CAD 418

Condition Monitored Maintenance : an Explanatory Handbook

Hong Kong Civil Aviation Department

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Hong Kong Civil Aviation Department

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FOREWORD

This publication is intended to provide general information on the concepts and practices of aircraft maintenance control by the use of Condition Monitored Maintenance Programmes. The explanations and examples given are not exhaustive, but are considered sufficient to provide complementary material to facilitate compliance with the requirements for these programmes which are prescribed in Hong Kong Aviation Requirements Section 1, sub-section 1.6-2.

In addition to describing the formation and functions of these programmes, the relationships between the traditional maintenance processes and Condition Monitored Maintenance are discussed.

Defined terms and proper nouns are indicated in the text by the use of initial capital letters (e.g. "On-Condition", "Hard Time"). Terms used are, in the main, as defined in the "World Airlines Technical Operations Glossary (WATOG)". For ease of reference defined terms and abbreviations are grouped at the back of the publication, in Appendix E.

So that the publication may serve a dual purpose and be of use in training schools and colleges as well as in industry, the level of exposition is aimed at being intelligible to persons without specialized knowledge.

The information given is correct at the time of issue of this document, but amendments to the Hong Kong Aviation Requirements may subsequently vary the information.

Note : 'Director' means the Director-General of Civil Aviation who is authorised for the purpose under the Air Navigation (Hong Kong) Order and includes any person who is delegated for that purpose.

APPLICATIONS AND ENQUIRIES

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The Civil Aviation Department Headquarters,
Airworthiness Office,
1 Tung Fai Road,
Hong Kong International Airport,
Lantau, Hong Kong.

REFERENCE DOCUMENT

Current Hong Kong Aviation Requirements - 1 (HKAR-1)

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1 INTRODUCTION

1.1 "Airworthiness" which, for the purposes of this publication, is defined as "the continuing capability of the aircraft to perform in a satisfactory manner the flight operations for which it was designed", is based on the expectation that flight operations will be performed with acceptable reliability in respect of flight crew work load; flight handling characteristics; flight performance/envelope availability; safety margins; welfare of occupants; punctuality; economics.

1.2 Time has not changed the objectives of airworthiness. What has changed is the size, complexity and increased performance of aircraft, together with improved design techniques and a more knowledgeable approach to the control of maintenance. Confidence in continued airworthiness has long been based on the traditional method of maintaining safety margins by the prescription of fixed component lives and by aircraft 'strip-down' policies. The call for changes to the basic philosophy of aircraft maintenance has been greatly influenced by the present day economic state of the industry as well as by changes in aircraft design philosophy allied to progress in engineering technology. These changes have, in turn, resulted in the necessity for the management and control of expensive engineering activities to take a new and more effective form.

1.3 It is from this background that a maintenance process known as Condition Monitoring* has evolved. It is necessary to attempt to correct a misunderstanding which has arisen about the term Condition Monitoring. Condition Monitoring is not a separate activity but a complete process which cannot be separated from the complete maintenance programme. It is not just an identification of a single maintenance action but is a basic maintenance philosophy.

1.4 Maximum use can be made of the Condition Monitoring process which includes a statistical reliability element (see 3.3), when it is applied to aircraft meeting the following criteria.

(a) Modern, multi-engined, Transport Category aircraft which incorporate in their design safeguards against the complete loss of the function which a system is intended to perform.

NOTE: These safeguards are provided by the provision of either Active Redundancy* or Standby Redundancy*. In simple terms the safeguards take the form of more than one means of accomplishing a given function. Systems (or functions within systems) beyond those necessary for immediate requirements are installed. These are so designed that with an Active Redundancy philosophy all the redundant Items* are operating simultaneously and, in simple terms, sharing the load to meet the demand. Thus in the event of failure of one of the redundant Items, the demand will continue to be met by the remaining

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*See Appendix E for definitions

serviceable redundant Items; this process continues up to the extent of the Redundancy* provided. The extent of the Redundancy provided, within practical limits, is related to the consequences of complete loss of the system function. (The term 'multiplicity of system function' is sometimes used in this context). With a Standby Redundancy philosophy only one redundant system is functioning at a time. If a function loss occurs, it is necessary to select (or activate) the functions provided by the 'standby' system(s). The principle is the same as for Active Redundancy and the term 'system redundancy' is sometimes used in this context.

(b) Aircraft for which the initial scheduled maintenance programme has been specified by a Maintenance Review Board† and to which a Maintenance Steering Group Logic Analysis‡ has been applied.

NOTES : (1) Examples of this class of aircraft are the Boeing 747, Lockheed L1011, Douglas DC10 and Concorde.

(2) For an aircraft type introduced into service by Maintenance Review Board and Maintenance Steering Group procedures and where Condition Monitoring tasks are prescribed, a Condition Monitored Maintenance Programme (the Programme) will have to be established, even for a single aircraft.

1.5 For aircraft not covered by the criteria of 1.4, the statistical reliability element of Condition Monitoring may, nevertheless, be applied for the purpose of monitoring system or component performance (but not be prescribed in the Maintenance Schedule as a primary maintenance process).

NOTE: For a statistical reliability element of a programme to be effectively used, a fleet minimum of five aircraft is normally necessary, but this can vary dependent upon the aircraft type and utilization. To date, in Hong Kong, reliability elements of these Programmes have not been applied to rotorcraft, although there is no fundamental reason why they should not.

2 PRIMARY MAINTENANCE

2.1 The Hong Kong Civil Aviation Department (CAD) recognizes three primary maintenance processes. They are Hard Time*, On-Condition* and Condition

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*See Appendix E for definitions.

†See Appendix A.

‡See Appendix A. Should fuller details of the Maintenance Steering Group process in respect of a specific aircraft be required, they would have to be obtained from the regulatory authority responsible for the initial certification of that aircraft.

Monitoring. In general terms, Hard Time and On-Condition both involve actions directly concerned with preventing failure, whereas Condition Monitoring does not. However the Condition Monitoring process is such that any need for subsequent preventative actions would be generated from the process.

2.2 **The Processes**

2.2.1 **Hard Time**

This is a preventative process in which known deterioration of an Item is limited to an acceptable level by the maintenance actions which are carried out at periods related to time in service (e.g. calendar time, number of cycles, number of landings). The prescribed actions normally include Servicing* and such other actions as Overhaul*, Partial Overhaul*, replacement (Replace in WATOG*) in accordance with instructions in the relevant manuals, so that the Item concerned (e.g. system, component, portion of structure) is either replaced or restored to such a condition that it can be released for service for a further specified period.

2.2.2 **On Condition**

This also is a preventative process but one in which the Item is inspected or tested, at specified periods, to an appropriate standard in order to determine whether it can continue in service (such an inspection or test may reveal a need for Servicing actions). The fundamental purpose of On-Condition is to remove an Item before its failure in service. It is not a philosophy of 'fit until failure' or 'fit and forget it'.

2.2.3 **Condition Monitoring**

This is not a preventative process, having neither Hard Time nor On-Condition elements, but one in which information on Items gained from operational experience is collected, analysed and interpreted on a continuing basis as a means of implementing corrective procedures.

2.3 Where a Maintenance Steering Group Logic Analysis has not been applied to a particular aircraft to establish and allocate the primary maintenance processes for each Item, the considerations of (a),(b) and (c) will be applied separately to all Items to determine the acceptability of the primary maintenance process.

(a) **Hard Time**

(i) Where the failure of the Item has a direct adverse effect on airworthiness and where evidence indicates that the Item is subject to wear or deterioration.

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*See Appendix E for definitions.

(ii) Where there is a 'hidden function' which cannot be checked with the Item in-situ.

(iii) Where wear or deterioration exists to such an extent as to make a time limit economically desirable.

(iv) Where component condition or 'life' progression sampling is practised.

(v) Where limitations are prescribed in a Manufacturer's Warranty.

(b) **On-Condition**

Where an inspection, or test of an Item to a prescribed standard (frequently in-situ) will determine the extent of deterioration, and hence the 'condition', i.e. any reduction in failure resistance.

(c) **Condition Monitoring**

Where a failure of an Item does not have a direct adverse effect on operating safety, and where (a) and (b) are not prescribed and no adverse age reliability relationship has been identified as the result of analysis of the data arising from a formalized monitoring procedure or programme.

