Serialized Item Management

A modeling platform for systems with life limited, serial tracked parts

John Sharp
TFD Group

Introduction

SIM is a total ownership cost and logistic planning modeling platform. Although originally designed for aero engines, it has wider application to any systems made up, at least in part, of life limited parts subject to serial tracking. At its heart lies TFD's MAAP® whole life logistic analysis platform, considerably enhanced to deal with life limited parts. TFD was selected for the development of SIM on the basis that our existing tool set most closely provided the functionality that was required[1]. The additional requirements peculiar to aero engines were the ability to handle serialized parts, analysis of FOD, non-constant hazard functions, secondary and subsidiary damage, tear-down matrices and embodiment of modifications and upgrades (both major and minor). In addition, new advanced data interfaces were needed to manage the large quantities of data required to model serial-tracked components and the complex support environment where airworthiness depends on the correct handling of configuration, alternative and substitute parts.

Developed in partnership with MTU, SIM is unquestionably the most sophisticated and complex decision support tool available for advanced mechanical systems extant. It has 3 principal functional capabilities:

- Predict future fleet conditions and performance
- Predict future maintenance demands by time and location and component
- Calculate optimal resource requirements to achieve a given operational availability (A_o)
- Support 'what if' analysis of operational or support options

SIM models support scenarios which enable users to optimize:

- Operational Planning – Operating fleet profile
- Maintenance Planning – Scheduled & unscheduled, hard life & MISSL
- Repair Process – Part failure (MTBF), FOD, secondary & subsidiary damage
- Modifications – Calendar-based, operating-hour based and opportunistic
- Optimized Logistic Support Analysis (LSA) resource requirements determination by location and time period, including spares, support equipment and manpower

SIM produces a "future history" of support activity in a detailed user-defined operating environment. By notionally operating each member of the fleet at each operating site according to operational plans, the model adds time and stress to every component of every system, according to individual duty cycles. These accumulated times lead to the need for both scheduled and unscheduled maintenance actions at specific locations on specific systems, involving serial-tracked individual parts. Based on the density of these maintenance events, the tear-down matrix and secondary and subsidiary damage anticipated, the model is then able to determine support resource demands generated at that time and place. Resource requirement output data are of detailed maintenance planning caliber for the short-run out to about 18 months[2]. Thereafter, life cycle or through life results are comparable to MAAP outputs based on non-serialized data. Note

[1] The requirement was originally established by the NATO Eurofighter and Tornado Management Agency (NETMA) to be implemented as the support modeling module of the Eurofighter EJ200 engine In-Service Support System (ISSS). The NETMA four nations' partners, Avio (Italy), ITP (Spain), MTU Aero Engines GmbH (Germany) and Rolls Royce, shared the ISSS development work with the modeling element falling to MTU.

[2] A consequence of using serial-tracked data, which provides used-time histograms for every part number population. Since these distributions lose fidelity the farther out they go, the enhanced accuracy of resource requirement prediction – extreme over the next few weeks – begins to diminish and lose significance at about 18 months. This is not crucial since the MRO shop planning horizon is usually within 18 months and long-lead time part orders are satisfactorily dependent upon mean population requirements.

that any time-bound changes in operation or support can be modeled with fidelity. This includes foreseen changes in configuration, deployment, fleet size, operating program and fleet, build-up and run-down. Sub-fleets can be included in the computations, as can modification campaigns. Once the resources required for a given modeling case are derived, SIM can optimize for operational availability and support investments enabling balance of investment decisions to be made trading between cost, time and fleet availability.

Who Should Use SIM?

The support of aero engines is highly complex and the cause-effect relationships of support decision options can only be rigorously evaluated through a robust model. Any organization that bears support risk associated with delivering engine, module or parts availability, or the business risks of providing the capacity for repair and overhaul, needs to be able to balance investment decisions that trade cost with delivery performance. Aero-engine original equipment manufacturers (OEMs), user fleet authorities, maintenance repair and overhaul (MRO) organizations need to be able to foresee the impact of strategic and tactical fleet support decisions on equipment availability and through-life support costs.

