



DETAILED OVERVIEW

The Spares Optimization System (S.O.S.) was originally developed by and for BHP Australia for its own use.

S.O.S. provides a scientific means for addressing and optimizing spare parts stock holding levels.

S.O.S. assesses the criticality rating of each item from both a maintenance engineering and an application point of view. The criticality of the spare to the overall business is then used as the major criterion to set safe minimum levels for stock holding policy.

Economic considerations are used to recommend the maximum level.

S.O.S. is primarily aimed at slow moving items, however it is also applicable to fast moving spares.

Knowledge of complex statistical analysis or detailed information on plant performance and failure characteristics are not required as **S.O.S.** is specifically designed to be fast and easy to use. While **S.O.S.** readily assesses slow moving stock items, it also identifies reductions in the quantity of new or replenishment stock items. **S.O.S.** is designed to be complementary to, not a replacement for, existing Computerized Maintenance Systems.

S.O.S. assesses the spare parts required to support the maintenance plan. Each item is processed and its criticality is used to set the minimum safety level, while economics set the order quantity or maximum level. While significant overall spares inventory investment savings are produced, this optimization of the mix of spares will actually improve the reliability of the plant.

S.O.S. assesses slow moving stock at reorder point. Often no changes are necessary to the existing stock control levels, however **S.O.S.** may recommend changes to maximum or minimum stock holding levels and reorder points. Immediate cost savings result from the reduction in quantities purchased.

The risk of stockout of critical maintenance spare parts is minimized through justifiably holding increased critical items. A benefit here is reduced conflict between the engineering and supply management departments.

S.O.S. also incorporates a Cost/Risk facility which analyses the stockout cost risks involved in not holding a spare against the purchase and holding cost of the spare itself. This provides additional information to enable a business decision to be made as to whether the spare should be held or not.

Industry averages indicate that 20% of maintenance inventory is fast moving and optimized well by traditional inventory management algorithms. These algorithms have a tendency to neglect the remaining 80% which contribute most to over or under stocking and increased holding costs.

S.O.S. quickly assesses the cost of holding stock against the consequences of running out of stock. The results are presented in an easy to read graphical form to assist decisions on high cost or contentious items.

Implementation includes tailoring to meet industry and site specific requirements; training, and consulting on their incorporation into existing operational procedures. This ensures decision making is continually improved.

S.O.S. is a stand-alone, network compatible, 'expert' advisory application. It is currently being used to optimize the operation of various commercial Maintenance and Supply Management Systems. As such, it is totally complementary to these systems.

S.O.S. improves the overall efficiency of an organization which leads to lower operating costs

S.O.S.:

- Identifies items where stock levels are shown to be excessive so these items can be listed for disposal
- Releases working capital from being tied up in over-stocked items
- Reduces the number of items held in the warehouse which results in better storekeeping and improved access to remaining stock.
- Reduces purchase/stores activity levels
- Reduces employee stress by providing a mechanism for assisting decision making and for setting stock policy for critical plant spares

S.O.S. works by asking a series of carefully worded questions in order to extract from the assessor, knowledge required to set max/min levels or in fact, whether to hold a spare at all.

The questions are focussed to apply weighting and consideration to criticality, failure pattern, history, usage, cost, risk, probability, lead time, common parts, duty, predictability, downtime, where used, source, alternative sources, planned use and other factors. The information derived is then mathematically assessed to provide a recommended holding level.

S.O.S. has a number of features built in to the recommended stock-level calculations and these are explained as follows:

Firstly, all **S.O.S.** calculations for suggested stock levels are based on multiples of issue sets - if for example, a particular spare is always used in multiples of 4 (eg. spark plugs on an 4-cylinder auto engine), then every Max/Min/Safety Stock and Order Quantity value will be calculated as a multiple of 4.

