Repair or Replenish ?

- Maintain or Invest ?

Cost/effective spares inventory control, spares procurement and maintenance

in a dynamic real world

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- Optimal spares replenishment
- Excess stocks definition
- Value of LRU/SRU repairs

Abstract:

By creating a stronger link between configuration management, operational and maintenance plans combined with recurrent spares revisions and optimisation, it is shown that considerable improvements in operational availability performance as well as total cost reductions can be achieved without any new funding.

1. Introduction

Let us start with two assertions relevant for maintenance logistics support:

- It is not possible to always be in an optimal state - but it always possible to aim at the optimum!
- Money should be spent where they are most useful, not necessarily on what they primarily were intended for!

Even if the statements may seem natural and obvious they should be considered more as visions than a description of the real world of today. However, by implementing these visions it can, as just one example, be shown that:

- It is possible, by moving money in an optimal way from repairs to replenishment (= no cost), to significantly improve the availability performance and correspondingly increase the number of operational systems.

It is a well known fact that the prerequisites and conditions for the operation of technical equipment is changing fast, maybe faster than ever before. As a consequence of this, even the prerequisites for maintenance support and planning is changing rapidly. Important parts of the maintenance support planning and repair activities are spares procurement, inventory control and workshop repairs of Repairable Items (LRUs/SRUs).

A number of advanced computerised tools have been developed to solve the problem of finding the optimal initial procurement of spare parts, repairables (LRU/SRU) and non-repairables (Discardables/Expendables). An example of such a tool is OPUS10.

During the initial procurement phase normally limited information is available concerning some characteristics; e.g. failure rates and logistic delay times, while other parameters are very clear, like system configuration, item prices, support organisation concept etc. Using tools like OPUS10 will give solutions that, with best known information about the future, are optimal at this point in time. But what can we do during the operational phase?

2. Spares are not a wholesalers stock

In many organisations spares causes frustration and confusion even if a lot of money have been put into both the spares themselves and the spares management system. Complaints like "we never have the spares we really need" and the contrary "we have a lot of spares that have never been used" are frequently heard. Other typical remarks are "the prices we have to pay for our spares are ridiculous" and "we have only operated these systems for a few years and now we cannot access spares any longer ".

One reason for these complaints is lack of understanding of the difference between a traditional wholesaler stock and a spares stock. Having studied a number of management system for spare parts it seems to be the rule, rather than the exception, that these software's has originally been designed more for wholesalers than for logistics support of spares. Typical differences are:

- Spares normally have low demand rates. Some items, frequently very expensive, may have an expected demand <1 during a 10 years period
- Trends or other methods to forecast when demands occur, are not available for most items
- The demand rate for a spare is not a function of the item price, but is basically controlled by
    1. The items failure generation
    2. The system configuration
    3. The number of operating hours
    4. The maintenance concept
- The cost per hours with stockout (backorders) may for critical spares be >> item price. (A wholesaler might loose the sales profit and maybe some goodwill)
- The LRU/SRU concept does not exist in wholesaler stocks. The traditional Wilson/EOQ formula is not applicable for these items.
- The fact that a spare part never been used, do not mean that the inventory investment has been wasted. Most spares can be considered more as a "fire insurance" than something that should have a turn-over. The less demand - the better
- The number of spares needed is a basically a function of time (Lead Time, Turn Around Time) and only to a minor extent a function of reorder cost.

The conclusion from these examples are that the management of spares stocks is to a large extent a different problem than the management of a wholesalers stock.

