Availability Workbench v1.0 Technical Specifications

System Requirements

Software

Windows 2000 SP3 (or later), XP, Vista (all versions) or Windows 7 (all versions). Note that if the .NET Framework version 2.0 and Windows Installer 3.0 are not installed you will be prompted to install them.

Hardware

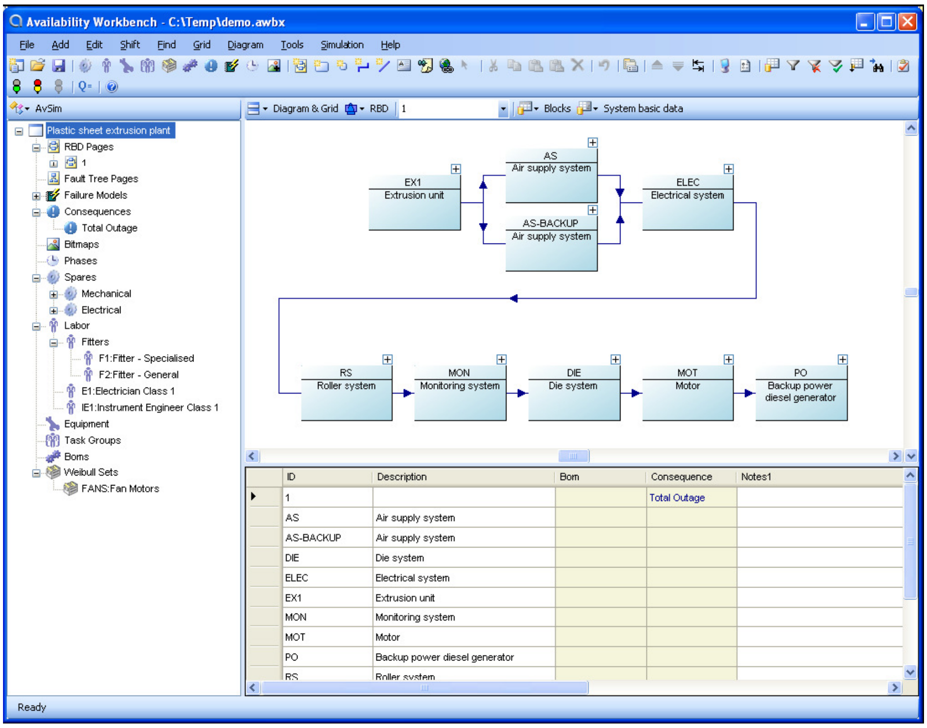
- Windows 2000 SP3 Intel Pentium 1.8 Ghz processor (or equivalent) and 128 MB memory.
- Windows XP Intel Pentium 1.8 Ghz processor (or equivalent) and 256 MB memory.
- Windows Vista or 7 Intel Pentium 1.8 Ghz processor (or equivalent) and 512 Mb memory (Home Basic) or 1 GB memory (all other versions).

The Availability Workbench installation occupies a maximum of 250 MB of disk space if installation of both .NET Framework version 2.0 and Windows Installer version 3.0 is required. In addition to this requirement disk space must be available for the creation of projects, report templates and correct functioning of the operating system.

A typical large Availability Workbench project will occupy up to a 100 MB of disk space and a 20 page graph report will occupy 3.5 MB.

Overview of the AvSim Module

The AvSim module of Availability Workbench (AWB) enables users to simulate the performance of their systems as a whole taking into account dependencies between the individual components. By simulating how a system will perform, users can determine the effects of design and operational changes, and hence optimize system performance. Whereas the RCMCost module may be used to optimize scheduled maintenance policy and intervals, the AvSim module may be used to predict overall system performance, optimize spare holdings, investigate the effects of design changes and operational configurations.



In order to simulate the availability performance of a system the program needs to know how individual equipment failures combine with other failures to reduce throughput, create hazards and affect system operational capabilities. This is done by constructing a RBD or fault tree diagram that represents how combinations of events (usually failures) interact to affect the system. The AvSim module of AWB allows you to quickly construct these diagrams through any number of indenture levels. These diagrams can represent standby and voting arrangements, phase-dependent configuration changes, switching logic and buffer facilities.

Failure and maintenance models may then be defined and attached to historical data using Weibull sets. Also, consequences may be defined indicating the financial, safety, environmental and operational effects of loss of availability or throughput.

Once this has been done, AWB can produce a full system availability simulation building a picture of how the system will perform though its lifetime. Special optimization facilities are provided for optimizing spare holdings and users can try out different design and operational models to reduce life cycle costs.

Functional Summary of the AvSim Module

- Dynamic memory allocation means no limits on number of blocks, gates or events that may be defined in a project
- AvSim+ v10 files may be opened in the AvSim module and saved as Availability Workbench projects
- Simulation 'Watch' facility for checking your system and spares echelon models
- Multiple-system spares tracking for fleet modelling
- Interactive construction of network or fault tree diagrams
- Sub-system blocks, allowing automatic network diagram pagination
- Blocks can incorporate bitmap pictures for convenient identification
- Pagination facilities for large fault trees
- Add RBD and fault tree structure and resources from library projects
- Grid filter, find and replace
- Custom grid layout templates
- Hyperlink and notes capability