3 CONDITION MONITORED MAINTENANCE

3.1 Introduction

Condition Monitored Maintenance, as a programme, is the formalized application of the maintenance processes Hard Time, On-Condition and Condition Monitoring to specific Items as prescribed in the Approved Maintenance Schedule. The controlling activity of Condition Monitored Maintenance is Condition Monitoring irrespective of whether Condition Monitoring is prescribed as a primary maintenance process in the Approved Maintenance Schedule or not. Condition Monitoring is repetitive and continuous, the key factor in its use being the introduction of aircraft embodying failure tolerant designs, which allow for replacement of some traditional failure preventative maintenance techniques by non-preventative techniques. Condition Monitoring is not a relaxation of maintenance standards or of airworthiness control; it is, in fact, more demanding of both management and engineering capabilities than the traditional preventative maintenance approaches. Each Condition Monitored Maintenance Programme is required to be approved by the Director.

3.2 Maintenance Activities

3.2.1 There are three types of maintenance activity.

(a) Maintenance applied at specified periods of time regardless of condition at that time. The maintenance activity may be a periodic overhaul, a bearing change, re-work, repaint, calibration, lubrication, etc. These result from Hard Time requirements.

(b) Periodic examinations, mostly at specified periods of time, but sometimes on an opportunity basis (e.g. when an item is removed for access) to determine not only the extent of deterioration but also that the deterioration is within specified limits. These result from On-Condition requirements.

(c) Actions applied in response to the analysis of condition clues produced by monitoring in-flight, hangar, workshop and other types of condition information sources. These result from Condition Monitoring requirements.

3.2.2 Condition Monitoring uses data on failures as items of 'condition' information which are evaluated to establish a necessity for the production or variation of Hard Time and On-Condition requirements, or for other corrective actions to be prescribed. Failure rates and effects are analysed to establish the need for corrective actions. Condition Monitoring can be used in its own right to identify the effects of deterioration, in order that steps may be taken to maintain the level of reliability inherent in the design of the Item. Although Condition Monitoring accepts that failures will occur, it is necessary to be selective in its application. The acceptance of failures may be governed by the relative unimportance of the function, or by the fact that the function is safeguarded by system Redundancy.

3.2.3 Maintenance of a particular Item could well be some combination of the three primary maintenance processes (Hard Time, On-Condition and Condition Monitoring). There is no hierarchy of the three processes; they are applied to the various Items according to need and feasibility. Maintenance Schedules which are based on the Maintenance Steering Group principles will have Hard Time, On-Condition, or Condition Monitoring specified as the primary maintenance process for specific systems and sub-systems as well as for individual Maintenance Significant Items.* Condition Monitoring can, therefore, be the primary maintenance process prescribed for an Item, in which case it has also to be used for controlling the availability of those functions which are not directly controlled by a prescribed On-Condition or Hard Time process; this control is provided by the statistical reliability element of Condition Monitored Maintenance. Items for which Hard Time and On-Condition are prescribed may, however, have the statistical reliability element of Condition Monitored Maintenance applied, not as a primary maintenance process, but as a form of Quality Surveillance.*

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*See Appendix E for definitions.

3.3 Statistical Reliability Element

3.3.1 The assessment of defect/removal/failure rate trend, of age bands at which items fail, or the probability of survival to a given life are, in most cases, used to measure the effect or suitability of the primary maintenance processes applied to Items. The assessment is made by examination of rates of occurrence of events such as in-flight defects, incidents, delays, use of Redundancy capability, engine unscheduled shut-downs, air turn-backs, etc., which are reported in accordance with the procedure associated with the reliability element of Condition Monitored Maintenance.

3.3.2 A practical statistical reliability element does not need to be complicated or costly to establish or to operate. Some Operators are reluctant to adopt such a practice because they are without computer facilities. Although a computer may be an advantage, particularly for data retrieval, it is far from essential, especially so for the smaller operator.

3.3.3 If the mystery of numbers and the various theories of probability are discounted, a statistical reliability programme, as an element of Condition Monitoring, is, in practical terms, the continuous monitoring, recording and analysing of the functioning and condition of aircraft components and systems. The results are then measured or compared against established normal behaviour levels so that the need for corrective action may be assessed and, where necessary, taken.

3.4 The Condition Monitored Maintenance Programme

3.4.1 A maintenance programme which provides for the application of Hard Time, On-Condition and Condition Monitoring is known as a Condition Monitored Maintenance Programme. A Programme has two basic functions. Firstly, by means of the statistical reliability element, to provide a summary of aircraft fleet reliability and thus reflect the effectiveness of the way in which maintenance is being done. Secondly, to provide significant and timely technical information by which improvement of reliability may be achieved through changes to the Programme or to the practices for implementing it.

3.4.2 A properly managed Programme will contribute not only to continuing airworthiness, but also to improvement of fleet reliability, to better long term planning, and to reduced overall costs.

3.4.3 The fundamental factors of a successful Programme are the manner in which it is organised and the continuous monitoring of it by responsible personnel. Because of differences in the size and structure of the various airlines, the organisational side of any Programme is individual to each Operator. Hence, it is necessary to detail the organisation and responsibilities in the Programme control documentation.

3.5 Programme Control Committee

3.5.1 Every Programme is required to have a controlling body, (usually known as the Reliability Control Committee) which is responsible for the implementation, decision making and day-to-day running of the Programme. It is essential that the Reliability Control Committee should ensure that the Programme establishes not only close co-operation between all relevant departments and personnel within the Operator's own Organisation, but also liaison with other appropriate Organisations. Lines of communication are to be defined and fully understood by all concerned. A typical Organisation and Data Flow Chart is shown in Appendix B.

3.5.2 The Reliability Control Committee is responsible for, and will have full authority to take, the necessary actions to implement the objectives and processes defined in the Programme. It is normal for the Quality Manager or the Engineering Manager to head the Committee and to be responsible to the Director for the operation of the Programme.

3.5.3 The formation of the Committee and the titles of members will vary between Operators. The structure and detailed terms of reference of the Committee and its individual members will be fully set out in the documentation for each Programme. The Committee will usually comprise the Quality or Engineering Manager, the Reliability Engineer or Co-ordinator, the Chief Development Engineer, and the Chief Production Engineer.

3.5.4 The Committee should meet frequently to review the progress of the Programme and to discuss and, where necessary, resolve current problems. The Committee should also ascertain that appropriate action is being taken, not only in respect of normal running of the Programme, but also in respect of corrective actions.

3.5.5 Formal review meetings are held with the CAD at agreed intervals to assess the effectiveness of the Programme. An additional function of the formal review meeting is to consider the policy of, and any proposed changes to, the Programme.

3.6 Data Collection

3.6.1 Data (or more realistically, collected information) will vary in type according to the needs of each Programme. For example, those parts of the Programme based on data in respect of systems and sub-systems will utilize inputs from reports by pilots, reports on engine unscheduled shutdowns and also, perhaps, reports on mechanical delays and cancellations. Those parts of the Programme based on data in respect of components will generally rely upon inputs from reports on component unscheduled removals and on workshop reports. Some of the larger Programmes embrace both 'systems' and 'component' based data inputs in the fullest of detail.

3.6.2 The principle behind the data collection process is that the information to be collected has to be adequate to ensure that any adverse defect rate, trend, or apparent reduction in failure resistance, is quickly identified for specialized attention. Some aircraft systems will function acceptably after specific component or sub-system failures; reports on such failures in such systems will, nevertheless, act as a source of data which may be used as the basis of action either to prevent the recurrence of such failures, or to control the failure rates.

3.6.3 Typical sources of data are reports on delays, in-flight defects, authorized operations with known defects (i.e. equipment inoperative at a level compatible with the Minimum Equipment List*, flight incidents and accidents, air-turn-backs; the findings of line, hangar and workshop investigations. Other typical sources include reports resulting from On-Condition tasks and in-flight monitoring (Airborne Integrated Data Systems); Service Bulletins; other Operators' experience, etc. The choice of a source of data, and the processes for data collection, sifting and presentation (either as individual events or as rates of occurrence) should be such as to permit adequate condition assessment to be made relative both to the individual event and to any trend.

3.6.4 **Pilot Reports**

(a) Pilot Reports, more usually known as "Pireps", are reports of occurrences and malfunctions entered in the aircraft Technical Log by the flight crew for each flight. Pireps are one of the most significant sources of information, since they are a result of operational monitoring by the crew and are thus a direct indication of aircraft reliability as experienced by the flight crew.