3. Spares Optimisation - A Case Study

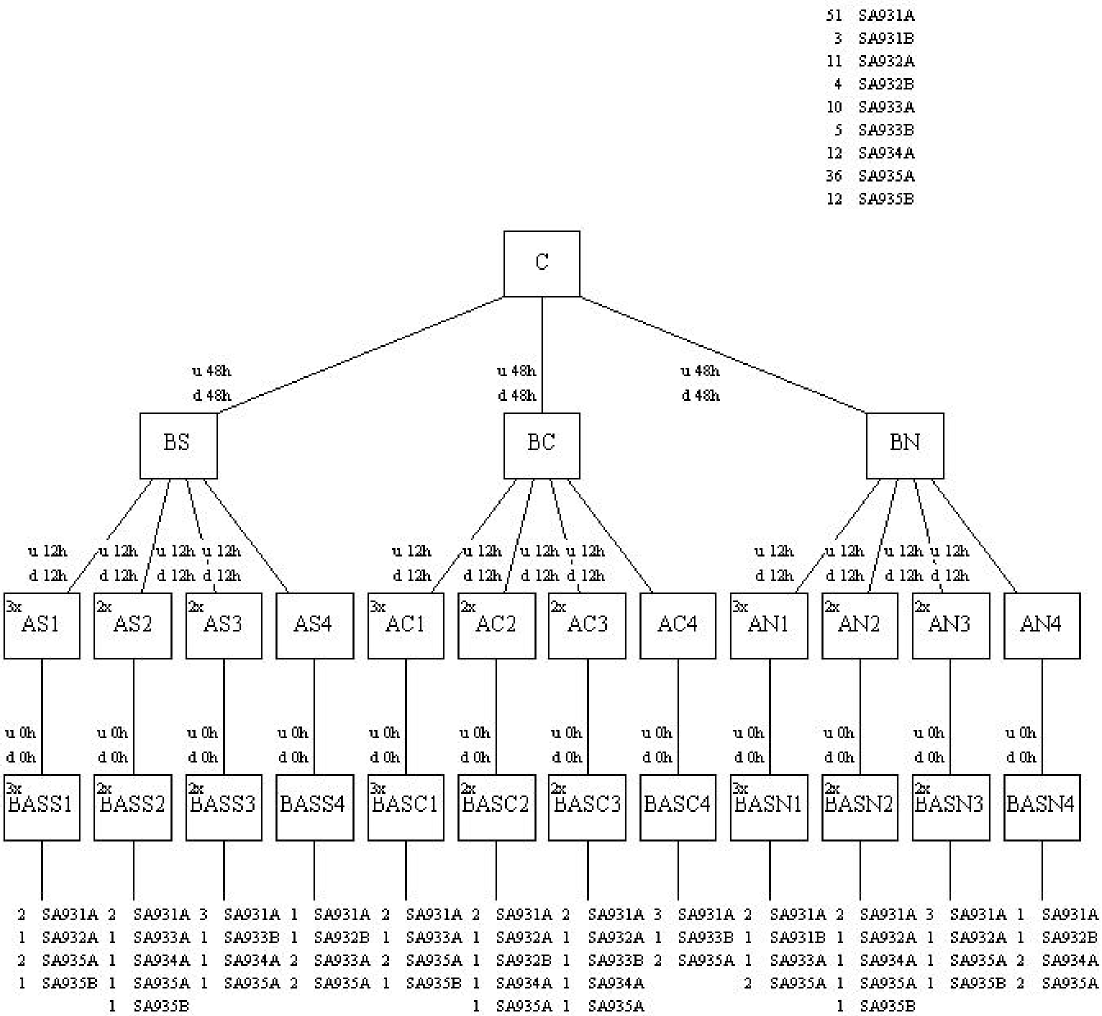
In this example data and prerequisites from a real world case is used. Due to the confidential commercial and to some extent even classified information in the real project, changes have been made in order not to unveil any confidential information.

The item prices and descriptions have been manipulated as well as the operational profiles and the logistics support structure, but without changing the basic characteristics of the real world case.

In this project, spares optimisation and logistics support analysis has been performed throughout the whole project, but until a couple of years ago all decisions has been based upon predicted information about e.g. failure rate (FRT) and repair turn around times (TAT).

3.1 The support organisation

We have a three level support organisation with 24 bases as operational sites, each with a A-level stock of spares, three B-level stores (with some repair capability) supporting 8 bases, and a central depot with workshops and spare parts all according to the following picture



In total there are 144 SA93 aircraft to be supported, of which 24 are the B-version.

