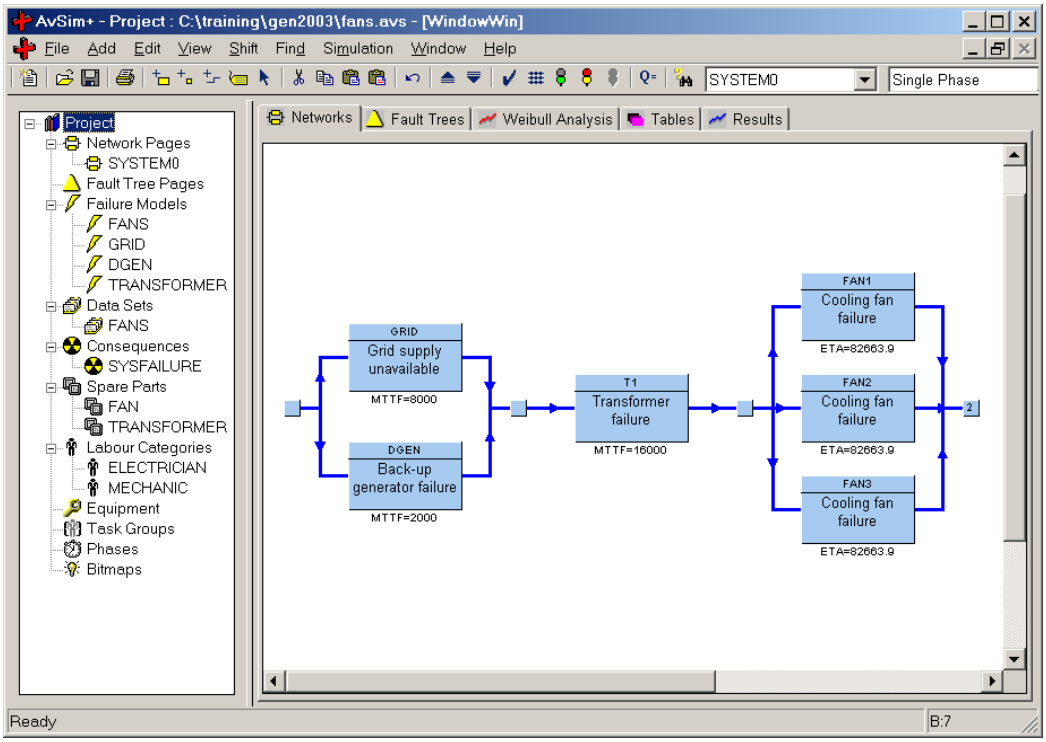
AvSim+ V9 Technical Specification

Overview

AvSim+ is a powerful availability and reliability simulator capable of analysing complex and dependent systems efficiently and accurately. AvSim's algorithms have been developed and enhanced over the past 15 years by Isograph's experienced team of reliability engineers, mathematicians and programmers. AvSim+ capabilities extend far beyond analysing the availability and reliability of complex systems. The program's Weibull, spares tracking (through multiple echelon levels) and task management functions allow users to implement a Reliability-Centred Maintenance (RCM) strategy aimed at reducing costs, optimising availability and managing planned maintenance tasks.

In AvSim+ the logical interaction of failures, and how they affect system performance, are modelled using a network diagram or fault tree. These diagrams may be used to model failure and success or levels of throughput in the system. Consequences are then assigned to any level of the logical diagram to indicate the effects of failures (financial, operational, safety and environmental). Labour, spares and failure data may be imported or directly entered into the program together with any operational phase information and task group assignments. AvSim+ will then analyse your system using efficient Monte Carlo simulation algorithms to provide availability and reliability parameters, life cycle costs, importance rankings etc. You may also optimise spare holdings and planned maintenance intervals.

All this information may be reported in standard (or custom) graphs and text reports or exported to your database or spreadsheet application.