- Attributes of diagram objects can be edited via easy-to-use dialogs
- User control of scaling, shifting and font selection
- Data verification for consistency checks
- Simulation of production capacity levels with target cost penalties
- Standby sub-systems modelled
- Modelling of spares dependencies and stock levels
- Models recycling of spares via a repair shop
- Spares optimisation facilities Provided
- Spares can be gathered into Bills of Materials, which may be associated with systems, sub-systems and components
- Batch ordering of spares with discounting
- Modelling of maintenance queuing
- Switching delays modelled
- Buffers modelled with depletion rates dependent on capacity requirement
- Powerful rules facility which allows modeling of strong dependencies such as opportunistic maintenance and 'hold for repair'
- Exponential, fixed, lognormal, normal and Weibull distributions for failure
- Lognormal, normal, Weibull and exponential distributions for repair
- Directly analyse historical data with the Weibull Analysis facility
- Models ageing and effectiveness of planned maintenance
- Scheduled maintenance interval optimisation
- Define financial, safety, operational and environmental consequences
- Models changing network and fault tree configurations during different phases
- Allows the modelling of different phase groups
- Phased time profiles
- Comprehensive reports interfacing with Microsoft Office products
- Graphs, plots, pie charts and time profile histograms
- Import and export facilities
- Data Link facility allows failure, maintenance and resource data to be shared between software modules
- Models the effects of condition alarms
- P-F curves for inspections and condition alarms
- Tracks equipment usage and costs
- Extended outage penalty costs modelled
- Maintenance activities may be organised into task groups
- Convert RCM FMECA data directly from RCMCost module
- NOT logic capability
- Individual labour task time factors
- Importance ranking for spares
- Spare volume and weight calculations
- Phased bi- and tri-Weibull facility
- Batch analysis of Weibull datasets
- Report designer outline allows easy editing of report properties
- Statistical error indicators
- Time profiles for different maintenance categories
- Record simulation details to file
- NPV calculation
- Application options allow the user to edit the features and appearance of a project, such as the tree control fonts and number of undo actions
- A declassify facility removes all descriptive data from a project
- Project statistics allow the user to view details about the size and content of a project
- An ERP portal allows the user to upload and download data to and from ERP systems such as SAP

Overview of RCMCost Module

What is Reliability-Centered Maintenance?

Reliability-Centered Maintenance (RCM) is a procedure for determining maintenance strategies based on reliability techniques and encompasses well-known analysis methods such as Failure Mode Effects and Criticality Analysis (FMECA). RCM procedures take into account the prime objectives of a maintenance programme, which are to:

- Minimize Costs

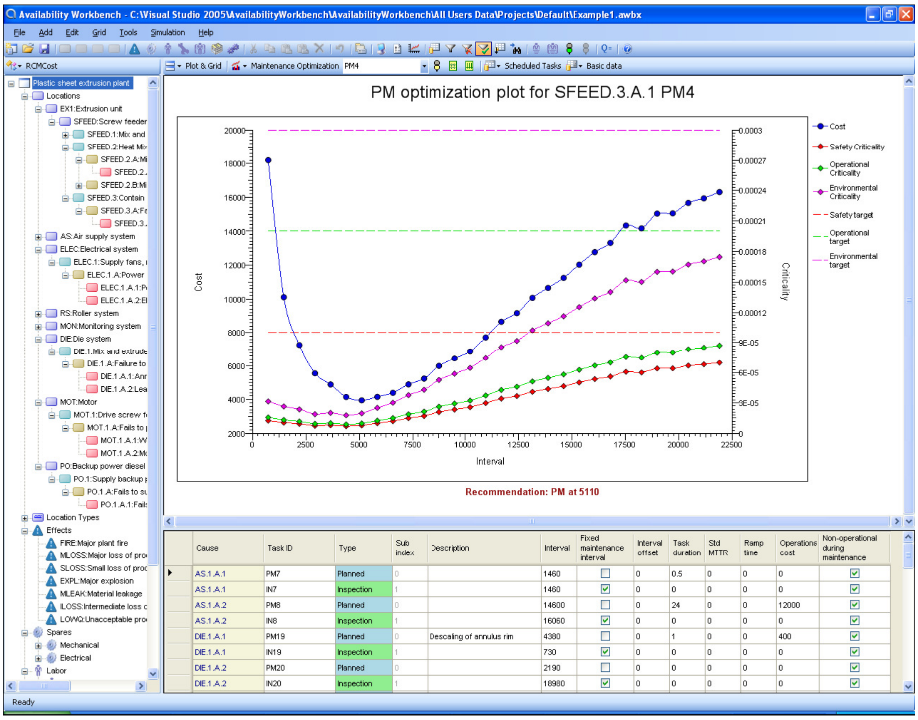
- Meet Safety and Environmental Goals
- Meet Operational Goals

The RCM process begins with a failure mode and effects analysis that identifies the critical plant failure modes in a systematic and structured manner. The process then requires the examination of each critical failure mode or cause to determine the optimum maintenance policy to reduce the severity of each failure. The chosen maintenance strategy must take into account cost, safety, environmental and operational consequences. The effects of redundancy, spares costs, maintenance labor costs, equipment ageing and repair times must also be taken into account along with many other parameters.

Once optimal maintenance policies have been recorded the RCM process provides system performance predictions and costs, expected spares requirements and labor manning levels. The RCM process may be used to develop a living strategy with the plant model being updated when new data is available or design changes take place.

How does the RCMCost Module of Availability Workbench Help?

The RCMCost module of Availability Workbench (AWB) provides the full framework for building the RCM model to represent your system. It provides facilities for storing RCM data and analyzing maintenance alternatives. It provides simulation algorithms to predict lifetime maintenance costs, spares costs and usage, maintenance labor manning requirements, safety and environmental risks and operational performance. In addition the RCMCost Module identifies critical failure modes (causes) and compares the cost, safety and operational benefits of different maintenance intervals.