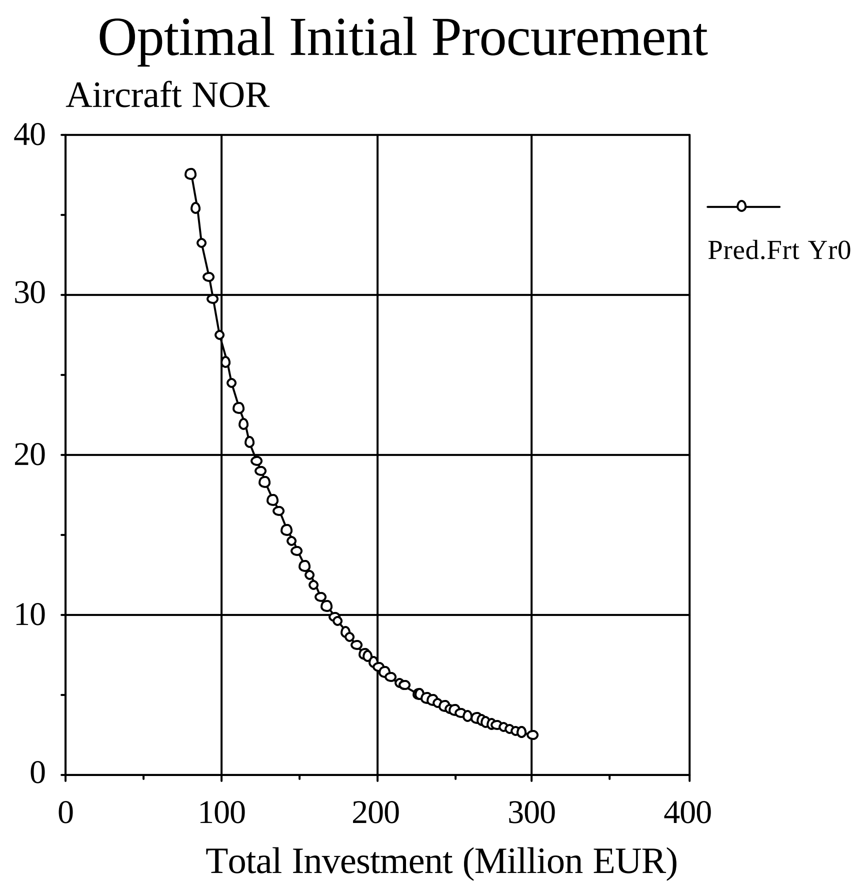
3.2 Initial procurement of spares

The number of ways to decide the initial quantity of spares are more or less unlimited, but in principle these are two main alternative methods:
Method 1: The initial quantity is based upon the contractors recommendations combined with manual judgements or other estimates.
Mehod 2: Analytical spares calculations and optimisations with tools like OPUS10 or similar - combined with method 1
Common for both alternatives is that we, as always, have limited knowledge of the future. The advantage with method 1, the by far most common method, is that it in some cases is faster, especially if the spares lists are short. It can however be shown that method two not only will give more cost /effective (optimal) assortments but is also more stable against wrong predictions or “guesses”. We will here illustrate method 2:

Based upon

1. an estimated utilisation of 55 flying hours/month (7.5%)
2. predicted failure rates per flying hour and workshop turn-around-times
3. including all Line Replaceable Units (LRU) and Shop Replaceable Units (SRU), in total 477 items,

the following optimal cost/effectiveness (Investment in LRU/SRU vs. average systems Availability) is calculated by the logistics support and spares optimisation tool OPUS10.



Each point on the curve is representing the optimal allocation of spares for the invested money.

The selected optimal Point (pt 40) has the following characteristics:

- Investment in LRU/SRU CI = 173 Million EUR
- Average Number of Aircraft Not Operational Ready NOR = 9.8 Aircraft
- Average Systems Availability: A = 93.0%
- Average Waiting Time: WT = 12 hours
- Marginal_Cost per NOR: MC/NOR = 7.5 Million EUR

If we look into more details, 16 of the 477 items (about 3%) will represent more than 60% of the spares investment, a rather common situation. This means that improved information, and even better, improved logistics for these items will have significant impact on the optimal spares calculations. The items are presented in the list below

IID Item identifier	DENOM "Description"	EPRC Unit price	STSIZ Stock size	CI Investment kEUR	% of Total Investment	Acc % of Total Investment
51000100A_193	463_51000100A	3041.570	5	15 207.870	8.8%	8.8%
51200100A	465_	752.360	17	12 790.120	7.4%	16.2%
51000100A	462_	3041.570	4	12 166.290	7.0%	23.2%
51500100A	468_	539.660	17	9 174.270	5.3%	28.5%
51600100A	469_	536.070	15	8 041.010	4.7%	33.2%
51100100A	464_	676.400	9	6 087.640	3.5%	36.7%
66110500A_227	404_REP_C	274.830	22	6 046.280	3.5%	40.2%
66110400A_227	378_REP_C	388.880	15	5 833.140	3.4%	43.6%
66110300A_227	362_REP_C	260.000	20	5 200.000	3.0%	46.6%
51400100A	467_	269.660	18	4 853.930	2.8%	49.4%
34400100A	103_REP_C	90.790	53	4 811.710	2.8%	52.2%
66110100A_227	350_REP_C	441.120	9	3 970.120	2.3%	54.5%
68110500A_207	443_REP_C	524.040	6	3 144.270	1.8%	56.3%
34300100A	95_REP_C	216.520	13	2 814.720	1.6%	57.9%
51720200A_193	473_51720200A_193	353.030	7	2 471.240	1.4%	59.3%
51720200A	472	333.820	7	2 336.740	1.4%	60.7%

4. The Dynamic World - nothing is constant

Now, one of the few things we really know about the future is that not only the real future will be different than expected, but also that the predictions, belief or expectations of the future will differ and alter as time passes on.

1. The number of systems operating changes
2. The usage (operational profile) or expected usage is changing
3. The systems are modified
4. The failure rates or the predicted failure rates might improve or increase
5. The existing spare stocks are not constant
6. The maintenance concepts are altered
7. The support organisation is varying

The natural question is: Is it possible to collect and use updated information about these dynamic characteristics to achieve a more cost/effective spares management, inventory control, workshop repairs and at the final end, better systems operation?
If the answer to this question is Yes, the next question will be: Is possible to use advanced tools like OPUS10 to continuously optimise and manage the spares assortment during the operational phase?
The third question is also obvious: Are the improvements worth the effort?

4.1 Operation

It is obvious that the need of spares for a certain item is a function of how many systems the item is included in, how these systems are used and where they are allocated.
It is also clear that this operational profile in most cases is not constant if we look over a period few of years. We might use the systems more or less than the original intentions, we might buy more systems or get rid of some, or maybe reallocate systems to new allocations.
All these changes are influencing the need of maintenance, logistic support and spares.
While in most cases the operational information is easy and straight forward to access, the updated information quite frequently is not actively used for the spares inventory control and management of spares. The potential for improvements is considerable.