Constructing a Network in AvSim+

Platform

Runs under Windows 95, 98, NT, 2000, Me, Xp. Recommended host memory requirements 128Mb+

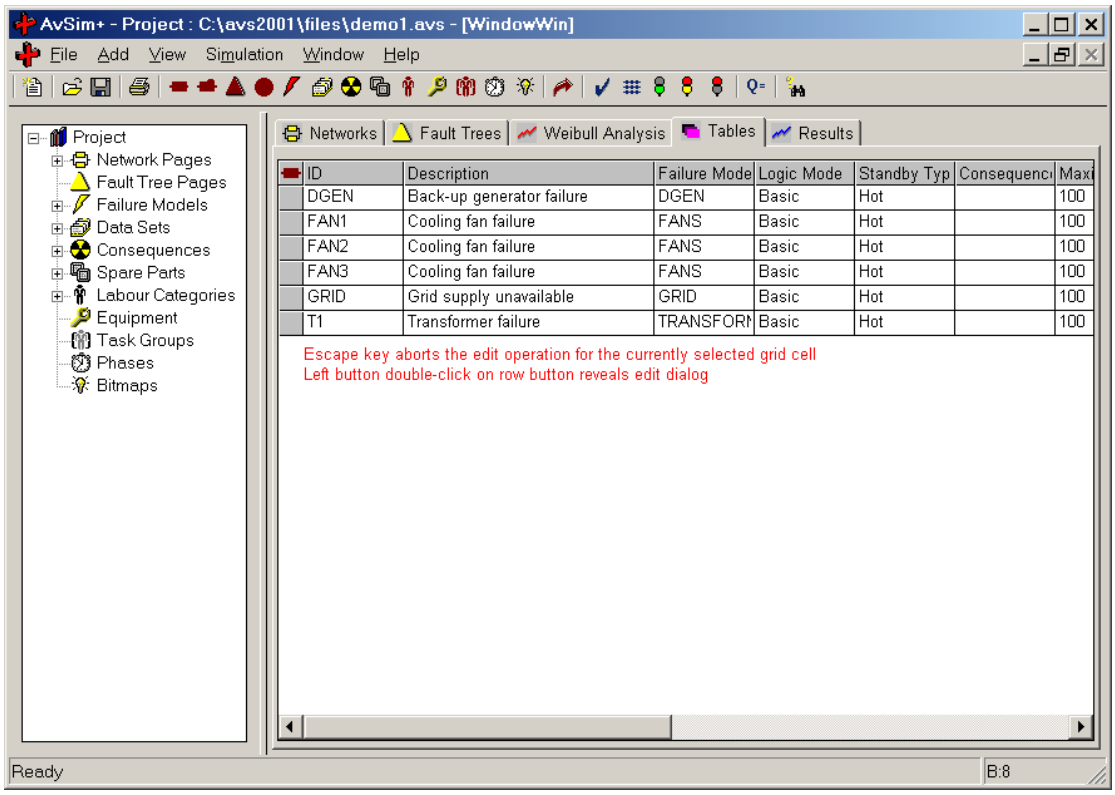
Summary of functionality :

- 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
- Append projects created by different users
- 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
- Batch ordering of spares with dicounting
- Modelling of maintenance queuing
- Switching Delays Modelled
- Opportunistic maintenance and 'hold for repair' modelling
- Exponential and Weibull distributions for failure
- Lognormal, normal 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
- Phased time profiles
- Comprehensive reports interfacing with Microsoft Office products
- Graphs, plots, pie charts and time profile histograms
- Import and export facilities
- Interfaces with other reliability products
- 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
- Import RCM FMECA data directly from RCMCost projects
- NOT logic capability
- Individual labour task time factors
- Importance rankings for spares
- Spare volume calculations
- Phased bi and tri Weibull facility
- Batch analysis of Weibull datasets
- Report Generator Wizard
- Statistical error indicators

Features

Quickly Build Diagrams with Drag and Drop

AvSim+ allows you to quickly construct fault tree or network diagrams (reliability block diagrams) using drag and drop facilities. Simply choose the preferred method to represent the failure logic of your system from the tabs at the top of the AvSim+ window and place the fault tree or block symbols in your diagram. If you are using fault trees then AvSim+ will automatically organise the diagram for you – you simply tell it the logical connections ! If you are using networks simply place the blocks on the screen, make the logical connections, and the program will automatically deduce the failure logic of the system. Whichever method you choose there is a powerful pagination facility which allows you to organise large and complex projects.



