NAVAL AIRCRAFT REPAIR POLICY ANALYSIS

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ABSTRACT

Ways of selecting the most cost-effective repair policy are discussed. All existing simulation models have some shortcomings and the future is considered.

Background

In 1983 the then Director General Aircraft (Navy) commissioned a major strategic review of the support of naval aircraft. The study was undertaken by a team from the PA Consulting Group who reported in October 1984. The Admiralty Board endorsed this report and the Aircraft Support Project was formed to implement its recommendations. These were very wide ranging and affected every aspect of support, but laid particular emphasis on the management of repair. The reason, of course, was that this area represented the major investment in both capital equipment and running costs and thus it was here that any improvements would have the most benefit. Further study focussed on the working of the repair loop, and a variety of initiatives are now in hand to excercise greater control over repairable assets and to increase the rate of flow of defective items through all parts of the process. When it is realized that a Sea King main rotor gear box costs about £250K, the importance of minimizing the pool of spares is abundantly clear. This work turned attention to how repair policy was determined, i.e. at what location and to what depth should repair be carried out.

The Problem

The problem of selecting the most cost-effective repair policy is, of course, not a new one. The situation is theoretically illustrated in FIG. 1, where the curve shows the limit of the service level available for a given investment. Thus if the current policy is positioned at X, the service level can be improved at constant cost or, the service level maintained for less cost. The search is for a point somewhere on the knee of the curve.

However there are many factors involved in influencing repair policy:

- Cost and physical requirements of repair facilities
- Cost of providing spares to the repair location
- Failure rate of the equipment and its sub-components
- Time between overhauls
- Human skill levels required to effect a repair
- Training costs involved in producing the required skill
- Cost of documentation to support repair
- Cost of software for testing purposes
- Operating requirements of the equipment
- Flexibility of support required in times of tension or war

- Job satisfaction of existing staff
- Support implications for the repair facilities themselves

These factors interact in a complex way, often in opposition. Herein lies a fundamental dilemma: equipment design is aimed at meeting a given performance specification and, whilst support criteria are beginning to be included in these specifications, nevertheless fundamental design decisions are made early in the development process which then constrain future repair policy options. Similarly, later in the equipment's life cycle, when it is actually in service, rarely is an analysis performed on how effective the repair policy has proved to be in practice. Very often the operating pattern, defect and overhaul rates may have changed significantly from those that pertained during development. But for lack of resources and data this exercise is seldom carried out. The data problem is interesting because the argument, as illustrated in FIG. 2, is a circular one. Collecting data is expensive; because the data is not available the analysis is not done; and because no analysis is made there is no demand for data which could be justified by improving the cost-effectiveness of repair policies.