4.2 Configuration Management

Another significant difference between spares and wholesaler stock is the behaviour of the “customer”. As long as a certain item is installed in an operating system it is a potential customer, but not afterwards.
It is unfortunately a rather common situation that the communication link between the configuration and the spare part stock is not good enough, so that items that are removed, e.g. due to modifications, from systems in operation are still found in the spares stock piles - and the new item, really needed as spare, is not found.

All changes in the system configurations and breakdown structure should influence the maintenance planning as well as logistic support (and spares).
There are many ways to create better links between configuration management and spares management - one way is the commercial. All major modifications should also include a review of the maintenance plans and a spares “revision” as a part of the contract and payments.

4.3 Demand Rate (DRT) Recording

A frequent answer to why spares management is performed without quantitative calculations is the lack of good data for the failure rates, FRT or the demand rate, DRT.
The demand rate is basically a function of the failure rate, the configuration, the number of systems in operation and the operational profile.

For the initial purchase we have to make reasonable “guesstimates” or predictions of how high or low the DRT will be. Maybe very rough, but anyhow based upon judgements or other available information from people with experience from similar equipment.
(Another approach, which is common but not recommended, is to claim that since some parameters are so uncertain, we start with 1 spare for each item and “see what happens”)
Unfortunately it seems to be the rule rather than the exception, that even after a long period of operation, good data for FRT or DRT are still missing - at least there are no straight forward way to get them. A very typical situation is zero or very few relevant demands, giving the feeling that no confident “statistics” is available.

Spares dimensioning and management is an integer problem. This a allowing for relatively high spread in the estimates of the DRT and the spares recommendation will still be the same.

It is also a fact that the number of important items, cost drivers, are normally less than 20% of the total number - in many cases less than 10%. By limiting the collection of statistics to these items only, the effort will be much lower and the most costly mistakes can be avoided.
It should also be noted that for high demand items (DRT > 50/year) the spares dimensioning is not critical from total cost point of view - it will normally be the maintenance costs for repair and spares consumption that will be dominating.

For a low demand item, especially if it is expensive, the capital and storage costs will be dominating and spares management and optimisation becomes vital. This is one reason why we should concentrate on these items.
Another important issue for low demand items is the maintenance concept. (What is done by the operator, what is done by the supplier and what is done at central workshops etc.?) It is not unusual that the sparing is not in line with the maintenance concept, frequently leading to excess stocks of some items and corresponding shortage of others.
Based upon this experience it is also clear that, in most cases, it is only realistic to have a reasonably good estimate of the mean value of the DRT, but in some (rare) cases even effects of reliability growth or wear out can influence maintenance planing and spares management.

4.4 Measuring Logistic Times

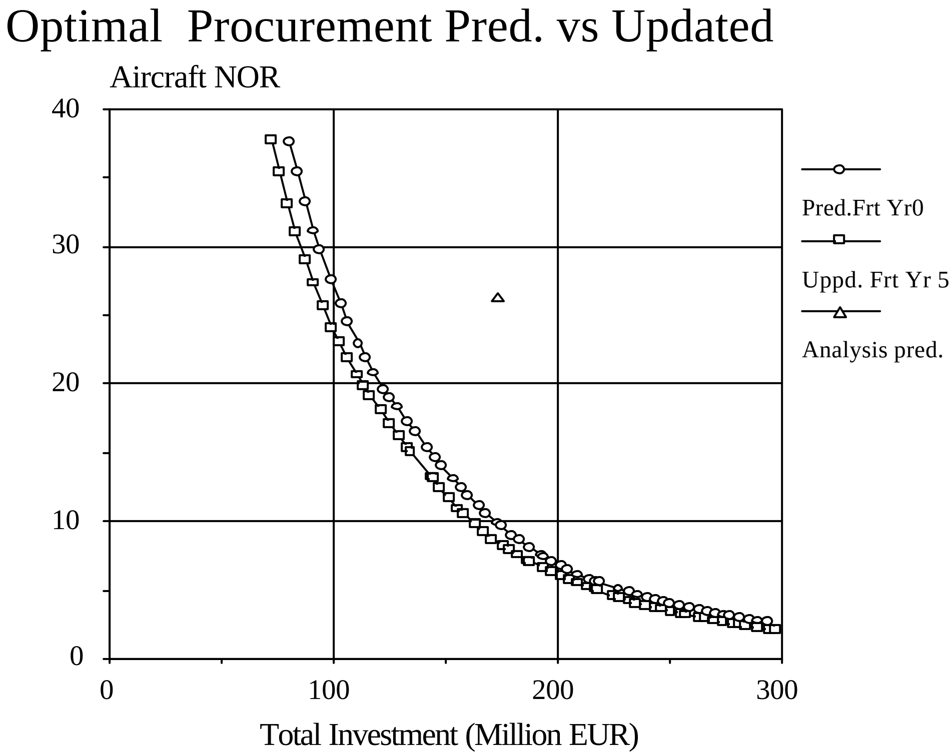
Having the same impact of the number of spares needed as the demand rate, focus should also be oriented to the logistic times like

- Repair Turn Around Times (TAT) in the workshop for LRU/SRU
- Lead Time (LT) for non-repairable items and
- Transportation times including all administrative delay times within the logistics support organisation.

