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Quarterly Technical Report - Report No. 7
July 1, 1993 - September 30, 1993
DARPA DICE Manufacturing Optimization

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Raytheon Company

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1. Summary

This is the Quarterly Technical Report for the DARPA DICE Manufacturing Optimization. The goal of the Manufacturing Optimization (MO) system is to facilitate a two tiered team approach to the product/process development cycle where a product design is analyzed by multiple manufacturing engineers, and product/process changes are traded concurrently in the product and process domains. The system will support Design for Manufacturing and Assembly (DFMA) with a set of tools to model manufacturing processes, and manage tradeoffs across multiple processes. The subject of this report is the technical work accomplished during the seventh quarter of the contract.

The main thrust of the seventh quarter was integration and test of the MO software and the development of the MO user manual. Highlighted in this report is the tutorial section of the user manual.

During the last quarter, Raytheon's activities will include test and demonstration of the MO System, as well as delivery of the software and final report.

2. Introduction

This is the Quarterly Technical Report for the DARPA DICE Manufacturing Optimization. The concept behind the Manufacturing Optimization (MO) system is to facilitate a two tiered team approach to the product/process development cycle where a product design is analyzed by multiple manufacturing engineers, and product/process changes are traded concurrently in the product and process domains. The system will support DFMA with a set of tools to model manufacturing processes, and manage tradeoffs across multiple processes. The subject of this report is the technical work accomplished during the seventh quarter of the contract.

Raytheon spent the seventh quarter on the integration and test of MO software, and on the development of the user manual. Highlighted in this report is the tutorial section of the user manual in order to demonstrated the use of available system functionalities.

3. MO Tutorial

3.1 Taking MO for a Test Drive

The objective of this tutorial is to acclimate you to the MO user interface and the basic MO functionality. This tutorial is written so that you can actually perform the step by step actions needed to execute the demonstration. It is assumed that you are familiar with and have access to a SUN workstation. It is assumed that all supporting external subsystems with MO are loaded on your workstation. Please note that the directory path names referenced throughout this tutorial were established for ease of readability. These path names are subject to change and should be verified with your site system administrator before proceeding with this tutorial.

This tutorial will feature the highlights of the MO system as applied to a printed wiring board. The first part of the tutorial will focus on the File, Analyzer, and Advisor functions, with the assumption that the product data and process model data are already available to the MO system. The tutorial will guide you through the steps of loading the product and process data, analyzing the product data against the process model, and viewing the results in a graphical or textual format. The second part of the tutorial will concentrate on the Modeler. You will learn how to add or modify data to an existing process model by exercising some of the Process Modeler features. The third part of the tutorial will explain how the MO system supports the two-tier team concept.

Helpful hints to keep in mind during your test drive through the MO system:

1) When a new window or form pops up, you must position the window with the mouse and click once to set the window location.

2) Use the **backspace key** to delete a previous character.

3) Most forms contain **Cancel** and **Help** buttons. The **Cancel** button will automatically abort all entries on the current form and the form will disappear. The **Help** button will provide information on the current form.

3.2 Starting the MO system

Start the program by typing **MO&** in a command window. After all data is read and the user interface components are created, the main window will appear. Figure 3.2 depicts the MO main window.

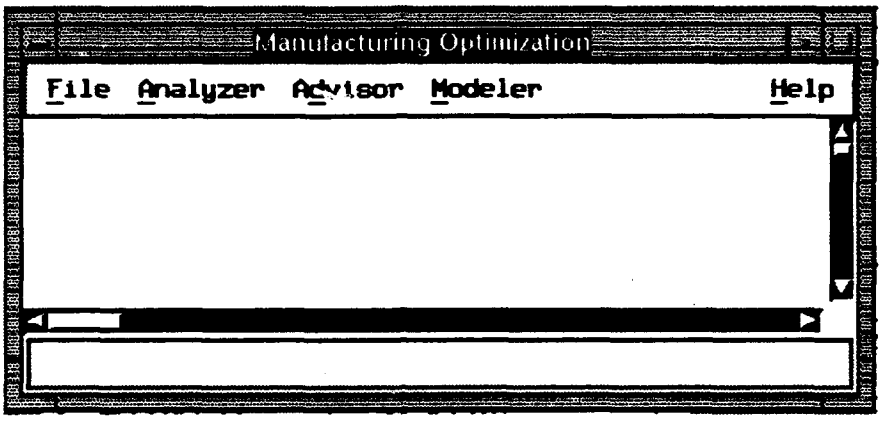


Figure 3.2 MO Main Window

3.3 Selecting the Product Data

To select or edit a product/STEP data file, select **File > STEP Data** from the MO main window. The **Select Step Data File** form will pop up displaying a list of filenames corresponding to the current product data available in the MO system. Verify that the directory path is **/MO/PRODUCT_DATA/*.rose** in the **Filter** field. If it is not, then you must click in the **Filter** field and change the path name. Another method is to select the desired path name from the **Directories** window. If the **Filter** field has been altered then click the **Filter** button to update all the windows in the current form. Select the filename **smalldemo.rose** from the list of files in the **Files** window. The entire path name of the product data file will appear in the **Step Data Selection** field. Click the **OK** button to load the product data. When the **Select Step Data File** form disappears, the product data has been loaded successfully. Figure 3.3 depicts the Select Step Data File form.