(b) It is usual for the Technical Log entries to be routed to the Reliability Section (or Engineer/Co-ordinator) at the end of each day, or at some other agreed interval, whereupon each entry is extracted and recorded as a count against the appropriate system. Pireps are thus monitored on a continuous basis, and at the end of the prescribed reporting period are calculated to a set base as a reliability statistic for comparison with the established Alert Level (see 3.8) e.g. Pirep Rate per 1,000 hr, Number of Pireps per 100 departures, etc.

(c) Engine performance monitoring can also be covered by the Pirep process in a Programme. Flight crew monitoring of engine operating conditions is, in many Programmes, a source of data in the same way as reports on system malfunctions.

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*See Appendix E for definitions.

3.6.5 Engine Unscheduled Shut-downs

(a) These are flight crew reports of engine shut-downs and usually include details of the indications and symptoms prior to shut-down. When analysed, these reports provide an overall measure of propulsion system reliability, particularly when coupled with the investigations and records of engine unscheduled removals.

(b) As with Pireps, reports on engine unscheduled shut-downs are calculated to a set base and produced as a reliability statistic at the end of each reporting period. The causes of shut-downs are investigated on a continuing basis, and the findings are routed via the Reliability Section to the Power-plant Development Engineer.

3.6.6 Aircraft Mechanical Delays and Cancellations

(a) These are normally daily reports, made by the Operator's line maintenance staff, of delays and cancellations resulting from mechanical defects. Normally each report gives the cause of delay and clearly identifies the system or component in which the defect occurred. The details of any corrective action taken and the period of the delay are also included.

(b) The reports are monitored by the Reliability Section and are classified (usually in Air Transport Association of America, Specification 100 (ATA 100) Chapter sequence), recorded and passed to the appropriate engineering staffs for analysis. At prescribed periods, recorded delays and cancellations for each system are plotted, usually as events per 100 departures.

3.6.7 Component Unscheduled Removals and Confirmed Failures

At the end of the prescribed reporting period the unscheduled removals and/or confirmed failure rates for each component are calculated to a base of 1,000 hours flying, or, where relevant, to some other base related to component running hours, cycles, landings, etc.

NOTE: Reports on engine unscheduled removals, as with reports on engine performance monitoring, are also a source of data and are reported as part of the Programme.

(a) Component Unscheduled Removals

Every component unscheduled removal is reported to the section which monitors reliability (the 'Reliability Section') and will normally include the following information:-

(i) Identification of component.

(ii) Precise reason for removal.

(iii) Aircraft registration and component location.

(iv) Date and airframe hours/running hours/landings, etc. at removal.

(v) Component hours since new/repair/overhaul/calibration.

Completed reports are routed daily to the Reliability Section for recording and for continuous monitoring for significant trends and arisings. Components exhibiting abnormal behaviour patterns are brought to the attention of the engineering staff responsible, so that detailed investigations may be made and corrective action may be taken.

(b) **Component Confirmed Failures**

(i) With the exception of self-evident cases, each unscheduled removal report is followed up by a workshop report in which the reported malfunction or defect is confirmed or denied. The report is routed to the Reliability Section. Workshop reports may be compiled from an Operator's own 'in-house' findings and/or from details supplied by component repair/overhaul contractors.

(ii) Where an unscheduled removal is justified the workshop reports will normally include details of the cause of the malfunction or defect, the corrective action taken and, where relevant, a list of replacement items. Many Programmes utilize the same type of report to highlight structural and general aircraft defects found during routine maintenance checks.

3.6.8 **Miscellaneous Reports**

Dependent upon the formation of individual Programmes, a variety of additional reports may be produced on a routine or non-routine basis. Such reports could range from formal minutes of reliability meetings to reports on the sample stripping of components, and also include special reports which have been requested during the investigation of any item which has been highlighted by the Programme displays and reports.

3.7 **Statistical Reliability Measurement**

3.7.1 To assist in the assessment of reliability, Alert Levels are established for the Items which are to be controlled by the Programme. The most commonly used data and units of measurement (Pireps per 1,000 hours, Component Removals/Failures per 1,000 hours, Delays/Cancellations per

100 departures, etc.) have been mentioned under "Data Collection". Too much importance should not be placed upon the choice of units of measurement, provided that they are constant throughout the time the Programme runs and are appropriate to the type and frequency of the event. The choice of units of measurement will depend on the type of operation, the preference of the Operator and those required by the equipment manufacturer.

3.7.2 There are arguments for and against the choice of the various sources of data to be used in the Programme for the purpose of statistical reliability measurement. Are statistics derived from Pireps better than those derived from reports on Delays/Cancellations? Are the statistics derived from reports on Component Unscheduled Removals better than those from reports on Confirmed Failures?, and so on.

3.7.3 The value of Pireps can vary where flight crews within the fleet have differing standards of vigilance, or where differing standards occur in the abilities of engineering staff. Where reasonable uniformity of reporting is not present then the difference between the number of Component Unscheduled Removals and those which are confirmed as failures can result in reports being unrepresentative of true reliability.

3.7.4 Information collected over many years has been analysed and statistically tested, and the following statements may be accepted as valid.

(a) Pireps are an acceptable measure of aircraft reliability as experienced by the flight crew. If such data shows large variations for non-reliability related reasons (e.g. as a result of overzealousness or reluctance in reporting), then such variations, as with any apparent change in reliability, should be investigated under the normal procedures of the Programme.

(b) A programme using both Pireps and reports on Delays/Cancellations as data in respect of systems and sub-systems will give a better measure than one using only Pireps. An even better measure will be obtained from a Programme using Pireps as well as reports on Delays/Cancellations and on Component Unscheduled Removals/Failures.

(c) Data in respect of systems and sub-systems should be supported by data based on components, as in most cases system reliability cannot be divorced from component reliability.

(d) Component Unscheduled Removals follow a nearly identical pattern to Component Confirmed Failures and the two are, therefore, equally significant. (See also 3.7.5).

(e) The number of reports normally follows a 'seasonal' pattern and can be statistically unrealistic during periods of aircraft low utilization.

(f) Where there is a sufficiently large fleet, a Programme which automatically corrects the units of measurement on a continuing basis for variations in aircraft utilization will be statistically more accurate and less prone to false indications.

3.7.5 When considering data based on components, it is useful to note that where a Programme is introduced for an aircraft fleet for the first time and in the early 'settling in' period, the number of failures which are not confirmed after an unscheduled removal can be as high as 40% for all components taken together. For individual components this can range from 5% for landing gear and flying control components to 65% for some communications and avionic components; thus indicating the need for inclusion of data on both unscheduled removal and confirmed failure of components.

3.8 Reliability Alert Levels

3.8.1 A reliability alert level (or equivalent title, e.g. Performance Standard, Control Level, Reliability Index, Upper Limit) hereinafter referred to as an 'Alert Level', is purely an 'indicator' which when exceeded indicates that there has been an apparent deterioration in the normal behaviour pattern of the Item with which it is associated. When an Alert Level is exceeded the appropriate action has to be taken. It is important to realize that Alert Levels are not minimum acceptable airworthiness levels. When Alert Levels are based on a representative period of safe operation (during which failures may well have occurred) they may be considered as a form of protection against erosion of the design aims of the aircraft in terms of system function availability. In the case of a system designed to a multiple Redundancy philosophy it has been a common misunderstanding that, as Redundancy exists, an increase in failure rate can always be tolerated without corrective action being taken.

3.8.2 Alert Levels can range from 0.00 failure rate per 1,000 hours both for important components and, where failures in service have been extremely rare, to perhaps as many as 70 Pireps per 1,000 hours on a systems basis for ATA 100 Chapter 25 - Equipment/Furnishings, or for 20 removals of passenger entertainment units in a like period.

3.8.3 Establishing Alert Levels

(a) Alert Levels should, where possible, be based on the number of events which have occurred during a representative period of safe operation of the aircraft fleet. They should be updated periodically to reflect operating experience, product improvement, changes in procedures, etc.

(b) When establishing Alert Levels based on operating experience, the normal period of operation taken is between two and three years dependent on fleet size and utilization. The Alert Levels will usually be so calculated as to be appropriate to events recorded in one-monthly or three-monthly periods of operation. Large fleets will generate sufficient significant information much sooner than small fleets.