Underestimates of the real logistic times are rather frequent. It is easy to forget the impact of different kinds of delays, e.g. customs, holidays and weekends, unexpected events of different kinds etc.
Measuring the logistic times for LRU/SRU implies tracing individual items, but for the optimal spares dimensioning only the mean values of TAT per item are interesting if Poisson distributed DRT is assumed (Palm's theorem).
For non-repairables it is the reorder point (= stock level initiating reorder) that is the important part of the spares management, not the reorder quantity. The reorder point is strictly a function of the LT (= Time delivered minus time ordered) and using the right LT is thus of vital importance to avoid backorders and systems unavailability.
Logistic times can be influenced by "rush orders", "fire alarms", air transports and other priorities. From spares management point of view it is essential to make clear whether or not priorities should be considered as normal and taken into consideration when the spares allocation is decided.
All changes in the logistic times are influencing the need of spares.
In the continuing case study we shall see how we can use updated information about e.g. the FRT (and thus even the DRT) for improved spares management and systems effectiveness.

5. The Case study - Updated information

After a number of years of operation it is possible to use real world data to verify (accept or reject) the predicted failure rates. The accuracy of predicted data may in some cases be rather poor. In this example we are simulating an uncertainty with a fraction of four, meaning that the updated real world based estimates of FRT might be between 4 times lower (1/4) and 4 times higher than the predicted FRT.
(In some real world cases the difference might be larger, but if the failure rate is extremely high compared to predicted it will normally initiate modifications or other actions)
The real world updated FRT has been simulated by transforming the predicted FRT for each LRU/SRU using random numbers between 0.25 and 4, but in such a way that the total overall FRT for the aircraft is basically unaffected.
Analysing the former optimal assortment of spares in OPUS10 will give the following result.



First of all we have calculated the new optimal Cost effectiveness curve with the updated FRT. We can see that optimal solutions with updated FRT are less costly than the corresponding efficiency with predicted FRT, but that the difference between the curves are rather small. This is not a coincidence, it is a normal result if the overall FRT is basically unchanged as in this case.
On the other hand, the solution we originally selected (pt 40) will be far from optimal (please note that we are assuming no corrections have been done since the initial procurement) and the efficiency is no longer fulfilling the requirement of NOR< 10.
The average Number of Aircraft not operating has increased to more than 26.
The main reason for this is that we will have too few spares LRU/SRU of those items having higher FRT than predicted and too many of those with better FRT.

5.1 Excess stocked items

We frequently hear complaints about “excess stocks”. Asking how the excess quantities are identified the answers are varying:

- Items in stock that seldom moves (?)
- Items we have more than 2 of in stock (?)
- Items that we don’t know what they are used for (?)
- Items with few backorders or very low risk of shortage (?)
- Items we have more of in stock than needed (?)

Using a tool like OPUS10 the definition of excess stock is becoming more specified:

- Items with more spares than optimal !

where the optimal number is defined by the input parameters and the computer calculations

By comparing the existing assortment with the new optimal assortments, with updated information, fulfilling our requirements we can easily see which items that are overstocked.
The most important 11 (of 477) items, representing more than 80% of the overstocked value (60 Million EUR), are listed here:

IID Item identifier	PRICE Unit price	Repair Actions Yr	STSIZ Stock size	STSIZ Stock size	Value	% of total overstock	Accum % of total overstock
			Acquired	Needed	Overstock		
51000100A	*3041.573*	*67.2*	*7*	*3*	*12166.292*	19.9%	19.9%
51000100B	*3041.573*	*73.0*	*7*	*3*	*12166.292*	19.9%	39.8%
51200100A	*752.360*	*56.4*	*17*	*9*	*6018.880*	9.9%	49.7%
51500100A	*539.663*	*59.8*	*17*	*8*	*4856.967*	8.0%	57.7%
51100100A	*676.404*	*25.1*	*9*	*2*	*4734.828*	7.8%	65.4%
66110400B	*388.876*	*38.3*	*16*	*7*	*3499.884*	5.7%	71.1%
36200100A	*61.011*	*33.5*	*37*	*8*	*1769.319*	2.9%	74.0%
51780100A	*193.596*	*12.3*	*13*	*6*	*1355.172*	2.2%	76.3%
38210100A	*227.416*	*48.3*	*11*	*7*	*909.664*	1.5%	77.8%
51781100B	*284.607*	*6.4*	*6*	*3*	*853.821*	1.4%	79.2%
51300100A	*163.933*	*42.3*	*11*	*6*	*819.665*	1.3%	80.5%
Sum					49150.784		

These items have an updated FRT that is significantly lower than predicted and thus we will need less spare LRU/SRU.