Availability Workbench 2007 AWB is designed to combine well-established reliability prediction techniques with engineering experience. The program does not decide on which maintenance policy or combination of policies to adopt. Instead it advises the individual user or workgroup based on the operational data provided. The program may be used to filter the most critical item (component) failures before detailed maintenance decisions are made.

The RCMCost Module provides interactive graphical facilities for constructing a location hierarchy diagram representing the logical connection between the sub-systems and equipments constituting the overall plant or system. This diagram may be extended to represent critical functions, their functional failures and their causes (engineering failure modes). System effects are identified which contribute to outage and operational costs as well as safety and environmental risks. The relative severity of different effects is specified by the user. This structured method for identifying failure modes and linking them with their effects on the system is known as Failure Mode Effects and Criticality Analysis (FMECA) and is a powerful analysis process in its own right. RCMCost allows flexible user-defined reports to be produced highlighting the most important contributors to operational costs and safety and environmental risks.

Failure data, maintenance parameters, spares information and maintenance labor details are all stored in an AWB project. This data is used to provide advisory information based on simulation models incorporated in the program. For example, different maintenance intervals may be compared for their effect on maintenance and operational costs. The user may then record the decision on which maintenance policy (if any) to adopt. This decision may include combinations of:

- Scheduled Planned Maintenance Tasks
- Condition Monitoring Alarms
- On-Condition Inspections (predictive maintenance)
- Inspections for Hidden Failures
- Commissioning Periods
- Re-Design

The RCMCost module will automatically advise the user on the overall cost, safety and environmental benefits of adopting a particular maintenance policy based on the data provided by the user. The program's flexible report facility allows RCM worksheets to be produced identifying the user's decisions.

Once the maintenance policy has been decided for all the critical system components the RCMCost module will provide predicted spares requirements, maintenance labor manning levels, system costs and operational performance data.

As new data is gathered during the plant lifetime, or system design changes are made, RCM related data may be easily modified and maintenance procedures may be adjusted to reflect the living status of the plant.

Standards Support and Decision Diagrams

AWB supports RCM standards such as SAE JA1011, MSG-3 and MIL-STD-2173(AS) by providing a structured method for entering FMECA data and simulating the effects of different maintenance strategies on cost, safety, the environment and operational issues. The RCM decision making process is therefore substantially enhanced by the ability to quickly simulate the effects of preventive tasks, inspection tasks and condition monitoring taking into account ageing, hidden failures, maintenance labor costs, spares costs and availability. RCM decision diagrams are utilized in MSG-3 and MIL-STD 2173(AS) to provide a logical process for workgroups to determine what type of maintenance strategy to adopt for a given failure cause. The diagrams ask questions that often require analysis before a conclusion may be reached. In addition these diagrams follow a sequential process that may not be appropriate in identifying the optimal task or combinations of tasks for a given failure cause. However, AWB provides the full flexibility required to allow users to quickly compare the effects of different practical maintenance strategies and condition monitoring using well-known scientific methods.

AWB may be used to produce reports complying to the SAE JA1011, MSG-3 and MIL-STD-2173(AS) standards. Reports may contain FMECA data, maintainability data and RCM decision data.

Functional Summary of the RCMCost Module

- Graphically constructed system hierarchy diagram
- Failure Mode Effects and Criticality Analysis (FMECA)
- Identification of critical failure modes
- Advice for decision making based on performance simulation
- Redundancy modelling
- Weibull analysis of field data
- Automatic analysis of work order data
- Optimisation plots for alternative maintenance strategies
- Group maintenance modelling
- Graphical time profiles for costs and resources
- Manual or automatic allocation of user-defined criticality rankings to equipment locations
- Flexible reporting providing customised worksheets
- Copy and paste facilities for data transfer
- Library facilities
- Convert AvSim RBDs and fault trees to location hierarchies
- An ERP portal allows the user to upload and download data to and from ERP systems such as SAP
- Import/Export to databases and spreadsheets

These features are provided in addition to the broader application features listed for the AvSim module, such as the enhanced grid view and data linking facilities.

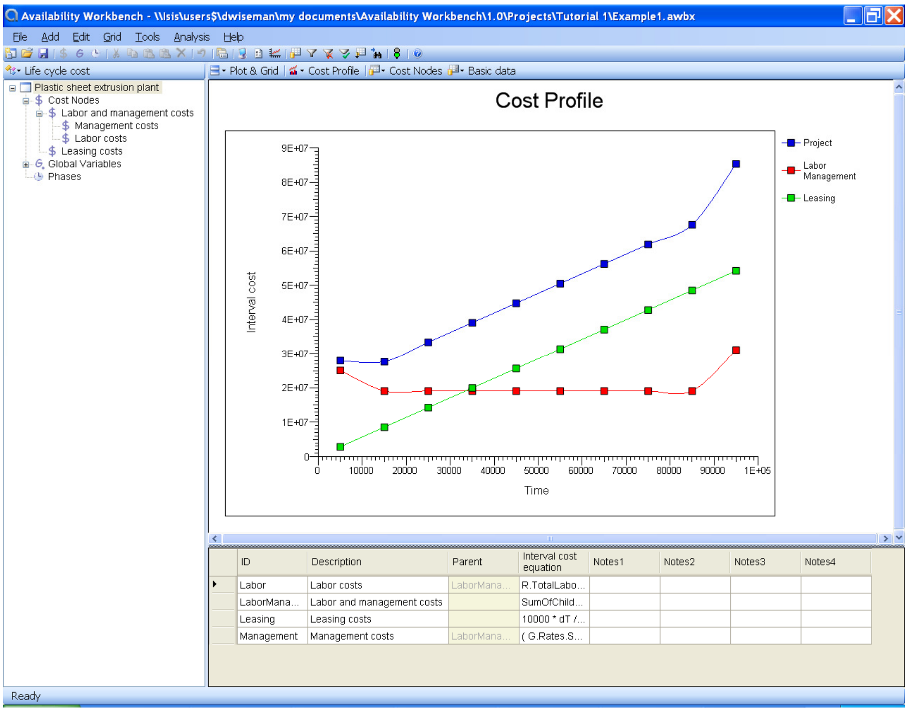
Introduction to the Life Cycle Cost Module