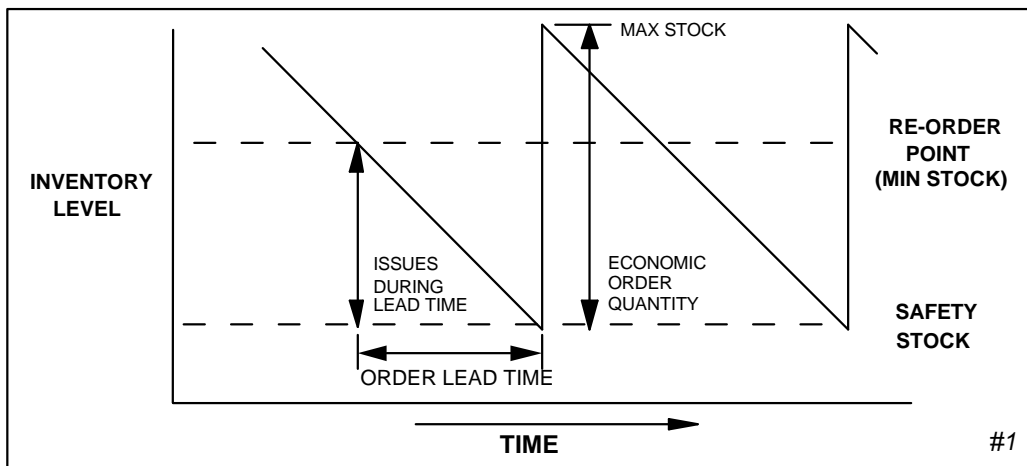
When **S.O.S.** calculates a recommended order quantity for a high usage, uniform demand item, it uses the standard formula for Economic Order Quantity (EOQ) which can be found in most inventory management text books, but incorporates a number of improvements to these formulae. In **S.O.S.**, the cost of raising a purchase order is automatically varied to allow for the difference in procedures and authorization levels between raising an order for low cost common items such as welding rods or pump seals, and raising a purchase contract for the supply of high cost major spares where a higher level of tendering, supplier evaluation and engineering inspection activity will take place.

When **S.O.S.** recommends that spares be kept in stock, it also recommends Max/Min stock levels.

The intent here is that the MINIMUM level is also the RE-ORDER POINT, and when that minimum level is reached, an order should be placed for the replenishment of stocks up to the Maximum level - ie: the *RECOMMENDED ORDER QUANTITY is the difference between the Minimum and Maximum stock levels.*

Where an Economic Order Quantity (EOQ) is calculated for fast moving/uniform demand items, that EOQ will be corrected upwards to equal the difference between Minimum and Maximum stock levels (ie: Recommended Order Quantity) if the rate of stock consumption during the replenishment lead time is greater than the economic order quantity (EOQ). Otherwise for these items, the Recommended Order Quantity is equal to the Economic Order Quantity.

This means that all spares stock levels can be controlled in the same, simple way. Under these MAX/MIN calculations where a re-order point is given, the following inventory level profile is established:



Under these conditions, the MINIMUM stock level is effectively the average stock level over time and the MAXIMUM stock level will never be achieved unless there are zero issues during the order lead time.

When calculating recommended stock levels, **S.O.S.** also takes a look at how many of the items are actually installed on the plant(s). If the number installed is large but the demand is low, then **S.O.S.** displays an extra note on the stock recommendation screen to suggest an appropriately inflated safety stock in case multiple failures occur , eg. cascade damage to conveyor idlers.

Similarly, **S.O.S.** will highlight other important information relating to the item which you may wish to take into account when setting the stock level figures. If, for example, the spare is likely to go out of manufacture whilst still in use, then it may be desirable to increase the order quantity above the recommended **S.O.S.** figure. Conversely, if the item has a limited shelf or technologically restricted life, then a lesser quantity may be appropriate.

When using **S.O.S.**, it is sensible to separate the assessment of spares stock-holding requirements for planned shutdowns and overhauls from the assessment of stock-holding requirements for general risk of failure. Replacement parts required for fitting during a planned shutdown can usually be purchased on an 'As Required' basis and **S.O.S.** will often recommend zero stock levels in this case, whereas in the case of unexpected failure, **S.O.S.** will probably recommend a nominal safety stock be kept on hand at all times. The level of this safety stock will often be very much less than the number of parts required for planned overhaul.

Alternative Items - If existing minimum stock levels are below the recommended **S.O.S.** figures, then a requirement to purchase exists. In this case, **S.O.S.** will ask you whether there are alternative items in stock which fit the particular duty. If an alternative exists, then the review is re-commenced using the combined stock quantities to establish whether there is still a need to purchase any items and, if so, to adjust the recommended order quantity accordingly.

Surplus Items - Similarly if the existing 'stock-on-hand' is significantly greater than the **S.O.S.** recommended maximum stock level, then **S.O.S.** will recommend steps be taken to dispose of or run-down that surplus.

