as shown next.



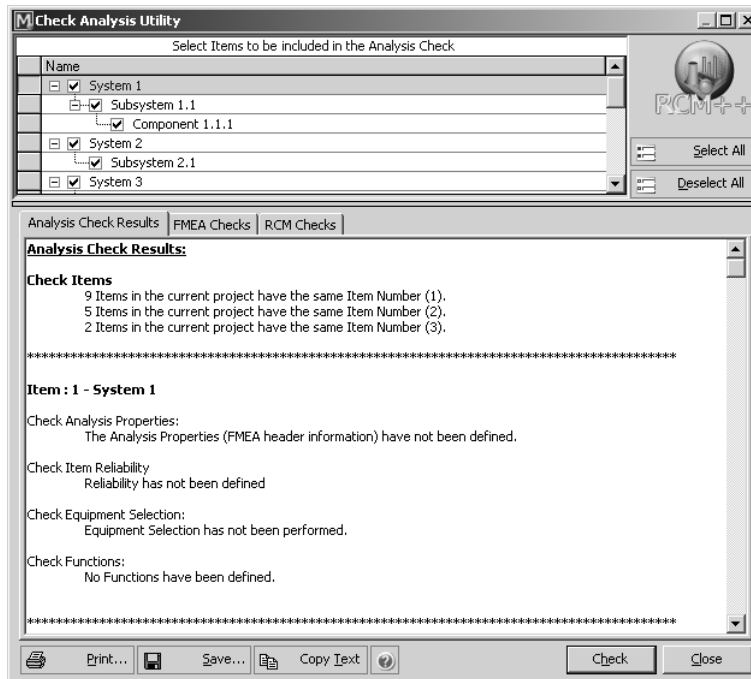
- Select the project called **4 - Check Analysis Data** and click **Import** to import the project into the current database. Click **Close** to close the import window.
- Open the project that you imported. With **Component 1.1.1** selected, the Project window will look like the figure shown next.



4.11.2 Run the Check Analysis Utility

- Select **Check Analysis** from the **Project** menu to open RCM++'s Check Analysis Utility. In this utility, the area at the top of the window allows you to select the items that will be considered when you perform the analysis check. The results will be displayed on the first page. The checks that can be performed are listed on the next two pages: FMEA Checks and RCM Checks.
- Click **Select All** to include all items in the check.

- Click the **FMEA Checks** tab to display the checks that are available for the functional failure analysis (FMEA). Click **Select All Checks**.
- Click the **RCM Checks** tab to display the checks that are available for the Reliability Centered Maintenance analysis. Click **Select All Checks**.
- Click **Check** to start the process. While the checks are being performed, a progress bar will be displayed at the bottom of the MDI. When the process is 100% complete, the Analysis Check Results area of the window will be updated with the results. The window will look like the figure shown next.



By scrolling through the results, you can see that the utility first compares all selected items to see if they have the same names and/or numbers. Next, the utility checks the analysis associated with each individual item and identifies any possible omissions or discrepancies.

4.11.3 Change the Options and Re-Check the Analysis

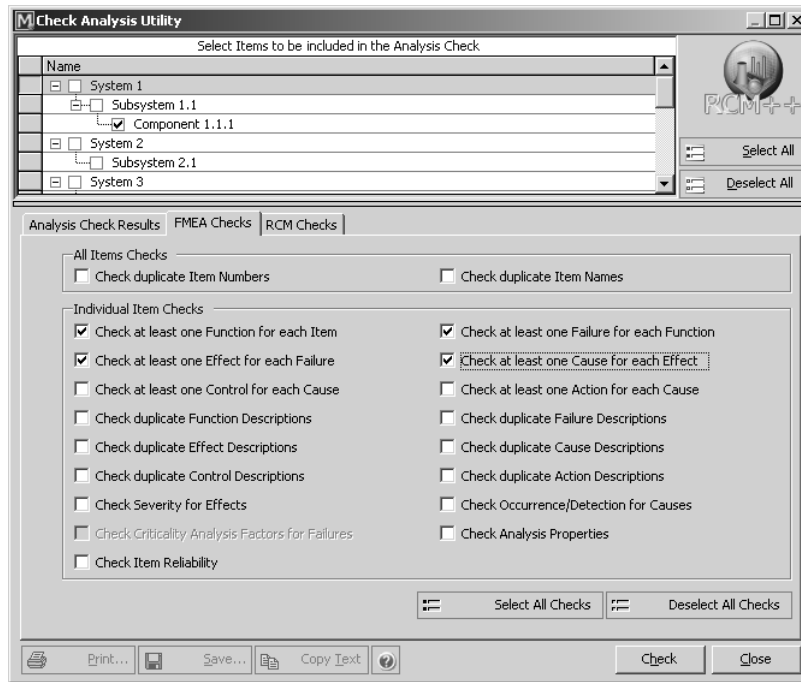
Now, suppose that you are only interested in the following checks for Component 1.1.1:

- The Equipment Selection has been performed for every item.
- At least one function, failure, effect and cause have been defined for each item.
- The Failure Effect Categorization has been performed for every effect.
- The Task Selection has been performed for every cause and the answers match the assigned tasks.

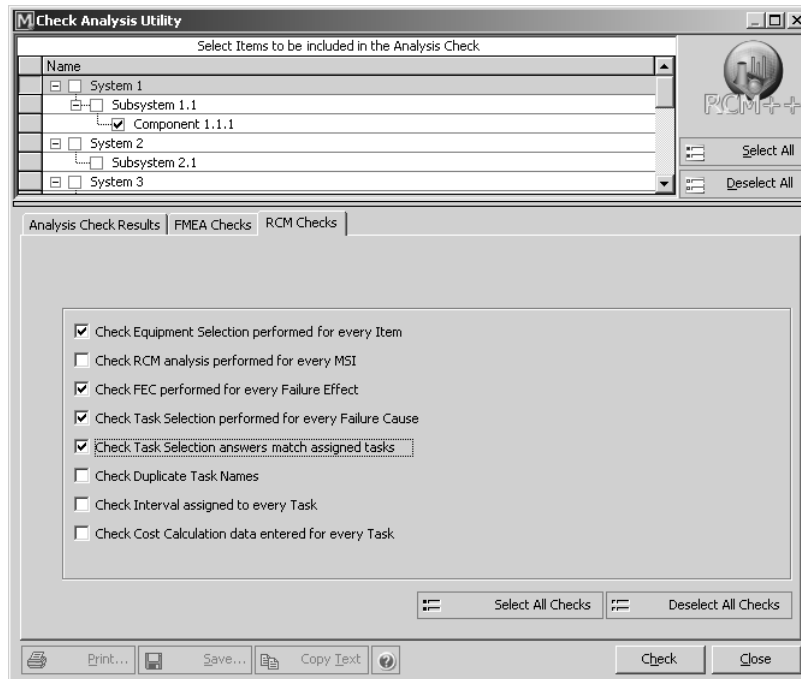
To configure the Check Analysis Utility to perform only those checks that are of interest to you, simply de-select the items and checks that you do not want to include in the results. Specifically, do the following:

- Click **Deselect All** to de-select all items and then select **Component 1.1.1** only.

- Go to the **FMEA Checks** page, click **Deselect All Checks** and then select the checks shown next.



- Go to the **RCM Checks** page, click **Deselect All Checks** and then select the checks shown next.



- Now, click **Check** to re-check the analysis, performing only those checks that have been selected for the selected item. By scrolling through the results, you can see the second set of check analysis results are less comprehensive than the original results.

4.11.4 Modify the Analysis and Re-Check

Finally, you may wish to modify the analysis and then re-check to make sure that the issue(s) that you addressed have actually been resolved. For this example, you will correct the first issue that has been identified for Component 1.1.1.

- To begin, click **Close** to exit the Check Analysis Utility and return to the Project window. Then select **Component 1.1.1** from the System Hierarchy and double-click inside the FEC column for the first potential effect associated with the first potential failure, **Effect 1.1.1**.
- Set the Failure Effect Category (FEC) for this effect to **EE - Evident Economic**, as shown next.

- Click **OK** to save the change and return to the Project window. Repeat the procedure for the other two effects in this analysis (Effect 1.2.1 and Effect 2.1.1). You can choose which FEC to assign to each effect.
- Re-open the Check Analysis Utility. The checks that were enabled the last time you used the utility are still enabled. Click **Check** to re-check the analysis for Component 1.1.1 only. As you can see, the warnings under “Check Effects” have been removed. Some additional issues under “Check Causes” remain but they will not be addressed for this example.

4.11.5 Print, Save or Copy the Results

If desired, you can print, save and/or copy the results generated by RCM++'s Check Analysis Utility.

- To send the results directly to the default printer on your computer, click **Print**. To save the results as a rich text format document (*.rtf), click **Save**. To copy the results to the Clipboard, click **Copy Text**.
- When you are finished experimenting with the Check Analysis Utility, click **Close** to exit the utility and then close the project and database before proceeding to the next example.

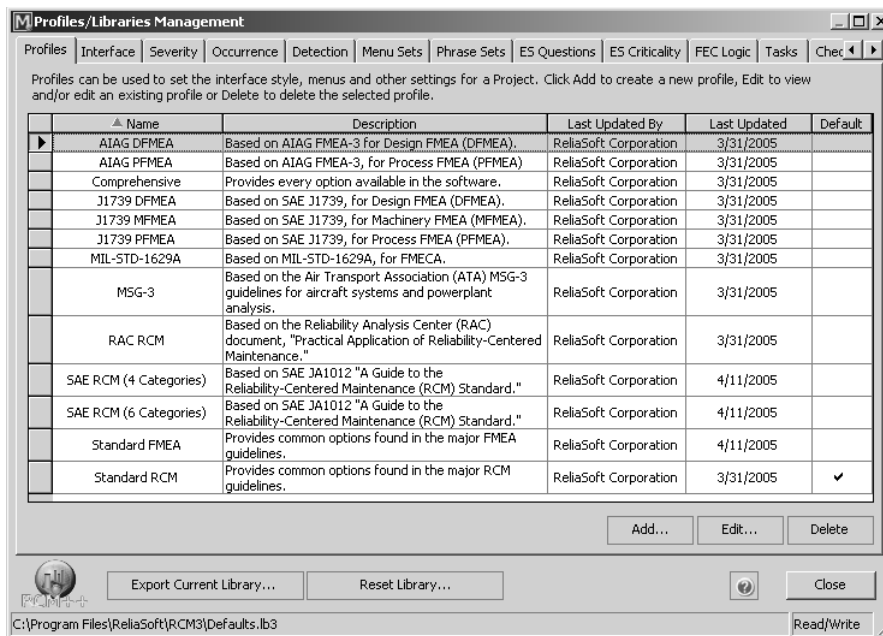
4.12 Example 11 - Using Profiles/Libraries for Customization

This example allows you to experiment with RCM++'s profiles and libraries functionality and guides you through the process to create your own custom libraries and profile.

RCM++'s profiles and libraries have been designed to allow flexible configuration of the software to fit the wide variety of analysis styles for RCM, FMEA and FMECA that exist within industry. You can manage these configuration resources with the Profiles/Libraries Manager.

4.12.1 Open the Profiles/Libraries Manager

- To open RCM++'s Profiles/Libraries Manager, select **Profiles/Libraries Manager** from the **Tools** menu. A window like the one shown next will be displayed.