5.2 Problems with overstocked LRU/SRU

The problems with these items are of a total different nature than for those items we are short of:

1. The manufacturer is probably not interested to buy these items back, and for sure not for the price he sold them
2. It is normally not so easy to sell them on the “open market” either.
3. As the items are LRU/SRU there are some other options:
    - Avoid expensive repairs until stock level = needed is reached (The non-repaired LRU/SRU may be put into some kind of “mothball”)
    - Prolong the TAT so that stock needed = stock acquired

The second option is unfortunately the most common, and is being done more or less “automatically”. The first one is much more interesting but requires logistics “skill” and some effort to implement.

5.3 Avoid expensive repairs

The cost of repairing a faulty LRU/SRU is normally not constant, it will depend upon the actual failure mode, time preferences, repair level and other circumstances.
For a given failure mode and situation it is believed that a reasonably good estimate of the repair cost always can be done by experienced maintenance technicians.

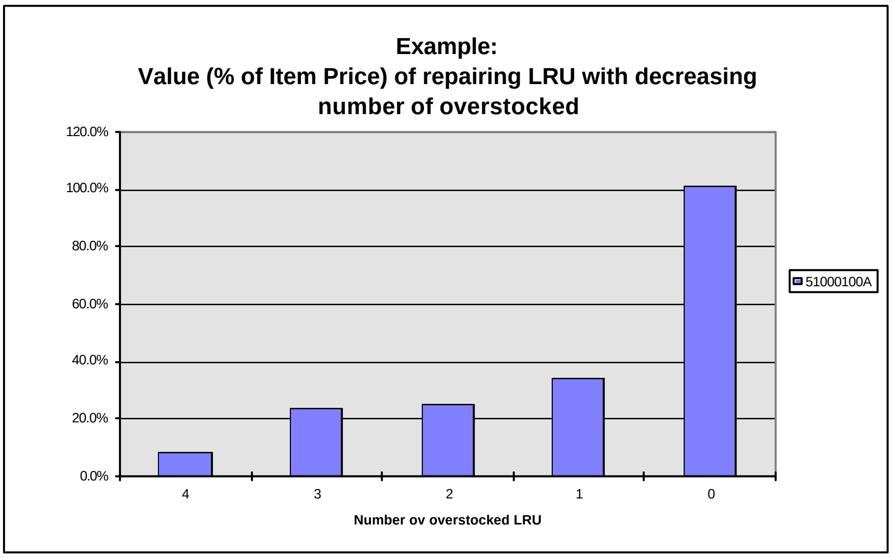
If we consider the value of repairing is higher than the cost the recommendation should normally be - repair. Otherwise we will not repair; giving us the options discard, scrap, or put it in the “mothball”, etc.
So, to be able to take the decision we need some kind of estimate of the value of the repair. It is believed that this value in most cases has been based more on “stomach feelings” rather than calculations.
(Some organisations are using the “rule of thumb” to do the LRU/SRU repair if the cost is less than half of the item price. This might be OK if you are in the right market situation - meaning that you can choose whether you want to repair or buy a new)
The real problem is that the value of repairing an LRU/SRU is not a constant and to a limited extent linked to the price of the item.

Here a method is presented showing how the value of repairs strongly depends of the number of spare LRU/SRU. (To simplify this example will only study the impact of the stock level for the item itself, but the value is also linked to the stock level of other items, this is especially the case for SRU)

We will use OPUS10 to calculate the value of the repair as a function of the number of overstocked LRU/SRU.
If we are in the position that we have too few spare LRU/SRU the value of the repair will by definition be higher than the item price and the decision to repair is in most cases obvious. We will not go deeper into that, even if it is realised that it happens that the repair cost is significantly higher than the item price.

5.4 Repair Value Calculations

Given that we have selected a certain point on the OPUS10 C/E-curve, we have also implicitly told how much we at most are willing to pay to reduce the number of systems Not Operational Ready - NOR. In our example point p40 was selected, which gave us A>0.93 and where the Marginal Cost per NOR, MC/NOR was roughly 7.5 million EUR.
As the price of a fighter aircraft is much higher than that, it indicates that we are willing to pay more than twice as much for a real physical aircraft than for an imaginary aircraft that comes available through more spare LRU/SRU.
For each overstocked item is a simple task for OPUS10 to analyse (through optimal reallocation) the impact of NOR if we reduce the number of overstocked items one by one. By multiplying the increase of NOR with the implicitly defined value per reduced NOR we have defined a maximal value of the repair. (Repairing means that we will keep the number of spare LRU/SRU constant while not repairing will decrease the number by one.)
Studying one of the cost driving overstocked LRU/SRU gives some interesting results: The item 51000100A which represented almost 20% (12 million EUR) of the overstocked value.



We can see that the value increases from less than 10% of the item price with an overstock of 4 up to over 100% when we are down to an overstock of 0 . If the repair cost for those items "put in the mothball" on average are 30% of the item price, the total "saving" in this case will be at least 3.6 million EUR. The failure flow is high, more than 5 per month, so it will not take long to "cash in". If it is possible to move money from the repair and maintenance budget to investments in LRU/SRU where there is shortage, se chapter 7, we will pretty soon be back on the availability target.