SIM provides a comprehensive modeling environment and scenario architecture that reflects all the typical triggers of support expenditure. It provides the capability to determine all the key support resources – spares, manpower, tools and facilities – required throughout an engine fleet's operating life. It allows testing of a wide range of operating, support, environmental, and reliability and maintainability (R&M) conditions to predict the impacts of change in any or all these conditions. This ability to understand the cause/effect relationship of changes in these conditions provides equipment procurement and support stakeholders with the insight necessary to make informed and auditable decisions.

As a generic modeling platform, SIM is designed for use with aero-engines or other systems that require individually serialized parts with declared finite installed lives. SIM's chief advantages over other maintenance planning approaches derives from its use of individual part histories, rather than having to assume that all members of a part number population have the same (mean) age. Accordingly, it is best used in combination with a continuous source of serial-tracked data and interface development is a crucial aspect of model implementation.

What is different about SIM?

SIM projects an engine fleet status and the associated support resource needs into the future with unprecedented fidelity. It takes account of projected operational commitments that may vary with time, to foresee maintenance requirements and resource demands with high precision. Since SIM is able to deal with the actual used-time distribution of a part-number population, forecasts of replacement requirements and even exposure to failure hazard are far more precise than planning algorithms limited to using population means. Since SIM is based on MAAP, it also contains the MAAP multi-resource marginal optimization capability, providing budget-quality cost forecasts and making crystal clear budget-cut trade-offs with fleet availability.

SIM Functional Capability

The number of factors driving the behavior of a fleet and its availability is very large. Some are inherent to the design of the system (e.g. reliability, maintenance plan) while others depend on environmental or operational factors (FOD rate, flying rate, mission profile). Many depend on the support organization (available resources, turnaround times and the like). Any tool used to model such complex reality must itself be complex, but this alone is not a guarantee of accuracy. As with all TFD analytical tools, the sound economic underpinning of SIM's algorithmic and cost content guarantee that a forecast savings will be a real savings and not just a notation in the financial records.

As with any analytical tool, a certain amount of rigor is also required in the structure and correctness of input data. SIM uses the TFD Data Vault® as its database layer. The database structure has been optimized for use with logistic analytical models and its input devices (both keyboard and import processes) are constructed to insure that common data errors are intercepted and either automatically corrected or logged for the user to correct at the first opportunity. The TFDdV is also common to all other TFD software applications – EDCAS, VMetric, TEMPO, MAAP and SCO. As a consequence, data generated for use in any of these applications is immediately available in SIM, or conversely.

Consider the support requirements of a new engine fleet. The technical behavior of new aircraft engines and their components is not predictable with certainty. Initial estimates are therefore required that will later be replaced by verified data. The goal of the system is to be able to predict, within given margins of uncertainty, the main aspects of operation and support, and how these aspects can be expected to interact with each other.

SIM addresses these issues by providing the following functions:

- Prediction of future fleet behavior, to be expressed in terms of operational availability, life usage, total arisings (failures), consequent maintenance burden and so on, when operational and logistical conditions are defined (including resources available or planned)
- Calculation of the resources necessary to achieve given levels of operational availability
- 'What if' analysis, including comparison of different scenarios and input assumptions to enable prediction of operating expenditure and optimization of resources

SIM provides appropriate outputs to enable cost-effective management of engine fleets and, where relevant, sub-fleets, entailing a mix of build standards deployed at bases with different operational roles, maintenance philosophies, capabilities and support arrangements. All have to be supported with resources to the required technical standards, in sufficient quantities, when required, without breaching economic constraints.

Modeling runs make projections into the future from snapshots of the fleet provided from the supporting management information system data source taking account of a large assortment of parameters related to logistical aspects and interactions between them. For example:

- **Fleet build up/run down**: such as delivery schedules, retirement from service, storage, aircraft attrition, deployments
- **Fleet operation and basing**: fleet hours and life usage by location
- **Reliability**: future engine, module and accessory arisings grouped by type
- **Environmental issues**: foreign object damage (FOD) rates by fleet and operating base
- **Maintenance**: elapsed times, resources used, manpower, spares
- **Fleet/engine configuration**: as built, as maintained, inspection life limits
- **Transportation**: times, locations, distances
- **Inventory/facilities**: demand rates, inventory levels asset pooling, all by item and location

The Development of SIM

SIM was developed directly from TFD's whole life cost modeling analytical platform tool MAAP. Because of their size and complexity, platforms like vehicles, ships and aircraft, and their major subsystems, inevitably have significant configuration differences even though they are members of the same fleets or even the same blocks. To cater for this, MAAP was built as a multi-system model allowing analysis of multiple system types in a single run while accounting for any commonality between them. This capability also allows multi-system or "system of systems" analytical excursions, mixing both system types and technologies in a single analytical excursion.