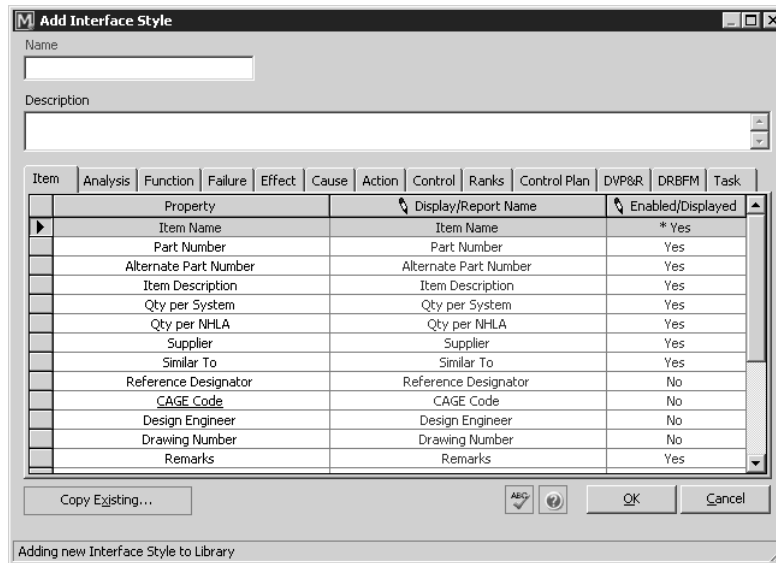
This window allows you to manage the libraries and profiles that are available to use in your RCM++ analyses.

4.12.2 Create a Custom Interface Style

As the previous examples in this training guide have demonstrated, an interface style is a pre-defined set of instructions to determine which data fields will be enabled/displayed in the RCM++ interface and report output, and what those fields will be called. For example, if your organization captures three levels of effect description (*e.g.* Local Effect, Next Level Effect and End Effect), then you can define the interface style to enable/display all three fields. If not, then you can define the interface style to enable/display only one field and rename the field to be called "Effect Description" or whatever terminology is appropriate for your application.

- To create your own custom interface style, which can be applied to the projects that you create in RCM++, begin by clicking the **Interface** tab in the Profiles/Libraries Manager. This page displays a list of existing interface styles.

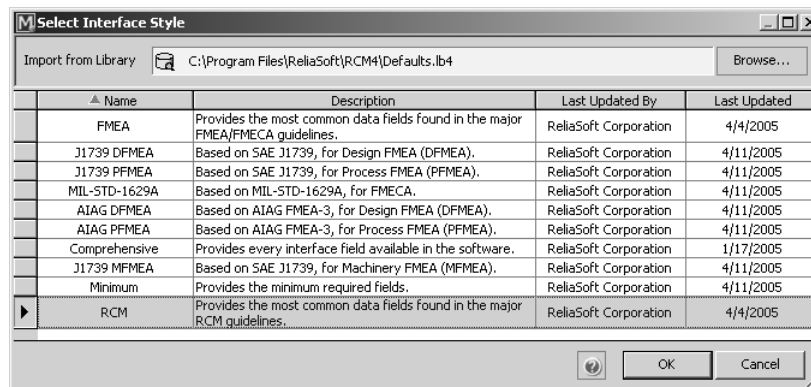
- Click **Add** to open the Add Interface Style window.



4.12.2.1 Copying an Existing Style

If there is an existing interface style that comes close to meeting your particular needs, you can copy the style and modify it as necessary to define the new custom style, following the steps described in this section. If this does not apply to you, you can skip ahead to the next section.

- To set the properties in your new style automatically based on the properties of an existing style, click **Copy Existing** and then select the style from the Select Interface Style window that is displayed, as shown next with the standard RCM interface style selected.

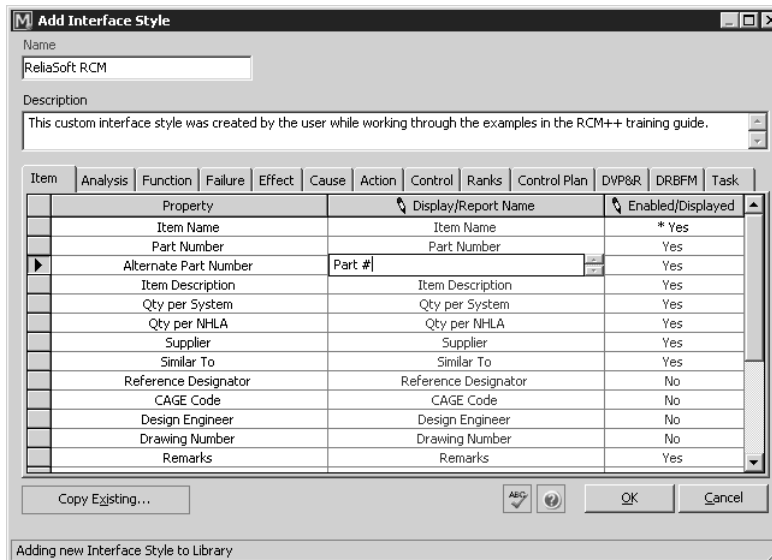


- Click **OK** to update the settings for the new interface style you are creating with the settings from the existing style. You can use these settings as a starting point and modify them as necessary to meet the specific needs that will be addressed by the new style.
- For **Interface Style Name**, type a name for the new interface style that will be meaningful to you, such as the name of your company and perhaps the type of analysis that the style is appropriate for (e.g. “ReliaSoft RCM”). This name must be unique among the interface styles that have been created in the active library file (*.lb4) on your computer.
- If desired, type a more detailed description of the purpose for the style in the **Interface Style Description** field.

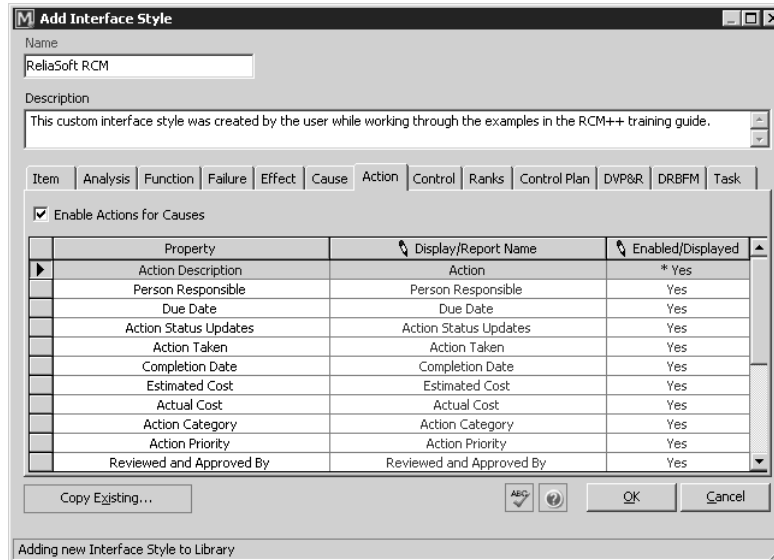
4.12.3 Record Properties Tabs

The Item, Analysis, Function, Failure, Effect, Cause, Action, Control, Task, Control Plan and DVP&R tabs of the Add Interface Style window allow you to determine which fields will be enabled/displayed in the interface and reports when this style is applied to the project and what the fields will be called. Each tab displays all of the properties that are available for the selected record type in a table with three columns:

- **Property:** Contains a list of all properties (data fields) that are available in RCM++ for the selected record type. You cannot change the information in this column.
 - **Display/Report Name:** Contains the names that will be used within the interface and report output to identify each property. You can change this name by clicking inside the cell and editing the text.
 - **Enabled/Displayed:** Contains an indication of whether or not the property (field) will be enabled/displayed in the interface and report output. You can set this to **Yes** or **No** by clicking inside the cell to toggle the selection.
- Take some time now to review the fields that are available for each type of record. Determine whether each field will be displayed and, if so, what it will be called in the interface and reports for projects that use this interface style.
 - For example, if you want to display the “Part Number” field for item records but you want to call the field “Part #” instead of “Part Number,” set the **Enabled/Disabled** column to **Yes** for that property and type “Part #” in the **Display/Report Name** column, as shown next.



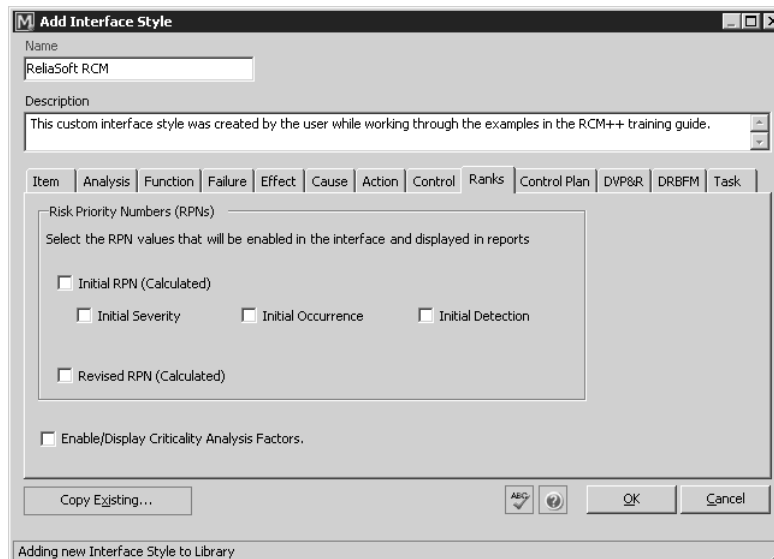
As you review the properties available for each record type, you will notice an Enable Actions for Causes option in the Action tab, and an Enable Controls for Causes option in the Control tab. These options can be found above the tables, as shown next for the Action tab.



If you de-select the **Enable Actions for Causes** option on the Action tab of the Interface Style window, then you will not be able to define actions for the analyses in projects that use this interface style. Any selections that have been made for Display/Report Name and Enabled/Displayed will be ignored by RCM++ because the Actions windows will not be available at all. De-selecting the **Enable Controls for Causes** option on the Control tab will have a similar effect for controls.

4.12.3.1 Ranks Tab

The Ranks tab allows you to determine whether Risk Priority Numbers (RPNs) and/or Criticality Analysis will be enabled for the projects that use the current interface style.



- Make the required selections to meet your particular needs and click **OK** to create the new interface style.

4.12.4 Create a Custom FEC Logic

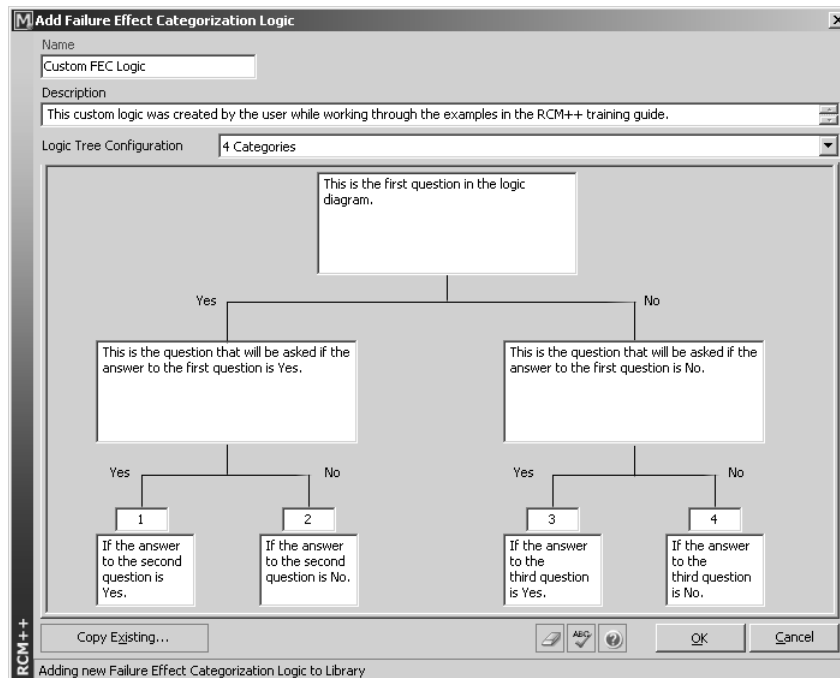
The FEC logics are pre-defined sets of questions and categories that can be used to evaluate the effects of failure in an RCM analysis.