The Life Cycle Cost (LCC) module of Availability Workbench allows users to build a hierarchical cost breakdown structure (CBS) through an unlimited number of indenture levels. The CBS may be directly linked to cost predictions produced by the RCMCost or AvSim modules. Other costs may be defined as time-dependent cost equations or simple numerical values. Global variables may be defined and utilized in the cost equations.

High-level costs are determined either by summating the cost values for child nodes in the CBS or by applying a user-defined cost equation. The syntax of cost equations is easy to understand and the construction of cost equations is assisted by an intelligent code-recognition utility that automatically reveals global variable lists as the user types in an equation.

Phase-dependent cost equations may also be defined. Phases are shared between the LCC and AvSim modules.

In summary the LCC module allows users to define life cycle costs other than those predicted by the RCMCost and AvSim modules. These costs may be integrated with predicted costs in the LCC cost breakdown structure to provide a time-dependent analysis of a system's whole life cycle cost process.

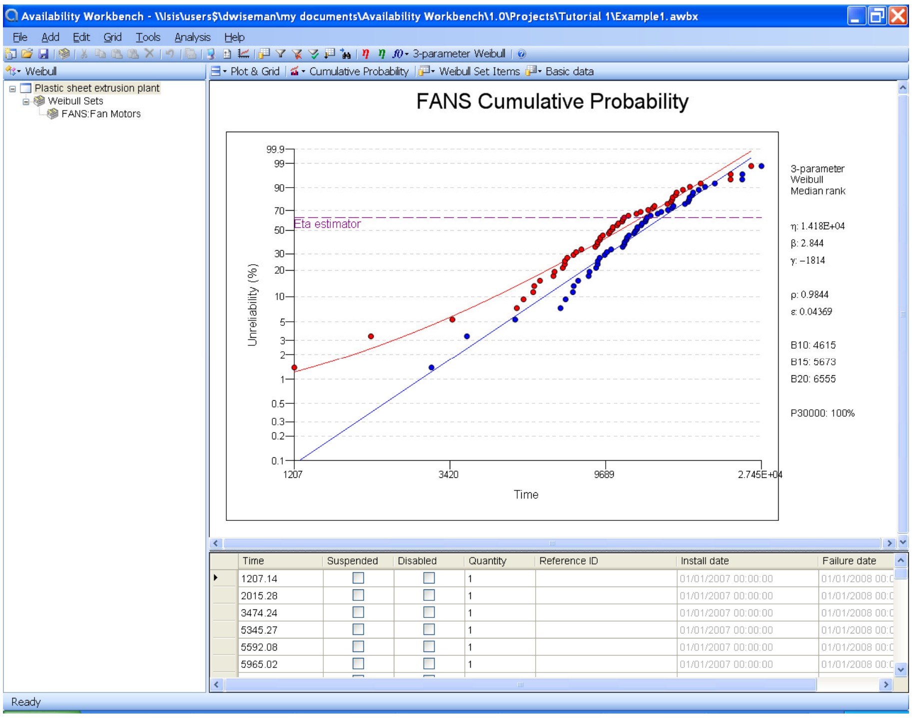


Functional Summary of the Life Cycle Cost Module

- Life cycle costs are represented by a cost breakdown structure
- The cost breakdown structure is composed of cost nodes (cost elements) in a cost tree structure
- Cost trees are constructed interactively
- Cost results from AvSim and RCMCost analyses performed in the same project file may be referenced as variables to be used in cost calculations
- The copy, paste and drag and drop facilities allow nodes of the cost tree to be copied or moved
- Cost functions calculate the cost to be applied at each cost node in the cost tree using either global variables or variables entered locally to the cost node
- The cost at a cost node is the cost generated by the cost function plus the cost of child nodes
- The analysis module calculates cost and cumulative cost through time at each cost node in the cost tree for each phase
- Any number of phases and any number of profile points per phase may be created
- Cost nodes, global variables and phases may be imported using the library facility
- Results are displayed on a customizable progfile
- Comprehensive reports interfacing with Microsoft Office products
- Extensive import and export facilities

Introduction to the Weibull Module

The Weibull module of Availability Workbench (AWB) analyzes historical failure data by assigning probability distributions that represent the failure characteristics of a given failure mode. The failure distribution assigned to a given set of times to failure (known as a Weibull set) may then be assigned to causes in the RCMCost location hierarchy diagram or failure models in the AvSim module. Assigning failure distributions to historical data in this way enables the AWB simulation engine to emulate the effects of failures on systems. Historical data is usually extracted from the Computerized Maintenance Management System (CMMS) or Failure Reporting and Corrective Action System (FRACAS) database using the AWB import or Dynamic Link Library (DLL) facilities. The failure distribution assigned to a given set of times to failure (known as a Weibull set) may be assigned to failure models that are attached to causes in a RCM location hierarchy, blocks in a reliability block diagram or events in a fault tree diagram.