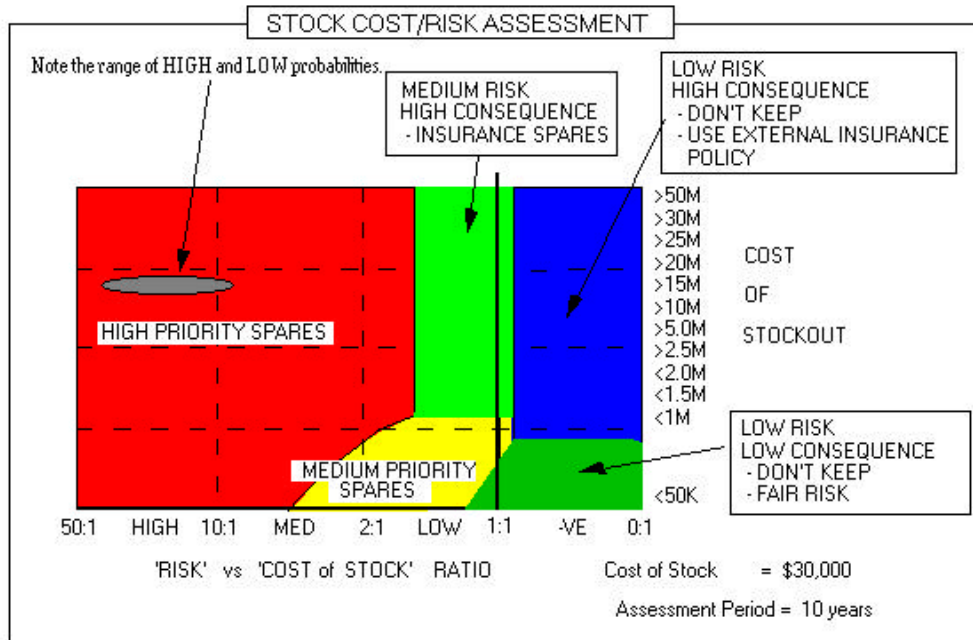
Using S.O.S. to Assess Stockholding Cost/Risk Factors

S.O.S. features a stock cost/risk assessment facility that will assist in the determination of the relationship between the costs that are likely to be incurred in the event of a plant failure when no spare is held (STOCKOUT COST) in comparison to the cost of stocking the spare (COST OF STOCK) and the cost value of the risk of failure applied to the Stockout cost (Risk).

The cost of stockout is calculated by **S.O.S.** from the item lead time, penalty cost if required to procure the spare on an urgent basis, production capacity loss and other details relating to the category of the spare and repair duration and temporary repair cost and effectiveness. Against this cost an estimate of the probability of unexpected service failure can be made based on acquired knowledge and experience of the failure pattern of the particular item.

By entering estimates for HIGH and LOW probabilities of unexpected failure, **S.O.S.** will plot the risk cost/stock cost ratio against cost of stockout.

Typical Cost/Risk assessment result is as follows:



The interpretation of this chart is simply to observe into which area of the chart the plot falls. The chart is divided into five general areas as shown;

- **Low Risk & Low Consequence (Cost of Stock outweighs Cost of Risk)**

In this case the company will normally accept the risk of not carrying the stock.

- **Low Risk & High Consequence**

If spares are expensive, then in this case, it is better for the company to have an external insurance cover against the probability of failure.

- **Medium Risk & High Consequence**

As above, but the risk of failure is sufficiently high to prohibit outside insurance cover - so the company must invest in its own Insurance Spares.

- **Medium Risk and Low Consequence**

Although the consequence is low the risk of failure is in the medium range - the company would normally stock spares in this category.

- **High Risk**

Cost of risk outweighs cost of stock - company must keep spares.

Depending on the level of certainty, the probability estimates can be narrowed or widened accordingly. Alternatively, the process can be re-cycled with different values, either for the

probability estimates themselves or to change other details, to determine what effect the individual changes have made to the overall analysis.

This analysis is particularly useful for high value slow moving stocks such as insurance spares in which case information needs to be available to weigh up the possible risks and consequences of not holding a spare against the immediate saving in cost that can be achieved by not proceeding with the purchase.

S.O.S. provides printed reports which sort these items by Risk, Cost of Stockout or overall Risk/Consequence rating - so that investment in high cost spares can be prioritized.

Other information resident within the **S.O.S.** files can be reported on using Microsoft Access reporting facilities. There is no limit to this type of ad-hoc reporting.

ASSESSMENT OF NEW SPARES

S.O.S. is a unique tool which allows Supply Management to set initial spares stock levels, even for new items for which there is no history, electronic or otherwise.