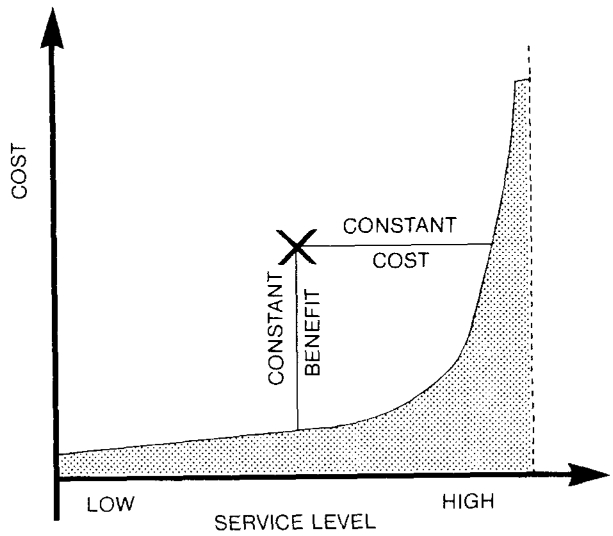

FIG. 1—COST v. SERVICE LEVEL

Existing Procedures

The scale of effort expended by the Fleet Air Arm on support planning for the introduction of new aviation equipment naturally varies considerably. Thus a new aircraft will have a dedicated team located at the manufacturer, the Special Maintenance Party (SMP), to carry out an evaluation. A new radar will probably have one senior rating on site with the contractor; and an aircraft modification, which introduces a new repairable item, will be handled part-time by one of the aircraft desks in DGA (N), supported (again part-time) by specialists at the Aircraft Support Executive (ASE). The influence of any of these on the design process is small, tending to focus on maintainability with, at best, only rudimentary analysis of repair policy and life cycle costs. The decision maker is given very little data or methodology support and consequently the resulting policy may simply reflect how similar equipments have been maintained in the past. It might be argued that this derives from well-established experience which has been iterated down the years to the 'best' approach. However, this is by no means certain, for quantification does not exist. Certainly such an evolutionary approach will not respond effectively to quantum changes in technology, operating pattern, or the support environment. The procedure described is essentially a sequential, open loop process which results in a philosophy of 'supporting the design' rather than 'designing the support'. In an ideal world the system would be more like FIG. 3, with a closed loop approach to the assessment of support policy.

