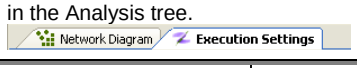
Understanding the IMPRINT Pro Environment – MAINTENANCE MODEL

Menus and Toolbars: Use these options to access helpful task network tools, execute models, run reports and save analyses.

Main Window: This window populates with new tabbed windows corresponding to the items you open in the Analysis tree.



Properties Window: View all properties for the selected node (Analysis, Scenario, Subsystem,etc) at a quick glance. Values may be changed through this window.

Analysis Tree: View a list of items in your analysis. Main categories include:

Warfighters: the types of people/ specialties (Maintainers) you pick to perform the maintenance in your Equipment Scenario.

Equipment: estimate maintenance man-hour requirements for your system.

Subsystems: the larger sections of your weapons system that are made up of components.

Components: individual pieces of equipment on your system that require their own specific repair tasks.

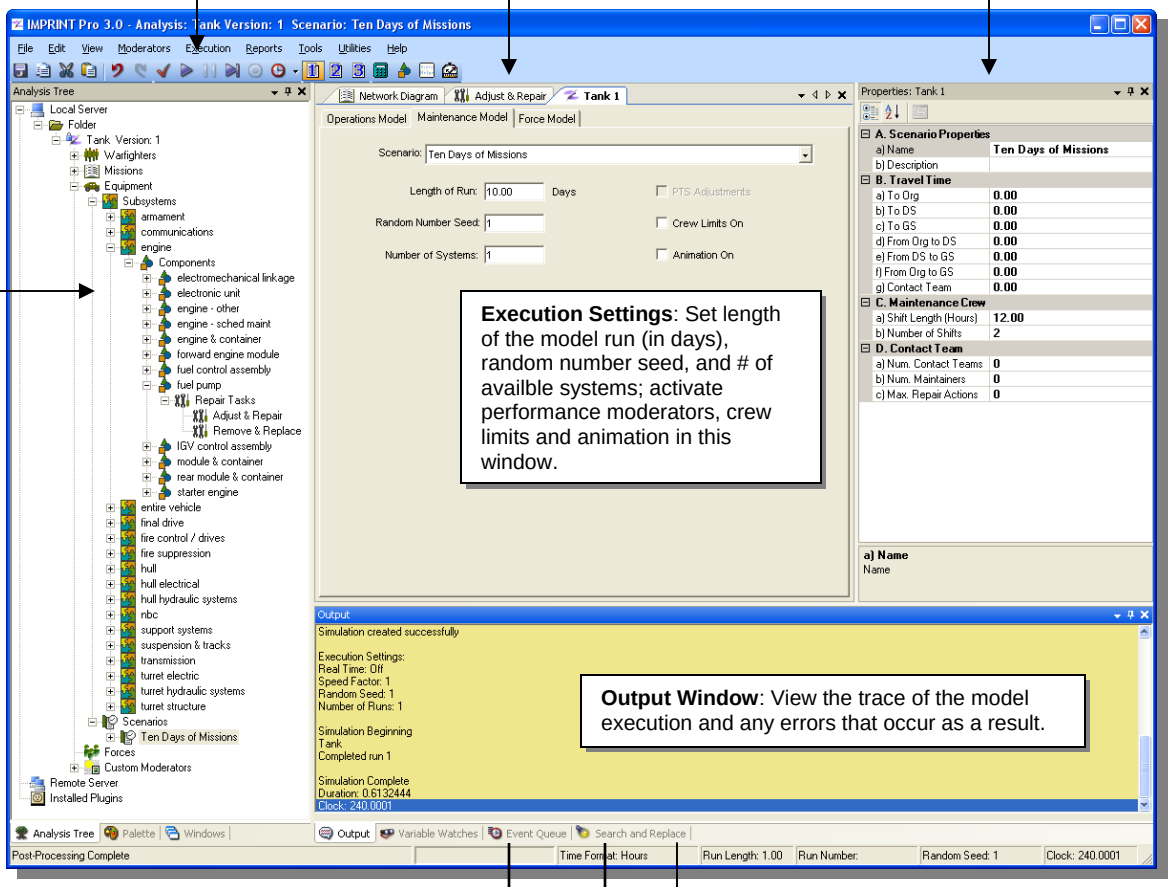
Repair Tasks: the maintenance performed on individual equipment components.

Scenarios: the conditions under which the system will be used.

Segments: definable portions of the scenario that drives system usage.

Custom Moderators: define your own custom stressors and custom training moderators to be applied to your network's tasks.