Each time a requisition to purchase maintenance spares is raised, **S.O.S.** can be used to check that the existing Max/Min stock levels are correct, or it can be used to set initial Max/Min levels for new items coming into stock for the first time.

There is no need to have a valid catalogue number for a new item before assessing the stock-holding requirements using **S.O.S.** **S.O.S.** can be used to decide whether to hold the item in stock or not, then raise a new catalogue number only if necessary.

In companies where there are a large number of spares stock purchases, it may not be feasible to use **S.O.S.** on every item. In these cases it is normal to set an agreed cost limit so that, for example, only those items costing more than say \$100 each (or where the total stock value exceeds \$500) are assessed.

The person who initiates the spares purchase requisition should normally be responsible for answering the **S.O.S.** questions - as that person should have a clear knowledge of what the spare is and what it is required for. The results of the **S.O.S.** assessment should be printed out and the **S.O.S.** assessment report appended to the purchase requisition so that the supply officer can set the correct Max/Min levels in the supply management system.

Because **S.O.S.** relies on the knowledge of the intended use of the spare by its requisitioner, there is no requirement for history information. Obviously, it would not exist.

The knowledge based **S.O.S.** question set will address each and every aspect of the need to hold or alternatives to holding a particular spare. It will then recommend a certain max/min level. No other methodology is capable of this form of assessment.

Assessors may well disagree with one or more answers to various questions but it is our users' experience that no one or two questions where debate has occurred, will influence dramatically the final **S.O.S.** recommendation.

At New Zealand Aluminium Smelters, **S.O.S.** was used to reduce manufacturers' recommended spares value for a new potline from \$1.2 million to less than \$600,000. Full warranty was retained and the savings were immediately realized.

ASSESSMENT OF SLOW MOVING SPARES

S.O.S. can be used to review existing spares stock levels to establish by how much those stocks can be reduced. In reviewing slow moving items, the age and condition and future demand for the item is considered by the system, whereas for a new/change item you need only to consider future demands.

S.O.S. frequently identifies critical spares which require an increase in existing stock levels. Users might agree with these recommended stock increases but choose not to accept them because - "we have lived with this risk for some years now - so why change". There is a requirement however, to state why the assessor did not accept the **S.O.S.** recommendation.

When reviewing existing stock levels, it is sensible to produce listings of items which have a high unit value and multiple units in stock - as these will probably offer the most likely chance of inventory reduction. It is easy to dispose of four items out a stock of ten, but more difficult to dispose of a single item if it is the only one there - unless it is definitely redundant or in very poor condition.