Editing Data in the List Control

Comprehensive Failure and Maintenance Models

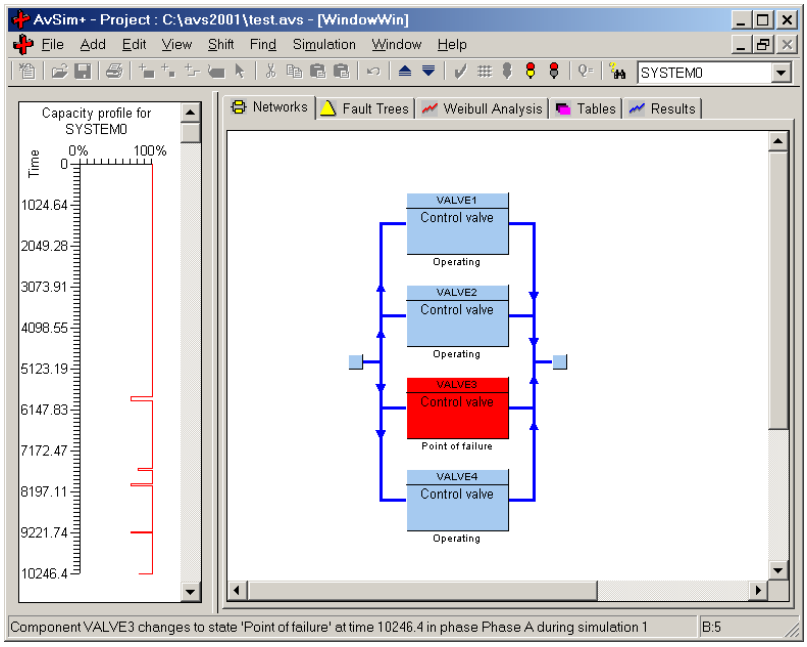
Once you have defined the logical fault tree or network structure of your project you can define comprehensive failure and maintenance models to represent the performance of components within your system. These models could be simple failure and repair models or they could represent complex dependencies including ageing, spares requirements, labour availability, operational phases, standby arrangements, etc. For new users the *Failure Model Wizard* will allow you to build new failure models by answering a few simple questions.

Directly Analyse Historical Data

Historical data (times to failure and times to repair) is automatically analysed using the Weibull Analysis facility and connected directly through to component failure models. This allows users to update their historical data records and almost immediately see the effects on predicted system performance.

Check the System Model with the Simulation 'Watch' Facility

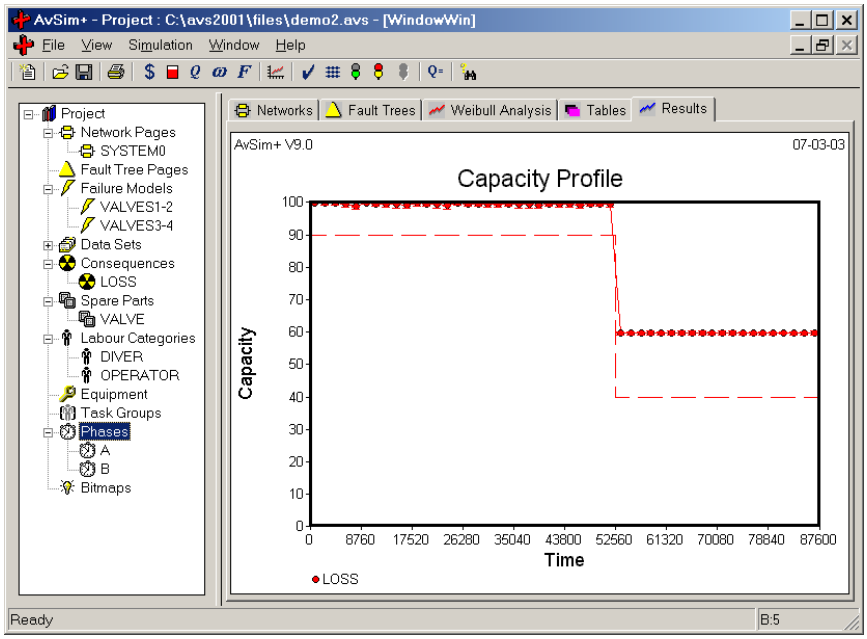
The AvSim+ Simulation 'Watch' facility allows users to check the logic of their system model by tracking events during a simulation and observing the effects on system availability or throughput. Spares may also be traced as they move between echelon levels using this facility.