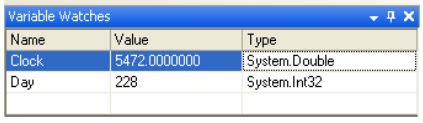
Installed Plugins: extend the runtime functionality of IMPRINT Pro by defining and calling your own plugins (requires Visual Studio.)



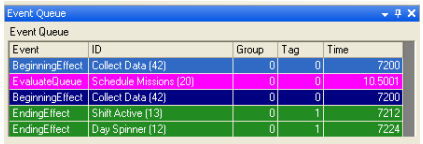
Execution Settings: Set length of the model run (in days), random number seed, and # of availble systems; activate performance moderators, crew limits and animation in this window.

Output Window: View the trace of the model execution and any errors that occur as a result.

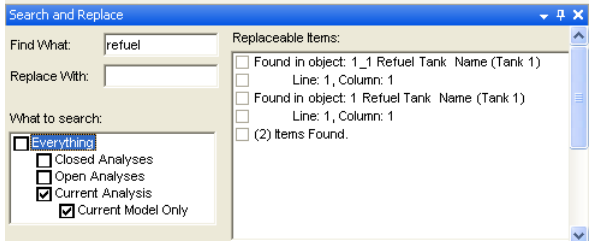
Variable Watches: view system variable in your analysis.



Event Queue: View the list of upcoming events in the Maintenance Model network.



Search and Replace: search your entire analysis for any text string, including names of variables, components and any other nodes in your analysis; replace the found string with a new text string.



Section Window (next to Analysis Tree): toggle through and redisplay hidden windows by clicking the corresponding icon. Note: some windows are available in the Operations module only.

Note: the following features are not available in the IMRINT Pro Maintenance Module (See Operations Module:)

- **Palette**
- **Network Diagram**

The Maintenance Model is defined by a 3-step process:

1. Define your equipment system components and their reliability (Subsystems, Components and Repair Tasks).
2. Define the frequency at which your system(s) will be used on a mission (Scenarios and Segments).
3. Adjust the manning levels of the Maintenance organization to determine optimal manning for your system (model execution and viewing reports).

Copyright 2009 Alion Science and Technology Rev. 7 021009

Creating a New Maintenance Analysis

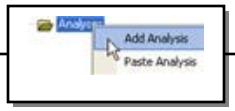
Define objectives

The Maintenance model helps to answer the following questions:

- How many people of each specialty are required to meet the system availability requirement?
- Which pieces of equipment (subsystems) are the high drivers for maintenance?
- How should each organizational level be staffed?
- How sensitive is my maintenance manpower requirement to the failure rate of individual components?

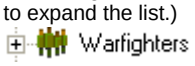
Add new analysis

Right-mouse click an existing folder in the tree; select **Add Analysis**.



Your new analysis appears in the tree. Click the **+** to expand.

Define Warfighters (Click the + next to the Warfighter node to expand the list.)



Warfighters are divided into three categories. For a Maitenance scenario choose to add **Maintainers** to perform the tasks in your model.

Right-click the **Maintainers** node and select **Add Maintainer**. Choose the desired specialties for your analysis.

Note: If your analysis also contains Missions from the Operations side, any Operator whose **Crew Maintainer** checkbox is checked may also be used as a Maintainer in the Maintenance model. Double-click the desired Operator Maintainer in the tree list to access this option.

Note: the Network Diagram component is NOT available in the Maintenance Module.

Defining Equipment

Define Equipment is broken down into two sections:

1. **Defining Subsystem** (its components, repair tasks, etc.)
2. **Defining Scenarios** (the conditions under which those Subsystems will be used).

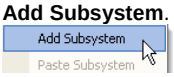
1. Defining Subsystems

Subsystems are parts of your weapons system that are made up of various components requiring maintenance (repair tasks) and maintainers to do these tasks.

1. Define Subsystems

Click the + next to **Equipment** to expand the nodes below. Look for the **Subsystem** node.

Right-mouse click the Subsystems node, and choose **Add Subsystem**.



A new subsystem appears. Double-click the new Subsystem, and enter a name in the window that appears. Select its Equipment Group Name.

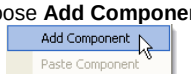
Example: "Armament"
Note: these groups are classified based on how they accrue usage:

- Mobility (distance traveled)
- Armament (rounds fired)
- Other (time)

Add Components

Click the + next to the new Subsystem to expand the nodes below. Look for the **Components** node.

Right-mouse click the Components node, and choose **Add Component**.



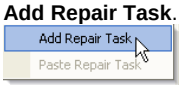
A new Component appears. Double-click the new Component, and enter a name in the window that appears.

Example: "Cannon Tube"

Add RepairTasks

Click the + next to the new Component to expand the nodes below. Look for the **Repair Task** node.