(c) Where there is insufficient operating experience, or when a programme for a new aircraft type is being established, the following approaches may be used.

(i) For a new aircraft type during the first two years of operation all malfunctions should be considered significant and should be investigated, and although Alert Levels may not be in use, Programme data will still be accumulated for future use.

(ii) For an established aircraft type with a new Operator, the experience of other Operators may be utilized until the new Operator has himself accumulated a sufficient period of his own experience. Alternatively, experience gained from operation of a similar aircraft model may be used.

(iii) A recent concept to be applied in setting Alert Levels for the latest aircraft designs, is to use computed values based on the degree of system and component in-service expected reliability assumed in the design of the aircraft. These computed values are normally quoted in terms of Mean Time Between Unscheduled Removal (MTBUR) or Mean Time Between Failure (MTBF) for both individual components and complete systems. Although these levels tend to be theoretical, they are, of course, based on a considerable amount of testing and environmental engineering and design analysis. Being purely initial predictions they should be replaced when sufficient in-service experience has been accumulated.

(d) There are several recognized methods of calculating Alert Levels, any one of which may be used provided that the method chosen is fully defined in the Operator's Programme documentation. It is not necessary for elaborate mathematical proofs or statistical methods to be explored in this publication; in fact neither is necessary for the operation of a Programme. The methods given herein as examples and many more, may be found in any standard test book on statistics.

(e) Typical acceptable procedures for establishing Alert Levels are described briefly in (i) to (iii), and some detailed examples of the methods of calculation are shown in Appendix C. It will be seen that the resultant Alert Levels can vary according to the method of calculation, but this need not necessarily be considered to be of significance.

(i) **Pilot Reports (Pireps).** For the following example calculations, a minimum of twelve-months' operating data has to be available, and the resultant Alert Level per 1,000 hours is :-

Calculation 1.
The three-monthly running average Pirep rate per 1,000 hours for each system (or sub-system), as in the Table of Example 1, is averaged over the sample operating period and is known as the Mean; the Mean is multiplied by 1.30 to produce the Alert Level for the given system. This is sometimes known as the '1.3 Mean' or '1.3$\bar{x}$' method.

Calculation 2.
The Mean, as in Calculation 1, plus 3 Standard Deviations of the Mean (as illustrated in Appendix C - Example 1).

Calculation 3.
The Mean, as in Calculation 1, plus the Standard Deviation of the 'Mean of the Means', plus 3 Standard Deviations of the Mean (as illustrated in Appendix C - Example 2).

(ii) **Component Unscheduled Removals.** For the following example calculations, a minimum period of seven quarters' (21 months') operating data has to be available, and the resultant Alert Level rate for the current quarter may be set in accordance with any one of the following.

Calculation 4.
The Mean of the individual quarterly Component Unscheduled Removal rates for the period of seven quarters, plus 2 Standard Deviations of the Mean.

Calculation 5.
The maximum acceptable number of 'Expected Component Unscheduled Removals' in a given quarter, as calculated using a statistical process in association with the Poison Distribution of Cumulative Probabilities (as illustrated in Appendix C - Example 3).

Calculation 6.
The Number of 'predicted Component Unscheduled Removals (or failures)' in a given quarter, as determined by the Weibull or other suitable statistical method.

(iii) **Component Confirmed Failures.** The period of operating experience has to be as in (ii) and the resultant Alert Level rate for the current quarter is the 'corrected' Mean of the individual quarterly Component Confirmed Failure rates for the period, plus 1 Standard Deviation of the Mean (as illustrated in Appendix C - Example 4).

3.9 **Re-calculation of Alert Levels**

(a) Both the method used for establishing an Alert Level, and the associated qualifying period, apply also when the level is re-calculated to reflect current operating experience. However if, during the period between re-calculation of an Alert Level, a significant change in the reliability of an Item is experienced which may be related to the introduction of a known action (e.g. modification, changes in maintenance or operating procedures) then the Alert Level applicable to the Item would be re-assessed and revised on the data subsequent to the change.

(b) All changes in Alert Levels are normally required to be approved by the Director and the procedures, periods and conditions for re-calculation are required to be defined in each Programme.

3.10 **Programme Information Displays and Reports**

3.10.1 **General**

As soon as possible after the end of each defined reporting period of a Programme, the Operator is required to produce graphical and/or tabular displays. These displays have to reflect the fleet operating experience for the period under review. The compilation and production of these displays from the day-to-day records has to be such that the essential information for each Item is in accordance with the requirements of the Programme.

3.10.2 The main purpose of displaying the information is to provide the Operator and the Director with an indication of aircraft fleet reliability in such a manner that the necessity for corrective actions may be assessed. The format, frequency of preparation and the distribution of displays and reports are fully detailed in the Programme documentation. Typical data displays are described in 3.10.3 to 3.10.9 and some examples are illustrated in Appendix D.

3.10.3 **Fleet Reliability Summary**

This display (see Fig. D1), which is related to all aircraft of the same type in the fleet, is usually produced in tabular form, and should contain the following minimum information for the defined reporting period:-

(a) Number of aircraft in fleet.

(b) Number of aircraft in service.

(c) Number of operating days (less checks).

(d) Total number of flying hours.

(e) Average daily utilization per aircraft.

(f) Average flight duration.

(g) Total number of landings.

(h) Total number of delays/cancellations.

(j) Technical Incidents.

3.10.4 **Aircraft Mechanical Delays/Cancellations**

The purpose of this type of display is to indicate the aircraft systems which have caused delay to or cancellation of flights as a result of mechanical malfunctions. It is normal for each display to show the delays/cancellations as a total for all systems (to represent fleet overall reliability, as in Fig. D2) as well as separately for the individual systems. The displays for the separate systems will usually show the delay/cancellation rate for the defined reporting period, the three-monthly moving average rate and, where appropriate, the Alert Level, and will present the information for a minimum period of 12 months.

3.10.5 **Engine Unscheduled Shut-downs**

This display (see Fig. D3) is the prime indication of engine in-service reliability and also, to a large degree, of total power-plant reliability. Because of the high level of reliability of engines and the consequently relatively low numbers of unscheduled shut-downs per fleet, both the actual number of shut-downs and the shut-down rate per 1,000 hours for the defined reporting period as a three monthly running average, shown as a graphical display, will provide useful information in addition to that of Fig. D3. To be of most use, when dealing with small numbers of unscheduled shut-downs, it is usual to present both types of information in such a way as to show the trend over a two-to-three-year period.

3.10.6 **Engine Unscheduled Removals**

This display is the supporting primary indication of engine reliability and is usually presented in a similar manner to unscheduled shut-downs. Many Operators show scheduled and unscheduled engine removals and unscheduled shut-downs on the same display; this is purely a matter of preference (see Fig. D3).

3.10.7 **Pilot Reports (Pireps)**

Pireps are presented by system or sub-system (normally identified in accordance with the classifications in ATA 100) in graphical and/or tabular form as a count, or rate, per 1,000 flight hours or 100 departures for the defined reporting period, for comparison with the Alert Level (see Fig. D5). Occasionally some Programmes include a Pirep presentation of Fleet Pilot Reports (see Fig. D4). This presentation shows the total number of Pireps for all systems and sub-systems and thus gives an overall picture of the total Pireps for the fleet of one aircraft type.

3.10.8 **Component Unscheduled Removals and Confirmed Failures**

(a) There are various methods of displaying component information (both graphically and tabular). The display may be on the basis of each individual component which has been prematurely removed (see Fig. D6), or on the basis of the total number of affected components per system (see Fig. D7). Experience has shown that a tabular presentation of unscheduled removals and confirmed failures on an individual component basis, preferably giving both numbers and rates per 1,000 hours, of the defined reporting period is the most useful.

(b) The format of any display of component information should be such that :

(i) Both unscheduled removals and confirmed failure rates may be compared with the Alert Levels so as to identify when the Levels are likely to be exceeded.

(ii) Current and past periods of operation may be compared.

3.10.9 **Workshop Reports**

A summary of the results of defect investigations, based on the Workshop Reports (see Fig. D8) is normally produced by component type for assessment by the Reliability Committee.