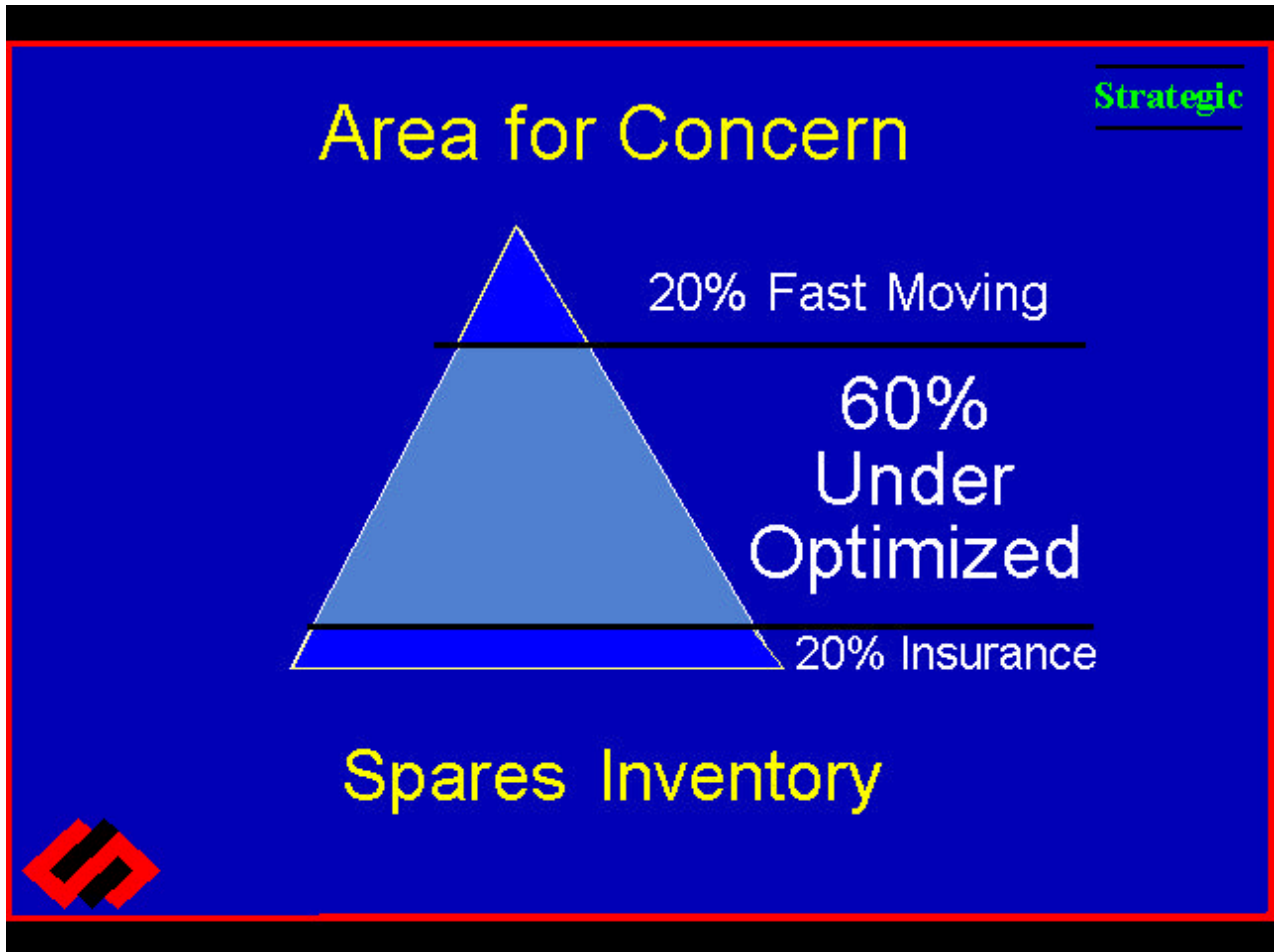
A number of people can work simultaneously in reviewing slow-moving stock lists, either by working with printed listings or more easily, by providing files of data downloaded directly from the CMMS system into a **S.O.S.** data file, so that the information on each item can be reviewed in **S.O.S.** without re-keying the data.

The existing CMMS system will be able to produce a listing (or file) of slow moving items for purposes of assessment using **S.O.S.**.

MEDIUM AND FAST MOVING SPARES

S.O.S. can be used to assess holding requirements for all spares types, slow medium or fast.

Most computerized maintenance management systems are more than capable of assessing correct max/min levels for fast moving items. Existing algorithms cater for fast moving items based on well documented history. Unfortunately, of the 100% of spares holdings, only 20% can usually be described as fast moving. This means that the remaining 80% (including 'insurance' spares) are not being assessed by the maintenance management system in an optimal way.



A typical spares holding

If we look at a typical spare parts inventory we find that 20% of the items provide 80% of the throughput. These items are usually optimized by making use of current supply management techniques.

Such techniques include algorithms to calculate Recommended Order Points and Economic Order Quantities (ROP/EOQ); Exponentially Smoothed and Double Exponentially Smoothed supply; etc. All of these methods have one factor in common, they each require the items to move fast enough to generate sufficient movements history for the algorithms.

However, the 80/20 rule also works the other way. That is, 80% of the inventory is not fast moving and therefore cannot be optimized by conventional supply management methods.

It could be argued that most organizations have a good idea of their non-moving insurance spare requirements, having spent some time evaluating these. The percentage of such items varies considerably from industry to industry.

In any case, the considerable majority of items are currently not well managed from the point of view of setting appropriate levels. For this reason there is always much room for improvement.

S.O.S. has been developed to handle the extremes of fast moving through to non-moving. The first so as to cater for new items coming into stock, the last to decrease the time and effort required to analyze and decide on whether to stock or not.

ASSESSMENT OF ITEMS USED IN ONE AREA

Some groups of items to be assessed will be used in the same area of the plant. These spares will be subject to similar service conditions. If it is known that the item/s being reviewed are all used in a particular area of plant then these items should be grouped by utilizing the same Plant/Equip number fields on the **S.O.S.** data input screen. By doing this unnecessary repetition of questions relating to the Plant/Area will be avoided.