Right-mouse click the Repair Task node, and choose **Add Repair Task**.



A new Repair Task appears. Double-click the new Repair Task, and enter theTask information in the window that appears.

Specify the desired maintenance action. **Preventive** and **Corrective** Maintenance Actions include:

- Adjust and Repair
- Inspect
- Remove and Replace*
- Test and Check
- Troubleshoot

*Spares are checked first. If the part is unavailable, system repair is delayed by the wait time set in the Spares window.

Example:

- Adjust and Repair
- DS, Off
- 45G
- Grade 20

Notes on Repair Tasks/ Maintenance Actions:

- **On:** Maintenance must be performed "on" equipment. **Example:** changing a tire or a filter
- **Off**: Maintenance can be performed "off" equipment. **Example**: fixing a hole in a tire after you've already replaced the tire with a spare.
- **ORG** (organizational level): this maintenance is sometimes referred to as unit maintenance; "On" system repairs only.
- **DS** (direct support): repair team is typically located at a facility nearby; maintenance can be performed on or off equipment (either system or specific part from system can go to the facility for repairs.)
- **GS** (general support): Maintenance facility is located remotely from system; parts of system must be sent to facility for repairs; "Off" system repairs only.
- **CT (Contact Team):** A mobile repair team goes out to the system to do repairs on system.
- **CC (Crew Chief)**: the maintenance can be performed by the operational crew accompanying the system; no separate contact team required for repair.
- **Note: Repair Tasks are performed in order of levels, i.e. Org (Level 1) performed first, DS (Level 2) performed second and GS (Level 3) performed third on any system requiring multiple repairs at multiple levels.**

Notes on Repair Tasks/ Maintenance Actions....continued

- **Specialty:** the type of Maintainer from your list of defined Maintainers that must perform this maintenance action (see Warfighters node.)
- **Specialty Number:** the number of Maintainers required to perform this maintenance task.
- **Specialty Grade:** the grade required of this Maintainer.
- **MOUBF:** the average number of operational units (rounds fired, miles traveled, hours passed) before the system is likely to fail. Note: a failure may cause a system to be unavailable and ultimately cause a delay or cancellantion of a scheduled segment (see "Segments" below.) Units are set through the Equipment Group of the parent subsystem.
- **MTTR:** the average amount of time required to repair the system. This may affect system availability. Average time may be varied by changing the Standard Deviation and dsitribution type.
- **% Abort:** the percentage of time this maintenace action will cause a specific system's participation in the segment to end prematurely.

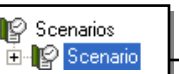
2. Defining Scenarios

Scenarios define the conditions under which the system and its components will be used. A Scenario may contain several segments (timed deployments of specific numbers of systems), each drawing from the same pool of resources (Maintenance Crew and Contact Team) for repairs.

Define Scenario

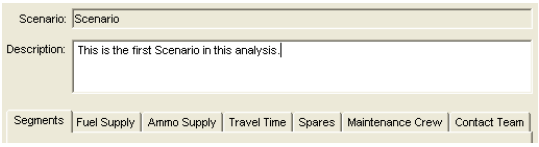
Right-mouse click the Scenario node, and choose **Add Scenario**.

A new Scenario appears in the tree.



Example: create one scenario for a 30-day run (call it "30 Days") and another one for a 10-day run (call it "10 Days.")

Double-click the new Scenario. Note the tabs which appear in the main window:

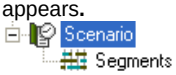


1. Define Segments

Note: A **Segment** is a scheduled deployment which establishes usage of a specific number of systems. This usage possibly leads to component failure.

Click the **+** next to the **Scenario** node in the tree to expand its contents.

A Segment node appears.



Right-mouse click the **Segment** node, and choose **Add Segment**.

A new Segment appears in the tree. Double-click the new Segment.

Segment Info

A segment is defined as follows:

- **Start Time/Day:** the time and day a segment starts if the minimum # of required systems is available.
- **Cancellation time:** the amount of time that the simulation will wait for the minimum number of systems to be available before cancelling the segment and decreasing operational readiness.
- **Duration Time:** the number of operational hours for this segment.
- **Priority:** When more than one segment has been defined to occur at the same time, the segments must compete for avaiable systems. The segment with the higher priority value will get available systems first.
- **Use Mission for Duration:** Use the mean Mission Performance Time of one of your Operational Missions as the segment duration. Note: you must first run this mission.
- **Number per Departure Group:** the # of systems per group that are sent out on this segment.
- **Time between Departures:** the elapsed time between each departure group.
- **Repeating:** check this option to cause a segment to repeat.
- **Repeat Mean Time:** the frequency at which the segment will attempt to repeat. Short repeat intervals may cause segments to overlap.
- **Repeat Standard Deviation:** The standard deviation used to calculate the frequency at which the segment will attempt to repeat.
- **Minimum Number of Systems:** the minumum # of systems that must be ready to begin the segment prior to the cancellation time in order to prevent all departure groups in this instance of the segment from being canceled.
- **Maximum Number of Systems:** the maximum # of systems that would be assigned to the segment if available.