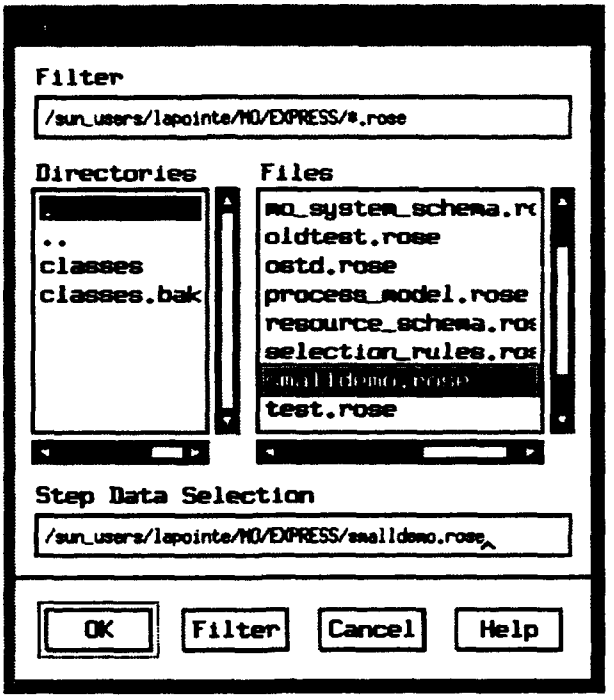


Figure 3.3 Select Step Data File Form

3.4 Selecting the Process Data

To select or edit a process model data file, select **File > Process Model** from the MO main window. The **Process Model Selection** form will pop up displaying a list of filenames corresponding to the current process model data available in the MO system. Verify that the directory path is **/MO/PROCESS_DATA/*.rose** in the **Filter** field. If it is not, then correct the path name as you would in the **Select Step Data File** form. The entire path name of the process model data file will appear in the **Process Model Selection** field. Select the filename **test.rose** from the list of files in the **Models** window. Click the **OK** button to load the process model data. When the **Process Model Selection** form disappears, the process model data has been loaded successfully. Figure 3.4 depicts the Process Model Selection form.

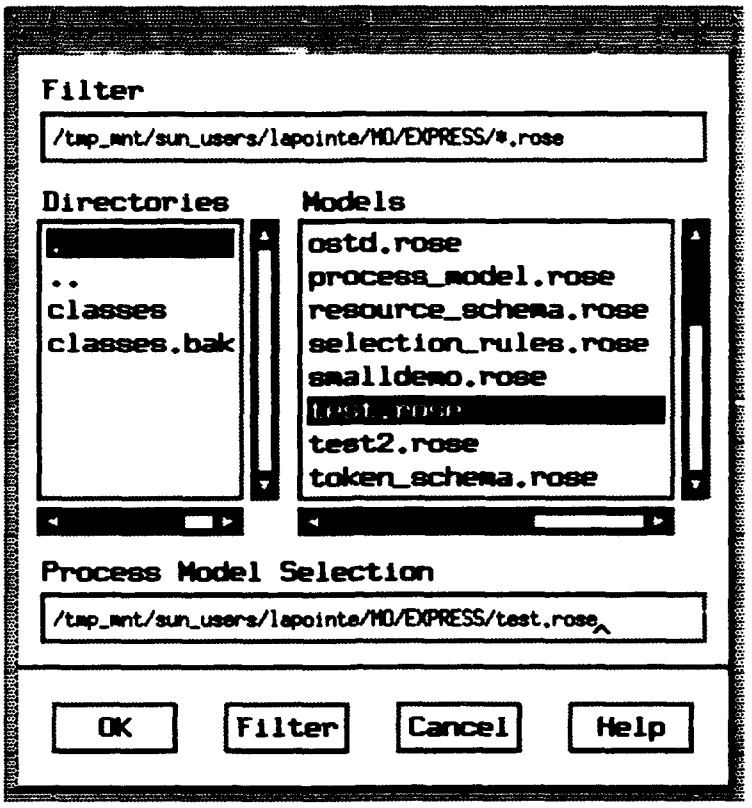


Figure 3.4 Process Model Selection Form

3.5 Accessing the Translators

To convert a RAPIDS design into STEP data format, select **File > RAPIDS to STEP** from the MO main window. The **RAPIDS to STEP** form will appear. Enter the **RAPIDS Design Name** in the designated field. Click the **OK** button to start the processing. The RAPIDS design will be stored into a STEP data file as STEP objects in the same directory as the RAPIDS design. Figure 3.5-1 depicts the RAPIDS to STEP form.

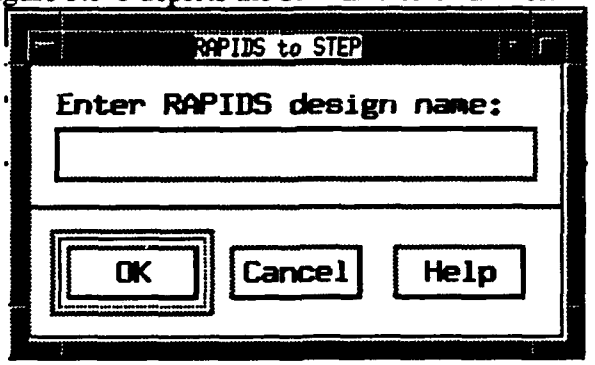


Figure 3.5-1 RAPIDS to STEP Form

To convert a STEP file to the RAPIDS system format, select **File > STEP to RAPIDS** from the MO main window. The **STEP to RAPIDS** form will appear. Enter the **Design STEP File** and the **RAPIDS Design Directory** into their respective fields. Click the **OK** button to start the processing. The STEP file will be stored in the RAPIDS system format in the directory specified. Figure 3.5-2 depicts the STEP to RAPIDS form.