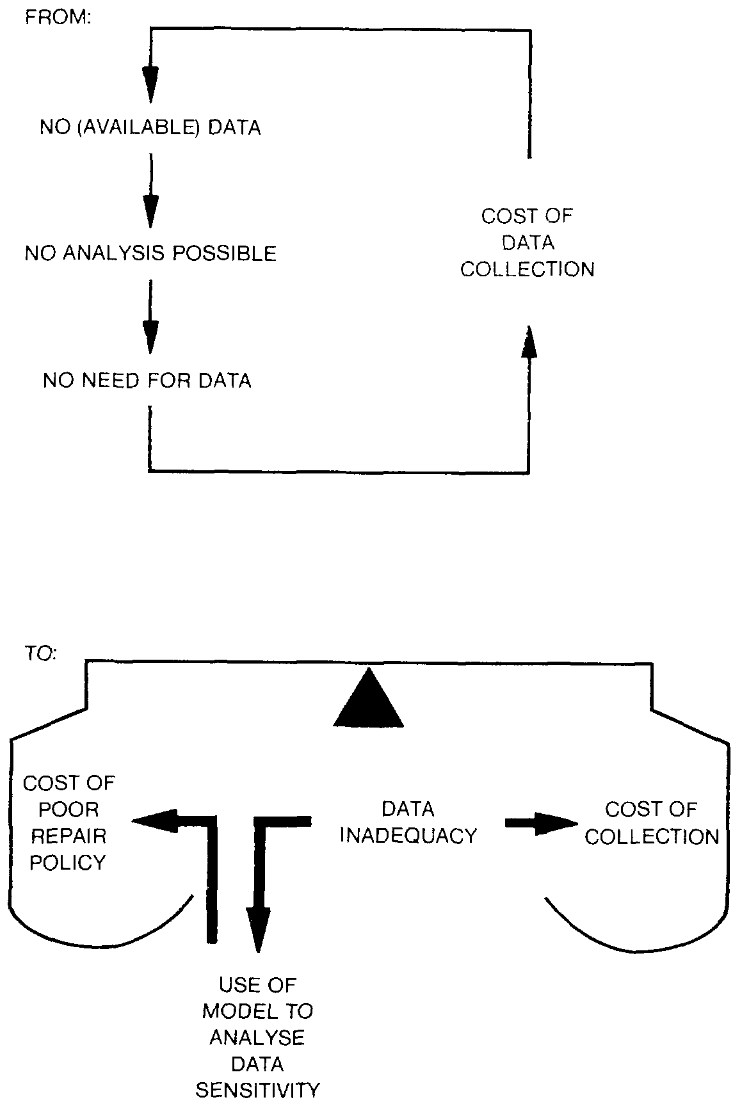

FIG. 2—INADEQUATE DATA—BREAKING THE VICIOUS CIRCLE

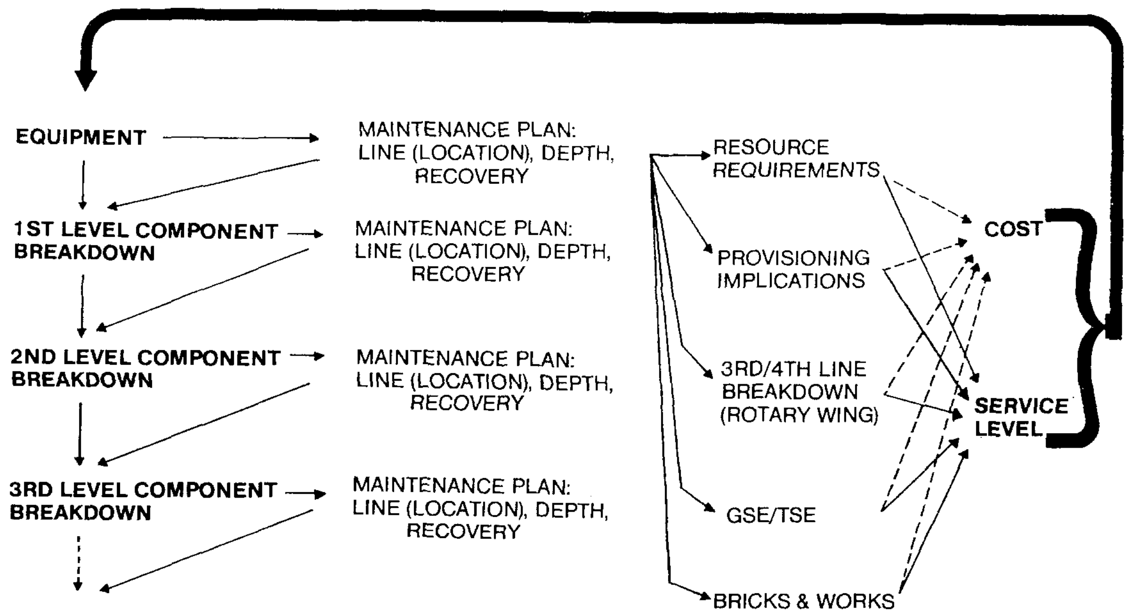

FIG. 3—CLOSED LOOP: DETERMINATION OF MAINTENANCE POLICY

Towards a Better Solution

Given the basic problem and the shortcomings of existing procedures, work began on finding a better method of reaching repair policy decisions.

Methodology

The first step was to review existing methodology. A search of the published literature revealed surprisingly little; less surprisingly what there was mainly emanated from the United States. Discussions were held with specific areas of expertise in the MOD and elsewhere and theoretical approaches to the problem emerged. These were:

(*a*) Global optimization

(*b*) Local optimization

(*c*) Heuristic

(*d*) Artificial Intelligence

Optimization can be likened to trying to find the top of a mountain in thick cloud as in FIG. 4. Global optimization will find point A, the true summit. Local optimization may arrive at either A, B, or C and will depend on the start point, X or Y. A heuristic approach is not strictly optimization but rather the application of a set of rules derived from experience or empirical evidence to produce an acceptable result. Artificial Intelligence is included for theoretical completeness but its evolution has yet to proceed to a stage where it could tackle a problem of the scale of repair policy analysis in a practical manner.

The advantages and disadvantages of the other three approaches are briefly:

(*a*) Global optimization is satisfactory for small problems, otherwise data and computation needs grow very rapidly.

(*b*) Local optimization can handle large problems but it may miss the best solution; nor will it be known how far from the optimum is the solution offered.