In the fields provided, enter in the information pertaining to this segment.

Note: If one segment has higher priority, systems are given to that segment until the maximum is filled. The other segment is then cancelled if its minimum cannot be met. If priority for two segments is the same, leftover systems (in excess of the minimum required by each) are split evenly.

Combat

Combat parameters describe the probability and severity of combat damage likely to be encountered on this segment and needed repair or replacement time.

- **Combat hits per hour:** the hourly probability that a system will sustain a combat hit.
- **Attrition if hit:** given a combat hit, the probability that the system is a total loss.
- **Replacement Time:** If the system is killed, this is the number of hours before the system can be replaced.
- **System Repair time if damaged:** the amount of time needed to complete the repairs.

Note: repair time affects system availability. Because components needing repair are unknown, all Combat Damage repair time is reported in the Combat Damage report and not included in the Maintenance Manhour reports.

Click the **Combat** tab. In the Combat window to follow, enter in the combat data. Then click **Ok**

Consumables

Consumables describe the distance traveled, fuel used and rounds fired (per armanent subsystem). They are used to accrue usage and cause components to fail, based on the MOUBF entered for repair tasks.

- **Distance per hour per segment:** the distance the system will travel during each hour of the segment.
- **Load time per segment:** any preparation, or load time, that is needed before the segment begins. Note: this number could affect system availability.
- **System Fuel Usage (gal/dist unit):** the amount of fuel used by each system (in gallons) per distance unit traveled.
- **Rounds per Segment:** the number of rounds that will be fired by that weapon system during a segment.

Click the **Consumables** button. In the window to follow, enter in the Consumables data. Then click **Ok**.

Fuel Supply and **Ammo Supply** tabs are used to calculate the # of transporters and associated manpower required to supply the necessary fuel and ammunition for scenarios. This is reflected in the Supply and Support results.

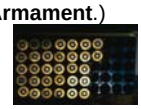
2. Fuel Supply

- **Use Fuel Supply:** check this option to factor suppliers and supporters in your manpower requirement estimates.
- **Transporter Name:** the label you give your transporter.
- **Capacity:** the quantity of fuel (in gallons) this transporter can carry each trip.
- **Specialty 1:** the type of Warfighter needed to operate this transporter.
- **Number:** the quantity of Specialty 1 Warfighters required to operate this transporter.
- **Maximum Number of Daily Trips:** the maximum # of trips your transporter can make in one day; this number affects the number of Warfighters and transporters required by your scenario. More trips means less overall transporters required.

Specify fuel quantity and specialties required for this system in this scenario.

3. Ammo Supply

(Note: in order to specify Ammo Supply, you must have a Subsystem of type **Armament**.)



Click the Ammo Supply tab and then click the **Add** button to add a new supply listing from your pool of defined armament systems.

For each Armament subsystem you add to this list, you may define:
Transporter: the label you give your transporter.
Weapon System: (must be of type Armament to appear here.)
Capacity (# rounds): the number of rounds this transporter carries
Specialty 1: the Warfighter specialty required for this transporter.
 # Specialty 1: the quantity of Specialty 1 Warfighters required to run this transporter.
Max # Daily Trips: the maximum # of trips your transporter can make in one day; this number affects the number of Warfighters and transporters required by your scenario. More trips means less overall transporters required.

Specify the ammunition quantity and speciaties required for this subsystem in this scenario.

4. Travel Time

Click the Travel Time tab. Specify the round-trip travel time, in hours, for three categories:

Travel time to (hours): the time required to transport the system from the location of system breakdown to the selected maintenance facility (Org, DS or GS.)
From [level] to [level]: the time required to transport the system between two specific maintenance levels, for example, from Org to DS.
Contact Team: the time it takes for the Contact Team to reach the system.
Notes: Travel Time is a one-time assessment per system per segment if maintenance is needed. It is added to maintenance time (total time to repair) to accurately reflect system availability and does not affect maintenance manhours. Note: maintenance is performed in order of Levels, i.e. Org, DS and then GS.

Enter in the times required for travel between the different Org levels.