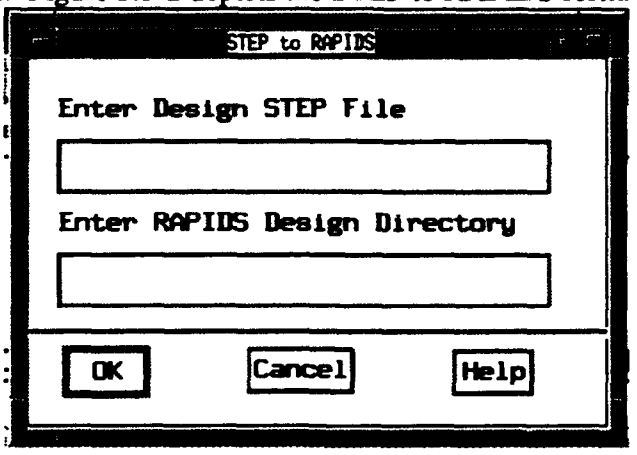


Figure 3.5-2 STEP to RAPIDS Form

3.6 Analyzing Manufacturability

To run the product data against the process model, select **Analyzer > Perform Analysis** from the MO main window. The analyzer will select the applicable processes, calculate the yield and rework rates, and determine the ideal and actual estimated cost of the part under analysis. Analysis is complete when the message window at the bottom of the MO main window displays "**Manufacturability Analysis is complete.**"

3.7 Viewing and Printing the Analyzer Results

Select **Advisor > Manufacturing Advisor** from the MO main window. The **MO-Advisor window** will pop up displaying the selections: **File, View, Graphs, Reports,** and **Help**. Figure 3.7-1 depicts the MO-Advisor window.

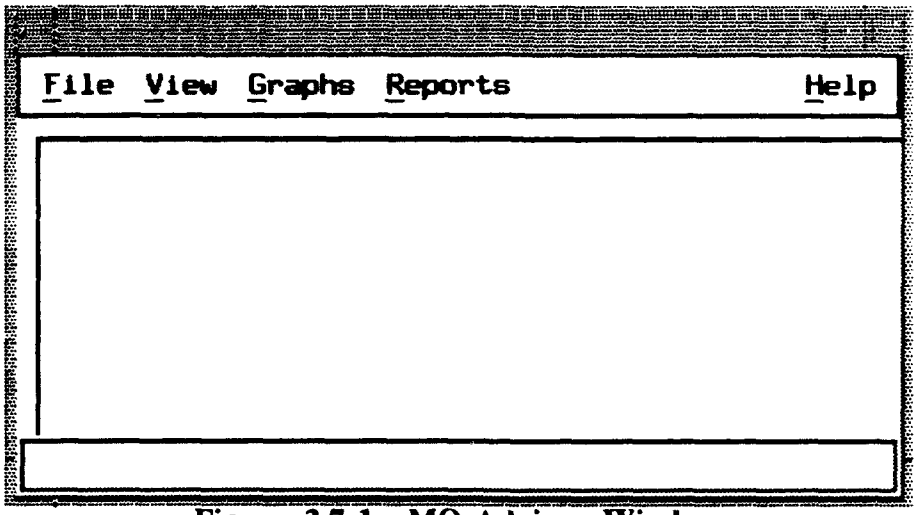
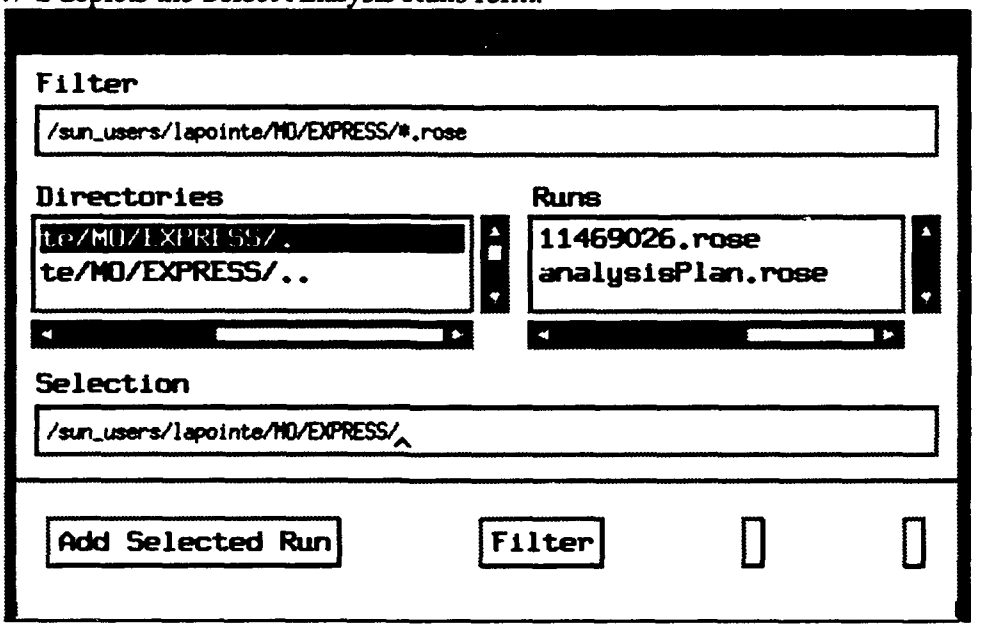


Figure 3.7-1 MO-Advisor Window

To choose an analysis run, select **File > Select Analysis Runs** from the MO-Advisor window. The **Select Analysis Runs** form will pop up displaying a list of filenames corresponding to existing analysis data available in the MO system. Look for the filename **testPlan.rose** in the current working directory. If it is not there, change the directory path name to **/MO/RESULTS/*.rose** in the **Filter** field. Select the filename **testPlan.rose** from the list of analysis data files in the **Runs** window. Click the **Add Selected Run** button to update the **Selected Runs** window. Click the **OK** button to load the analysis data. The analysis data has been loaded successfully when the Select Analysis Runs form disappears. Figure 3.7-2 depicts the Select Analysis Runs form.