3.11 **Problem Identification**

Having collected the information, and having presented it in a timely manner it should now be possible to identify any problems and to assess the necessity for corrective actions. The information, having been sifted and categorized (normally in ATA 100 Chapter order) as individual events and/or rates of occurrence, can be analysed using engineering and/or statistical methods. The analysis can be made at various stages in the handling of the data to differing degrees. Initially, reports on flight defects, delay causes, engine unscheduled shut-downs, workshop and hangar findings, other operators' experience, etc., should be analysed individually to see if any immediate action is desirable. This initial individual analysis will highlight any need for immediate short term actions, e.g. the preparation of Mandatory Occurrence Reports, safety reports, fleet campaigns, with the long term corrective actions following after the later, collective, stages of analysis.

3.12 Corrective Action

3.12.1 The effectiveness of corrective action will normally be monitored by the very process which revealed the need for it - the Condition Monitoring process.

3.12.2 Corrective actions taken to improve the reliability of systems and components, and ultimately that of the fleet, will vary considerably and may typically include one or more of the following :-

(a) Changes in operational procedures or improvements in fault-finding techniques.

(b) Changes to the scope and frequency of maintenance processes which may involve Servicing and inspection, system Tests* or Checks*, Overhaul, Partial Overhaul or bench testing or the introduction or variation of time limits, etc.

(c) Modification action.

(d) Non-routine inspections or adjustment.

(e) Change of materials, fuels and lubricants.

(f) Use of different repair agencies.

(g) Use of different sources of spares.

(h) Variations of storage conditions.

(j) Improvements in standards of staff training and technical literature.

(k) Amendments to the policy/procedures of the Programme.

3.13 Threshold Sampling

3.13.1 Threshold sampling is the process whereby a maintenance limitation prescribed in the Maintenance Schedule (e.g. Hard Time) is varied in the light of experience gained from any source (e.g. scheduled and unscheduled maintenance, unscheduled removals). The prescribed

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*See Appendix E for definitions.

maintenance limitation is the 'threshold upper limit', and, dependent upon the experience gained, can be either substantiated or varied. Maintenance activities (e.g. time for removal, extent of restoration) are normally related to actual experience of the Item in service (known as 'the experience age band'). When it is considered that the prescribed maintenance activity may be varied, threshold sampling may be used as a means of establishing confidence in the proposal. If when the threshold upper limit is reached, the condition of the item is such that a variation is justified, then a new threshold upper limit may be set.

3.13.2 In setting the number of samples and any other qualifying conditions, both engineering assessment of the design and service experience are taken into account. Evidence derived from other activities (e.g. unscheduled removals or removals scheduled for other purposes) will supplement scheduled sampling and the removal itself may, if representative, be substituted for a scheduled sampling removal.

3.13.3 When the optimum period for a particular workshop activity has been determined, threshold sampling will be discontinued and a Hard Time limitation for workshop activity (e.g. Overhaul) will be prescribed.

3.13.4 A typical example of the use of threshold sampling is the control of the 'release for service' periods of certain gas-turbine engines, where some of the units on the engines are subject to individual Hard Time limitations (e.g. turbine disc lives, refurbishing intervals). These individual limitations are, in most cases, established and varied by the process described in 3.13.1 to 3.13.3. The outcome is that the engine release period for installation in the aircraft is then fixed by the expiration of the lowest unit Hard Time limitation.

3.14 Quality* Management

3.14.1 With the major issues of airworthiness and the economical allocation of vast sums of money being involved, it is essential that Quality Control* should be applied as an overall control of the Maintenance Programme. Each Programme will describe the managerial responsibilities and procedures for continuous monitoring of the Programme at progressive and fixed periods. Reviews, to assess the effectiveness of the Programme, will also be prescribed.

3.14.2 There are various methods, both engineering and statistical, by which the effectiveness of the Programme may be evaluated, and these include :-

(a) An assessment of the Programme Document (see 4) and any subsequent amendment (e.g. with a view to possible extra activities).

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*See Appendix E for definitions.

(b) Surveillance of the Programme activities by the Quality Management Department.

(c) Review by the Programme Control Committee to confirm that corrective actions taken are correctly related to the performance trends and to the reports produced.

NOTE: Generally there would be two levels of committee activity, functional and managerial; the functional activity covering the practicality of corrective actions, and the managerial activity covering the overall Quality management of the Programme.

(d) Assessment of reports on incidents and accidents, as these could be potential criticisms of the effectiveness of the Programme.

3.15 Review of the Programme

It is normal for each Operator to review the effectiveness of his Programme, in conjunction with the CAD, at annual intervals. At this review consideration will be given to any proposed major changes in the Programme structure and policy so as to obtain the optimum benefits from the operation of the Programme.

4 THE PROGRAMME DOCUMENT

4.1 Approval

Approval of the Programme (as identified by the 'Document') will depend on the results of an assessment as to whether or not the stated objectives can be achieved. The approval of the Document then becomes a recognition of the potential ability of the Organisation to achieve the stated objectives of the Programme.

NOTE: The Quality Department of the Organisation, together with the CAD, monitors both the performance of the Programme in practice as well as its continuing effectiveness in achieving the stated objectives.

4.2 Essential Qualities of the Programme

Condition Monitored Maintenance Programmes can vary from the very simple to the very complex, and thus it is impractical to describe their content in detail. However, the Document has to be such that the considerations in (a) to (j) are adequately covered.

(a) It generates a precise, specific and logical Quality assessment by the Operator of the ability of the Organisation to achieve the stated objectives.

(b) It enables the Director initially to accept, and, with subsequent continued monitoring, to have confidence in, the ability of the Organisation to such an extent that the Director can renew Certificates of Airworthiness, approve changes to the maintenance schedules, etc., in accordance with evidence showing that the objectives of the Programme are being achieved.

(c) It ensures that the Operator provides himself with Quality management of his Organisation.

(d) It provides the Operator with a basic for the discharge of his moral and legal obligations in respect of the operation of aircraft.

(e) It enables the Director (as the Airworthiness Authority) to discharge its duties and legal obligations in respect of the maintenance aspects of airworthiness, and, where applicable, to delegate certain tasks to the Operator.

(f) The manner of presentation has to be acceptable to the Director.

(g) With (a) to (f) in mind, it states the objectives of the Programme as precisely as is possible, e.g. "maintenance of designated components by reliability management in place of routine overhaul", "Condition Monitoring as a primary maintenance process".

(h) The depth of description of the details of the Programme is such that :-

    (i) The details can be understood by a technically qualified person.

    (ii) Those factors which require formal CAD acceptance of any changes are clearly indicated.

    (iii) All significant non-self-evident terms are defined.

(j) In respect of individuals or departments within the Organisation :-

    (i) the responsibility for the management of the Document, and

    (ii) the procedures for revision of the Document, are clearly stated.

4.3 Compliance with HKAR-1

(a) The Document is required to contain at least the information prescribed in HKAR-1, Sub-section 1.6-2

(b) The Document may either be physically contained within the Approved Maintenance Schedule, or be identified in the Approved Maintenance Schedule by reference and issue number, in such a manner that the Approved Maintenance Schedule could be deemed to contain it by specific statement and cross-reference.

4.4 **Assessment of Programme Document**

The following questions (not necessarily definitive) may assist in making a preliminary assessment of the adequacy of the Programme Document :-

(a) Is the Document to be physically contained within the Approved Maintenance Schedule? If it is to be a separate document, is it satisfactorily linked with, and identified within the Approved Maintenance Schedule?

(b) Are the objectives of the Programme clearly defined? e.g. 'Maintenance of designated Items by reliability management in place of routine overhaul', 'Confidence assessment of overhaul periods', 'Condition monitoring as a primary maintenance process', 'Airworthiness/economic Quality management of maintenance'.

(c) Does the Approved Maintenance Schedule clearly state to which Items the Programme is applicable?

(d) Is there a glossary of terms associated with the Programme?

(e) What types of data are to be collected? How? By whom? When? How is this information to be sifted, grouped, transmitted and displayed?

(f) What reports/displays are provided? By whom? To whom? When? How soon following data collection? How are delays in publishing controlled?

(g) How is all information and data analysed and interpreted to identify aircraft actual and potential condition? By whom? When?

(h) Is there provision within the Organisation for implementation of corrective actions and is this identified within the Document? How are implementation time periods, effects and time for effect manifestation provided for?