5. Spares

Click the Spares tab. Spares are defined as follows:
Subsystem: the subsystem whose spare part may be required during a scenario run.
% Available: the % of time a spare will be available when needed.
Wait in Hours: the time a system must wait for a spare to become available if needed.

Note: in order for the crew chief to be able to work on a particular subsystem, **% Available** must be set to 100% for that subsystem. Spares affect only the Repair and Replace tasks at the 1st Level (ORG) which are the only tasks that the Crew Chief would be able to perform.

Enter in the % Available and Wait in Hours of spare parts for each separate subsystem.

6. Maintenance Crew

The Maintenance Crew tab helps establish crew constraints.
Note: you must have Repair Tasks and their respective levels defined before Maintenance Crew Shifts can be added.

Click the Spares Maintenance Crew Tab. Maintenance Crew is defined by the following:

Shift Length: the number of hours a shift lasts.
Shifts per Day: the number of shifts of this length in a 24-hour period; shift length is constrained such that the shift length x the shifts per day cannot exceed 24 hours.
Level: the maintenance shift level whose data you are entering.

For each specialty listed in the grid, enter the number of maintainers of each Specialty that are assigned to each shift.

- **Gray**: minimum number required; this value is calculated by examining all repair tasks for the maximum # of maintainers of the same specialtiy that are needed on a single repair task.
- **White**: number of maintainers assigned.

In the fields provided, enter the shift requirements. Adjust the remaining fields as necessary. **Note**: checking **"Crew Limits On"** in the Execution Settings window activates these optional crew constraints.

7. Contact Team

The Contact Team is a mobile repair team that travels out to the system to do repairs.

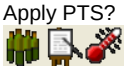
The Contact Team tab is defined as follows:

1. The number of Contact Teams available for the entire scenario.
2. Number of multifunctional maintainers in each Contact Team.
3. The maximum number of repair actions that can be waiting for CT attention at once per team. If this number is exceeded, maintenance actions are then routed to the selected maintenance level (Org, DS, and GS).

Enter the number of teams, maintainers per team and the maximum number of repair actions that can wait for a team at any one time.

Performance Moderators

Apply PTS?



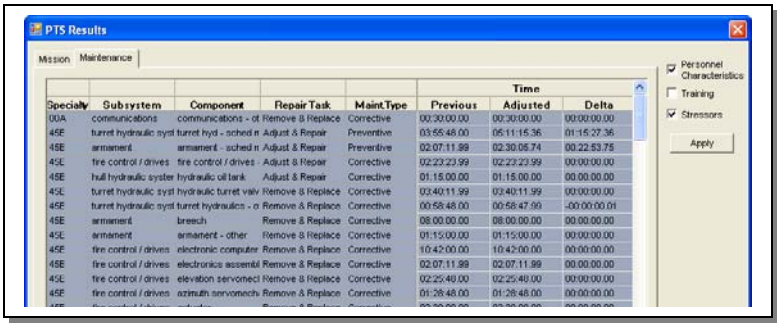
Yes

PTS allows you to assign performance moderators (heat, cold, vibration) in your model. These moderators work in conjunction with repair task types impact calculated repair task times.

Note: in Maintenance, each of the different repair task options automatically map to predetermined combinations of the Fine Motor Discrete, Visual and Cognitive taxons. Only the performance modifiers known to affect these three taxons will affect the MTTR (Mean Time to Repair) time of your repair tasks.

No

Go to **Moderators→ Settings,** and then select the desired category (Personnel, Training or Stressors). Enter in the changes in each of the desired categories.



Go to **Moderators→ Results**. Check the option(s) on the right that apply, and then click **Apply** to view modified times.

Save your analysis

Executing your Model

Set speed

From the Utilities menu (or Toolbar), choose **Simulation Speed**.

Speeds range from 25% to 800%.

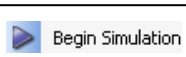
Set Execution Settings

From the Execution menu choose **Settings**.

1. Specify Maintenance Scenario.
2. Specify length of run (days) and Random Number Seed.
3. Specify # of systems available for start.
4. PTS Adjustments: check this option to use performance moderators set in PTS window.
5. Crew Limits On: check this box to enable crew constraints defined in the Scenario Maintenance Crew tab. Otherwise crew available for tasks is unlimited.

Run Model

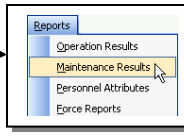
From the Execution menu (or Toolbar), choose **Begin Simulation**.



As the analysis runs the output window displays all events related to model execution.

Run Reports

In the Reports menu, choose **Maintenance Results**.



Excel launches, and reports display.

Alter model and rerun simulation until desired results are achieved.

END