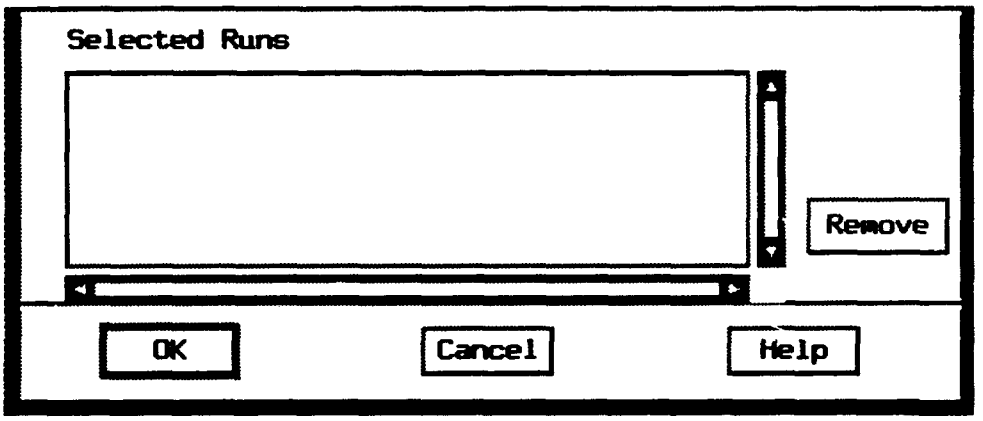


Figure 3.7-2 Select Analysis Runs Form

To specify viewing the process activity from an analysis run, select **View > Processes** from the MO-Advisor window. (**All Activities** is the default option.) **Processes** has been selected when the message "**Advisor View Status is set.**" is displayed in the message window at the bottom of the MO main window.

To view the production quantity data in a graphical format, select **Graphs > Quality Graphs > Prod.QTY** from the **MO-Advisor window**. A new window will pop up displaying a graph of the production quantity (y-axis) versus the process (x-axis). Across the top of the graph are the various graphical representations: **bar, line , pie,** and **stack bar.** The default display for a production quantity graph is a line chart. If you click on the bar icon, the graphical representation will change from a line chart to a bar chart. Click on a point in the line graph and a small pop up window will appear displaying the exact quantity value for the specified point. Click the **Close** button to remove the **Prod QTY versus Process** graph. Figure 3.7-3 depicts the Prod QTY versus Process graph.

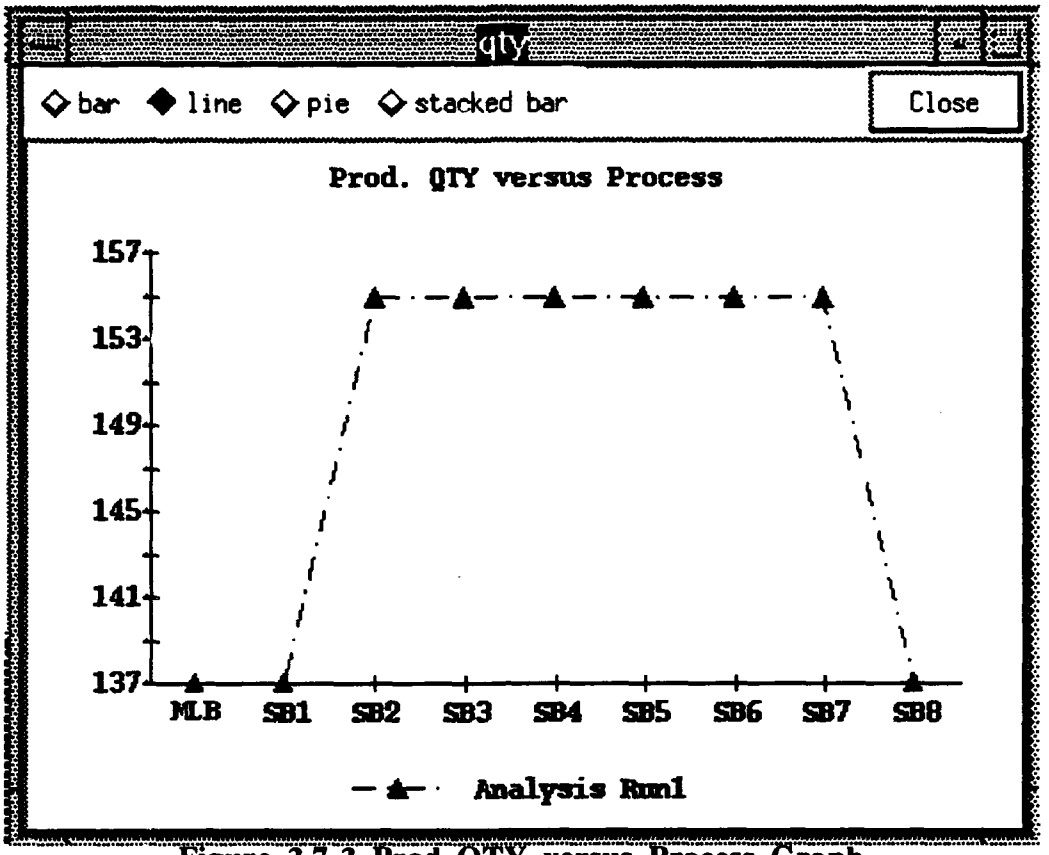


Figure 3.7-3 Prod QTY versus Process Graph

To view the yield analysis data in a textual format, select **Reports >Advisor Reports.** The **Select Report Type(s)** form will pop up with a list of report types: **Process Flow, Yield/Rework, Costing,** and **Final Report.** Figure 3.7-4 depicts the Select Report Type(s) form. The process flow report is the default. Select report type **Yield/Rework** and click the **OK** button to generate the report. Below is a sample report based on the process flow and corresponding yield results for a PWB Fabrication process.