5.5 Problems with overstocked non-repairables

The problem with overstocked non-repairables (Discardables/Expandables) are normally easier to handle than repairables:

1. As long as there exists any reasonable need (demand) for these items, the problem will solve itself, sooner or later
2. Items in stock, but no longer installed in any operating system are obsolete, not overstocked.
3. The interesting thing about non-repairables is the safety stock (reorder point), not the actual existing stock level
4. The calculation of the optimal safety stock is a task for tools like OPUS10. The value of calculating optimal reorder quantities with the EOQ-formula is normally limited for spares.

5.6. Understocked items - How to afford to buy them?

To define what we mean by understocked is easy for repairables (LRU/SRU) if we are using a tool for spares optimisation: <u>It is simply items with aquired quantity less than optimal.</u> For non-repairables items are considered as understocked if the quantity in stock less than optimal reorder point.
In this case there will obviously be some items with too few in stock, as their demand rate is much higher than predicted. For these items a replenishment procurement will be very cost/effective.
There are two major reasons why replenishment procurement may cause problems unless this has been planned for in early project phases:

1. There is no money in the budget
2. The LRU/SRU is not in production any longer and has to be specially manufactured, and the unit price of the item will be dramatically higher.

The second problem is of course tricky, but it might still be cost/effective to buy an understocked item, even to a much higher price than during the initial phase. The calculation of this can be done with a spares optimisation tool.

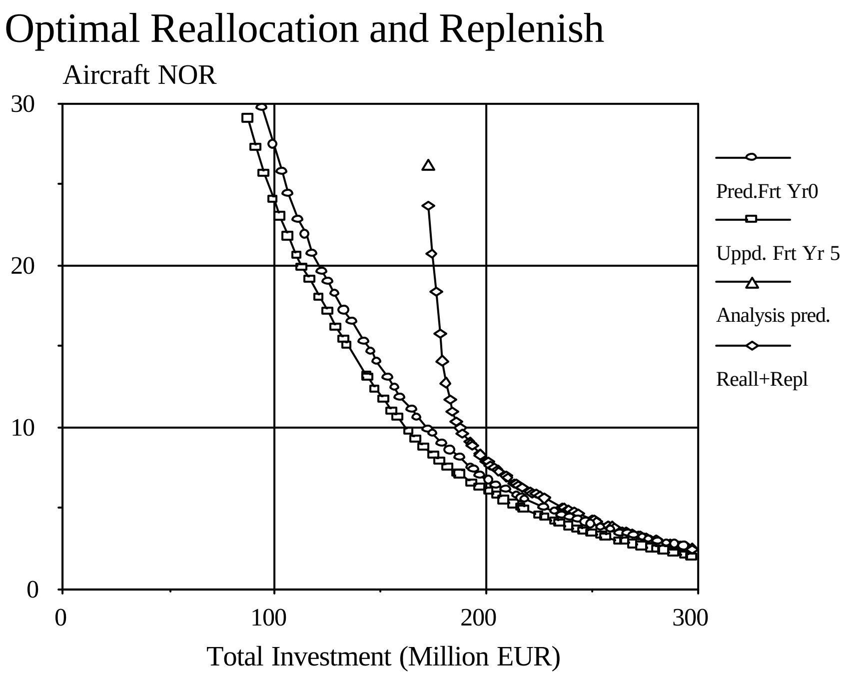
The first one may be even more tricky, and there are of course a number of options:

a) Request more money
b) Wait, and reserve money in next years budget
c) Make money available but letting overstocked item pay, e.g. by avoiding unnecessary repairs.

We will look closer into the last options, as it is believed always to be of interest to have an increased availability without any new funding.

5.7 Reallocation and Replenishment Procurement

To improve the situation we can let OPUS10 do an optimal reallocation of the assortment according to p40 and from that new starting point do an optimal replenishment procurement of those items we are short of. The result can be seen in the following curve



Doing a reallocation of existing spares, requiring no investments, will improve the number of aircraft not in operation a bit (from NOR = 26.2 to 23.7), but it is a general experience that the improvement achieved reallocating an assortment, previously optimised by OPUS10, is rather limited.
(The reallocation is preferably done by routing repaired LRUs/SRUs to the most cost/effective sites, not by moving around items on the shelf, which might be quite costly)

By allowing a relatively small (15 Million EUR = 8% of total investment) replenishment procurement, we will soon be on target NOR < 10.
The 8 most cost/effective items to replenish, are listed on next page:

Item identifier	Denomination	Unit price	Replenishment QTY	Repl. investment	Total Stock	Expected beckorders	DeltaNBO	DeltaNBO per EUR
63600100A	332_REP_C	0.900	3	2.700	33	0.002349	0.0168	0.00623
35100200A	129_REP_C	11.570	5	57.850	11	0.073373	0.2459	0.00425
41200301A	269_	8.760	6	52.560	39	0.037553	0.1960	0.00373
63100100A	302_REP_C	110.670	3	332.010	10	0.402433	0.7746	0.00233
32500100A	38_	2.130	1	2.130	28	0.002315	0.0045	0.00210
69100100A	333_REP_C	19.210	1	19.210	5	0.035663	0.0387	0.00202
34100102A	88_REP_C	20.000	1	20.000	5	0.034714	0.0374	0.00187
51720200A	472_	333.820	6	2002.920	13	1.216938	3.7217	0.00186