Weibull sets may also represent collections of actual historical repair times for a given task. The Weibull module can assign distributions that represent possible fluctuations in repair times. Repair Weibull sets can be assigned to tasks associated with causes in the RCMCost module or failure models in the AvSim module.

The historical times in a failure Weibull set will represent the age of an equipment at the point of its first failure. Times in a repair Weibull set represent the time it takes to repair an equipment.

In summary, the Weibull module of AWB analyzes sets of historical data and assigns appropriate distributions for use in simulations by the RCMCost and AvSim modules.

The Weibull Analysis Module analyzes historical data using the following distributions:

- Exponential Distribution
- 1-Parameter Weibull Distribution
- 2-Parameter Weibull Distribution
- 3-Parameter Weibull Distribution
- Bi-Weibull
- Tri-Weibull
- Lognormal Distribution
- Normal Distribution
- Weibayes
- Phased Bi-Weibull
- Phased Tri-Weibull

AWB automatically fits the selected distribution to the data provided and displays the results graphically in the form of cumulative probability plots, failure rate plots and probability density function plots.

Data may be entered manually by the user or imported from other packages or transferred via the Windows clipboard.

New data can be analyzed and assigned in 3 simple steps:

- Enter or import the data
- Select a distribution type
- Assign the Weibull Set to the appropriate causes in the RCMCost module or the failure models in the AvSim module

What's New in Availability Workbench?

Availability Workbench (AWB) is a new software package that brings together of each of Isograph's industry-leading simulation packages into a single, integrated application. AWB comprises 4 modules - Availability Simulation (AvSim), Reliability Centered Maintenance (RCMCost), Life Cycle Cost (LCC) and Weibull.

The release of AWB has provided the opportunity for many new features and enhancements to be implemented. A summary of the new features added at the application level will be given first, followed by lists of those specific to each module.

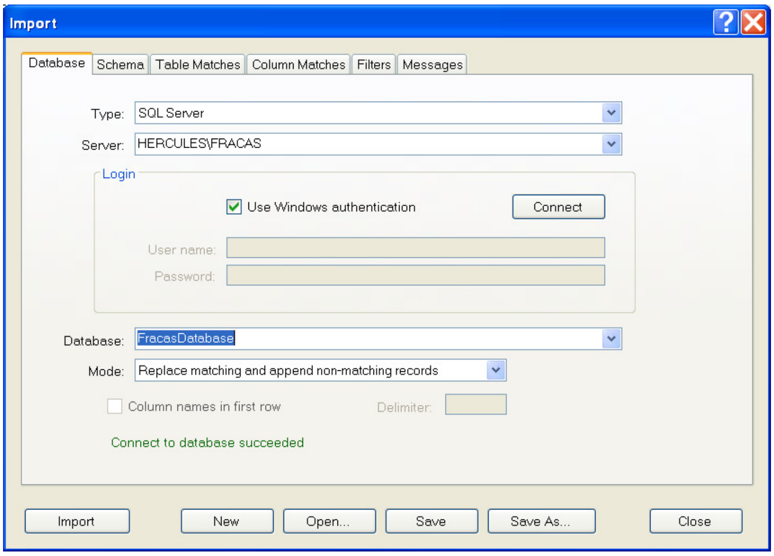
Application

Dynamic Memory Allocation

AWB has been developed in the Microsoft .NET environment. One of the advantages of this is that memory may now be allocated dynamically during project construction. As a result, there are no longer any formal limits on the numbers of blocks, events, locations and other resources that may be defined in a project. Furthermore, the use of the .NET environment has allowed the length of descriptive fields and notes fields to be extended to 255 and 2000 characters, respectively.

Enhanced Import/Export Facilities

The Import/Export facilities in AWB allow data to be transferred to and from XML, Oracle and SQL Server databases and the Windows Clipboard. This is in addition to the Excel, Access, CSV and delimited text file import/export formats that were available in AvSim+ or RCMCost. AWB also allows the user to filter data that is imported to or exported from a project. A filter may be applied to each column match specified in the import/export settings. Multiple filters may be defined for each table match.



Convert Between AvSim and RCMCost

The integrated nature of AWB allows the user to directly convert AvSim RDB's and fault trees to RCMCost location structures and vice versa.

Data Links

The integrated nature of AWB allows for data links to be established between failure models in the AvSim module and causes in the RCMCost module. Either of these resources may be updated with failure and maintenance information from the other by way of a user-friendly data links interface. Links are established automatically when transferring AvSim RBD's and fault trees to RCM locations, and vice versa, and may also be created manually.

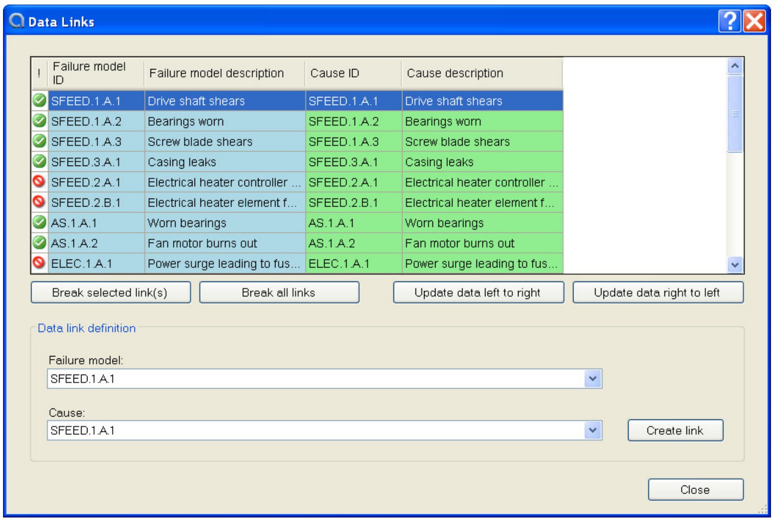


Diagram Report Options

AWB provides enhanced settings for diagram reports. These include page filters, symbol sizes and diagram rotation.