Using the Simulation Watch Facility to track Capacity Changes

Determine Lifetime Costs and Production Capacity

AvSim+ allows you to model costs and production capacity as well as availability and reliability. Labour, spares and other miscellaneous costs are taken into account during each simulation. In addition, consequences may be assigned to system failures allowing the cost of failures to be included in the calculation.



Viewing the System Capacity Profile in AvSim+

Safety, Environmental and Operational Impacts Modelled

By allocating safety, environmental and operational consequences to selected system failures you will be able to determine the frequency and duration of each type of consequence. Severity values may be assigned to a given consequence allowing safety, environmental and operational criticality values to be determined over the lifetime of the system.

Optimise Spares Holdings and Scheduled Maintenance

AvSim+ provides facilities to allow the user to optimise spares holding at site and/or depot. In addition AvSim+ will automatically determine optimum scheduled maintenance intervals.

Powerful Monte Carlo Simulator

The AvSim+ Monte Carlo simulator engine is the result of 10 years development during the evolution of the AvSim+ product. The simulator enables AvSim+ to model complex redundancies, common failures and component dependencies that cannot be modelled using standard analytical techniques. Some typical dependencies that can strongly effect the availability and reliability of a system are given below.

- Warm and cold standby arrangements
- Queuing for labour
- Queuing for spares from site, depot and factory
- Hold for repair
- Opportunistic maintenance

Sophisticated Reports, Diagrams and Graphs

The AvSim+ Report Generator allows you to select from a range of standard reports or quickly design your own customised reports. You can design your own headers and footers, choose your own fonts, insert your own pictures, sort and filter data and much more !

Paginated network or fault tree diagram reports are automatically produced and can be transferred to other packages such as Microsoft Word in the form of Windows metafiles.

You may also choose from a wide range of sophisticated scientific graphs and charts or create your own graphs and charts. You can display multiple graphs on the same page and easily modify scales, legends, titles etc.

Import and Export

AvSim+ provides a flexible import/export facility that allows the user to transfer data to and from Microsoft Access databases, Microsoft Excel spreadsheets and text delimited and fixed length files.

What's New in Version 9 ?

AvSim+ Version 9.0 provides a substantial range of new and extended modelling facilities compared to Version 8 of the program. In particular this new version contains a simulation 'watch' facility to help users check the logic of their system models and a complete multi-system multi-echelon level spares availability model.

Simulation 'Watch' Facility Added

This new facility allows users to step through the simulation process and observe component and system state changes as well as tracking the actual movement of spare parts between echelon levels. State changes are displayed on the network or fault tree diagram and system availability or capacity changes and spare movements are displayed on a time graph.

New Spare Part Tracking Algorithm

AvSim+ now tracks individual spare parts or batches of spare parts as they move through different echelon levels. This enables AvSim+ to be used for accurate optimisation of spare holdings. Multiple systems may also be modelled in AvSim+ with common or separate site storage capabilities.

Batch Ordering and Discounting

Spares may now be batched when supplied from source. The user may specify the batch quantity and the discount obtained compared to ordering single items.

Spare Volume

Spare volumes may now be recorded in an AvSim+ project. The program will calculate total spare volumes being held at different echelon levels.