6. Recommended approach

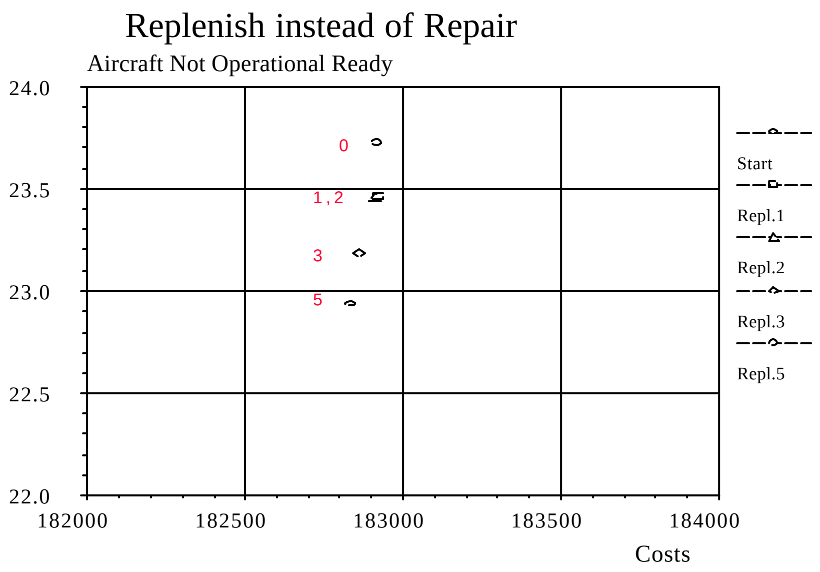
a) Repair the failed item (LRU/SRU) according to policy if calculated repair value is greater than estimated repair cost
(Information about configuration, existing stocks, demand rates, repair times and a value per hour of operation is needed)
b) Otherwise, use of the saved repair money for (optimal) replenishment procurement of (understocked) spares.
The failed item may be discarded or put in a mothball
c) Start with replenishment of Items with Unit Price < Budget (=Saved repair costs) (Restricted Replenishment)
d) In some cases it may be effective to accumulate saved repair costs to be able to replenish expensive items

6.1 An Example: Typical event sequence of failed items

1. A medium costly item, with a limited number of overstocked, fails
2. A medium costly item, with only 1 overstocked, fails
3. An expensive item, with several overstocked, fails
4. An expensive item, with 0 overstocked, fails
5. A relatively cheap item with a large number of overstocked fails

How will Cost (Investments minus Saved repair costs) develop, and what happens with number of Not operating (NOR) aircraft. The reduction in cost combined with improved NOR is shown in the following picture (Note: Event 4: Repair was selected)

Improve NOR at no Cost



7. Analysis, Recommendations and Improvements

The updated information about DRT, TAT/Lead Time, Configuration, Existing allocation is used for cost/effectiveness analysis (by e.g. OPUS10) of status and recommended actions.
Example of standard recommendations

1. Too many spares: Stop reorders, Stop/Postpone repairs, Sell out
2. Too few spares: Replenish/Reorder - Use saved repair costs
3. Non-optimal allocation: Reallocate by re-routing repaired/replenished items
4. Too long logistic times: Speed up, Make Agreements/Commitments

8. Improvements

The possible improvements achieved by better spares inventory control, cost effective maintenance and spares procurements is summarised in the following list:

1. No unnecessary spares - just necessary
2. No unnecessary reorders
3. No unnecessary item (LRU/SRU) repairs
4. Having better quality than expected will give less DRT. Having less DRT the need for spares will be reduced - we shall of course use that advantage
5. Having better logistics - meaning shorter times - less spares are needed. Even this potential shall be used.
6. Cost/effective (optimal) trade-offs between
    - Central/Regional/Local Stocks
    - Critical/None critical items
    - Cheap/Expensive items
    - Short/Long Lead Times
    - Complete item or parts (LRU/SRU) etc.

9. Concluding Remarks - Summary

Methods used for wholesaler stocks can in most cases not be transferred to spares stocks. Creating a powerful link between configuration control, operational plans, maintenance activities and spares management, combined with optimisation is shown to be the way to cost/effectiveness.
Several trade-offs are available, some are more cost/effective than others.
Take advantage of the fact that the value of repairing an LRU/SRU is not constant, in fact - Nothing is constant!

List of References:

1. Isdal, Tor G: Dynamic Spares Allocation - A Cost/Effective Insurance
   Presented at 15th International Logistics Congress. Exeter 1999
2. Systecon AB: OPUS10 - Logistics Support and Spares Optimisation Software
3. Wååk Olof:
4. Etc.

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