- To create your own custom FEC logic, which can be applied to the projects that you create in RCM++, begin by clicking the **FEC Logic** tab in the Profiles/Libraries Manager. This page displays a list of existing FEC logics.
- Click **Add** to open the Failure Effect Categorization Logic window.

This window also provides the ability to copy the properties of an existing logic into the new logic and requires a unique name for the scale (as described for interface styles in Section 4.12.2.1). The following options are available when defining an FEC logic:

- **Logic Tree Configuration:** Allows you to specify whether your logic diagram will have 3 questions and 4 categories, 4 questions and 5 categories or 5 questions and 6 categories. For 5 category diagrams, you must also specify whether the last question occurs in the yes (left) branch or no (right) branch.
- **Questions:** Depending on your selection for the Logic Tree Configuration, the window displays 3, 4 or 5 text boxes to allow you to type the questions that will appear in the logic diagram.
- **Categories:** Depending on your selection for the Logic Tree Configuration, the window displays 4, 5 or 6 sets of text boxes to allow you to type the categories that will appear in the logic diagram, along with their short abbreviations.

The window shown next provides an example of what your screen might look like as you add entries to the new custom FEC logic. The appearance will vary, of course, based on the information that is appropriate to your particular needs.



- When you have fully defined the FEC logic, click **OK** to save the changes and add the new custom settings to the list of available FEC logics.

If desired, you can follow a similar procedure to define custom settings for other RCM analysis logics and Risk Priority Number (RPN) rating scales. The features in each window are different to accommodate the specific requirements of the settings that you are defining.

4.12.5 Create a Custom Menu Set

A menu set is a pre-defined set of options that will be available in the menus that appear throughout the RCM++ interface.

- To create your own custom menu set, which can be applied to the projects that you create in RCM++, begin by clicking the **Menu Sets** tab in the Profiles/Libraries Manager. This page displays a list of existing menu sets.
- Click **Add** to open the Add Menu Set window.

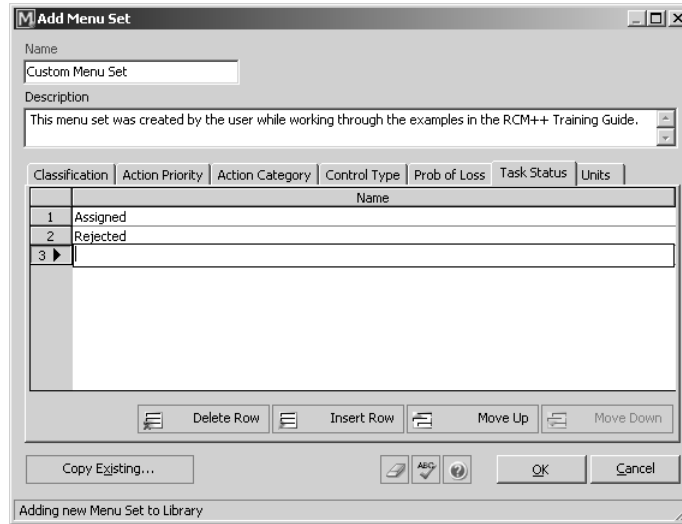
This window also provides the ability to apply the properties of an existing menu set into the new set and requires a unique name for the menu set (as described for interface styles in Section 4.12.2.1). In addition, each of the seven tabs displayed in this window allows you to set the options available within a particular menu. The tabs include:

- **Classification:** Allows you to set the options that will be available for the Classification menu that can be enabled/displayed in the Cause Properties window.
- **Control Type:** Allows you to set the options that will be available for the Control Type menu that can be enabled/displayed in the Control Properties window.
- **Action Category:** Allows you to set the options that will be available for the Action Category menu that can be enabled/displayed in the Action Properties window.
- **Action Priority:** Allows you to set the options that will be available for the Action Priority menu that can be enabled/displayed in the Action Properties window.
- **Prob of Loss:** Allows you to set the options that will be available for the Probability of Loss menu that can be enabled/displayed in the Failure Properties window.
- **Task Status:** Allows you to set the options that will be available for the Status menu that can be enabled/displayed in the Task Properties window.
- **Units:** Allows you to define the base unit for all time-based calculation inputs in the project (*e.g.* Item Operating Time, Task Interval, Task Duration, etc.) and the conversion multipliers for the other units that are available.

Note that the order of the options in each menu reflects the order in which the options will appear in the menu within the interface. The following buttons allow you to manage the options that have been defined for each menu.

- **Delete Row** deletes the currently selected option from the menu.
- **Insert Row** inserts a new option above the currently selected option in the menu.
- **Move Up** moves the currently selected option up one place in the menu.
- **Move Down** moves the currently selected option down one place in the menu.

The window shown next provides an example of what your screen might look like as you add entries to the Task Status menu for your new custom menu set. The appearance will vary, of course, based on the information that is appropriate to your particular needs.



- Define the menu options for each of the seven menus and click **OK** to save the new menu set.

4.12.6 Create a Custom Profile

As the previous examples in this training guide have demonstrated, profiles provide a quick and easy way for you to assign the interface style, rating scales, menu set and RCM logics to the projects that you create and manage with RCM++.

- To create your own custom profile, which can be applied to the projects that you create in RCM++, begin by clicking the **Profiles** tab in the Profiles/Libraries Manager. This page displays a list of existing profiles.
- Click **Add** to open the Add Profile window.
- Type a unique name and, if desired, type a more detailed text description.
- Next, select the custom interface style that you created in Section 4.12.2 from the **Interface Style** menu, which displays a list of all existing interface styles defined on your computer.
- Then select the custom menu set that you created in Section 4.12.5 from the **Menu Set** menu.
- Then select the rating scales to be used for any RPN calculations that may be performed in the project.
- Now, click the **RCM** tab and select the RCM logics that will be applied to the project, including the custom FEC logic that you created in Section 4.12.4.
- When you have made all selections, click **OK** to create the new profile. When you apply this profile to a new or existing project, the interface style, RPN rating scales, menus and RCM logics used within the project will be updated automatically to fit the custom preferences that you have pre-defined.
- To investigate more advanced features of RCM++'s profiles and libraries, leave the Profiles/Libraries Manager open and proceed to the next example.

4.13 Example 12 - Advanced Techniques for Profiles/Libraries

This example guides you through the processes required for more advanced profiles and libraries management techniques in RCM++. With this example, you will obtain settings from another library, modify the project properties directly within a project, create a new library set based on the properties that have been defined for a particular project and create and activate your own custom phrase library.

4.13.1 About Library Files

The profiles and libraries settings that have been defined on your computer are stored by default in the **defaults.lb4** file in the RCM++ application directory on your computer (*e.g.* C:\Program Files\ReliaSoft\RCM4). Therefore, each user can manage the profiles and libraries stored on his/her computer independently of other users. If you want to obtain new or updated settings information from another user's computer, you can import that record from the library file on that user's computer to the defaults.lb4 file on your own computer. You can also export your custom settings to a new library and then set this library as the active library for the projects you create. In addition, you can set the active library location in a shared network location so that all users have the same profiles and libraries.

4.13.2 Export Library to Another File

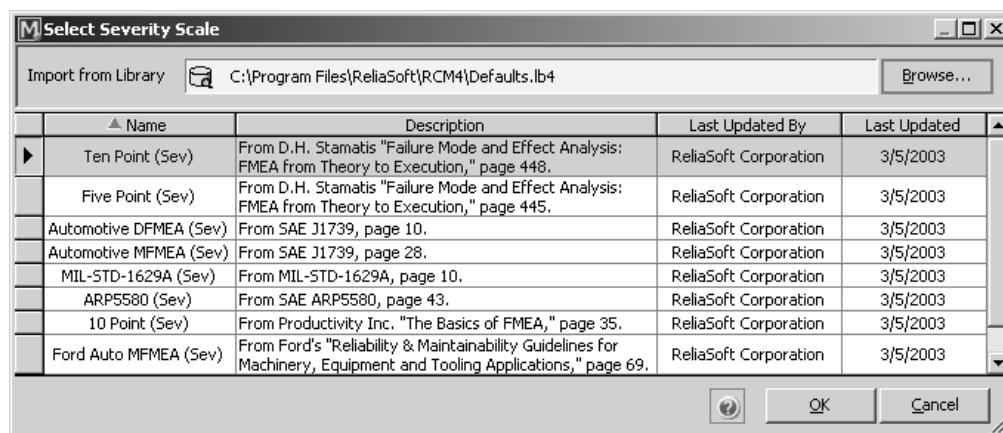
- With the Profiles/Libraries Manager already open, click the **Export Current Library** button and type **TrainingLibrary** for the name of the new library file (*.lb4) that you are creating.
- Click **Save** to create the file.

4.13.3 Delete a Rating Scale

- Go to the **Severity** page of the Profiles/Libraries Manager and select the **Ten Pt (Sev)** rating scale that is shipped with the software.
- Click **Delete** to delete the rating scale from the active library.
- Since there is no undo for delete, you will be prompted to confirm that you want to delete the rating scale. Click **Yes** to continue.

4.13.4 Obtain Settings from Another Library

- Click **Add** to open the Add Severity Scale window. Click the **Copy Existing** button to display a Select Severity Scale window like the one shown next.



- By default, this window displays a list of all the severity rating scales that have been defined in the active library on your computer. However, you can click the **Browse** button at the top of the window to select a different *.lb4 file to import a rating scale from.

- After clicking **Browse**, choose the **TrainingLibrary.lb4** file that you created in the previous step.
- You can see that the **Import from Library** field at the top of the window now displays the TrainingLibrary.lb4 file and the table has been updated with the severity scales that exist in that *.lb4 file.
- Select the rating scale called **Ten Pt (Sev)** and click **OK**. The Add Severity Scale window will now be updated with the properties of the rating scale that you imported from the other library file.
- Click **OK** to save the new rating scale into your library then close the Profiles/Libraries Manager.

4.13.5 Modify Project Properties Directly Within the Project

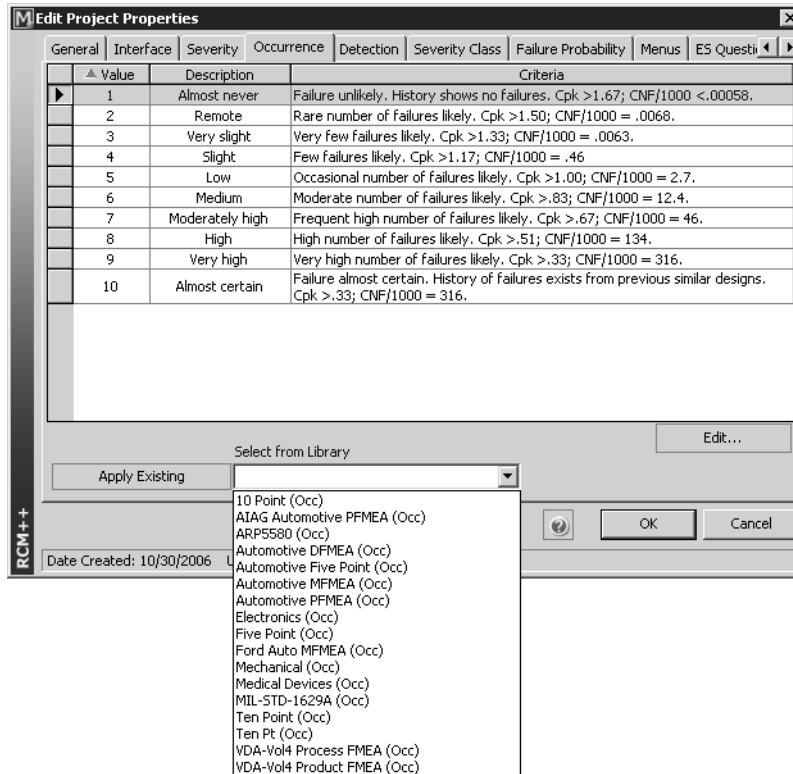
Although the previous examples in this training guide have always set the project properties automatically with a pre-defined profile, you can also modify the project properties directly within an existing project. These changes apply to the project only and have no direct effect on the profile and libraries that were used to set the project properties originally.