Buffer Distribution Added

A buffer distribution model has been added to allow users to model stored capacity during a simulation. For example, a tank may hold enough liquid to supply flow in a process plant when the normal pumped supply is unavailable due to a fault in the system. The tank can only supply liquid for a limited period of time. In AvSim+ you may now add a block in parallel to the normal supply route to represent the tank. The new block would be associated with the buffer failure distribution.

Switching and Start-Up Delays

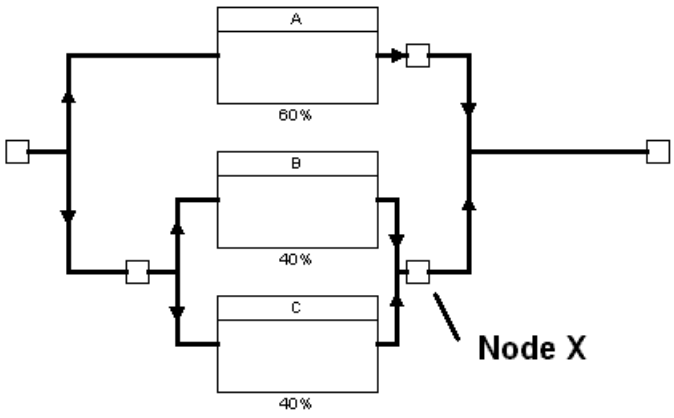
Switching delays may now be modelled by specifying the delay time for the appropriate block or event.

Condition Alarm Model Added

AvSim+ now allows users to assign a condition alarm model. The effectiveness of the alarm is determined by the P-f interval, P-f curve type and detection probability specified by the user.

Local Standby Flag

Local standby flags are used to control when a standby block is required to 'start-up' to replace the functionality of a failed block in the network diagram. Local standby flags are normally only needed when modelling throughput capacity. Consider the small system below. Unless the user sets a local standby flag, AvSim+ will assume that block C will be in standby when Block A is working and block B is failed. This is because from a traditional availability point of view the system is 'UP' with just A working. However, if we are modelling throughput this behaviour would result in the system operating at 60% capacity only. If we set the local standby flag on for node 'X' the program will treat the lower parallel arrangement (block B and block C) as if it was independent from block A from the point of view of determining the standby status of C. Now when block B fails block C will start-up to replace the lost capacity.



Probability Curves Added for Inspection P-F intervals

AvSim+ now allows users to specify step, exponential or linear probability curves for the P-F interval.

Equipment Now Modelled

Equipment usage and costs are now modelled. The availability of equipment can affect system availability. Equipments are modelled in a similar way to labour categories.

Extended Outage Cost Penalties

For some systems additional cost penalties may be incurred if an individual outage lasts more than a given amount of time. You may now specify these additional costs (up to 4 time steps may be specified) via the consequence dialog.

Paste Special Includes Lower Level Blocks

Paste Special will now copy the structure below system blocks. Blocks will be renamed as before.

Opportunistic Inspections

Opportunistic inspections may now be performed as well as opportunistic planned maintenance. The dependent event for opportunistic inspections is specified in the block or event dialog.

Data Sets Assigned to Maintenance Tasks

Data sets may now be assigned to corrective, planned and inspection maintenance tasks. The Weibull distribution can also be directly assigned to maintenance tasks.

Fitting Weibull Distributions Manually

Weibull distributions may now be fitted manually to input data. In the Weibull module choose the *Analysis, Set Distribution Parameters Manually* pull-down menu option to access this facility. Note that as the user changes the Weibull parameters the unreliability, failure rate and pdf plots automatically change. You may now ask AvSim+ to display averaged estimates of the failure rate over up to ten time regions (select the *Edit, Data Set Graph Scales* menu option to vary the number of regions) to help align the Weibull failure rate manually.

Calculating Unreliability for a Weibull Distribution

AvSim+ now calculates the unreliability of each data set distribution at a given time point. To set the required time point select the *Edit, Data Set Analysis Options* in the Weibull module.

Data Set Unreliability Estimation by 90% and 95% Rank Methods

In addition to estimating unreliability values for a data set using the median rank method, AvSim+ now allows users to choose the 90% and 95% rank methods. This means that the associated data set distribution will represent an upper 90% or 95% confidence level.