Fabrication Process Selection/Cost Estimation Report

MLB - layers 1, 14 OVERALL YIELD is 94 percent

Opno	*Description*	*Ideal($)*	*Actual($)*	*Rework($)*	*Yield*	*Rework*	*# Units*
10	mark part no	0.123	0.12	0.00	100	0.000	137
30	oxide treat	1.111	1.11	0.00	100	0.000	137
40	bake panels	0.444	0.44	0.00	100	0.000	137
50	lay up	3.123	3.12	0.00	100	0.000	137
60	laminate	0.600	0.80	0.00	94	0.000	137
80	route excess	0.715	0.92	0.00	100	0.000	128
90	oxide strip	0.250	0.32	0.00	100	0.000	128
110	drill tooling	0.220	0.28	0.00	100	0.000	128
130	drill	12.123	15.12	1.23	92	0.005	128
160	electroless	0.661	0.66	0.00	100	0.000	117

170	copper panel	0.555	0.55	0.00	100	0.000	117
180	electrostrike	0.512	0.70	0.00	98	0.000	117

Fabrication Yield Analysis Report

MLB - layers 1, 14 OVERALL YIELD IS 94 percent

Opno	*Design Feature Description*	*Value*	*Scrap Per Feature*	*Opno Yield*
60	14 layers and 8 substrates	N/A	6.000	94
130	annular ring	8.00	8.000	92
180	aspect ratio	4.00	2.000	98

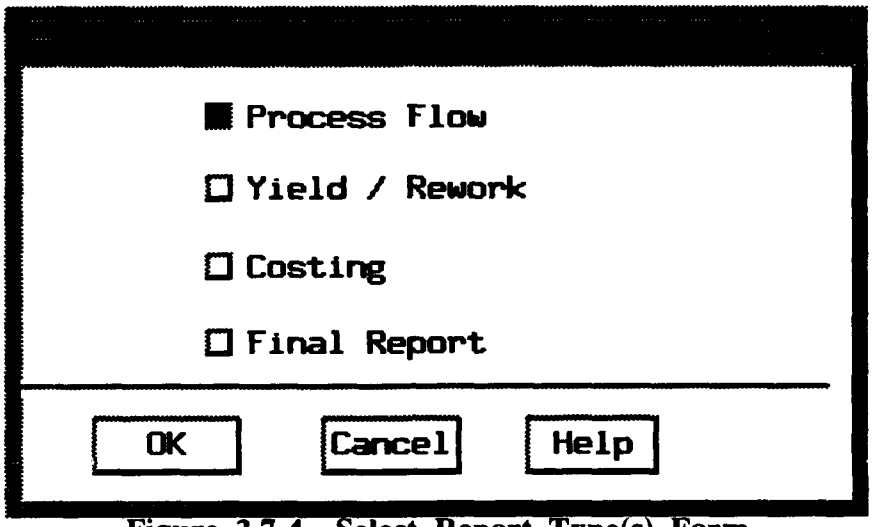


Figure 3.7-4 Select Report Type(s) Form

To leave the Advisor tool, select **File > Exit** from the MO-Advisor window.

3.8 Using the Process Modeler

To access the Process Modeler, select **Modeler > Process Modeler** from the MO main window. The **MO - Process Modeler** window will appear with the following selections: **File**, **Edit**, **View**, **Print**, and **Help**. Figure 3.8-1 depicts the MO-Process Modeler window. To choose an existing process model, select **File > Models** from the **MO - Process Modeler** window. The **Process Model Selection** form will pop up with a list of filenames corresponding to the current process models available in the MO system. Verify that the directory path is **/MO/PROCESS_DATA/*.rose** in the **Filter** field. If it is not, then correct the path name as you would in the **Select Step Data File** form. The entire path name of the process model data file will appear in the **Process Model Selection** field. Select the filename **testModel.rose** from the list of files in the **Models** window. Click the **OK** button to load the process model. The process model has been loaded successfully when

the Process Model Selection form disappears. Figure 3.8-2 depicts the Process Model Selection form.

To add a new activity node to an existing process model, select **Edit > Add Sibling** from the MO - Process Modeler window. The **Manufacturing Activity Specification** form will pop up. Enter the name of the new activity node into the **Name** field. Enter a brief description of the new activity node into the **Description** field. Select **Process** in the **Activity** window to define the new activity as a process. Select **Concurrent** in the **Child Ordering** window to impose an order of concurrent flow. Figure 3.8-3 depicts the Manufacturing Activity Specification form.

Click the **Rules** button in the **Manufacturing Activity Specification** form to add, remove or change selection rules for an activity node. The **Selection Rules** form will appear displaying all the selection rules for an activity node. Figure 3.8-4 depicts the Selection Rules form. Click the **New** button in the **Selection Rules** form to create a new rule. The **Rule Specification** form will appear allowing you to specify the attributes, entities, and operations for your new rule. Figure 3.8-5 depicts the Rule Specification form. Click the **Add to Rule** button to incorporate your selections. When the rule is completely defined, click the **OK** button and the **Rule Specification** form will disappear. Click the **OK** button in the Selection Rules form to complete the rule modifications for an activity node.

