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RELIABILITY OF COMMERCIAL HELICOPTERS

W. B. Petrie

Bristow Helicopters Limited,
Redhill, England.

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THE UNIVERSITY, BRISTOL, BS8 1HR, ENGLAND.

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Synopsis

This lecture highlights the problems of reliability of the helicopter and its component parts as seen by the commercial operator. It does not present any statistical analysis or provide failure rates as these are invariably available from the manufacturer who spends too much time on producing statistics and not enough on reliability programmes.

It offers the manufacturer aspects of reliability from an operational and cost, rather than technical or statistical, point of view.

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Definitions

i) Reliability

The characteristic of a unit (from a complete aircraft to a minor component) which will enable it to perform a specified range of functions within specified limits under specified conditions for a specified period of time.

ii) Defect

Any primary malfunction in a system, sub-system or component which requires correct action tc restore its designed functions.

iii) Failure

The inability of a component to perform the task for which it was designed for reasons attributable to design, manufacture, maintenance or environment.

Manufacturers tend to define a failure as any defect which causes a delayed departure or aborted flight. This goes without saying but the operator adds the financial penalty of the repair costs which directly affect his direct operating costs plus the additional requirement for spare components to be held.

iv) Direct Operating Costs

The cost per flying hour of an aircraft which include repair and overhaul costs of the airframe, engines, avionics, mechanical, hydraulic and electrical components plus fuel and oil. It excludes cost depreciation, insurance and crew costs.

Reliability will therefore directly affect the DOC of an aircraft.

RELIABILITY OF COMMERCIAL HELICOPTERS

Since the introduction of the commercial helicopter the operator has relied on the military to set the reliability standards which had to be achieved by the manufacturers. This has not proved to be adequate for the commercial operator whose task in the main is a very different one from the military task. Also the manufacturer is now discovering that the commercial jam he used to put on his military bread and butter is now becoming his bread and butter. Commercial contracts are now being negotiated between operators and manufacturers which will require written guarantees including reliability.

Unfortunately research in our two learned bodies, the Royal Aeronautical Society and the Institute of Mechanical Engineers shows very little has been written on the subject of reliability, particularly in the commercial field.

My definitions above are obviously open to discussion but they serve as a good guide to the commercial view of reliability. What then becomes obvious is that the reliability of the whole equals the lowest reliability of any system or component therefore in many cases the considerable amount of money which is spent on improving reliability of engines, gearboxes and other major components is invalidated when the aircraft develops a record of unreliability due to constant failures of minor items.

It is agreed that the reliability being built into the major components will be cost effective through meeting targeted T.B.Os. with obvious life development being available which will help to reduce the DOCs for the aircraft. It must also be considered that if every major component is removed in a serviceable condition at its TBO then the TBO is too low. Life extension programmes must then be instituted to determine the life limiting component in the assembly, this must be carried out in strictly controlled conditions in conjunction with manufacturers and airworthiness authorities. As early as possible it must be established if the life limiting component is due to safety or cost. This development phase (which may last for the life of the aircraft) will require very close co-operation with the manufacturer and the Airworthiness Authority. This co-operation is not always as good as the operator wishes as all manufacturers, and I repeat all manufacturers, are notorious for their lack of frankness. This is not improving with the current increase in litigation problems.

Reliability must be considered together with condition monitoring for life development. All large operators will operate a reliability programme, but may not call it this ! The management of this programme will generate the conditions and rules for the programme. The programme will have to fully document all the requirements as this document will become the focal point of further development to give adequate reliability. The manufacturer of a helicopter or the component, the operator and the Airworthiness Authority concerned must work very closely to decide further life extensions and what corrective action has to be taken.

This reliability programme will rely on continuous routine assessment of system malfunctions, component defects, removal and failure rate trends. It will obviously identify rapidly any flying hour or age bands which are relevant.

In flight occurrences will be recorded in the Technical Log by the aircrew but it is essential that engineering staff involved in the programme extract and record from the Technical Log as well as from all defect reports all occurrences and cross reference two alternative systems where necessary.

Obviously before any reliability programme is instituted two basic questions must be answered :-

1. Will a failure or partial failure affect safety ?

2. Will a failure have an adverse economic effect ?

Most helicopter companies delay too long their requirement to review their maintenance programme in respect of reliability, and will then invariably find that they are so preoccupied with day to day problems that essential progressive work in the areas of system monitoring and reliability are receiving little,if any,priority. Where statistics are kept figures are often produced mainly by the manufacturer to show good mechanical despatch reliability, however, in the role of the helicopter with very short flight times and multiple sectors, any mechanical delay will cause a series of late departures. An excellent mechanical delay rate of only 97% will mean a delay rate of 15% if four further flight delays are incurred as a result of the original one mechanical delay.