MAAP is able to model actual operating and support sites, rather than abstract support echelons. Each location or site can also be characterized by different deployment of systems, operating programs and operational availability targets. Moreover, the systems operating at these different locations, may themselves be characterized with different attributes such as demand rates, maintenance times and the like. Finally, maintenance capabilities at each location can be made to vary by changing maintenance event data to adjust NRTS or BCM rates[3] and enter repair delay times and other attributes. In short, there are few, if any, attributes of systems, maintenance capability or operational requirements that can change by location for which SIM is unable to take account.

MAAP and SIM are activity-based or process models. Cost estimates are generated by aggregating predicted resource requirements of all the events involved in deploying, operating and maintaining systems over the life cycle. This focus on identifiable cost-creating mechanisms and their effects distinguishes process models from parametric models which rely on historically derived cost-estimating relationships to produce broad cost estimates of uncertain validity and dubious relevance.

SIM Attributes and Capabilities

SIM's attributes and capabilities are many and complex. It is founded on Logistic Support Analysis principles and, like all TFD tools, is designed to provide decision makers with the essential information required to address classical logistic questions.

SIM accounts for all resource-consuming activities under varying assumptions about a system's usage. Cost and resource profiles can be generated system by system and time-slice by time-slice over the entire equipment program life or a portion of it. The result is an unsurpassed ability to assess the immediate and downstream cost impacts of proposed changes in operational activity, or the operational impacts of budgetary changes. SIM also provides visibility of the phased relationship between operating and support costs. The design allows separate modeling of costs incurred during a defined initial support period and then over the remainder of the life cycle to allow explicit separation of customary acquisition and support budgets.

SIM, and its parent tool MAAP, are the only true *resources-to-readiness* tools available today.

A notable strength of TFD's approach to accounting for costs over the life cycle is the flexible chart of accounts. SIM uses thousands of basic cost definitions. Costs can be attributed to individual end-items, groups or to the whole system. These "cost atoms" are combined, according to any set of accounting rules, into user-specified cost molecules. In this way virtually any cost breakdown structure can be replicated.

Systems are modeled as hierarchies of maintenance-significant elements with no limits on size or indenture. The analyst progresses from the lowest removable item up through sub-systems, equipments, systems, and finally fleets organized as squadrons or other operational aggregations. Cost elements and resource requirements are handled appropriately at each level of the hierarchy. All levels in the hierarchy are tied to each other with duty cycle information, allowing extremely accurate accounting of operating times for every component in every system.

Events and Event Networks

The main focus of the analytical software engine is the event. An event is any activity that leads to a requirement for, or the consumption of, resources. Every resource-significant component of a system can be idealized as a set of events such as operating events, maintenance events (both scheduled and unscheduled), training, transportation and upgrade events. The system amounts to a superset of all the events that its operation and support entails. Each event triggers requirements for resources: parts, manpower, facilities, tools, training, energy and data.

In the early stages of a system's life cycle, the detail of many events will be sketchy. However, it is usually straightforward to construct notional events to reflect whatever is known. For example, if a vendor claims particular values of system MTBF and maintenance man-hours per operating hour, this is enough, in combination with operating intentions, to establish a rough order of magnitude resource commitment and ownership cost profile. Moreover, early design efforts can be modeled at as high a level of abstraction is required – even though, at the other end of the spectrum, great detail leads to great accuracy in maintenance and operational planning.

[3] Not repairable this station (NRTS) or beyond capability of maintenance (BCM) rates: both mean the fraction of unserviceable items received by a shop that cannot be repaired there.

Component usage patterns follow from the system's intended operating profile in a straightforward manner and can therefore be transformed readily into a stream of events over the life cycle. By treating events in this way, SIM achieves accuracy, completeness and validity of total ownership cost estimates and realistically captures the time-phased relationships between system operation and resource demands.