(j) Is there a requirement that the Approved Maintenance Schedule be amended, and is the method of doing so included in the Programme, e.g. variation of time limitations, additional checks?

(k) Is there a requirement that Maintenance Manuals be amended and is the method of doing so included in the Programme, e.g. maintenance practices, tools and equipment, materials?

(l) Is there a requirement that the Operations Manual/Crew Manual be amended, and is the method of doing so included in the Programme, e.g. crew drills, check lists, defect reporting?

(m) What provision is made for corrective action follow-up and for checks on compliance with original intention, e.g. those which are not working out in practice, spares provisioning, time-tables for the incorporation of modifications?

(n) Who is responsible for the management of the Document?

(o) Is there a diagram of the relationship between the departments and groups concerned with the Programme and does it show the flow of Condition Monitoring data, its handling and the prescribed reaction to it?

(p) Are all of the departments involved in the Programme included and are there any responsibilities not allocated?

(q) What Quality management processes are contained within the Programme in respect of :-

  (i) Responsibility for the Document itself and the procedure for its amendment?

  (ii) Monitoring of the performance of the Programme by statistical reliability and other methods?

  (iii) Committee consideration of Programme implementation and monitoring of performance?

  (iv) Consideration of reports on incidents and accidents and other events which can affect airworthiness?

  (v) Programme management and discipline?

5 CONDITION MONITORED MAINTENANCE AND THE AIRWORTHINESS AUTHORITY

5.1 Maintenance based solely on the traditional methods of fixed component lives and 'strip-down' policies constitutes a very simple condition control process. Its administration, effectiveness and the legal obligations of all concerned are easily defined. When, for any Item, these traditional processes are replaced by Condition Monitored Maintenance, confidence in the unmanifest condition of the Item can only be through confidence in the procedure for controlling that condition, i.e. the Condition Monitoring process.

5.2 Most of the latest generation of aircraft have been so designed that their reliability is based on the extensive use of multiple Redundancy, thus achieving the continued availability of system function, even in the event of failures. The scope of this 'System Redundancy' and 'multiplicity of system function' (see 1.4(a) NOTE) is such that it allows maintenance to be almost totally controlled by Condition Monitoring as the primary maintenance process, with a few items controlled by the On-Condition process and even fewer controlled by the Hard Time process. This, in turn, has meant that the maintenance of the aircraft as a whole can be effected by the provision of a Condition Monitored Maintenance Programme, in which every form of Condition Monitoring is used. Most of the important systems and Items have Condition Monitoring as their primary maintenance process, with Items essential to system function having their failure resistance assessed by the On-Condition process. The availability of the function of other systems is controlled almost entirely by Condition Monitoring.

5.3 It is impractical to assess the continued airworthiness of an individual multiple Redundancy aircraft by the traditional physical survey approach because of its size, complexity of design and economic considerations. As a result, confidence in continued airworthiness of the fleet is preserved by ensuring that the Operating Organisation has the ability to identify and control, within an appropriate timescale, events which could otherwise lead to a reduction in airworthiness. A statistical Quality Control process is used to take measurements of the reliability of the aircraft. These measurements do not directly assess the airworthiness/economic condition of the aircraft, but use operating data (delays, flight defects, etc.) as a confidence check on the continuing ability of the Maintenance Organisation to control that condition. Renewal of the Certificate of Airworthiness then becomes a periodic re-affirmation of the continued acceptance of the procedure which has been approved for maintaining the airworthiness of the aircraft. The Programme Document serves to identify this procedure.

5.4 In addition to the obvious advantages which are generated by the achievement of the objectives of the Programme, the formalized structure and operation of a Programme can provide the Airworthiness Authority with confidence that the Condition Monitoring processes are effectively contributing to continuing airworthiness, as well as informing all concerned about the reliability of the aircraft in question.

APPENDIX A - A SHORT INTRODUCTION TO THE BASIC PRINCIPLES OF MAINTENANCE STEERING GROUP LOGIC ANALYSIS

Airline and manufacturer experience in developing scheduled maintenance program for new aircraft has shown that more efficient programs can be developed through the use of logical decision processes.

In July, 1968, representatives of various airlines developed Handbook MSG-1, "Maintenance Evaluation and Program Development", which included decision logic and inter-airline/manufacturer procedures for developing a maintenance program for the new Boeing 747 aircraft.

Subsequently, it was decided that experience gained on this project should be applied to update the decision logic and to delete certain 747 detailed procedural information so that a universal document could be made applicable for later new type aircraft. This was done and resulted in the document, entitled, "Airline/Manufacturer Maintenance Program Planning Document", MSG-2. MSG-2 decision logic was used to develop scheduled maintenance programs for the aircraft of the 1970's.

In 1979, a decade after the publication of MSG-2, experience and events indicated that an update of MSG procedures was both timely and opportune in order for the document to be used to develop maintenance programs for new aircraft, systems or powerplants.

An ATA Task Force reviewed MSG-2 and identified various areas that were likely candidates for improvement. Some of these areas were the rigor of the decision logic, the clarity of the distinction between economics and safety, and the adequacy of treatment of hidden functional failures. Additionally:

A. The development of new generation aircraft provided a focus, as well as motivation, for an evolutionary advancement in the development of the MSG concept.

B. New regulations which had an effect on maintenance programs had been adopted and therefore needed to be reflected in MSG procedures. Among those were new damage tolerance rules for structures and the Supplemental Structural Inspection program for high time aircraft.

C. The high price of fuel and the increasing cost of materials created trade-off evaluations which had great influences on maintenance program development. As a result, maintenance programs required careful analysis to ensure that only those tasks were selected which provided genuine retention of the inherent designed level of safety and reliability, or provided economic benefit.

MSG-3, ORIGINAL REVISION:

Against this background, ATA airlines decided that a revision to existing MSG-2 procedures was both timely and appropriate. The active participation and combined efforts of the FAA, CAA/UK, AEA, U.S. and European aircraft and engine manufacturers, U.S. and foreign airlines, and the U.S. Navy generated the document, MSG-3. As a result there were a number of differences between MSG-2 and MSG-3, which appeared both in the organization/presentation of the material and in the detailed procedural content. However, MSG-3 did not constitute a fundamental departure from the previous version, but was built upon the existing framework of MSG-2 which had been validated by ten years of reliable aircraft operation using maintenance programs based thereon.

The following reflects some of the major improvements and enhancements generated by MSG-3 as compared to MSG-2.

1. Systems/Powerplant Treatment:

   MSG-3 adjusted the decision logic flow paths to provide a more rational procedure for task definition and a more straightforward and linear progression through the decision logic.

   MSG-3 logic took a "from the top down" or consequence of failure approach. At the outset, the functional failure was assessed for consequence of failure and was assigned one of two basic categories:

   A. SAFETY
   B. ECONOMIC

   Further classification determined sub-categories based on whether the failure was evident to or hidden from the operating crew. (For structures, category designation was "significant" or "other" structure, and all functional failures were considered safety consequence items).

   With the consequence category established for systems/powerplants, only those task selection questions pertinent to the category needed to be asked. This eliminated unnecessary assessments and expedited the analysis. A definite applicability and effectiveness criteria was developed to provide more rigorous selection of tasks. In addition, this approach helped to eliminate items from the analytical procedure whose failures had no significant consequence.

   Task selection questions were arranged in a sequence such that the most preferred, most easily accomplished task, was considered first. In the absence of a positive indication concerning the applicability and effectiveness of a task, the next task in sequence was considered, down to and including possible redesign.

   Structures Treatment:

   Structures logic evolved into a form which more directly assessed the possibility of structural deterioration processes. Considerations of fatigue, corrosion, accidental damage, age exploration programs and others, were incorporated into the logic diagram and were routinely considered.

2. MSG-3 recognized the new damage tolerance rules and the supplemental inspection

programs, and provided a method by which their intent could be adapted to the Maintenance data certificate restraints. Concepts such as multiple failures, effect of failure on adjacent structures, crack growth from detectable to critical length, and threshold exploration for potential failure, were covered in the decision logic of the procedural material.

3. The MSG-3 logic was task-oriented and not maintenance process oriented (MSG-2). This eliminated the confusion associated with the various interpretations of Condition Monitoring (CM), On-Condition (OC), Hard-time (HT) and the difficulties encountered when attempting to determine what maintenance was being accomplished on an item that carried one of the process labels.