The reliability of minor rotable components and accessories is the largest single factor in the overall despatch reliability of an aircraft, remember as I said before the reliability of the aircraft equals the lowest reliability of any component or system fitted.

All the above statements apply equally to fixed wing aircraft and helicopters. The helicopter is a much more complex reliability problem due to :-

1) The designers inability to build in alternative structural load paths or redundant systems in the case of rotor blades, dynamic structures and transmissions.

2) The high vibration levels at which the helicopter is required to operate.

3) The intolerant environment in which the helicopter spends most of its life such as heat, cold, sand and salt, etc.

In the case of (1) above the concept of reliability must be based on the premise that if the probability of failure is high the consequence must be minor, therefore conversely, if the consequence is catastrophic the probability must be minute. All reliability trials and life extensions programmes must proceed accordingly.

Redundancy in rotor systems is impossible therefore in our view manufacturers must do very much more to ensure the reliability in this area. Composite rotor blades may go a long way in this area, but the total experience on them is still low. New technology is going into dynamic structures with apparent success, however, inattention to design detail recently caused a catastrophic accident to a new technology helicopter.

Redundancy in transmissions is unthinkable, however, a recent paper presented at the Royal Aeronautical Society commented that if the current designs represent the ultimate in reliability, serious consideration must be given to such drastic and penalizing solutions. In flight monitoring systems of transmissions must tell the crew what is actually happening within the transmission. At present the chip detector light tells the crew

a) An electrical connection has chafed and is shorting.

b) A minute piece of locking wire was left in the transmission at the last overhaul and has now found its way to the magnetic plug.

c) Gear scuffing is taking place, or a bearing is spalling which presents no hazard and is only of economic significance.

d) The main rotor mast thrust bearing has failed, balls are fracturing and the upper thrust race is breaking up, the mast and rotor head are about to depart from the helicopter.

From a single red light on the instrument panel the pilot has to make a decision. All the above experiences have been met, fortunately No.4 only once, however, 1, 2 and 3 are very regular occurrences within transmissions, therefore to give the crew confidence in the reliability of the transmission they must either be given good information or no information.

In the case of (2) above, the high vibration levels probably lead to the highest nuisance value in delayed departures through the unreliability of instruments, relays, transducers, avionic equipment, etc. Every new type of helicopter entering commercial service suffers severely from these failures. Standard aircraft items are bought virtually off the shelf and obviously given inadequate environmental testing to prove their suitability in a helicopter. This is always evident by the excessive failure rate which is developed out by modification action in the main by the component manufacturers at the operators requirement and cost. Helicopter manufacturers are renowned for standing back and ignoring any responsibility in the area of minor components. The operator has already had to spend more money than he budgeted by purchasing excessive numbers of spares to prevent his aircraft being grounded through the unreliability of these components, and he also has in addition the rectification costs of the failed items, all of which again go to affect the DOCs of that particular aircraft. All the above comments also apply to simple items such as engine mounts, control rods, bearings, etc. and this problem is usually exacerbated by the manufacturers inability to meet the demand as all the operators are affected by the same problem at the same time. I would repeat that the introduction of every new type of helicopter has involved these reliability problems. The comparison is interesting whereas we have had the problems noted above on every new type that we have introduced into our Company, but not to the small turbine fixed wing aircraft (we currently operate 20 types of helicopter and 7 types of fixed wing).

In the case of (3) above, the vibration environment has been discussed, however, the operating environment will greatly affect the reliability. It took several years of pressure from the operators to persuade some manufacturers to delete magnesium where possible on their structures for helicopters working to offshore oil platforms, or even based offshore. Continuous withdrawal of an aircraft for anti-corrosive repair makes it just as unreliable as one which suffers continuous mechanical defects. A helicopter which has to be withdrawn from service after flying in heavy rain to replace rotor blade protection is unreliable, the helicopter which has to be withdrawn for rotor blade replacement due to sand erosion is unreliable, the helicopter which has to be withdrawn for engine changes because of sulphidation due to continuous operation in very hot ambient temperatures with an engine that is intolerant to sulphidation is unreliable, even if the engine did achieve superb reliability in fixed wings in the cold, clean air of 20,000 ft. plus. The helicopter which has to be withdrawn due to engine ice damage or inflight shutdown due to wet snow ingestion is also unreliable.

When the above environmental effects of heat, humidity and sand are added to the vibration problems of minor rotables previously discussed, the reliability rate can be appalling.