- Open the **AuthorizedUsers.rx4** database from the Training folder in your application directory (*e.g.* C:\Program Files\ReliaSoft\RCM4\Training). The Username is “**username**” and the Password is “**password**” for this login secure database.
- Next, open the **Project Properties** window for the project called **Sample Project**.

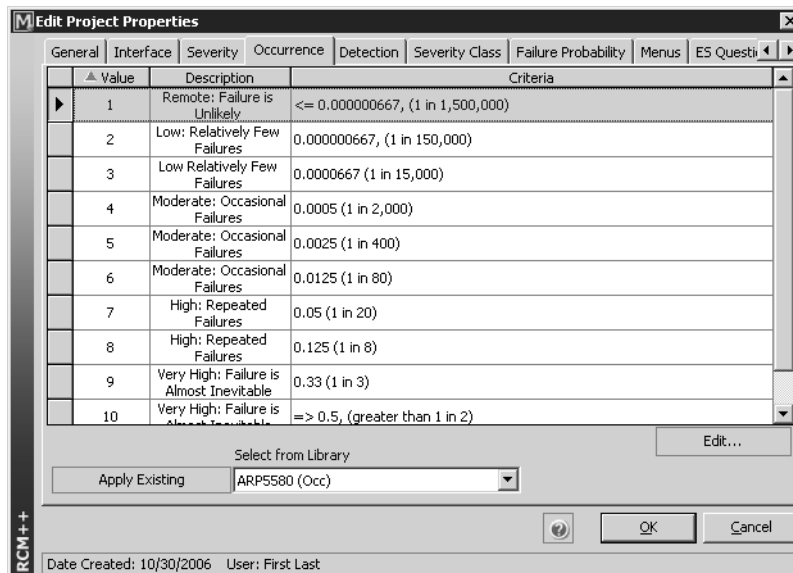
As you can see, the properties for this project were originally set based on the Standard FMEA profile that is shipped with RCM++. For this example, suppose that all of the properties from the Standard FMEA profile are appropriate for the project except that you would like to choose a different Occurrence scale and make a few adjustments to the interface style.

- To change the Occurrence scale assigned to this project, first click the **Occurrence** tab and then click the **Apply Existing** button at the bottom of the page. If a warning message is displayed, click **OK** to continue. This message simply reminds you that if you change the rating scale for the project and the project already has records that have been rated according to the old scale, you may need to re-set the ratings for those records according to the new scale in order to avoid inconsistencies in RPN calculations.

- After clicking the **Apply Existing Occurrence Scale** button, the menu to the right will become enabled and you can select a different Occurrence scale to apply for this project, as shown next.



- Select the **ARP5580 (Occ)** scale (created based on the SAE's ARP5580 guideline and shipped with RCM++) to update the Occurrence scale for the current project, as shown next.

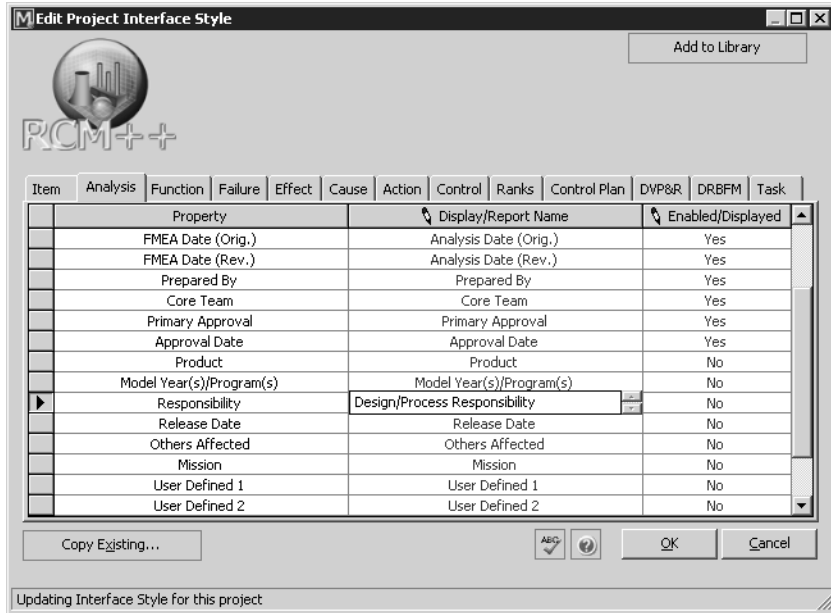


- Next, click the **Interface tab** to edit the interface style that has been defined for this project. On this page, click the **Edit** button to open the Edit Project Interface Style window.
- For this example, suppose that the standard interface style is acceptable except for the following:
 - Users will not be able to enter Design Engineer or Drawing Number for item records.

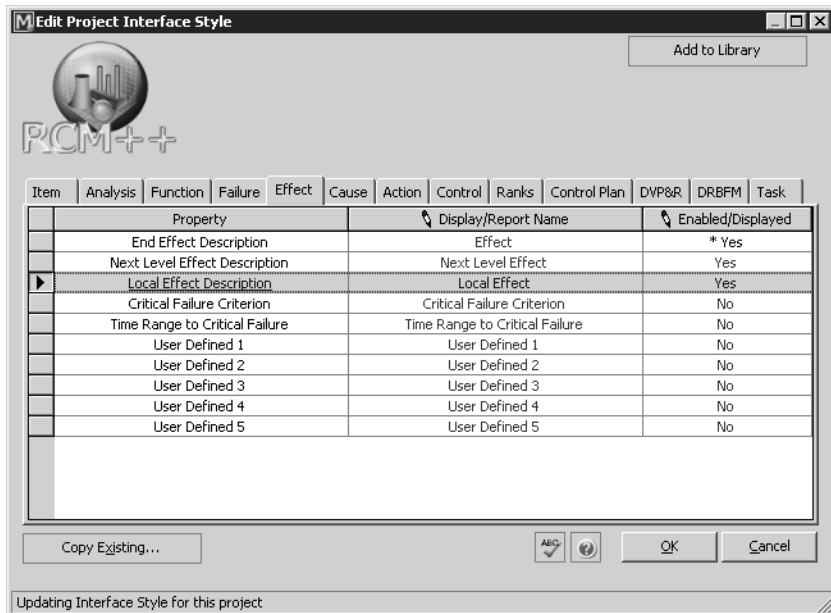
- The Responsibility field for the Analysis Properties will be called “Design/Process Responsibility.”
- Users will be able to enter three levels of effect descriptions for effect records, called End Effect, Next Level Effect and Local Effect.

To make these changes, do the following:

- From the Item page of the window, click inside the **Enabled/Displayed** column in the row for the Design Engineer property and set the value to **No**. Then disable the Drawing Number property as well.
- Next, click the **Analysis** tab and then click inside the **Display/Report Name** column for the **Responsibility** property. Edit the text to set the label as **Design/Process Responsibility**, as shown next.



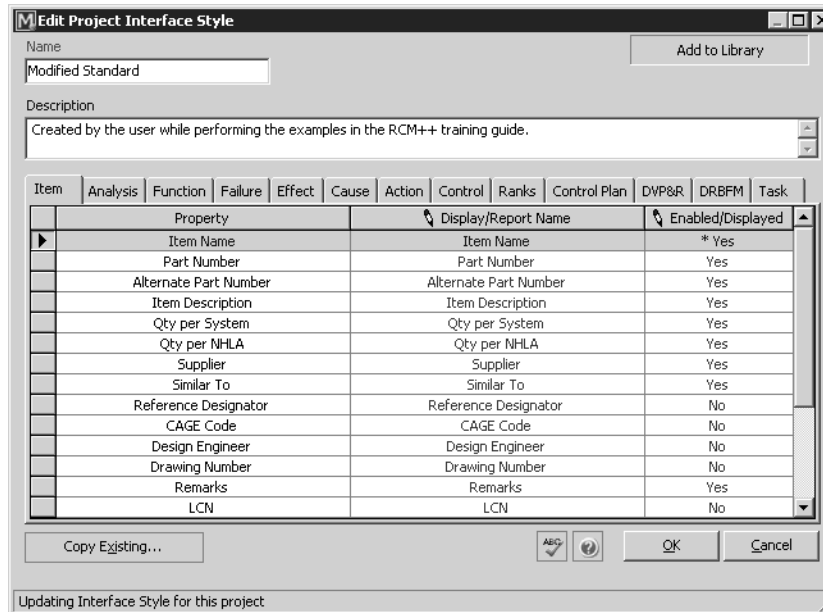
- Finally, click the **Effect** tab and then enable the **Next Level Effect Description** and **Local Effect Description** properties, as shown next.



4.13.6 Create a New Library Set Based on Project Properties

The changes that you have made to the interface style will be applied to the current project when you click **OK**. In addition, if you want to save the modified interface style in your library so that it will be available to apply to the projects that you create and modify in the future, do the following:

- Select the **Add to Library** option in the top right corner of the window. The Name and Description fields will become enabled.
- Type a name (required) and description (optional) for the new interface style that will be added to the library, as shown next.



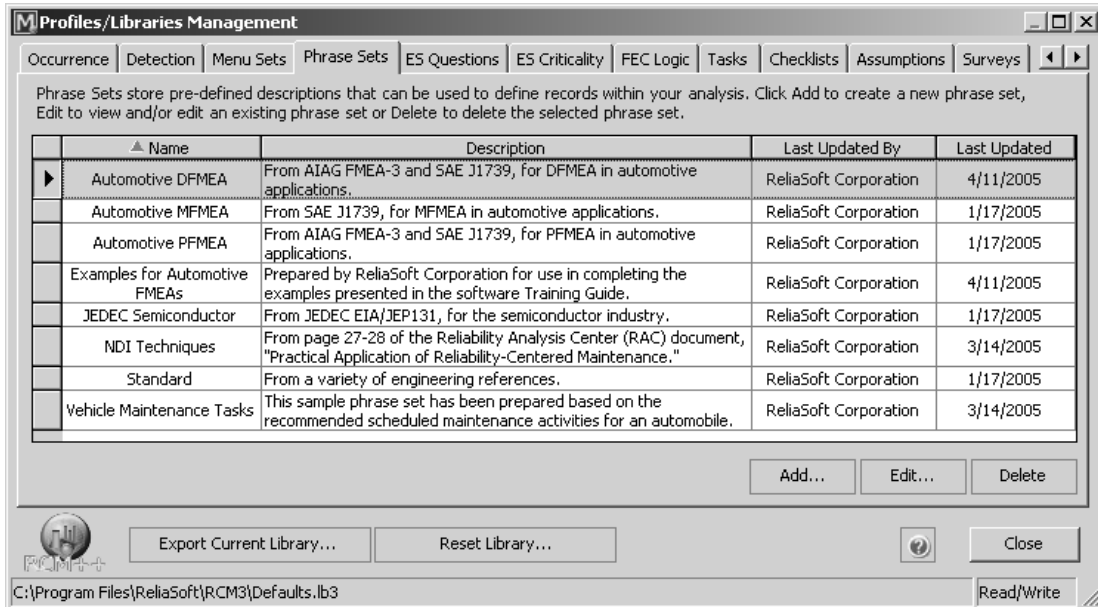
- Now, click **OK** to apply the modified interface style to the current project and add it to the library for future re-use.
- Click **OK** to close the Project Properties window.