   By using the task-oriented concept, one would be able to view the MRB document and see the initial scheduled maintenance program reflected for a given item (e.g., an item might show a lubrication task at the "A" frequency, and inspection/functional check at the "C" frequency and a restoration task at the "D" frequency).

4. Servicing/Lubrication was included as part of the logic diagram to ensure that this important category of task was considered each time an item was analyzed.

5. The selection of maintenance tasks, as output from the decision logic, was enhanced by a clearer and more specific delineation of the task possibilities contained in the logic.

6. The logic provided a distinct separation between tasks applicable to either hidden or evident functional failures; therefore, treatment of hidden functional failures was more thorough than that of MSG-2.

7. The effect of concurrent or multiple failure was considered. Sequential failure concepts were used as part of the hidden functional failure assessment (Systems/Powerplant), and multiple failure was considered in structural evaluation (Structures).

8. There was a clear separation between tasks that were economically desirable and those that were required for safe operation.

9. The structures decision logic no longer contained a specific numerical rating system. The responsibility for developing rating systems was assigned to the appropriate manufacturer with approval of the Industry Steering Committee.

MSG-3, REVISION 1:

In 1987, after using MSG-3 procedures on a number of new aircraft and powerplants in the first half of the 1980's. it was decided that the benefits of the experience so gained should be used to improve the document for future application; thus, Revision 1 was undertaken.

This revised document includes changes developed by American and European airframe manufacturers, American and European airworthiness authorities, supplemented and agreed to by the Air Transport Association of America and other airline representatives.

The major improvements and enhancements reflected in items one through nine above were basically unchanged and remain applicable to this revised document.

The following are some of the more noteworthy revisions that have been incorporated:

1. Table of Contents and a List of Effective Pages: ADDED.

2. Clarification that MSG-3 is used to develop an "initial scheduled maintenance program".

3. The task - "Operating Crew Monitoring": DELETED.

4. Section addressing "Threshold Sample": REVISED.

5. Section addressing "Program Development Administration": DELETED.

6. "Top-down approach" - explanation of process: ADDED.

7. "Visual Check" added to "Operational Check" task.

8. System/Powerplant and Structures logic diagrams: REVISED.

9. Task selection criteria table: ADDED.

10. Inspections:

    Detailed Inspection - REVISED.
    Directed Inspection - DELETED.
    External Surveillance Inspection - DELETED.
    General Visual Inspection - DELETED.
    Internal Surveillance Inspection - DELETED.
    Special Detailed Inspection - UNCHANGED.
    Walk Around Check Inspection - DELETED.

11. Clarification of hidden functional failure: "one additional failure".

12. Inspection/Functional Check task question revised.

13. Reference to a "User's Guide" for procedures related to administration and forms added.

14. Reference to "off-aircraft" deleted.

15. Operating Crew Normal Duties - "Normal Duties" revised to delete pre-flight and post-flight check list; added "on a daily basis" for frequency of usage with respect to normal crew duties.

16. Added that procedures for handling composite of other new materials may have to be developed.

17. Reference to specific U.S. Federal Air Regulations: DELETED.

18. Definition of "Operating": REVISED.

19. Defined logic for failures which may affect dispatch capability or involve the use of abnormal or emergency procedures. Failure-effect Category 6 is now identified as "Operational - Evident".

20. Noted that each MSI and SSI should be recorded for tracking purposes whether or not a task was derived therefrom.

MSG-3. Revision 2:

In 1993. MSG-3 Revision 2, was incorporated. The most significant changes introduced were:

1. To adapt MSG-3 logic procedures to assure development of tasks/intervals associated with the aircraft's certificated operating capabilities.

2. To provide guidelines which ensure that a consistent approach be taken with respect to tasks/intervals required to maintain compliance with Type Certification requirements.

3. To provide guidelines on the development of Corrosion Prevention and Control Programs.

4. To introduce procedures to determine the appropriate scheduled maintenance requirements for composite structure.

5. To revise inspection task definitions.

MSG-3 Section 2.4 and its respective logic diagrams have been revised to add an evaluation process to insure the Corrosion Prevention and Control Program (CPCP) is considered in the evaluation of each Structural Significant Item (SSI) and every zone.

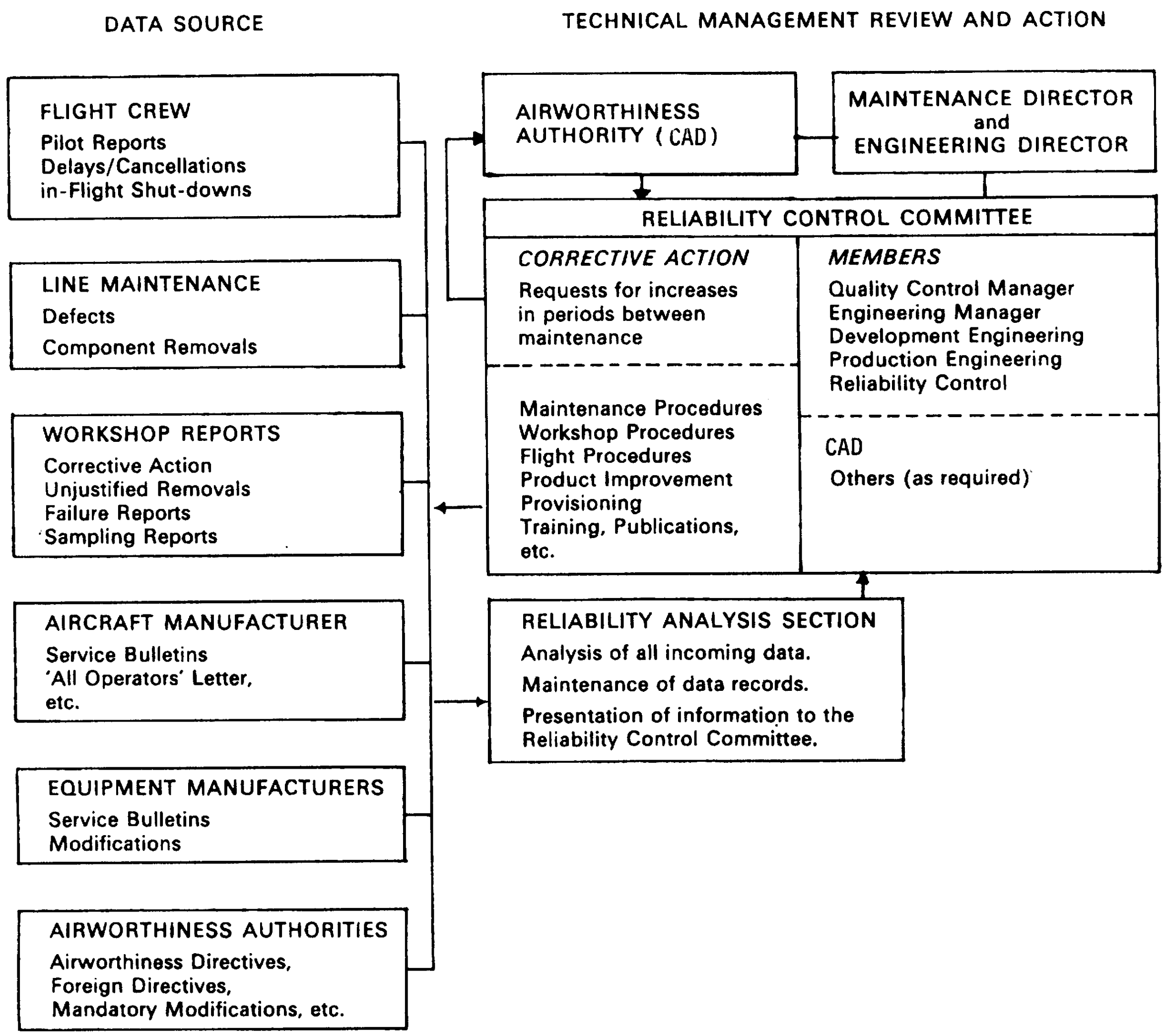
Damage Sources Section 2.4.3.1 now includes a discussion of non-metallic materials (composites).

Procedures Section 2.4.4.1 has been revised to add Procedure and Decision blocks for the CPCP evaluation and edited to produce a more ordered flow of the Procedure and Decision block numbers.