I would like to conclude by taking an extract from a paper I presented to the Royal Aeronautical Society a few years ago which was based on my personal view which I try to include in any lecture or in any discussions with manufacturers which is "design for maintenance and reliability". This has been preached by my Company over the years but has in the main fallen on deaf ears because the military stranglehold on the manufacturers has been too strong, however, with the wind of change and the number of commercial helicopters now becoming significant, the manufacturers are having to listen to the commercial operator's requirements. Too many manufacturers have designed on the principle that engines and other major components will be "fitted and forgotten" until they reach their TBO. They also used the same philosophy for all minor items and were reluctant to become involved in reliability trials. We as operators know otherwise. The American maintenance and reliability parameters set up for the UTTAS project show that the American military at least have learned and it is essential that all manufacturers from now on, not only design for performance, but for maintainability and reliability.

As commercial operators what do we require for our future aircraft? The obvious answer is performance, sensible economics and from the engineering point of view, reliability with maintainability. So far we have had designs with emphasis on performance to the degradation of maintenance and reliability. It is important that all manufacturers realise that the most sophisticated aircraft with the most superb performance is of no use when in the hangar.

What we require, not in any order of priority, basically is :-

(a) Composite rotor blades which are erosion and corrosion resistant, the former for cost, the latter for safety, and both for total reliability.

(b) Cockpit indications of blade integrity and disc loading.

(c) Bifilar or nodular construction for vibration absorption but it must have built in vibration analysis to identify unacceptable vibrations which are masked by the vibration absorption system. Otherwise all components which are not in the vibration absorption system will continue to degrade through high vibration levels. It is also necessary to have a plug in vibration analyzer system for smaller aircraft as the capital cost of some vibration equipment will be too high to include in the small aircraft operation and all operators are not in the large twin engine business nor do they have unlimited funds available.

(d) Built in emergency lubrication systems are essential to any transmission areas that will not allow flight to continue without lubrication.

(e) Redundant hydraulic and electrical systems will have to be incorporated.

(f) All electrical equipment must be installed in environmentally controlled areas of the aircraft.

(g) The aircraft must have the ability to carry out in flight tracking and balancing.

(h) One grease and one oil to lubricate all systems will do very much towards improving reliability as it will eliminate errors that are made by the operator who very often has to use indigenous staff for this task.

(i) A reliable debris monitoring system for each transmission which adequately identifies the problem must be fitted in each aircraft, and must give the pilot adequate information.

(j) A reliable fire warning system which will take into account the vibrations that will be encountered over many thousands of hours of helicopter use.

(k) Built in particle separators for the engines with anti-ice protection, engine desalination and power recovery washing equipment which is readily adaptable to major changes of climatic conditions. The incorporation of these items will go a long way towards improving engine reliability on the helicopter.

(l) Module replacements of engines and main transmissions in the field with field decontamination procedures in case of bearing failure, etc. which has caused metal contamination.

(m) Little engine sophistication with good fuel specifics.

(n) Simple fuel control units, preferably fuel operated as it is obviously much easier to filter fuel than air in the environment in which the helicopter operates, and the fuel control unit is a notoriously unreliable area of all helicopter engines.

(o) Engine and transmissions should have minimal external oil lines to prevent leaks occurring in service which again can make an aircraft unreliable through very minor seal failures, etc.

(p) Visible evidence of fuel and oilfilter blockage or bypass should be provided with a caution being indicated showing that any further contamination will give a no-go indication.

(q) High cyclic lives must be built into all rotating components with a cycle counter on engines which will take into account part cycles.

(r) Tolerance of today's fuel problems which include high aromatic content leading to nozzle and blade erosion. Engines must also have high resistance to sulphidation which is very common in the helicopter environment particularly operating in the areas of gas burn off flares as sulphur reduction in crude oil is invariably carried out at a very early stage in the process, and the helicopters can spend very many hours flying in this sulphur polluted atmosphere.

Conclusion

I have refrained from presenting a mass of statistics and graphs but have attempted to identify that there is a problem of communication between the manufacturers and the operators which must be resolved. Manufacturers are invariably surprised at the problems presented by the operator, and often even more surprised at the solutions suggested by him. There have been many cases where the manufacturer has launched into a very expensive reliability improvement programme (which is paid for in the end by the operators) without the operators knowledge, when he would possibly have preferred to continue to live with a high failure rate component as he has already purchased enough spares to contain this problem.

I would ask all manufacturers to work much more closely with the commercial operator to ascertain their requirements and problems, with particular reference to reliability as it is felt by the operator that there is too little correlation between technical and commercial specifications, they should in fact be complimentary programmes. Often there is no true commercial specification and the commercial attitude is usually to get the technical specification at the lowest possible price. This is when the operator is faced with reliability problems. Any technical specification should also have a clear reliability objective without the necessity of test programmes over long periods, which is usually concluded in service by the operator at some considerable cost. The component manufacturer, and this includes engines, must remember that he has two customers, the helicopter manufacturer and the ultimate operator. Both customers should co-operate in defining this specification, but this is obviously commercially difficult.

Future component and system designs should have a joint technical and commercial specification to ensure that function and reliability objectives are clearly defined and met.

References

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