When adding new items, the Plant and Equipment numbers can be set as a default and then reset as appropriate when moving to another area. Any Plant/Equipment number can be deleted along with the stock items attached to it.

If there is any thought that the profile of answers for a particular area is not appropriate and a change is made, **S.O.S.**, will give you a warning that other items under the same Plant/Equipment number may be affected. These should be checked to see if any changes in recommended quantities have resulted.

ASSESSMENT OF ITEMS USED IN MORE THAN ONE AREA

Some spares to be assessed will be used in different areas of the plant or across different sites. These spares may also be subject to different service conditions and may or may not have the same Catalogue Number. If it is known that the item under review in one area is also used in other plant areas, then this can be 'flagged' on the **S.O.S.** data input screen to alert stores personnel to the potential for stock rationalization.

In view of the fact that assessors (eg foreman, supervisors etc) from different plant areas may be undertaking an assessment of the same item, it is necessary for a consistent approach be adopted to the answering of **S.O.S.** questions in order to ensure that the most appropriate stock holding figure is obtained.

If the item concerned is used in more than one application in the assessor's plant area, then for **S.O.S.** purposes, the item should be assessed using information related to the most critical application.

If there is any thought that the stock figures recommended by **S.O.S.** are not appropriate (ie. figures biased towards the most critical application) then it is a simple matter to re-assess the item by changing the answers to one or two of the relevant questions to represent a more average situation for the range of applications or duties concerned, and noting the reason in the comment field.

By quickly re-assessing the item in this manner it can be determined how sensitive the **S.O.S.** recommendation is to the changed answers - in most instances there will be very little, if any, difference in the figures recommended.

If there are different stock numbers used to identify the same or similar items used for different plant applications, then a comment should be made to alert Stores personnel to the situation and allow them to take action to have all the items held under a common catalogue number , ie. parts rationalization.

Where it is known that the same item is used outside the current plant area and control, then this information can be flagged on the **S.O.S.** data input screen. This will alert stores personnel to the possibilities for stock rationalization. Where separate item assessments have been carried out for each area, the individual **S.O.S.** figures should be used as the starting point for making a determination of a composite figure to cover all locations.

BENEFITS AND SAVINGS FROM THE USE OF S.O.S.

S.O.S. has been implemented in over 800 sites and the results achieved follow a similar pattern in most cases. Some extraordinary savings have been achieved.

A typical **S.O.S.** implementation will achieve recommended inventory reductions of 15-25%. This is the net result after a procedure which normally flows as follows:

Of the items assessed using **S.O.S.**, around 50% are found to be set at reasonable control levels. Of the remaining 50%, three quarters of those parts are recommended for reduction in holdings, while the final quarter is subject to recommended increase on a cost/risk basis.

So another critical benefit from the use of **S.O.S.** is in the **optimizing** of spares holdings, for a better mix of spares balancing business cost/risk against the cost of holding stock. **S.O.S.** will always recommend increased holdings where the absence of a part can cause damage to the business and it will make this assessment in a scientific, auditable and repeatable manner.

One of the extraordinary results came from BHP Steel itself. At the Pt Kembla facility in 1989, there was \$120 million worth of spare parts, growing by 10% per year. At that time, BHP believed that it had every maintenance management tool available to it. **S.O.S.** was implemented and after the first twelve months, the growth was stopped. By early 1995, the value of spares at Pt Kembla had fallen to \$56 million. It now stands at under \$50 million.

At New Zealand Aluminium Smelters (NZAS - a part of Rio Tinto), used **S.O.S.** to reduce the immediate cost of one set of spares for a new pot line by over 50%, from \$ 1.7 million to less than \$ 700,000.

In North America, Texas Utilities, PacifiCorp, Colorado Utilities, Arizona Utilities, GPU Nuclear, Tampa Electric, Florida Power, New York Power, Detroit Edison, New York Power and Southern California Edison have all acquired this Australian developed methodology.

Of these, Detroit Edison attribute reductions to the value of \$US 9.5million directly to the influence of S.O.S, while Texas Utilities have presented the benefits of S.O.S to other US power generation authorities under the auspices of EPRI. PacifiCorp in Salt Lake City attribute \$US14million in savings in one twelve month period to S.O.S.

Tennessee Valley Authority used SOS as the focal point for a five year project to reduce spares levels by \$US100 million. At the end of year four, total reductions exceeded \$US94 million.

At Hydro Quebec, SOS was applied to manufacturers spares lists of \$C2.4million. An immediate benefit of \$C750,000 was achieved through the SOS assessment of true need for spare items.