Assign Adjustment Factors to Individual Models

Phase dependent adjustment factors (affecting the MTTF of the associated blocks or events) may now be assigned to individual failure models. If the local adjustment factor is not equal to 1 it will override the global adjustment factor set for each defined phase.

Task Groups Added

Task groups have now been added to AvSim+. Scheduled maintenance activities may now be assigned to a task group. Task groups allow users to assign planned maintenance and inspection intervals to a group of components. Opportunistic maintenance may also be assigned on a group basis. Planned maintenance interval optimisation may also be performed on a task group basis.

RCMCost V3 Special Import Facility

RCMCost V3 users may now import their RCMCost project data directly into AvSim+. To access this facility choose the *Special Import, Import RCMCost V3 Project* pull-down menu option.

Results Summary Dialog Extended

The Results Summary Dialog now includes information on spare parts, labour categories and equipment.

Interval Optimisation

Users may now specify the minimum interval and interval increment for planned maintenance interval optimisation.

NOT Logic Capability Added

Users may use NOT logic in networks and fault trees. In networks NOT logic is assigned by selecting the 'Apply NOT Logic' check bock for a node. During a simulation, if no success path can be found through to a given node, the equipment represented by the node is deemed to be unavailable. However, if NOT logic is applied at the node the equipment would be deemed to be available. In fault trees not logic is added to the model by including a NOT gate in the diagram.

Consequences Assigned at Component Level

Consequences may now be assigned at the component block level in network diagrams and at the event level in fault trees.

Corrective Delays and Task Time Factors for Labour

You may now specify a corrective logistic delay for each labour category. In addition, when assigning labour categories to a failure model, you may now specify the active crew time spent if different from the mean time to repair the component.

Spare Importance Ranking

The new spare importance ranking facility allows users to identify which spare parts have a significant affect on system availability. In effect the spare part importance ranking allows you to optimise spare holdings from an availability viewpoint. Rankings are achieved by performing full simulation runs and recording the sensitivity of unavailability with variations in spare part capacity.

Spare Volume

Volumes may now be assigned to each spare part category. Volumes are automatically summated by the program for each echelon level.

Grid Control Added

A grid control facility has now been added to allow easy editing of tabular data.

Phase Bi and Tri-Weibull Added

Two new distribution fitting methods have been added to the Weibull module. The Bi and Tri-Weibull methods define Weibull distributions over two or three time regions respectively. Allowing each Weibull distribution to operate in a single time region allows more accurate distribution fitting where the failure rate follows a bath-tub curve.

Special Import/Export of Spares/Labour/Equipment to CSV File Added

Selection of the appropriate File, Special Import/Export pull-down menu options allows users to quickly export and import spares, labour and equipment assignments.

New Standard Deviation and Error Indicator Calculations Added

AvSim+ now reports the standard deviation and estimated error for total down time (TDT) calculations for system blocks and gates. An overall estimated error percentage is also displayed during the simulation process.

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

$$F(1) = \frac{65}{1000} = 0.065$$

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.

For example, the simple expression

$$Q(t) = \frac{\lambda}{\lambda + \mu}(1 - e^{-(\lambda+\mu)t})$$

may be used to determine the unavailability , *Q*, of a single component at time *t* where

λ = constant failure rate
μ = constant repair rate

This expression assumes that the failure and repair of the component is independent of the state of any other component in the system. This may not be the case if the component is in standby to another component (where the standby failure rate is less than the operating failure rate). In addition the component may be influenced by other external factors such as the availability of spares and labour to perform scheduled and corrective maintenance. The component's reliability behaviour may also change during different operational phases. In addition, if it is a mechanical component, its failure rate may increase with time (ageing) and therefore the simple expression above inaccurately represents the behaviour of the component.

By using simulation methods AvSim+ is not restricted to handling only independent component failures and repairs and can easily model dependencies on spares, labour and operational phases. In addition the Weibull failure distribution may be used to handle ageing components.