4.13.7 Create a Custom Phrase Set

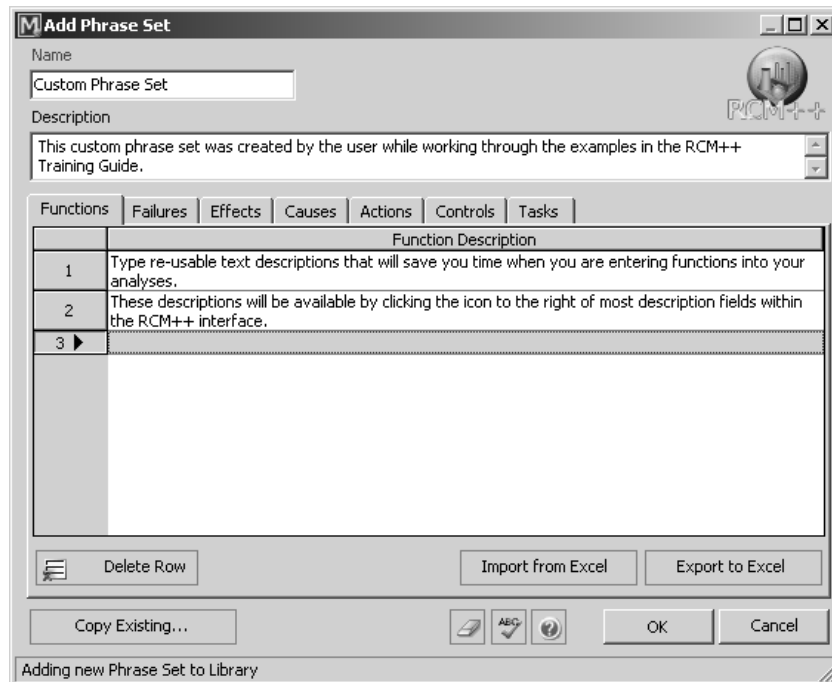
In addition to the settings that are applied in the Project Properties window, RCM++ allows you to manage other pre-defined resources within your library file: phrase sets, checklists, ground rules and assumptions lists and quality surveys. As the examples in this training guide have demonstrated, you can use phrase sets to quickly and easily enter descriptions for the records you create in your analyses. The other records are available for use in the software's Analysis Planning utility.

For this example, you will be creating a custom phrase set.

- Select **Profiles/Libraries Manager** again from the **Tools** menu. Then click the **Phrase Sets** tab to display a list of all the phrase sets that have been defined on your computer, as shown next.



- Click **Add** to open the Add Phrase Set window. This window works in a similar fashion to the windows that you have used to create your own custom Profiles/Libraries settings. Follow a similar procedure now to pre-define descriptions that may be of use to you when you are creating function, failure, effect, cause, control, action and task records in your analyses. If you have phrase sets already defined in Excel, you can import them on the appropriate tabs of this window.



- When you have fully defined your own new custom phrase set, click **OK** to add the phrase set to the library.

- Click **Close** to close the Profiles/Libraries Manager and then select **User Setup** from the **File** menu to open the User Setup window. Click the **Descriptions** tab. You can see that your new custom phrase set has been added to the list of phrase sets that are available on your computer.
- If you would like to activate this phrase set so that its descriptions will be included in the Select Existing windows when you edit analyses on your computer, mark the checkbox next to the phrase set name and click **OK**.

After you are finished experimenting with these advanced profiles/libraries management options, you can close the project and the database before proceeding with the next example.

4.14 Example 13 - Using Revision Tracking Features

This example allows you to experiment with RCM++'s revision tracking capabilities and guides you through the process to create and manage baseline versions of an RCM++ database.

For this example, you will work with a sample database that has been prepared by ReliaSoft, which contains sample data related to imaginary products. *Sample data sets are not intended to be realistic.*

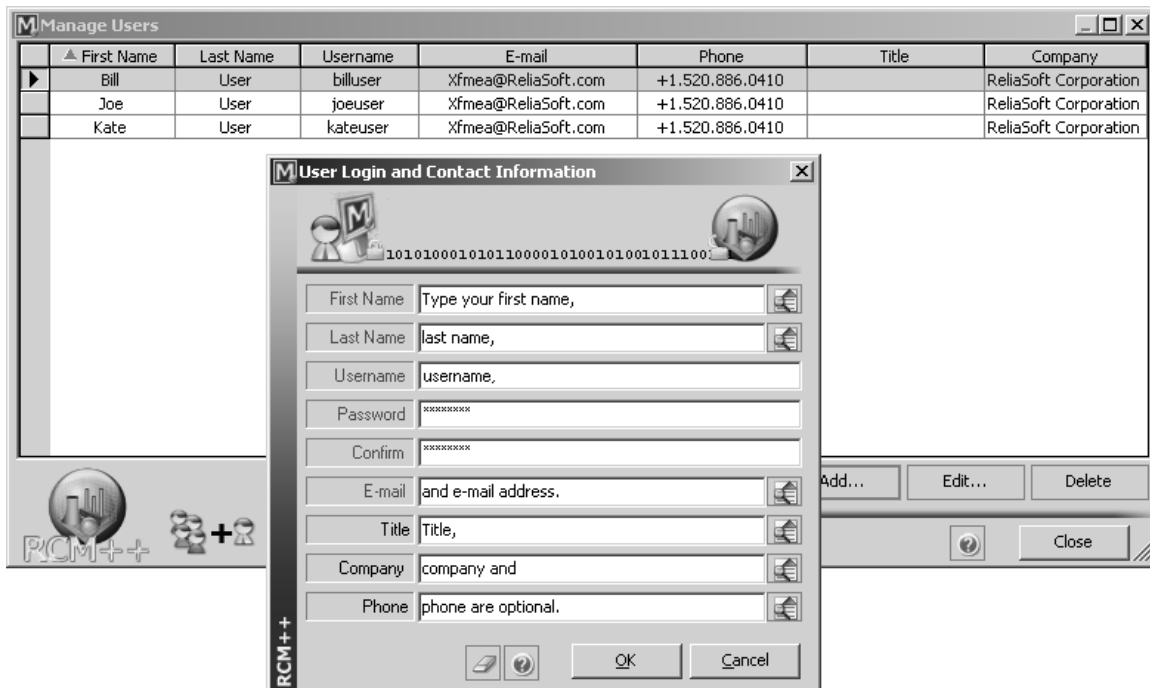
4.14.1 Open and Log In to an Existing Database

Open the database called **AuthorizedUsers.rx4** in the Training folder in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training). Log in with the following administrative user account:

- **Username:** username
- **Password:** password

4.14.2 Create a New User Account

- Select **Administrative Options** from the **Tools** menu and then use the same account information to log in to the administrative utilities for this database. Click **Manage Database Users** and then create a new user account for yourself.



- Close the Manage Users window and then close the database and open it again, logging in with your new user account.

4.14.3 Edit Record and View Last Updated Username and Timestamp

- Next, open the project called **Sample Project**.
- Double-click the item called **Component 1.1.1** in the System Hierarchy to display the Item Properties window. Type **RS12345** for the Part Number, **1** for the Qty per System and **1** for the Qty per NHLA.
- Then click **OK** to save the changes and close the window.
- Double-click the item again to re-open the properties window. You can see that the status bar at the bottom of the properties window now displays the date/time when you made the change to the item record and the first and last name associated with the user account that you logged in under.

4.14.4 Open the Revision Tracking and Management Window

- Now, select **Revision Tracking** from the **Tools** menu to open the Revision Tracking and Management window, as shown next.



You can see that the top of the window displays some information about the current database. Note that the appearance of the window on your computer will vary depending on the specific attributes of the database that you are using.

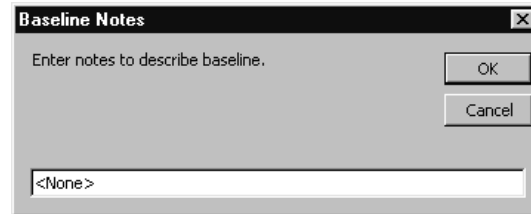
In addition, the window provides revision tracking options on two pages, separated by tabs. The Manage Baselines page allows you to create and manage baselines of the current database, which are exact replicas of the database at a particular point in time. You may wish to use a baseline to “roll back” to an exact state that the database was in. You will notice that one baseline has already been created for this sample database.

The Database Logins page allows you to view a record of every login to the current database, including the date/time of the login and information on the user who performed the login.

4.14.5 Store a Baseline Within the Database

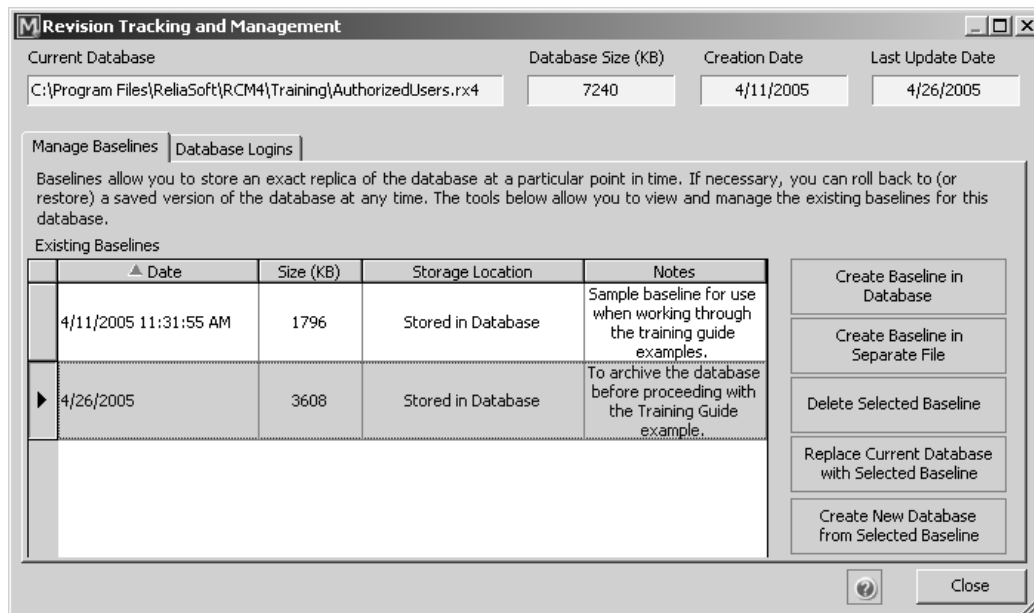
You can store baselines inside the current database or as separate files outside of the database.

- To create a baseline inside the database, click **Create Baseline in Database**. A window like the one shown next will be displayed.



You can use this window to type notes about the baseline that you are in the process of creating. These notes can be used to identify the purpose and/or contents of the baseline at a later time.

- Type the following text and click **OK** to proceed.
 - To archive the database before proceeding with the Training Guide example.
- A message will be displayed that indicates that the baseline was created successfully. Click **OK** to continue. The window will now look like the figure shown next.