Click the **Resources** button in the **Manufacturing Activity Specification** form to add/remove resources and edit setup and run times. The **Resource Utilization Specification** form will appear displaying all the resources currently stored in the process model. When the resource information form is complete, click the **OK** button and the **Resource Utilization Specification** form will disappear. Figure 3.8-6 depicts the Resource Utilization Specification form.

Click the **OK** button in the **Manufacturing Activity Specification** form to add the new activity node to the existing process model.

To leave the Process Modeler tool, select **File > Exit** from the MO-Process Modeler window.

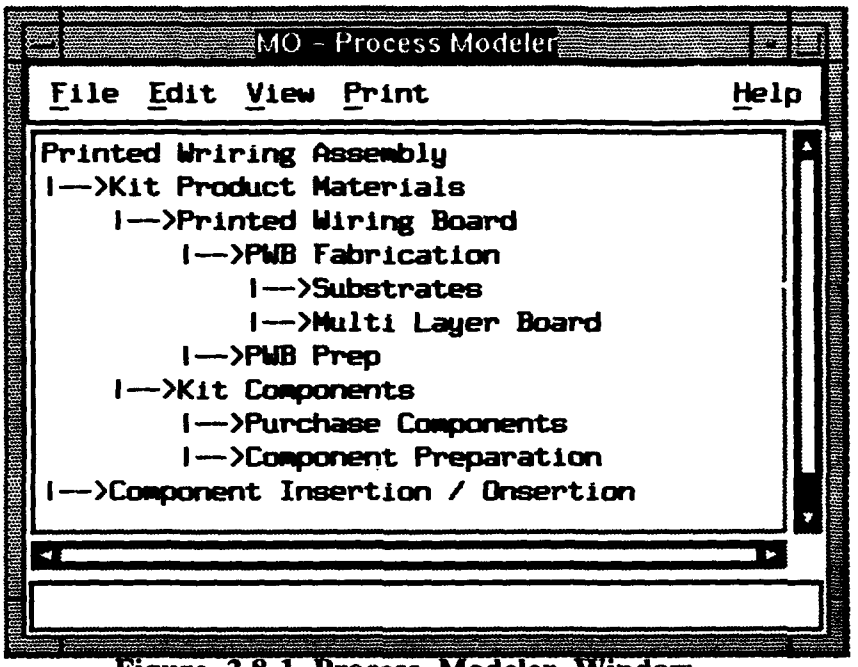


Figure 3.8-1 Process Modeler Window

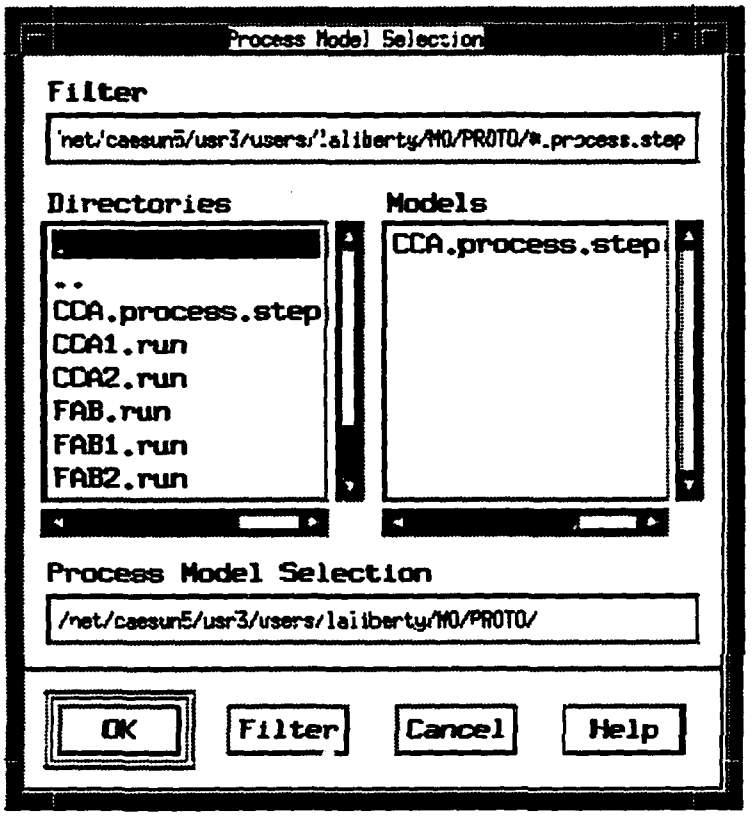


Figure 3.8-2 Process Model Selection Form

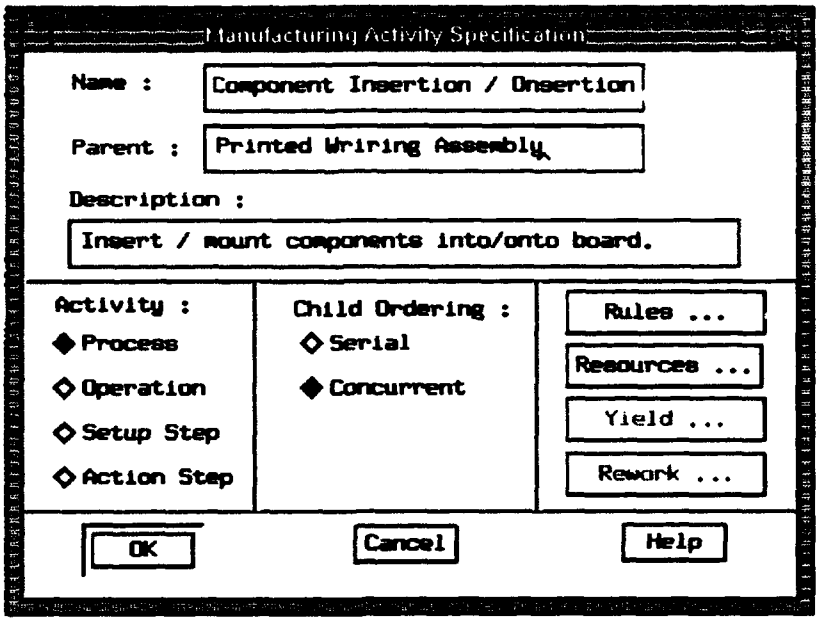


Figure 3.8-3 Manufacturing Activity Specification Form

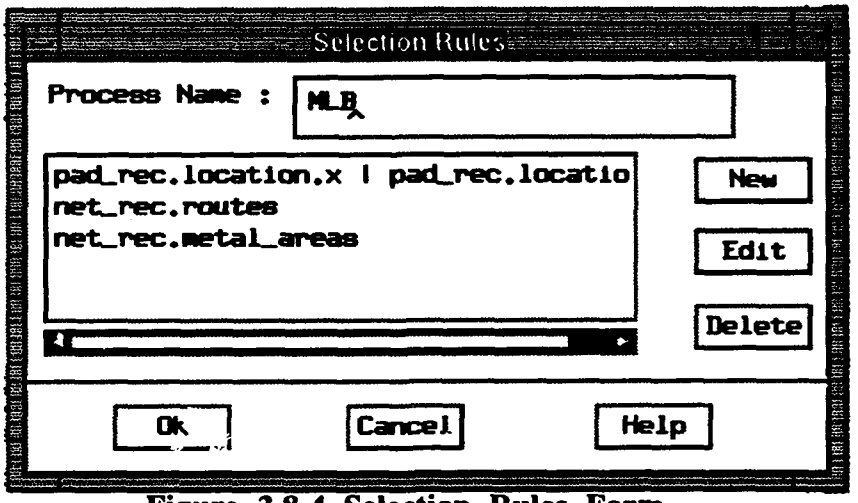


Figure 3.8-4 Selection Rules Form

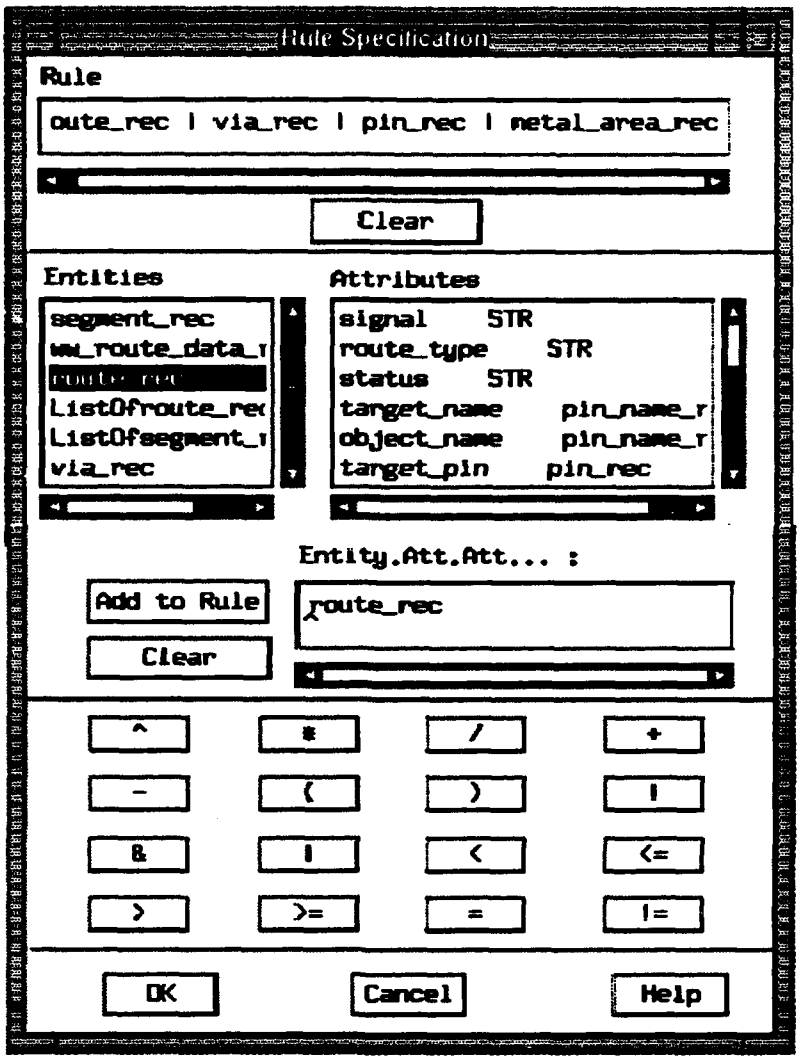


Figure 3.8-5 Rule Specification Form

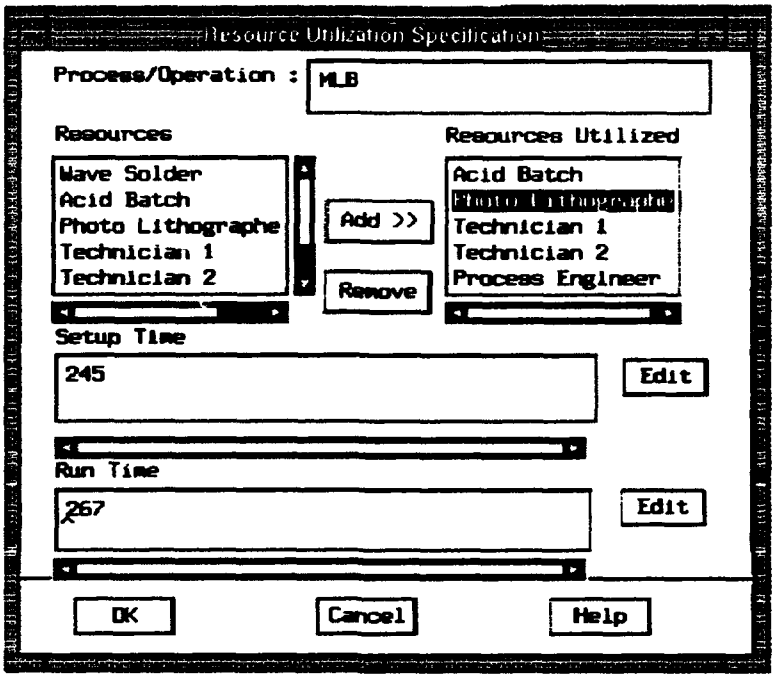


Figure 3.8-6 Resource Utilization Specification Form

3.9 How MO Supports the Two-Tier Team Concept

Up to this point, the tutorial has been explaining the MO functionality from a single user's perspective. This section explains how MO will support the two-tiered team approach by enabling multiple engineers to analyze and share results.