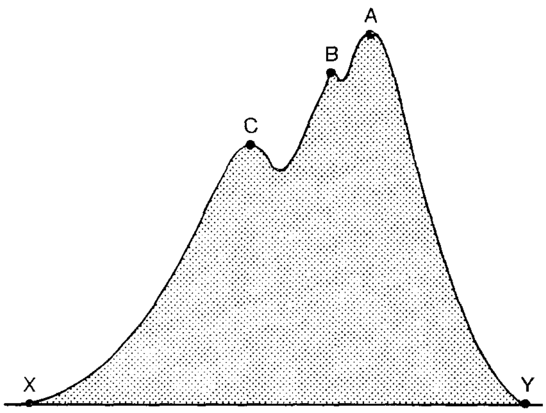

FIG. 4—OPTIMIZATION OF DECISION-MAKING
A: GLOBAL OPTIMIZATION
B,C: LOCAL OPTIMIZATION
X,Y: ALTERNATIVE START POINTS

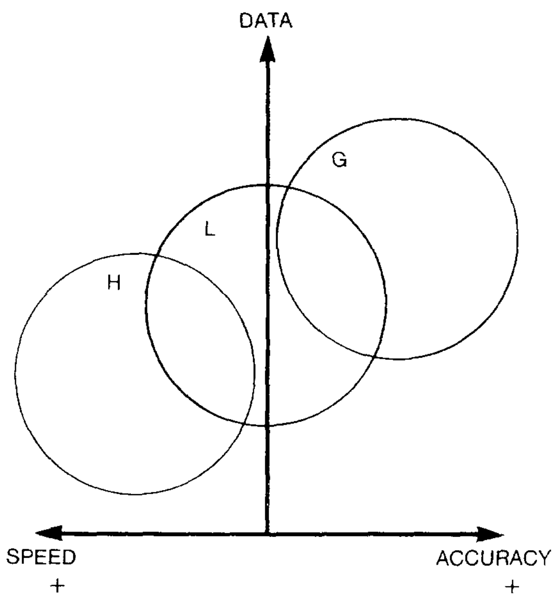

FIG. 5—OPTIMIZATION OF DECISION-MAKING
H: HEURISTIC
L: LOCAL
G: GLOBAL

(*c*) Heuristic approaches give quick results and need the least data and computation, they are good for comparative studies, i.e. 'what if' questions. However there is no guarantee of finding the best solution and the relevance of the inbuilt rules may change with time.

The broad comparison of data requirements, accuracy and speed implied by the three techniques is illustrated in FIG. 5.

Current Systems

The Americans have attempted to solve the 'support the design' dilemma by the use of the concept of Integrated Logistic Support (ILS) and defining the procedures of Logistic Support Analysis (LSA) in Mil. Std. 1388. LSA documents in great detail the processes of support definition, and its outputs are fed back to influence the equipment design in order to improve supportability.

One of the fundamentals of Mil. Std. 1388 is that not every task needs to be completed in every case. One can thus be selective depending on the type and complexity of the equipment being evaluated. Nevertheless one of the key elements is what is termed Level of Repair Analysis (LORA). LORA contributes both to the trade-off stage of LSA, when alternative support strategies are being considered, and to task analysis, where resources required by the chosen option are defined in detail. LORA assumes that all genuine failures are repaired by replacing the defective item and then determines the most economic location for that repair to take place. In the United States each of the armed services have produced their own decision support aid in the form of a LORA model. Thus the U.S. Army has an Optimum Supply and Maintenance Model (OSAMM), the U.S.A.F. employs Network Repair Level Analysis (NRLA) and the U.S.N. has a number of models based on Mil. Std. 1390B. In the U.K. the Royal Air force has developed a model at the Central Servicing Development Establishment, Swanton Morley, known as RPA84. This essentially performs a similar task by enumerating the cheapest support option for an equipment by considering the costs of up to 133 different repair policies.

Model Limitations

All the existing models have limitations. In order to make the problem tractable the numbers of lines of servicing are restricted, typically to two or three, and the indenture depth is also normally confined to the equipment, main units and modules. Other limitations are:

- The failures are usually assumed to arise randomly and are thus represented by a poisson or compound poisson distribution. One model, the so called 'Gas Turbine Model' from the U.S.N. Air Systems Command uses a Weibull distribution and so can include wear-out or ageing processes.
- Resources such as items of test equipment are not always treated as discrete, indivisible items placed at a specific location.
- Not all models allow a choice of optimizing to the least cost or to the best service/availability level for a given cost.
- Supply and return times are usually averaged and may not well represent a naval situation of wide geographical dispersion and so a broad spread of actual times.
- Only one model, OSAMM, appears to allow overflow of repair to the next repair level if capacity is exhausted at a higher echelon.
- Differentiation of repair capability between locations at the same basic line of service is not usually considered, e.g. one might have slightly different depths at a shore Naval Air Station compared to a CVSA, although both have a second line capability.