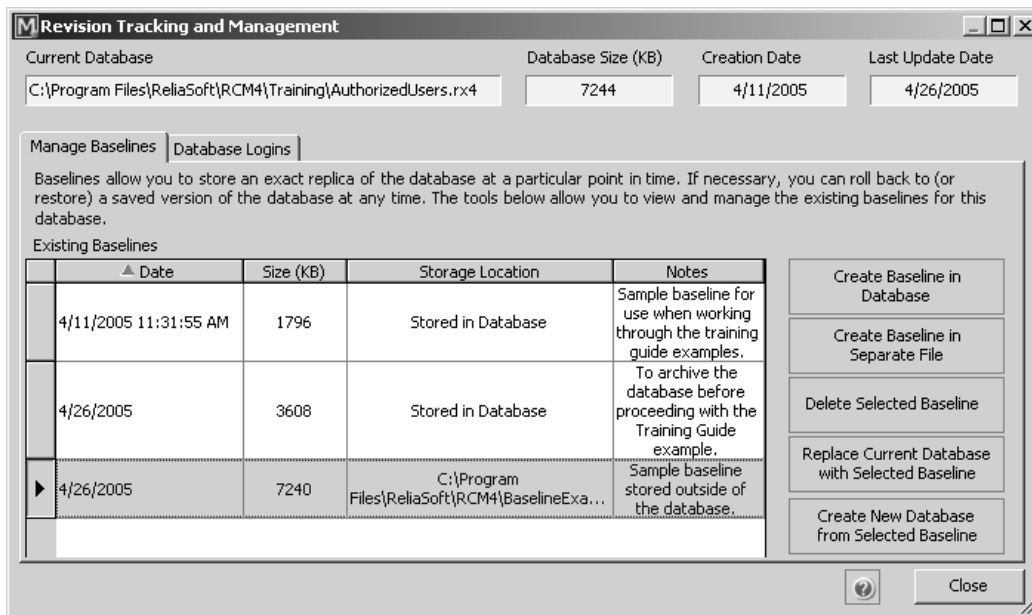
This baseline file is stored inside the database and will be transferred with the database if you e-mail the database to a colleague or create a copy of the database in another location, etc. However, storing the baseline inside the database also takes up space within the database, which may become an issue for very large databases. If space inside the database is (or becomes) a concern, you may prefer to create the baselines as separate files outside of the database. This process is described next.

4.14.6 Store a Baseline Outside of the Database

- To create a baseline as a separate file outside of the database, click **Create Baseline in Separate File**.
- A window will be displayed to explain that if the link does not remain consistent (*e.g.* if you move the baseline file or transfer the database to another user who does not have access to the baseline file in the

same location), then you will not have full baseline management capabilities for that baseline. In other words, you will not be able to replace the current database with the selected baseline if the file does not exist in the original location. Likewise, you will not be able to create a new database from a selected baseline if the link is not consistent. Click **Yes**.

- You will again be prompted to enter notes to help identify the baseline. Type the following text and click **OK**.
 - Sample baseline stored outside of the database.
- Next, you will be prompted to specify the location and filename for the new baseline file. Type **BaselineExample** and click **Save** to create the file.
- Click **OK** to close the confirmation message that is displayed. The window will now look like the figure shown next.



You can see that the full path/filename for the new baseline file is displayed with the entry in the list of existing baselines. Only the link (and not the actual file) is stored inside the database and only the link will be transferred with the database.

4.14.7 Create a New Database from a Baseline

You can use the baselines that you have stored (both inside the current database and outside the database in separate files) to either replace the current database or to create a new database. If you select to replace the current database with a selected baseline, this will have the effect of “rolling back” the database to the exact state it was in at the time that the baseline was created. This action cannot be undone and will overwrite any changes that have been made to the database since the creation of the baseline.

If you select to create a new database from a selected database, the current database will remain exactly the same and a new database will be created that re-creates the state of the database at the time that the baseline was saved.

- To create a new database from one of the baselines in the current database, select any of the existing baselines and click **Create New Database from Selected Baseline**.
- You will be prompted to enter the path/filename for the new database. Type **BaselineDatabase** for the filename and click **Save**.

- A message will be displayed that indicates that the database was created successfully. Click **OK**.

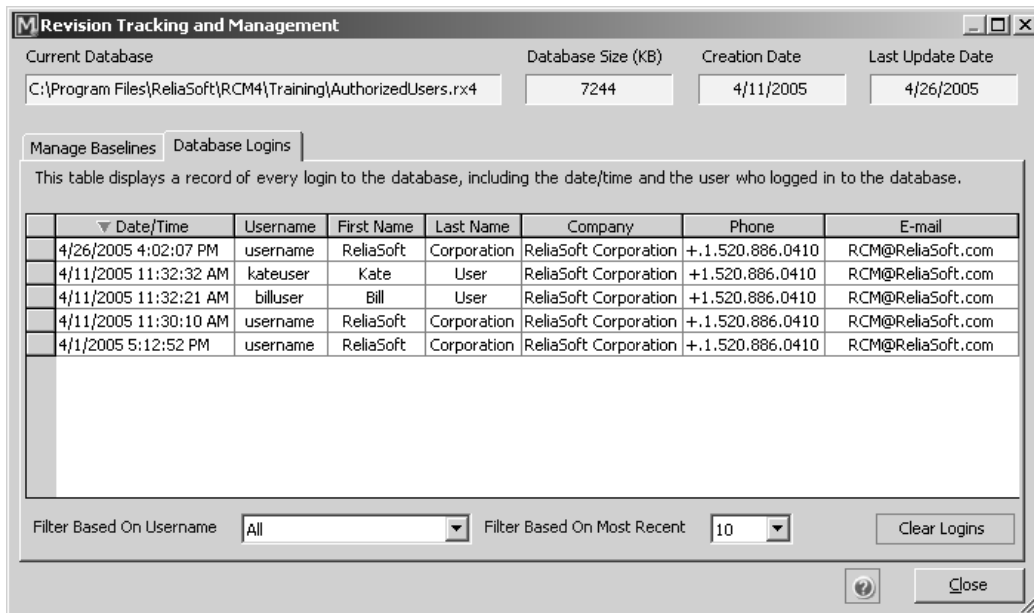
4.14.8 Open the New Database

The new database, BaselineDatabase.rx4, will be an exact replica of the current database at the time that the baseline was created.

- To confirm this, click **Close** to close the Revision Tracking and Management window and then open the new database that you just created.
- You can take some time now to review the new database to confirm that it is an exact replica of the original database at the particular point in time.

4.14.9 Re-Open the Original Database and Review Database Logins

- Now re-open the original database for this example, **AuthorizedUsers.rx4**, then select **Revision Tracking** from the **Tools** menu.
- Click the **Database Logins** tab to display the second page of the Revision Tracking and Management window, as shown next.



The appearance of the window will vary depending on the particular properties of your database. It will display a list of every login that has been made to the current database, including the date/time and information on the user who performed the login.

By default, all records will be displayed. However, you can filter the records based on username or based on the most recent login date/time using the corresponding drop-down menus.

- When you have finished investigating RCM++'s revision tracking functionality, click **Close** to exit the window. Then close the project and the database.

4.15 Example 14 - Using Change Logs

This example allows you to experiment with RCM++'s Change Log feature and guides you through the process to create and manage versions of an RCM++ database.

For this example, you will work with a sample database that has been prepared by ReliaSoft, which contains sample data related to imaginary products. *Sample data sets are not intended to be realistic.*

4.15.1 Create a New Login Secure Database

The first step is to configure the software so that new databases are login secure, if you have not done so already.

- To do this, select **User Setup** from the **File** menu and click the **Settings (1)** tab.
- Select the **Enable Login Security features for new databases** option and click **OK** to close the User Setup.
- Next, create a new database called **ChangeLogExample.rx4**.
 - In Step 1 of the Database Creation Wizard, type **username** in the Username input box and type **password** in the Password input box. Type the rest of the required information in the Creator/Administrator Information area (indicated with red text).
 - In Step 2 of the Database Creation Wizard, select **Yes, I would like to add other users now**. The Manage Users window will appear.
 - Click **Import** and select **AuthorizedUsers.rx4** from the Training folder in your application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training) and click **Open**.
 - Select all available users and click **Import**, then close the Manage Users window.
 - In Step 3 of the Database Creation Wizard, select **Yes, I would like to create a project now** and click **Finish**.
- When prompted to create a new project, click **Cancel**.

4.15.2 Import an Existing Project

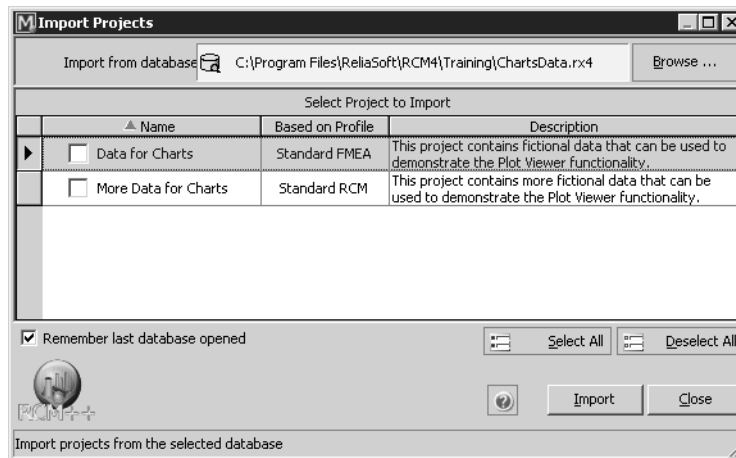
- Select **View Project Explorer** from the **File** menu or click the **View Project Explorer** icon.



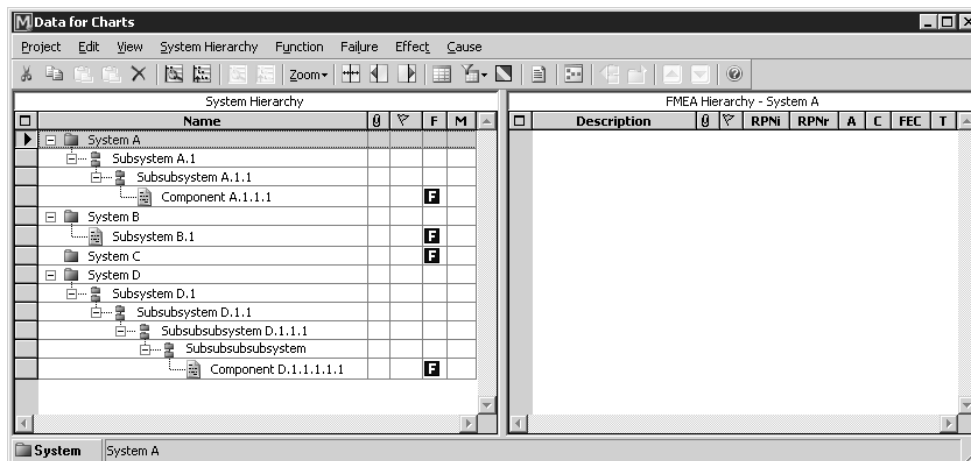
- Select **Import Projects** from the **Project Explorer** menu or click the **Import Projects** icon.



- When prompted to select a database to import from, navigate to the Training folder in the application directory (e.g. C:\Program Files\ReliaSoft\RCM4\Training) and select the database called ChartsData.rx4. The Import Projects window will be displayed, as shown next.