By explicitly handling time as a modeling dimension, SIM captures the resource implications of dynamic deployment schedules that may be unique to each operational platform[4]. As a result, the effects of phased development, introduction and retirement of operational platforms, changing operational cycles and tempos are all reflected in the resources consumed and, hence, total ownership or through life cost. Costs are logged when they occur, not as an average over several time periods in the life cycle. Long lead times and similar phenomena are dealt with explicitly, by placing expenditures in the time stream at the place they would be incurred, even though the part purchased or trained person (in training) won't actually be employed for one or more time periods.

Operating phases cue the analytical engine to turn various subsystems on, off or to standby as appropriate. As the model walks through the sequence of operating events that define a system's life cycle, each subsystem and subsidiary component logs its own operating time. These lower-level clocks trip scheduled and unscheduled maintenance events as appropriate, embedded in the systems operating at each location. As a result, SIM knows both where and when each resulting maintenance demand will occur – and the consequent requirement for the resources consumed by each event. Since the resources have delay times associated with them, the model also knows when it must initiate procurement, training and transportation events to make sure a given resource is available at the place and time required.

To account correctly for the aggregation of costs and resources, SIM uses the concept, not dissimilar to a fault tree, of a maintenance event network (MEN) whereby an initial event such as a FOD damage event triggers a logical sequence of additional events. Governed by the tear-down matrix, the engine is inducted into maintenance and torn down. According to the example MEN shown in Figure 1, three modules must be removed from the engine and, with different frequencies, parts must be removed from the modules. The probabilities shown on the tear-down paths are a result of individual part hazard functions and tracked used-time and tear-down instructions associated the physical structure of the engine.

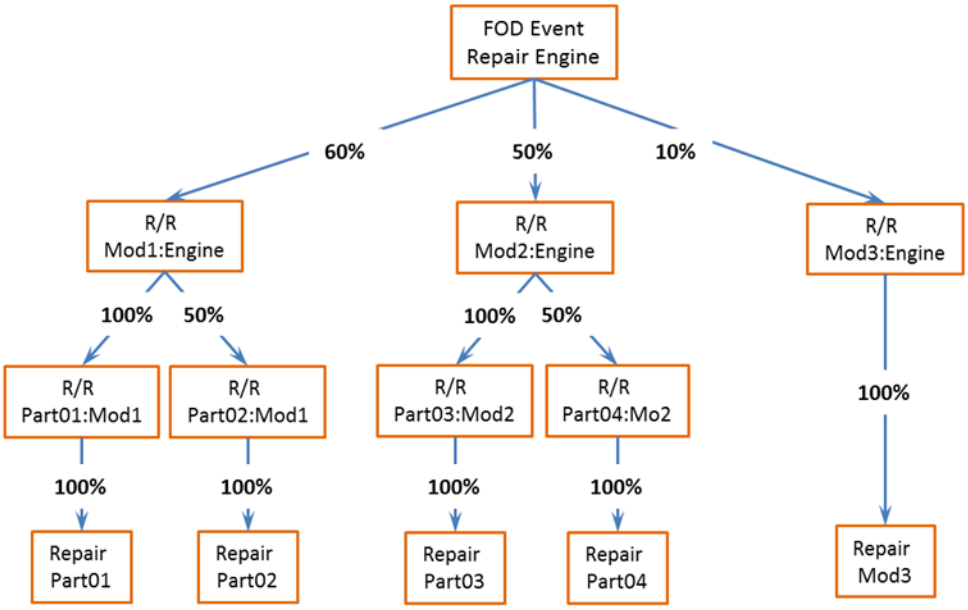

Figure 1: An Example of a Maintenance Event Network Resulting From FOD Damage

4 Conventional life cycle cost models tend to use time as a variable, making no real distinction between costs incurred in different time periods.

In this example, a single FOD event triggers logical maintenance activity paths for Modules 1, 2 and 3. After initial removal, Module 1 will require removal & repair on 60% of occasions; during its repair, Part 1 will be removed for repair, and then repaired, on 100% of occasions while Part 2 will be removed and repaired on 50% of occasions. However, if Module 3 is damaged, then both Module 1 and Module 2 must be removed, solely to gain access. This requirement is governed by the tear-down matrix. If both Module 1 and Module 3 are damaged, then only Module 2 is removed for access. SIM will not double count required effort even in the most complex circumstances.