The benefits available from **S.O.S.** are demonstrable even during a trial implementation of a few days. Many current **S.O.S.** users acquired a licence immediately after seeing **S.O.S.** deliver savings into the hundreds of thousands of dollars, even during the initial trial.

Spares Optimization System - S.O.S.

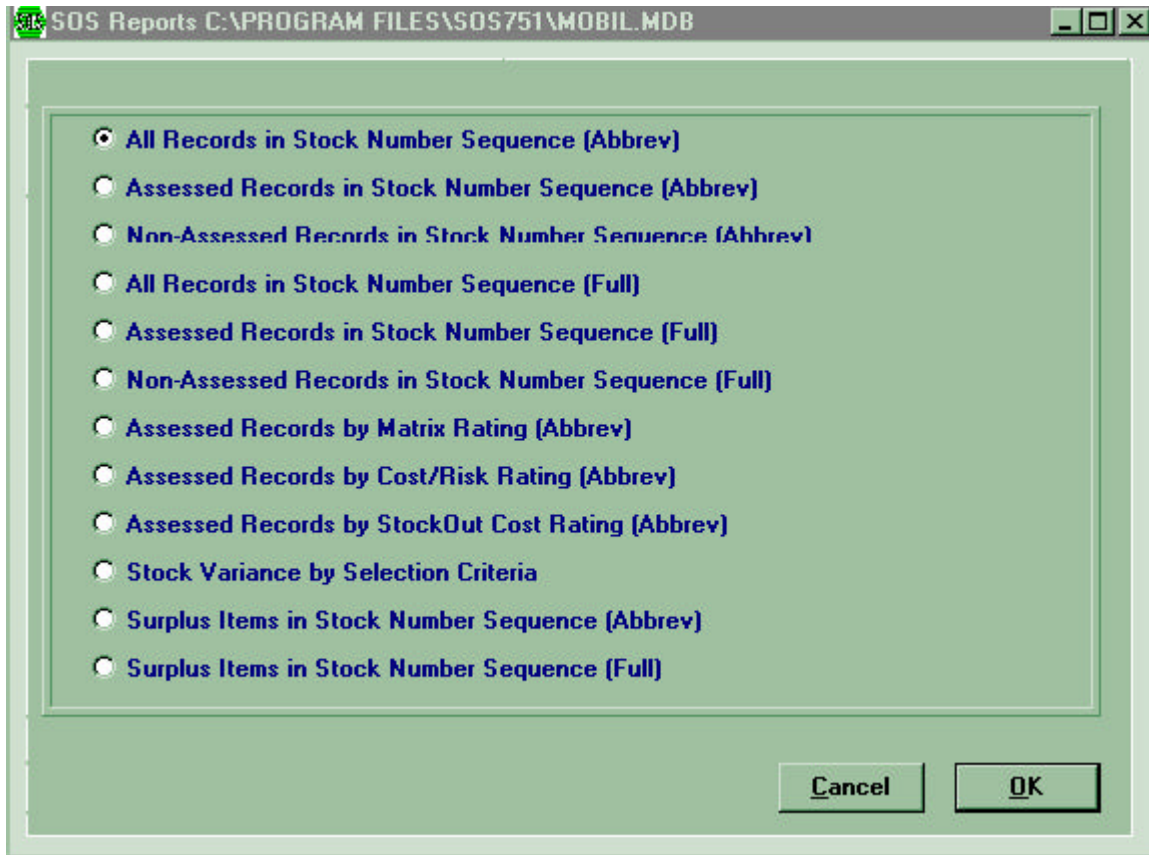
Even when we are presenting **S.O.S.** to clients, we often use it to assess current replenishments while we are on site. This type of assessment invariably achieves immediate and tangible savings.

Similarly during trials, clients are often surprised when S.O.S. recommends an increase in a particular holding. In every case though, the logic has proven irrefutable and the clients are even more satisfied that S.O.S. is providing an optimizing service, not a 'slash and burn' approach.

Over all the time that **S.O.S.** has been used in the field, no item in any client site, has suffered a stockout where the item's control levels have been set by **S.O.S.**

REPORTS AVAILABLE WITHIN S.O.S.

S.O.S. incorporates a number of set reports as follows:



Because the S.O.S. files are all stored in Microsoft Access tables, there is no limitation on the number or content of additional reports relating to spare parts which have been assessed.