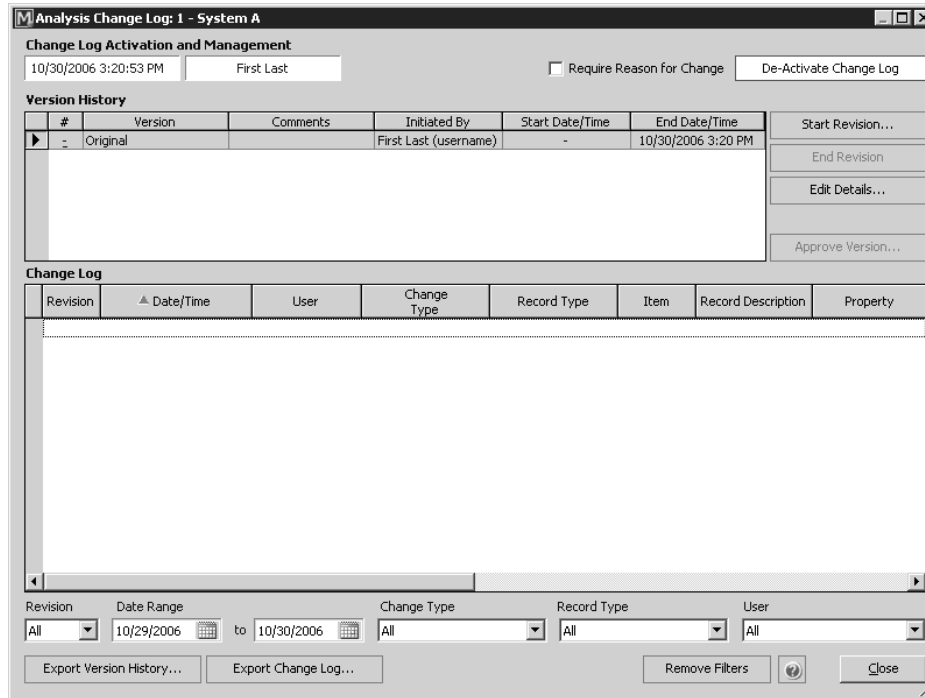
- Select the project called **Data for Charts** and click **Import** to import the project into the current database. Click **Close** to close the import window.
- Open the project that you imported. With **System A** selected, the Project window will look like the figure shown next.



4.15.3 Activate a Change Log

- With **System A** selected, select **Activate Change Log** from the **System Hierarchy** menu. You will see a warning notifying you that activating a Change Log for this item and its sub-items will mean that users

can only make changes to the analysis when a Revision is in progress. Click **Yes** to continue. The Analysis Change Log window will appear, as shown next.

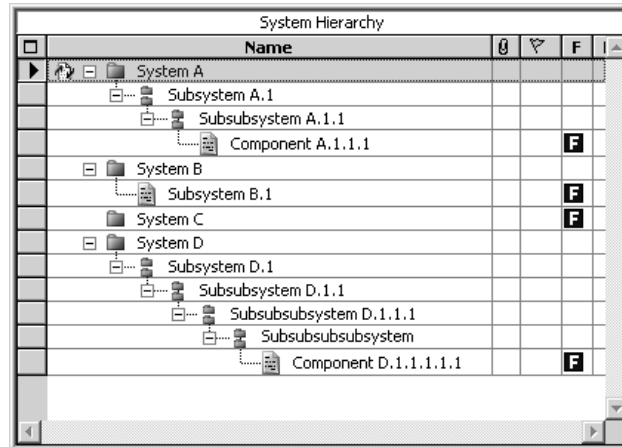


You will see in the Version History table that the only version of the analysis currently in existence is the original version. Now that you have activated a Change Log for this system, there must be a Revision currently in progress in order to make changes; if no Revision is in progress, the system and its sub-items will be locked. Once a Revision is in progress, all changes made to the analysis will be logged. Note that you can configure a Revision to require a reason for every change made, if desired, by selecting **Require Reason for Change** in the Analysis Change Log window. It is also possible to require electronic approval when each Revision is ended; this ensures that no further changes can be made to the analysis until the user(s) designated as approvers have “signed off” on the most recent Revision.

4.15.4 Start a New Revision

- Click **Start Revision** to begin a new Revision. The Version Details window will appear. Select **Major** to number the Revision as a major revision to the original version (*i.e.* 1.0) instead of as a minor revision (*i.e.* 0.1), and enter **Revision 1** in the Version Label field.
- Click the **Assign Approvers** button and assign Kate User as the approver for this version then click **OK**. Click **OK** once more to return to the Analysis Change Log window. You will see that the new Revision now appears in the Version History table.

- Click **Close** to return to the Project window. You will see that there is now a Change Log icon beside System A in the System Hierarchy panel, as shown next.

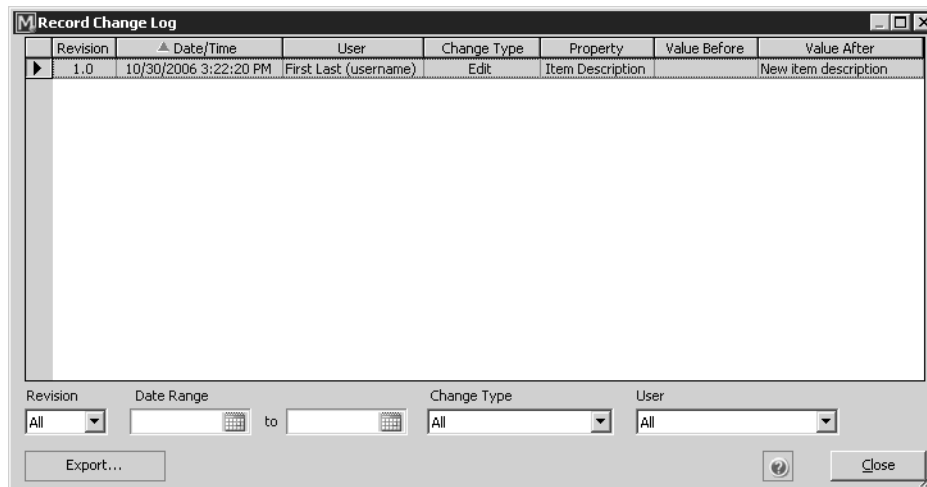


This indicates that a Change Log is active for the System, and that a Revision is currently open.

4.15.5 Make Changes to the Analysis

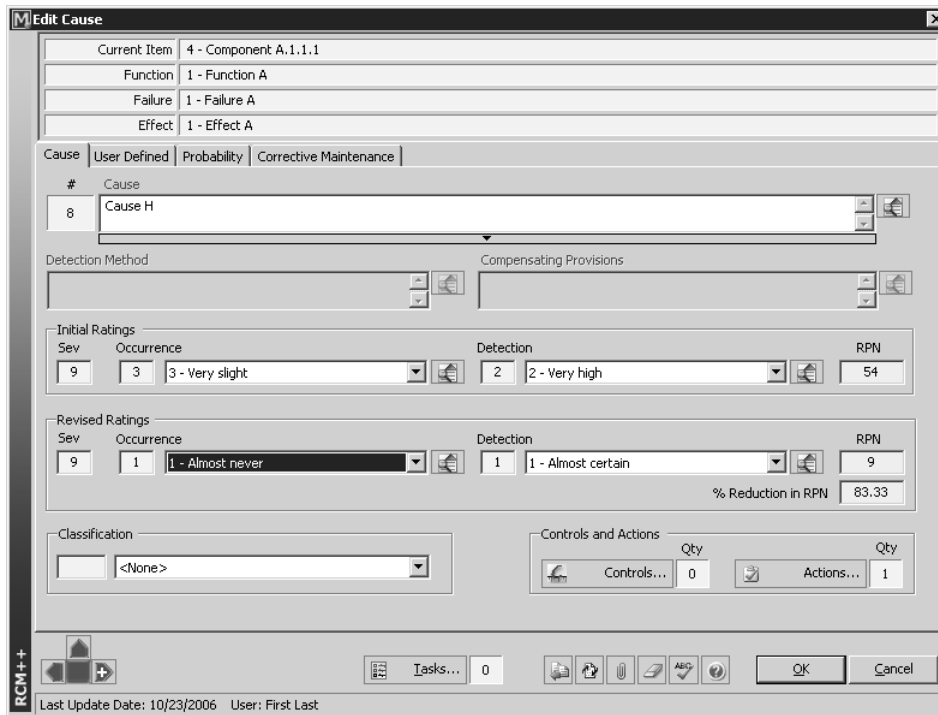
Change Logs track all changes made to an item and/or its sub-items, both to the items themselves and to any associated records in the FMEA. To see this process, you will now make a few changes.

- Double-click Subsystem A.1 to open its Item Properties window. You will notice that the **Change Log** icon at the bottom of the window is unavailable; this is because no changes have been made to the item. In the Item Description field, enter **New item description** and click **OK** to save your change.
- Re-open the Item Properties window for Subsystem A.1. You will see that the **Change Log** icon has become active. Click the icon to open the Record Change Log window, as shown next.

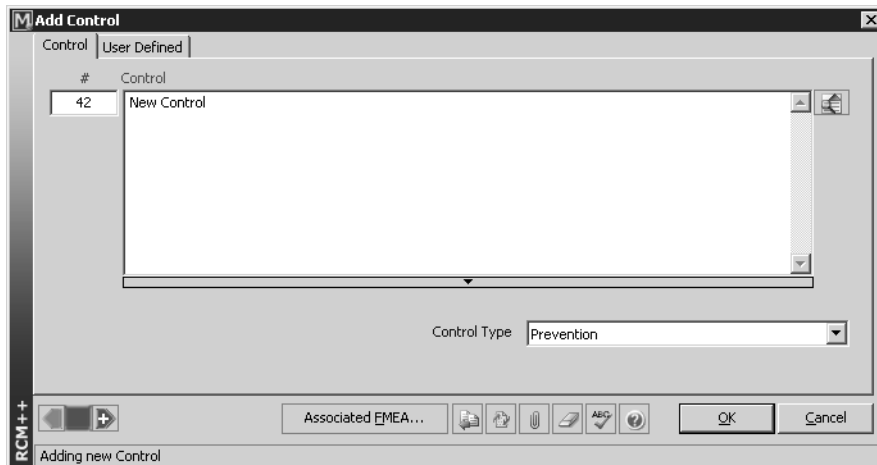


- Click **Close** to return to the Project window.
- Select **Component A.1.1.1**. In the FMEA Hierarchy panel, double-click **Cause H** under Effect A to open the Cause Properties window.

- Change the Revised Occurrence rating for the cause to **1 - Almost never**, as shown next.



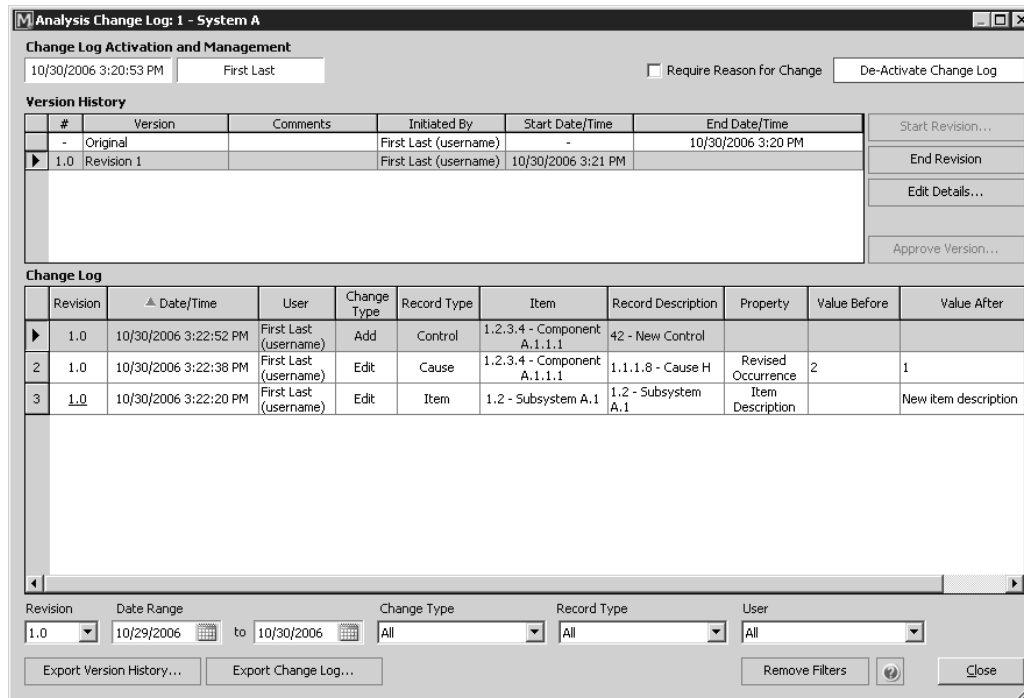
- Click the **Controls** button to open the Controls Manager then click **Add Control**. In the Control Properties window, enter **New Control** for the name and select **Prevention** as the Control Type, as shown next.