• One of the main cost drivers when weighing up repair policy is the implied cost of spares. Ideally the model should optimize the distribution of spares within a complete equipment in order to maximize availability within a given cost. However this leads on to a whole further class of specialist aids known as Stockage Models. Only OSAMM amongst the LORA/RPA models attempts this level of sophistication, the others all assess the spares cost with a variety of simplifying assumptions.

• The actual optimization process varies significantly. Most models merely evaluate all the repair options according to set rules and rank the results. NRLA constructs a network model and optimizes by finding the conditions to give the maximum flow rate through the model. OSAMM uses a Multiple Integer Programming software suite and General Lagrangian analysis. Not surprisingly OSAMM needs a significant size of mainframe computer.

The Way Ahead

From the investigations conducted it is apparent that there is as yet no model that ideally suits the Fleet Air Arm's requirements. However it is also clear that present analysis techniques and available computing power make the production of such a model feasible, albeit it would represent a sizeable investment. At the same time a Repair Policy Analysis aid is urgently needed to improve the quality of decision making as the Fleet Air Arm embarks on the major update of all its front line aircraft and begins the introduction process for the Merlin (EH 101). It is fortuitous that all three services are reviewing their methods of determining support policy and a form of Integrated Logistic Support is likely to be the way forward. This in turn will lead to the devolution of much of the support analysis process to industry. If this is to be the case, then the way in which industry conducts Repair Analysis will need to be structured and auditable. The time therefore seems opportune to begin to evolve a joint service approach to the production of a Repair Policy Analysis Aid and its steady evolution as policies and techniques are refined.

The choices for how to staff and procure such a system are not straightforward. What is needed is a team who will develop an initial standard of decision aid and then carry forward its development as experience and capability grow and the user's requirement evolves. There are probably five options:

- An internal MOD team
- A Defence equipment contractor
- A contracted consultancy
- A retained consultancy
- A university department

The key factor is finding the best method to attract and then retain the necessary quality of staff. Whichever route is chosen the production of the software is unlikely to be quick.

Therefore the Fleet Air Arm is looking for an interim solution. A relatively inexpensive, commercially available software package, which will run on a PC, is being evaluated to see if this could provide a viable, even if limited, model. Hopefully this will prove satisfactory and as well as focussing attention on the need to obtain proper data and so make more numerate decisions, it will also allow valuable experience to be gained. This in turn will permit the better definition of the long-term solution. Although this model may have some limited stockage analysis capability it will probably be more effective to utilize a specialist model for any in-depth assessment. A likely solution is a model called OPUS produced by Systecon AB of Sweden. This is a flexible multi-echelon, multi-indenture, analysis tool already in use at a number of locations in the U.K.

The best model in the world would be useless unless fed by accessible, reliable data. Similar data are needed in order to support decision making at all levels of the organization; therefore as part of its activities the Aircraft Support Project sponsored a major Information Technology (IT) Strategy Study. This has resulted in an agreed, coherent programme for the evolution of IT systems throughout the Fleet Air Arm.

Conclusions

The present methods employed by the Fleet Air Arm are not a satisfactory means of determining repair policy and are unlikely to lead to the most cost-effective solution; meanwhile the support bill climbs inexorably upwards. If an adequate rate of new procurement is to be sustained, then every effort must be made to arrive at cost-effective support policies and to ensure that these policies remain relevant throughout an equipment's life cycle. Whilst Repair Policy Analysis is a complex problem its determination can be aided by the sensible use of modelling and the evolution of computer power and analytical techniques will steadily improve the efficacy of these aids. The Fleet Air Arm does not have the resources, nor would it be sensible, to sponsor the development of a decision aid solely for its own purposes, but it intends to gain experience with an existing model and then to seek wider support to develop an system capable of tackling a wide spectrum of defence equipment support problems.

Finally it must be emphasized that models of the type discussed do not replace human judgement and experience; they are useful aids to faster, better informed decision making but must be applied intelligently and their limitations well understood by their users.

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