MENs can be created 'drag and drop' graphically by the user. Events can be re-used many times (e.g., test, repair and test again) and MENs can be nested with the same or different definitions. Each event can consume resources of any type which users can define. This approach is a powerful and flexible methodology for creating the complex and numerous triggers and activities that draw upon maintenance resources.

Libraries

SIM provides great flexibility to model many operating and support environments. A user can create libraries of systems and environments containing any number of distinct operating and support units. Any number of system types can be assigned to an operating unit, and a separate operating scenario can be assigned to each system type. The operation of each system type at each operating unit can be modeled at any level of detail desired. For example, a training flight lasting one-hour might be modeled as a series of phases, each lasting, perhaps, a few minutes. Alternatively, a fleet's entire life cycle might be modeled much more coarsely as a sequence of flying patterns, measured in days, weeks or months. The TFD Database holds information about these resources in Resource Libraries which can grow without limit. Library resources are readily tagged to the stream of events to create a resource stream that extends over the life cycle.

Outputs and Reports

SIM's primary output is to the Chart of Accounts which enables onwards population of a series of data tables. Model outputs are obtained by interrogating the resource stream and the input data with particular aims in mind. Different kinds of decisions, or different decision criteria, give rise to different reporting requirements. There is no limit to the variety and richness of the reports. SIM can generate a variety of standard reports addressing system availability, maintenance planning, parts life distribution, support and test equipment, initial and replenishment spares, procurement schedules, manpower and training, and facilities requirements. However, because the capabilities and uses of the tool are many and varied, and users may wish decision support information to be presented in various ways, TFD will work with customers to determine the precise graphic and tabular outputs needed to best deliver the information desired.

Multi-Resource Optimization

Resource optimization is a key capability. Program success boils down to coaxing a satisfactory level of performance from a system at an affordable cost over its useful life. This entails, among other things, identification and quantification of:

- Resources consumed in operations and support activities; and
- Investments in stocks of the resources, over and above consumption, required to meet performance goals.

The consumption aspect is straightforward. The activity analysis process derives the pattern of resource consumption from the pattern of operating and maintenance events expected to occur at particular times in particular places. If an event takes place, the consumable resources assigned are deemed to be consumed. Those resources include recurring cost components such as parts, labor, tools (support equipment), facilities and energy and non-recurring components such as training courses, software and documentation.

However, the required capital investment is a function not only of the pattern of events but also of a performance objective expressed as the required target Operational Availability (A_o). Any change in the pattern of events, changes the A_o target and the resource requirements. For many years the attendant resource to readiness problem defied analysis. Although it was possible to verify the performance potential of proposed multi-resource solutions using simulation, there was no coherent method for generating such solutions in the first place. Optimization was available only in the case of spare parts considered in isolation.

SIM embodies the MAAP Budget Optimized System Support (mBOSS) to generate optimal multi-resource support solutions. These are time-slice by time-slice curves of A_o versus Cost similar to spares optimization tools except that the resource selections represented by the points on the curves encompass not only parts but also tools and skilled manpower. Accordingly, the set of resources that can least harmfully be done without is identified simply by retracing the optimal sequence of resource additions.