- Click **OK** to add the control then click **Close** to close the Controls Manager. Finally, click **OK** to close the Cause Properties window.

4.15.6 End the Revision

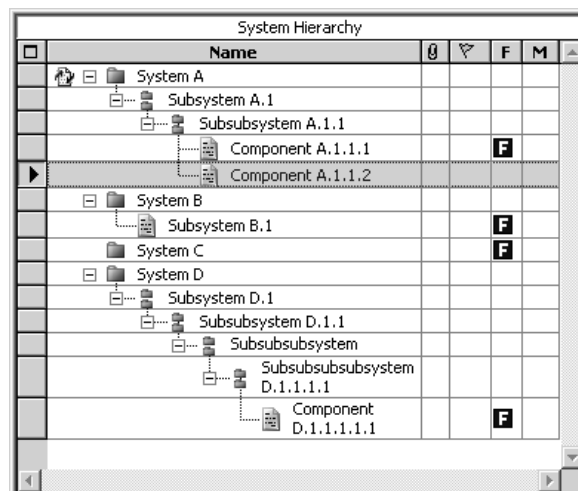
- In the System Hierarchy panel, select **System A** and select **View Change Log** from the **System Hierarchy** menu. In the Analysis Change Log window that appears, you will see that each of the changes you made to the analysis is listed in the Change Log table, as shown next.



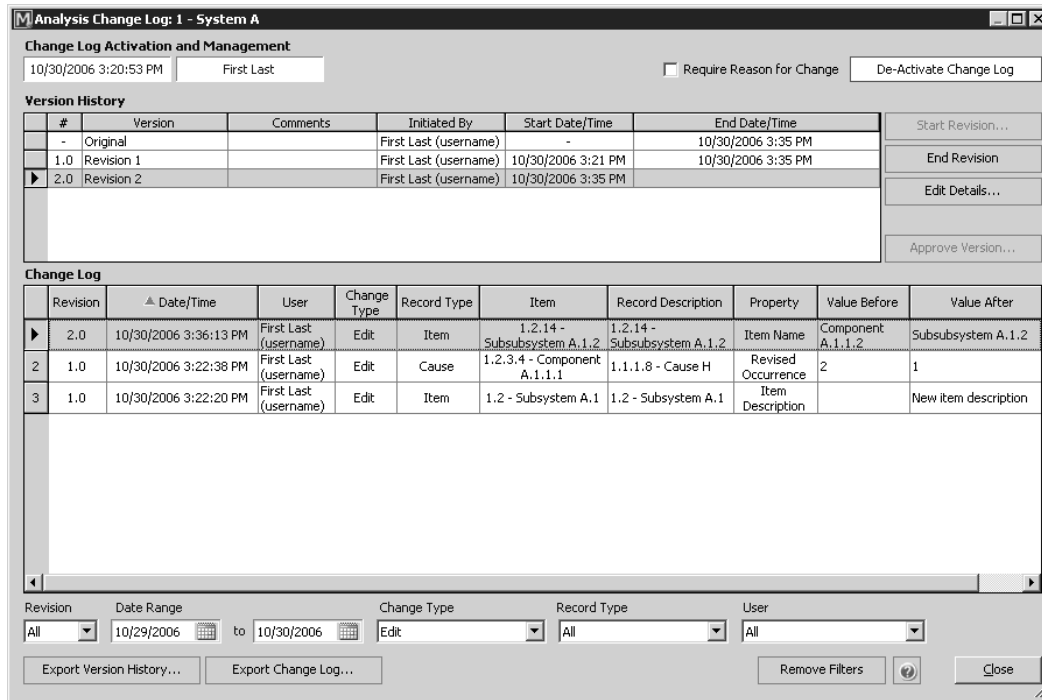
- Click **End Revision**. You will see a warning stating that users will not be able to make changes to the current version of the analysis unless the Revision is re-opened. Click **Yes** to proceed.

4.15.7 Track More Changes in Another Revision

- Repeat the steps given above to start a new Revision, which you will call **Revision 2**.
- Close the Analysis Change Log window.
- In the System Hierarchy, add a new component, **Component A.1.1.2**, under Subsystem A.1.1, as shown next.



- With Component A.1.1.2 selected, select **Promote Item** from the **System Hierarchy** menu.
- Double-click the promoted item to open the Item Properties window and change its name to **Subsubsystem A.1.2**, then close the Item Properties window.
- Select System A in the System Hierarchy and select **View Change Log** from the **System Hierarchy** menu.
- In the Analysis Change Log window, click **End Revision**.
- You will notice that only the changes from the most recent Revision are currently displayed in the Change Log table. You can use the filters below the table to specify criteria for which changes are displayed. For example, select **All** in the **Revision** field. All of the changes from both Revisions are displayed. Then select **Edit** in the **Change Type** field. Only changes of type Edit from both Revisions are displayed, as shown next.



4.15.8 Export Change Log Information

You can export the information from either the Version History table or the Change Log table to Microsoft Excel, if desired.

- Click **Export Change Log** to export the current contents of the Change Log table to Excel (note that because you have filtered the change records that are displayed, the exported data will correspond to the filtered data shown in the Change Log table).

- In the Save File As window that appears, name the file **Change Log** and click **Save**. RCM++ will generate a spreadsheet of the current Change Log view. Once the spreadsheet has been exported, it will automatically open in Microsoft Excel, as shown next.

Revision	Date/Time	User	Change Type	Record Type	Item	Record Description	Property	Value Before	Value After
2	10/30/2006 3:36:13 PM	First Last (username)	Edit	Item	1.2.14 - Subsystem A.1.2	1.2.14 - Subsystem A.1.2	Item Name	Component A.1.1.2	Subsystem A.1.2
1	10/30/2006 3:22:38 PM	First Last (username)	Edit	Cause	1.2.3.4 - Component A.1.1.1	1.1.1.8 - Cause H	Revised Occurrence	2	1
1	10/30/2006 3:22:20 PM	First Last (username)	Edit	Item	1.2 - Subsystem A.1	1.2 - Subsystem A.1	Item Description		New item description
1	10/30/2006 3:22:20 PM	First Last (username)	Edit	Item	1.2 - Subsystem A.1	1.2 - Subsystem A.1	Item Description		New item description

- Once you have finished viewing the report, close Microsoft Excel, then close the project and the database.

4.16 Example 15 - Perform Your Own RCM Analysis

This example guides you through the steps to perform an RCM or FMEA/FMECA analysis for one of your own products or processes. It has been designed to bring together all of the techniques that you have practiced by working through the examples in this training guide. The example will help you to focus your new skills toward performing a real analysis that will be of interest to you and your organization.

All instructions for this example are very general and the appearance of the windows will vary depending on your particular processes and information.

4.16.1 Use the Setup Wizard to Configure the Software

If you did not already go through each step of the Setup Wizard, which guides you through the process to configure RCM++ to fit the specific way that you and your organization work on RCM or FMEA/FMECA analyses, you may want to take some time to do so now.

- To open the Wizard, select **User Setup** from the **File** menu and then click **Run User Setup Wizard** from the first page of the User Setup window.



- When you have completed all of the steps, click **Finish** to apply your own customized settings and close the wizard.

4.16.2 Overview of Basic Analysis Steps

The basic steps required to perform your own analyses are presented next. Specific instructions for performing each of these actions have been included within the previous examples of this training guide and/or in the *RCM++ User's Guide*.

For this example, you will perform those steps that are applicable to your particular analysis requirements.

- **Database:** Create a database, with or without Login Security enabled.
 - **Users:** If the database has Login Security enabled, create an account for each authorized user.
- **Project:** Create a project with the appropriate properties to fit the requirements of your analysis. If applicable, use the custom profile that you created in Example 11 to quickly set the project properties.
- **Items:** Create one or more items in the System Hierarchy for the project.
- **Equipment Selection:** If applicable, use the Selection Questions or Criticality Factors method to identify the equipment that will be analyzed with RCM techniques.
- **Analysis Properties:** If applicable, define the analysis properties for one or more items in your project. These properties will be used to set the “header” information in printed report output and also the info in analysis properties reports.
- **Item Reliability and Maintainability:** If applicable, define the reliability and maintainability characteristics for the item(s) in your analysis. This information will be used in item properties reports, quantitative criticality analyses and maintenance task cost calculations, if performed.
- **Functions, Failures, Effects and Causes:** For each item that you want to analyze, define functions, failures, effects and causes, including all relevant properties.

- **Failure Effect Categorization:** If applicable, perform the Failure Effect Categorization for each effect that has been identified in your RCM analysis.
- **Controls:** If applicable, define the current controls that have been identified for each cause in the analysis.
- **FMEA/FMECA Risk Assessment:** If applicable, use the Risk Priority Number or Criticality Analysis method to assess the risk associated with potential failure causes and to prioritize issues for corrective action.
- **Actions:** If applicable, define the recommended actions that have been identified for each cause in the analysis.
 - If desired (and possible on your computer), you may want to send notification e-mails to the people responsible for completing recommended actions. To enable this functionality, select the **Enable action notification e-mails** option on the E-mail page of the User Setup and set the related properties.
 - Monitor the progress on recommended actions.
- **Maintenance Task Selection and Definition:** If applicable, use the Task Selection logic and/or maintenance task cost comparisons to select and define the maintenance tasks that will be applicable and effective for your RCM analysis. If desired, you can also package the maintenance tasks that have been assigned.
- **Check Analysis:** Use the Check Analysis utility to identify any possible discrepancies and/or omissions within the project. Address the appropriate issues and use the Check Analysis utility to confirm that the issues have been resolved.
- **Plots and Charts:** Use the Plot Viewer utility to create a variety of pareto (bar) charts, pie charts and matrix charts based on the information within the project.
 - If desired, copy/paste the chart information into separate report documents and/or save the chart graphics as Windows metafiles (*.wmf) that can be used in other applications.
- **Print-Ready Reports:** Generate a variety of print-ready reports for the information contained within the project in Microsoft Word and/or Excel.
- **Control Plans, DVP&Rs and Other Related Analyses:** If desired, perform related analyses including transferring Design FMEAs to Process FMEAs, Process Flow Diagrams, Control Plans, DVP&Rs, DRBFMs, Relationship Diagrams, etc.

4.16.3 Share Your Experience

If the analysis that you have prepared for this example contains non-proprietary and non-confidential information and you would like to share your work with other users who are learning the features of ReliaSoft's RCM++, we invite you to send the database file to ReliaSoft Corporation for possible inclusion among the example files shipped with RCM++.

If you would like to share your analysis, please contact us via e-mail at RCM@ReliaSoft.com.