Application Options

AWB sees the introduction of a broad range of application options. These options affect the features and appearance of the application globally. For example, the user may edit the fonts used for the tree control, plots, grid and pop-up texts. Default plot colors may also be changed, as can the number of previous actions stored by the Undo facility.

Declassify Project

AWB possesses an integral declassification tool that may be used to remove all descriptions and notes from a project. This allows the user to protect classified information in the event that the project is to be passed to an outside party, for example, Isograph technical support.

Shared Resources

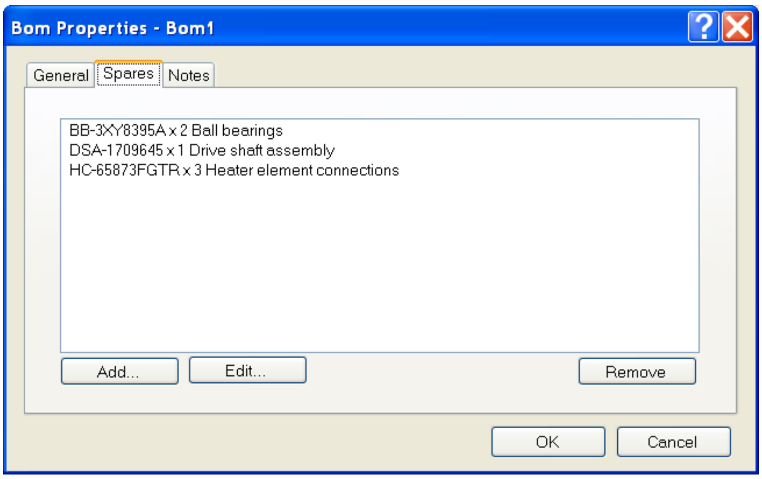
Certain types of resources created in either the RCMCost or AvSim modules are shared. That is, resources created in a project will be available for use in both the AvSim logic diagram and the RCMCost location hierarchy. The resources concerned are Spares, Labor, Equipment, Task Groups, BOMs and Weibull sets.

Resource Types

The user may define Types for each system resource. A Type is a group to which resources may be allocated. Types do not affect the analysis of the project, but are a useful project management tool.

BOMs

Bills of materials (BOMs) may be compiled from the spare parts defined in a project. When a BOM is associated with a block, event or location, only the spares listed in that BOM will appear when assigning resources to the associated tasks.



Library

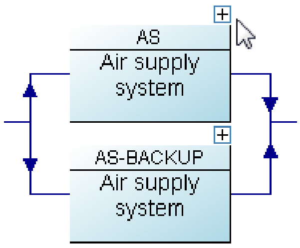
An AWB project may be connected to a library file, allowing AvSim projects to be constructed using systems and resources from another project or a library. This was not possible in AvSim+ v10.

Additional Tags and Fields

A number of descriptive fields and check boxes have been added to help identify tasks and installations in a system. These include SCADA tag ID for alarms, Mandatory Task check box for scheduled maintenance tasks and Operation No for all tasks.

Enhanced Project Views and Navigation

The user may now choose from an expanded set of views. These include Diagram, Grid, Plot, Plot & Grid and Library. The Report Designer (successor to Report Generator) may now be viewed in the diagram window of AWB as well. Furthermore, navigation of RBD's has been enhanced, allowing the user to drill down through levels by clicking on the + icon that appears above subsystem blocks.



Grid Options

The grid display may be filtered using one of a set of predefined layouts. For example, the Cause table may be displayed in the grid basic data, FMEA, FMECA and strategy layouts. Furthermore, the user may create custom layouts and export them to files. Layout files may then be imported to other projects.

Multi-Threading

If AWB is installed on a multi-processor machine, the user may allocate a specific number of processors to performing project analyses. For example, if the software is running on a Quad-Core PC, the user may allocate 2 out of 4 processors to running the analysis, thus leaving 2 processors free for other tasks. Alternatively, if the machine in question is a dedicated server, all of the available processors may be allocated to the analysis, thus significantly improving the performance.

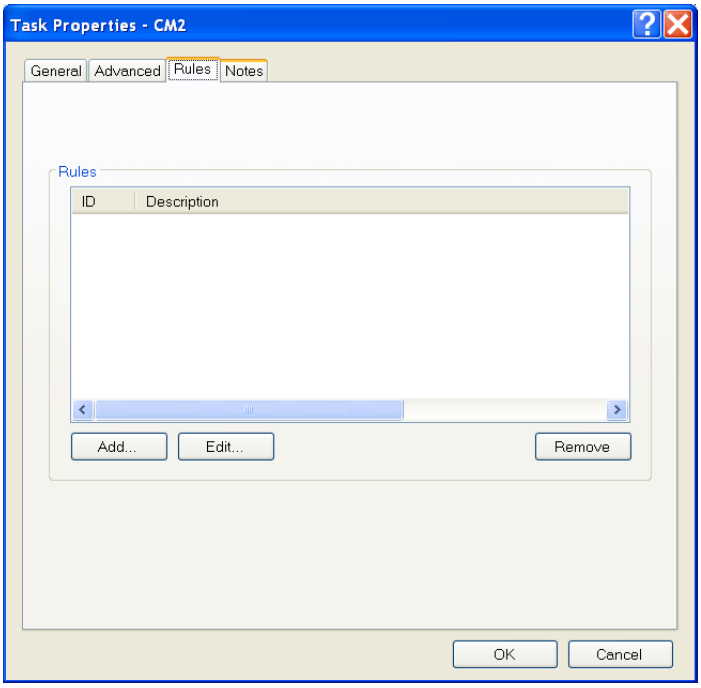
<u>AvSim</u>

AvSim+ v10 Files

AWB may be used to open, edit and analyse AvSim+ v10 project files. These may then be saved as AWB project files.