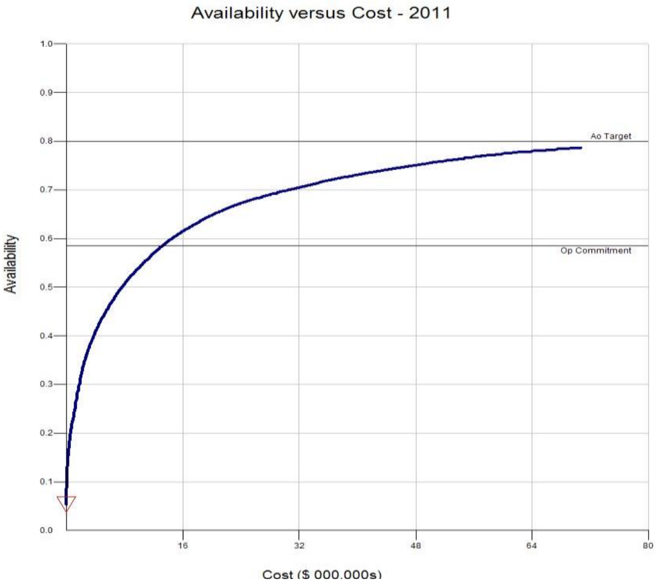

Figure 2: A_o vs. Investment Cost

mBOSS works its way through the resource list estimating the delay time associated with each permissible number of each resource. Once this has been done, the list of resource investment opportunities can be sorted in descending order of the delay time avoided per unit of cost. It is also possible to calculate an A_o value associated with each resource increment in the ordered list and, from this, derive a graph of A_o versus resource cost similar to that shown in Figure 2. Every point on this graph represents the least cost resource solution for the performance achieved.

Age-Related Reliability Effects

SIM possesses the ability to propagate discrete events in time and space. However, to meet the specific needs of aero-engine systems with serialized parts SIM is able to incorporate alternative age-to-failure distribution functions chosen from Weibull, Normal, Gamma, Lognormal or Exponential. All the analyst has to do is nominate the age-to-failure distribution and provide two parameter values to characterize it.

Assume a scenario where the age to failure of a part expressed in operating hours or cycles as appropriate is Weibull-distributed with a shape parameter of 10 and a mass parameter of 1,500, which implies a mean age to failure of about 1,400 age-units. The initial age profile, which is provided by a snapshot from the asset management system, includes about 40% of items nearing the mean age to failure. The graph below shows the predicted failures in each time-slice.

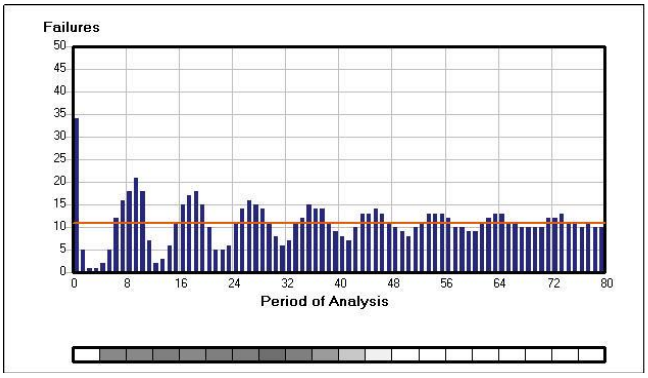

Figure 3: Predicted Failure by Time

The early pronounced peaks and troughs arise as components fail but the overall rate levels out as they are repaired or reconditioned to zero-life and re-enter the pool. These initial variances, which could take many years to smooth depending on the failure and usage rates, have resource implications that would not be seen in a more simple, but typical, assumption of the nearly constant hazard rate that eventually emerges.

An analyst could enter a different event frequency for each time-slice, having taken the trouble to apply the applicable age-to-failure distribution to successive age profile snapshots obtained externally. However, the manual effort tends to cause error and so SIM automates the task of calculating the expected number of failures in each time-slice by multiplying the age distribution profile by the profile of hazard values in each age bracket. This approach enables SIM to handle changes in the hazard rates over time as the age profile of a population of components evolves or the proportion of modified components increases. The hazard function can also change according to the number of repairs the item has undergone.

Life Distribution and Minimum Issue Life (MISSL)

The distribution of used life (time since new) for each part can be tracked and updated throughout the model to calculate future life distributions of the fleet. This can, in turn, be used to define the additional replacement activity during engine repair for parts that do not meet their specific MISL requirement. As MISSL policy is critical to the efficiency of fleet management, users can explore different values to observe the impact on fleet-wide support characteristics and costs as shown in Figure 4.