In a two-tiered approach, multiple engineers analyze the same product model utilizing their respective process models. In our example, the PWB would be analyzed by a fabrication engineer and an assembly engineer using the MO functions which were described earlier in the tutorial. When the individual engineers, complete their analysis, they would notify each other of the location of their analysis results so that each could view and compare results utilizing the MO Advisor module. Described below are the steps that the fabrication engineer would follow to view and compare the assembly engineer's results. The assembly engineer would follow similar steps.

The fabrication engineer would first bring up his own results on the terminal screen. See section 3.7. Leaving his own results displayed, the fabrication engineer then follow the same steps to display the assembly results, selecting the assembly engineer's analysis results filename in the **Select Analysis Runs** form. After selecting the **OK** button, the assembly

results are loaded in the Advisor. The fabrication engineer can now view similar formatted graphs and/or reports by using the same Advisor functions that he previously used to display his own results. Then with both sets of results displayed on the his terminal screen, he can visually compare and contrast the results. The assembly engineer would be doing the same on his terminal screen. This enables the product to be viewed across multiple tiered processes facilitating the assessment of product design changes across these processes. The result is a collaboratively engineered design.

Once finalized, one of the team members would generate a report to aid in identifying the suggested design changes for the manufacturing team. To view a report, select **Reports >Advisor Reports.** The **Select Report Type(s)** form will pop up with a list of report types: **Process Flow**, **Yield/Rework**, and **Costing**. Select the report options of your choice and click the **OK** button to generate the custom report.