Rules

Rules are a new feature for AWB that give the user greater power to dictate the behavior of the system than was possible in AvSim+. Rules may be associated with blocks, systems, tasks and consequences. The user may use rules to specify changes in system logic and parameters by phase or block state, depending on where the rules are defined. There is no limit on the number of rules that may be created for each block, system, task or consequence.

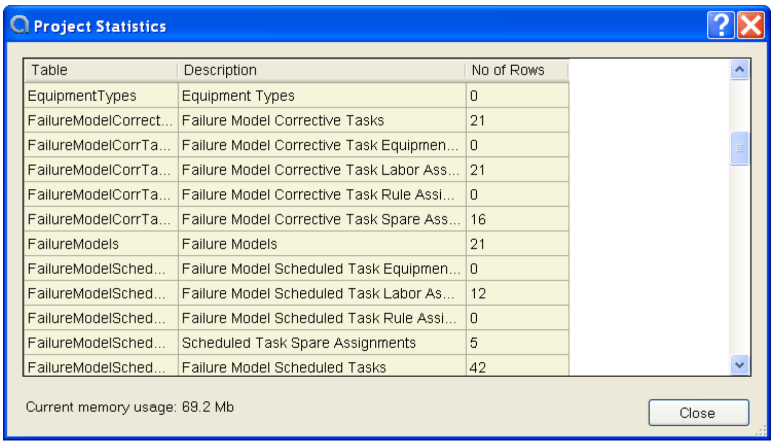


Optimize Maintenance Intervals by Availability

In AWB maintenance intervals may be optimized for cost or availability. This option may be set in the Project Options. Previously, AvSim+ only allowed optimization of maintenance intervals by cost.

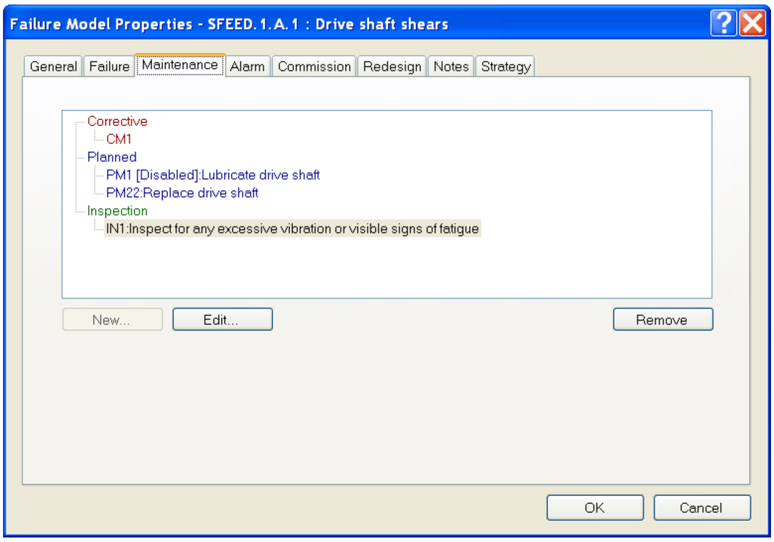
Project Statistics

A new feature has been introduced for AWB that allows the user to view the statistics for a project. These include the number of each type of system component and resource used and the memory usage for the project.



Enhanced Maintenance Strategy

More than one of each type of scheduled maintenance task may now be assigned to a failure model. In the event of an inspection or alarm detecting an imminent failure the program will implement the first planned maintenance task listed that has the Secondary Action Task check box turned on. Furthermore, a Strategy tab has been introduced to the failure model dialog that conveniently allows the user to turn tasks on and off.



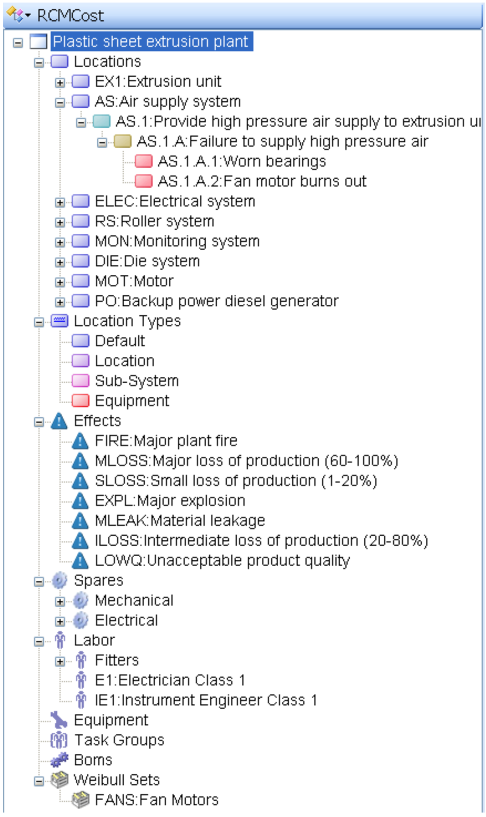
RCMCost

RCMCost v4 Files

AWB may be used to open, edit and analyze RCMCost v4 project files. These may then be saved as AWB project files.