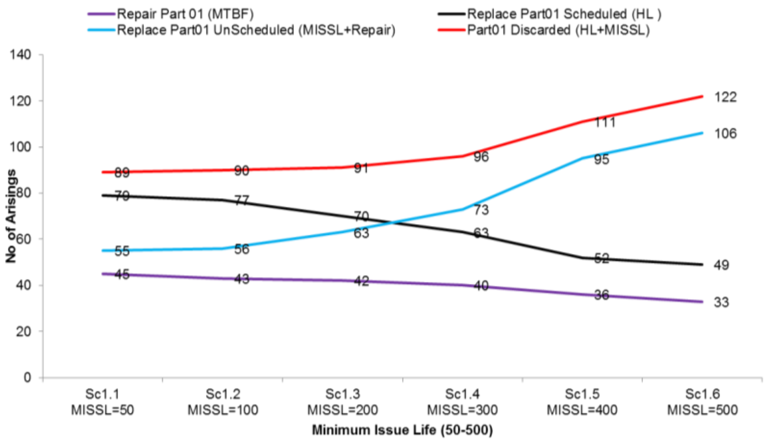

Figure 4: Trend as Minimum Issue Life

The light blue line indicates the replacement rate of a life limited part for varying MISSL. As MISSL is increased, more remaining life must be available on the installed part and, as a result, the arising rate increases. As SIM discards any part that reaches the end of its life – either a hard life limit or because the MISSL prevents use of its remaining life – the red line shows the increasing replacement rate. Similarly, the black line shows that, as MISSL increases, fewer parts will reach their full Hard Life.

However, because increasing MISSL implies that younger parts are used and these are less likely to fail, the overall effect shown by the purple line is fewer overall rejections. This improvement, of course, can only be purchased at an increase cost of parts.

Using this type of analysis, the fleet manager can explore the impacts on arisings and, therefore, on operations and costs by varying MISSLs. While the interrelationships and their impacts may be easy, in principle, to comprehend for simple engines in small fleets, they are almost impossible to understand intuitively for large fleets of engines, each with hundreds of life limited parts, differing configurations and different operating environment. SIM provides the capability to explore MISSL policy options with substantial confidence in the outcomes.

Modification and Upgrade

SIM supports major system enhancements, modifications and upgrades. Events are triggered either as scheduled tasks based on calendar, flying hours or an opportunity basis as engines are removed for another reason. This powerful feature makes it straightforward for the analyst to evaluate the rate of upgrade embodiment and value of the return on investment. By modeling varying embodiment policies, with their associated performance improvements, it is possible to derive break-even and ROI information from which business cases can be constructed. For a simple example of a modification embodiment campaign conducted purely on an opportunity basis, the annual cost is shown in Figure 5.

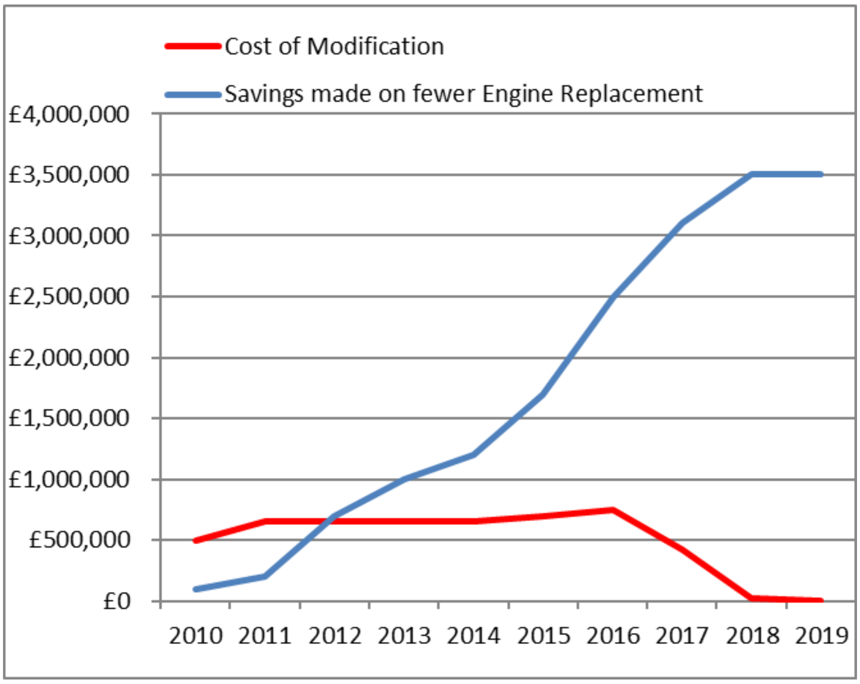

Figure 5: Modification Costs and Savings Over Time

A part is being replaced with a new, more reliable part, but at an investment cost including both the cost of the new part and that of the replacement work. The red line indicates the annual cost of the embodiment Event which quickly ramps up to a nearly steady state until, by 2018, the embodiment is nearly complete. The blue line shows the annual saving created by the reduced engine removal rate of the new, more reliable post-mod part. The break-even point occurs in 2012, after which there is a valuable saving. Although not shown, there is also operational benefit from reduced engine rejections.