3.10 Terminating the MO System

To leave the MO system, select **File > Exit** from the MO main window. An acknowledgment window will pop up prompting you to confirm the exit. Click the **OK** button as shown in Figure 3.9 to exit the MO system completely.

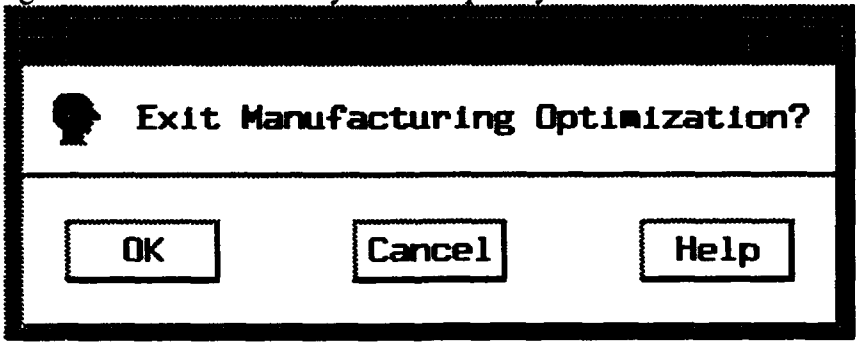


Figure 3.9 Acknowledgment Window

4. Conclusions

During this reporting period, the main thrust was on the integration and test of the MO software system, as well as the development of the user manual. Highlighted in this quarters technical report is the tutorial section from the user manual.

During the last quarter, Raytheon's activities will include test and demonstration of the MO System, as well as delivery of the software and final report.

5. References

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6. CDRL No. 0002AC-5, July 1993, System Description For The Manufacturing Optimization (MO) System, Contract No. MDA972-92-C-0020.

7. CDRL No. 0002AC-6, September 1993, User Manual For The Manufacturing Optimization (MO) System, Contract No. MDA972-92-C-0020.

6. Notes

6.1 Acronyms

ASEM	Application Specific Electronic Module
CAEO	Computer Aided Engineering Operations
CDRL	Contract Data Requirements List
DARPA	Defense Advanced Research Projects Agency
DFMA	Design for Manufacturing and Assembly
DICE	DARPA Initiative In Concurrent Engineering
MO	Manufacturing Optimization
MSD	Missile Systems Division
MSL	Missile Systems Laboratories
OSF	Open Software Foundation
PWA	Printed Wiring Assembly
PWB	Printed Wiring Board
PWF	Printed Wiring Fabrication
ROSE	Rensselaer Object System For Engineering
STEP	Standard for Exchange of Product Model Data

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