Project Control Tree

The RCMCost location structure and associated resources are now displayed in the project control tree of AWB. This new interface allows the user to access and edit resource data more easily.

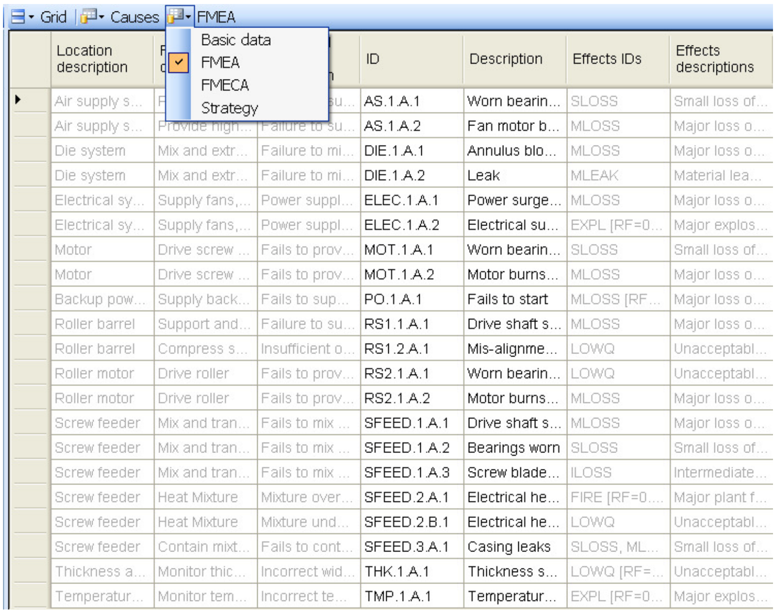


Location Types

The user may now create a list of location types. These types may be color coded and associated with locations in the hierarchy structure. A location that is associated with a location type will be displayed in the color allocated to that type.

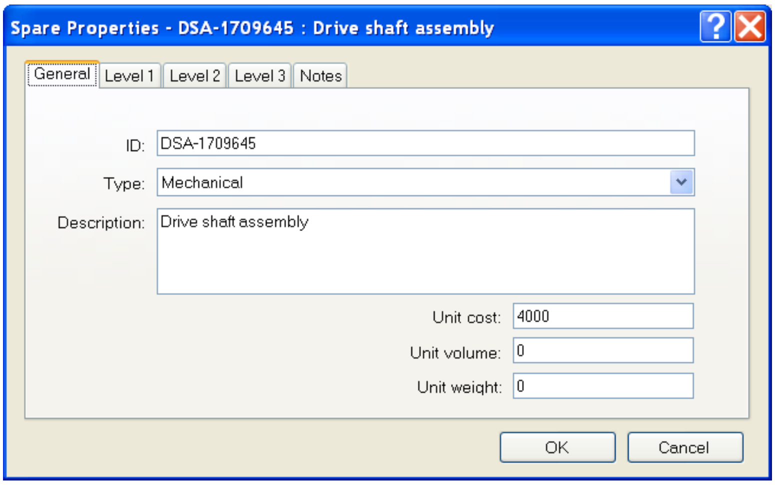
Grid Options

The grid display may be filtered using one of a set of predefined layouts. The Cause table may be displayed in the grid using one of a set of predefined layouts. These include basic data, FMEA, FMECA and strategy. Furthermore, the user may create custom layouts and export them to files. Layout files may then be imported to other projects.



Spare Parts Storage Levels

Spare parts storage levels may now be modeled in the RCMCost module. Storage levels 1 and 2 are available, as is a logistic time delay for the manufacturing level.



Weibull

More Detail in Data Sets for AvSim Module

The Disabled, Install Date and Failure Date columns may all now be used with the AvSim module. Previously, it was not possible to disable a data point in AvSim+, nor could times to failure be inferred from installation and failure dates. Furthermore, Reference IDs (Work Orders) may be assigned to data points. This was not possible in AvSim+ v10.

B Life Values

Three B life values may be entered for a data set. This was not possible previously in AvSim+ v10.

How Simulation Works

AvSim+ employs Monte Carlo Simulation Methods to estimate system and sub-system parameters such as unavailability, number of expected failures, production capacity, costs etc. The process involves synthesising system performance over a given number of simulation runs. Each simulation run in effect emulates how the system might perform in real life based on the input data provided by the user. The input data can be divided into two categories – a failure logic diagram and quantitative failure and maintenance parameters. The logic diagram (either a fault tree or a network diagram in the case of AvSim+) informs the computer program how component failures interact to cause system failures. The failure and maintenance parameters inform the program how often components are likely to fail and how quickly they will be restored to service. By performing many simulation runs the computer program can build up a statistical picture of the system performance by recording the results of each run.

Monte Carlo Simulation must emulate the chance variations that will effect system performance in real life. To do this the computer program must generate random numbers that form a uniform distribution. AvSim+ uses the Microsoft run-time library to generate pseudo random numbers.

As an example of how simulation works consider the following example. Suppose we wish to determine the unreliability of a complex system over a period of 1 year. A simulation model of the system could be developed which emulates the random failures and repair times of the components in the system. The model might be run over the system lifetime of 1 year 1000 times and each time a component fails the model determines whether the system has failed. If the system does not survive on 65 of the lifetime simulations then the system unreliability, $F(1)$, could be estimated as $F(1) = 65 / 1000 = 0.065$.

Simulation methods are generally employed in reliability studies when deterministic methods are incapable of modelling strong dependencies between failures. In addition simulation can readily handle the reliability behaviour of repairable components with non-constant failure or repair rates