SIM Installation, Interfaces and Licensing

SIM is Windows-based and possesses all the familiar features such as cut, copy, paste, drag and drop. There is an installation Wizard and the software is designed to run on standalone medium-specification PCs and laptops and on networks. Full details of minimum hardware standards, licensing and Technical Support are available on request.

Ideally, a SIM installation would use advanced interfaces that include data error reporting, reduce the workload and improve the consistency and quality of data for the model. Where acknowledged data standards (e.g. LSA) are implemented, standard data transfer generic approaches can be adopted, although all input data must be processed through TFD data verification software to insure accuracy. Modeling activity can be conducted without interfacing albeit at the cost of increased manual effort which, for large and complex fleets, may be prohibitive. TFD has the knowledge and experience to devise and implement an appropriate compromise between cost, manual effort and data integrity. Ultimately, the quality of model outputs is dependent upon the data rather than the method of inputting the data.

TFD can provide flexible end-user licensing ranging from straight purchase, to lease and time-based options. We also offer a complete data management, modeling and analysis service delivered by a team of experienced analysts.

Summary of Benefits

SIM provides decision makers with the following benefits:

- **Through Life Management Planning**

  Linking together all the assets, support elements, events, constraints and resources to deliver a comprehensive ‘future history’ of a given operational scenario.

- **Operational and Maintenance Planning**

  Using live or historical data from a 'fleet snapshot', projected in time according to user-defined rules, SIM can forecast future optimized resource needs to enable budget forecast and intelligent negotiation based on trade-offs between resource cost and fleet availability. This 'true' used life distribution gives extremely accurate assessment of maintenance resource requirements out to about 18 months. Thereafter, model results have the same predictive accuracy as MAAP runs.

- **Total Asset Visibility**

  ERP systems often claim to offer total asset visibility. However, users must use the embedded viewing options which are probably more suited to asset managers than logistics support decision makers. SIM's comprehensive user interface (UI) equips modelers with instant visibility of fleet disposition and condition in a style suited to logistics analysis, operations and support management planning.

- **Inventory Planning and Multi-Resource Optimization**

  The cost impact of procurement and support decisions can be tested by 'what if' modeling and analysis using SIM. Unlike single-item modeling options typically available in ERP systems, the multi-resource optimization algorithms of SIM insure that fleet inventory expenditures are minimum for any given A_o target. SIM optimizes all resources (spares, skills, support equipment and facilities) in exactly the same way. As a consequence, support managers have a powerful and comprehensive basis for support planning that includes the ability to trade-off support approaches based on different resource combinations.

- **Modification Change Management**

  Judging how to price upgrades to customers and how to manage embodiment across fleets and sub-fleets has always been a challenge. SIM's ability to calculate both the cost and the performance impact gives fleet managers the ability to derive strategies for managing the complexities of the changes that such upgrades inevitable prompt. In addition, SIM is the ideal tool to help crystallize business cases and pricing proposals for modifications, identifying spend profiles and likely rates of return on investment.

- **Proposal Preparation and Supplier Tender Analysis**

  Commercial managers can develop investment appraisals, internals and customer proposals while suppliers' bids can be evaluated by modeling the impact of their terms through SIM 'what if' models. Through the insight provided by SIM outputs, fair judgments and auditable business decisions can be made with reduced operational and commercial risk.

- **Exhaustive Resource Analysis and Reporting**

  SIM contains a comprehensive suite of reports, for each model scenario and its associated assumptions, the requirement for parts, support equipment, skills and facilities, pre or post optimization, across a time period ranging from 3 months to decades. Reports are designed to be used by logistics support analysts and managers, not accountants.

For More Information

If SIM sounds like it might meet your requirements and you would like more information or a demonstration, please contact us. We can provide Webex briefings, slide packs and evaluation software, as well as schedule a site visit to meet you and your staff for more detailed discussions.