TRAINING ON S.O.S. AND SKILLS REQUIRED

S.O.S. is an expert system, designed and developed by maintenance engineers for maintenance engineers. Its ability to perform revolves around the principle of extracting knowledge resident in your personnel, in order to scientifically calculate optimal spares holdings.

In general, S.O.S. is simple to operate. We are able to fully train client personnel in one or two days so that they are able to proceed unassisted.

S.O.S. operates using a series of carefully worded questions, each of which is designed to extract a piece of information about a part or parts, which will allow S.O.S. to apply its internal mathematics to establish optimal levels.

Our experience is that client personnel, after the training period, are able to process significant quantities of spares very quickly. Familiarity with the question sets facilitates faster processing and assessors are found to accelerate their processing as time goes on. One reason for this is that assessors find that in the long term, they do not spend time debating the 'correct' answer to one or two questions which might be contentious, as they find that the end recommended optimum holding levels are rarely affected by the answers to those contentious questions.

The confidence of assessors in the recommendations of S.O.S. increase as they proceed through the holdings, to the extent that large numbers of items can be processed at each session. Further, S.O.S. allows for similar items to 'bring forward' responses already given, so that operators do not have to repeat processing which applies to those items.

Number of people appropriate to train:

This is very much dependent upon the client's exact requirements in terms of personnel availability and eventual planned usage of S.O.S..

Normally, where a training facility includes a number of PC's and shared printing resource etc, we recommend no more than two trainees per PC. Two is an appropriate number as the trainees can share the experience of responding to the questions and physically operating the software.

SOFTWARE INTERFACING CAPABILITIES AND REQUIREMENTS

S.O.S. in its generic form, uses the Microsoft Access 97 database format to store spares assessment data in tables.

It is a Visual Basic application, using Crystal Reports. S.O.S. runs on all Windows platforms and can be installed for network use in a number of user dictated formats.

Strategic's existing clients utilize most commercially available computerized maintenance management systems.

The Access database was chosen because of its wide commercial use and because it complies with industry standards for open database facilities. Access is able to provide import/export functions so that it is not a complicated task to download spares information.

Clients often have their main CMMS produce a report (to a file) which contains all the high value, slow moving parts, for instance.

After the completion of assessment for optimizing holdings, revised max/min levels may then be exported back to the CMMS.

INFORMATION TECHNOLOGY IMPLICATIONS

S.O.S. is not a resource hungry Windows program. It requires 486 processor or better and will run in 16mb of system memory.

Current systems in use at your facility will no doubt already exceed these requirements

1. Minimum Hardware specification to operate the software:

- 80486 or better
- 16mb main memory or better

2. Recommended hardware specification to operate the software:

- Pentium processor
- 32mb memory -

3. Hard disk sizing requirements and performance factors

The requirement for disk space is a function of the volume of spares to be assessed at the one time using S.O.S.. We would not see this as a major issue. The expected performance of a large S.O.S./Access database is not dramatically affected by size.

USER DOCUMENTATION

Strategic makes User Manuals available under the terms of its License Agreement.

The Manual and Quick Reference Guide are provided electronically for duplication within an organization.

S.O.S. incorporates on-line, hypertext based help. This includes field-sensitive assistance to users.

The manual includes worked examples and provides guidance as to the optimum manner in which to approach spares optimization, not just the operation of the S.O.S. software.

ANNUAL SOFTWARE SUPPORT AND MAINTENANCE AGREEMENT

The S.O.S. methodology is under constant review for the potential to improve its usefulness to clients. The main source of subject matter for enhancement and development is our extensive current user base.

Strategic maintains a Software Improvement Register, within which client requests for enhancements are stored. Planned changes are categorized from level one to three, depending upon the significance and overall benefit perceived to be available from including the change in a future release of S.O.S..

Level One enhancements are judged to be of sufficient value to be included in the next planned release. Level Three enhancements may fall into the 'cosmetic' category or might be of limited benefit to the overall user base.

Ongoing Software Maintenance, Technical and consulting support:

Strategic provides licenced users with the option of a Software Support and Update Agreement (SSUA). Under the terms of this agreement, users can expect to receive any new releases of S.O.S. along with updated documentation.

Users may also contact Strategic under the terms of the SSUA for customer support and for assistance generally in the operation of S.O.S.. Support can be provided through several time zones so organizations can be assured of virtually unlimited support timing.

The SSUA covers twelve months support and continues thereafter unless terminated under terms described within the SSUA.