The Glossary - Appendix A Inspection Level Definitions have been revised to apply to Systems, Powerplants and Structures, and definitions related to CPCP have been added.

It is suggested, in order to fully comprehend the MSG-3 concept, that the entire MSG-3 document be reviewed and considered prior to accepting or modifying its approaches to maintenance programs development. A User's Guide or Policies and Procedures Handbook may be adopted with guidance and approval of the Industry Steering Committee.

APPENDIX B — TYPICAL ORGANISATION AND DATA FLOW CHART



APPENDIX C — ALERT LEVEL CALCULATIONS

Example 1 — Pilot Reports (Pireps) by Aircraft System per 1,000 Flight Hours

Method : Alert Level per 1,000 flight hours = Mean of the 3 monthly Running Average 'Pirep' Rates per 1,000 flight hours (for past 12 months) plus 3 Standard Deviations.

System : Aircraft Fuel System (ATA 100, Chapter 28)

Month	Pireps (monthly)	Pireps (3 months cumulative totals)	Flight Hours (monthly)	Flight Hours (3 months cumulative totals)	Pirep Rate per 1,000 hr (3 months running average) (x)
Nov	42	—	2400	—	—
Dec	31	—	2320	—	—
Jan	58	131	2350	7070	18
Feb	46	135	2300	6970	19
Mar	58	162	2560	7210	22
Apr	26	130	2600	7460	17
May	42	126	2750	7910	16
Jun	65	133	3100	8450	16
Jul	78	185	2880	8730	21
Aug	74	217	2700	8680	25
Sep	58	210	3000	8580	24
Oct	54	186	2650	8350	22
Nov	35	147	2610	8260	18
Dec	46	135	2330	7590	18

N = 12

(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
18	−2	4
19	−1	1
22	2	4
17	−3	9
16	−4	16
16	−4	16
21	1	1
25	5	25
24	4	16
22	2	4
18	−2	4
18	−2	4
$\Sigma x = 236$		$\Sigma(x - \bar{x})^2 = 104$

$$\text{MEAN } (\bar{x}) = \frac{\Sigma x}{N} = \frac{236}{12} = 19{\cdot}67$$

$$\bar{x} \text{ (rounded)} = \boxed{20}$$

$$\text{STANDARD DEVIATION (SD)} = \sqrt{\frac{\Sigma(x - \bar{x})^2}{N}} = \sqrt{\frac{104}{12}} = \sqrt{8{\cdot}67} = 2{\cdot}94$$

$3 \times \text{SD} = 8{\cdot}82$ rounded to $\boxed{9}$

ALERT LEVEL = Mean + 3 SD = 20 + 9 = <u>29</u>

Example 2 — Pilot Reports (Pireps) by Aircraft System per 1,000 Flight Hours

Method : Alert Level per 1,000 flight hours = The Mean (as in Example 1), plus the Standard Deviation of the 'Mean of the Means', plus 3 Standard Deviations of the Mean.

Data as in Example 1

System : Aircraft Fuel System (ATA 100, Chapter 28)

Pirep Rate per 1,000 hr— 3 months running Av. (x)	Mean of x (X)	Difference of X from $\bar{X}$ (D)	(D^2)
18	18·5	1·3	1·69
19	20·5	0·7	0·49
22	19·5	0·3	0·09
17	16·5	3·3	10·69
16	16·0	3·8	14·44
16	18·5	1·3	1·69
21	23·0	3·2	10·24
25	24·5	4·7	22·09
24	23·0	3·2	10·24
22	20·0	0·2	0·04
18	18·0	1·7	2·89
18			
	218·0 = ΣX	23·7 = ΣD	74·79 = $\Sigma(D^2)$

N now = 11 and thus $\bar{X}$ (the mean of the means) will $= \frac{218}{11} = \underline{19{\cdot}8}$

STANDARD DEVIATION OF MEAN OF MEANS

$$= \sqrt{\frac{\Sigma(D^2)}{N} - \left(\frac{\Sigma D}{N}\right)^2} = \sqrt{\frac{74{\cdot}79}{11} - \left(\frac{23{\cdot}7}{11}\right)^2}$$

$$= \sqrt{6{\cdot}80 - 4{\cdot}64} = \underline{1{\cdot}47}$$

Therefore ALERT LEVEL = 19·67 (as in Example 1) + 1·47 + 8·82 (as in Example 1)

= 29·96 rounded to $\boxed{30}$

Example 3 — Component Unscheduled Removals by Individual Components in a Three-Monthly Period

Method : Alert Level = 95% cumulative probability of the Poisson Distribution based on past 21 months experience* to provide an Alert Level for use as a three-monthly period of comparison.

(a) **Component : Auto-pilot Pitch Amplifier**

number of components per aircraft,	n	=	1
number of unscheduled removals in past 21 months,	N	=	62
fleet utilization hours in past 21 months,	H	=	36840
number of component running hours in past 21 months,	T	=	$(n \times H) = 36840$
fleet utilization hours in current 3 months,	h	=	5895
number of component running hours in current 3 months,	t	=	$(n \times h) = 5895$
number of unscheduled removals in current 3 months,	x	=	12

Mean unscheduled removal rate, $\lambda = \dfrac{N}{T} = 0{\cdot}00168$

Expected number of unscheduled removals in current 3 months

$$= \lambda t$$
$$= 0{\cdot}00168 \times 5895$$
$$= 9{\cdot}9 \text{ rounded to } \boxed{10}$$

Referring to Fig. C1 by entering the graph at $\lambda t = 10$ the intersection with 0·95 (95% probability) gives the maximum acceptable number of unscheduled component removals (A value) for the 3 month period as 15.

By comparing the current value of $x = 12$ one can see that an 'alert' situation does not exist for this component.

(b) **Component : Temperature Control Valve**

$n = 3$, $N = 31$, $H = 36840$, $T = 3 \times 36840 = 110520$, $h = 5895$, $t = 3 \times 5895 = 17685$, $x = 9$

$\lambda = \dfrac{31}{110520} = 0{\cdot}00028$, $\quad \lambda t = 0{\cdot}00028 \times 17685 = 5{\cdot}01$ rounded to $\boxed{5}$

from graph, acceptable A value = 8. Current value of $x = 9$, therefore Alert Level is exceeded.

---

* For large fleets the past twelve months experience may be used with a one-monthly period of comparison.

APPENDIX C

Example 4 — Component Confirmed Failures by Individual Components in a Three-Monthly Period

Method : Alert Level = The 'corrected' Mean of the Quarterly Failure Rates plus 1 Standard Deviation of this mean, based on past seven calendar quarters of confirmed component failure rates per 1,000 hours to provide an Alert Level for use as a quarterly period of comparison.

Component: Main Generator

Calendar Quarter	Quarterly Failure Rate (u)	Corrected Rate (C)	(C^2)
2/74	0·21	0·63*	0·397
3/74	0·38	0·38	0·144
4/74	0·42	0·42	0·176
1/75	0·84	0·84	0·706
2/75	0·59	0·59	0·348
3/75	0·57	0·57	0·325
4/75	1·38	0·63*	0·397
TOTALS (Σ)	4·39	4·06	2·493

N = 7

QUARTERLY MEAN FAILURE RATE $= \frac{4{\cdot}39}{7} = 0{\cdot}63$

CORRECTED MEAN FAILURE RATE $\bar{C}$ $= \frac{\Sigma C}{N} = \frac{4{\cdot}06}{7} = \underline{0{\cdot}58}$

STANDARD DEVIATION, SD

$$= \sqrt{\frac{\Sigma(C^2) - \frac{(\Sigma C)^2}{N}}{N - 1}}$$

$$= \sqrt{\frac{2{\cdot}493 - \frac{(4{\cdot}06)^2}{7}}{6}}$$

$$= \sqrt{\frac{2{\cdot}493 - 2{\cdot}355}{6}}$$

$$= \underline{0{\cdot}15}$$

ALERT LEVEL $= \bar{C} + 1SD = 0{\cdot}58 + 0{\cdot}15 = \underline{0{\cdot}73}$

* Where an individual Quarterly Failure Rate falls outside plus or minus 50% of the uncorrected Mean Quarterly Failure Rate (0·63 in this case), then this Mean is to be used as a Corrected Rate in place of the uncorrected Quarterly Rate.

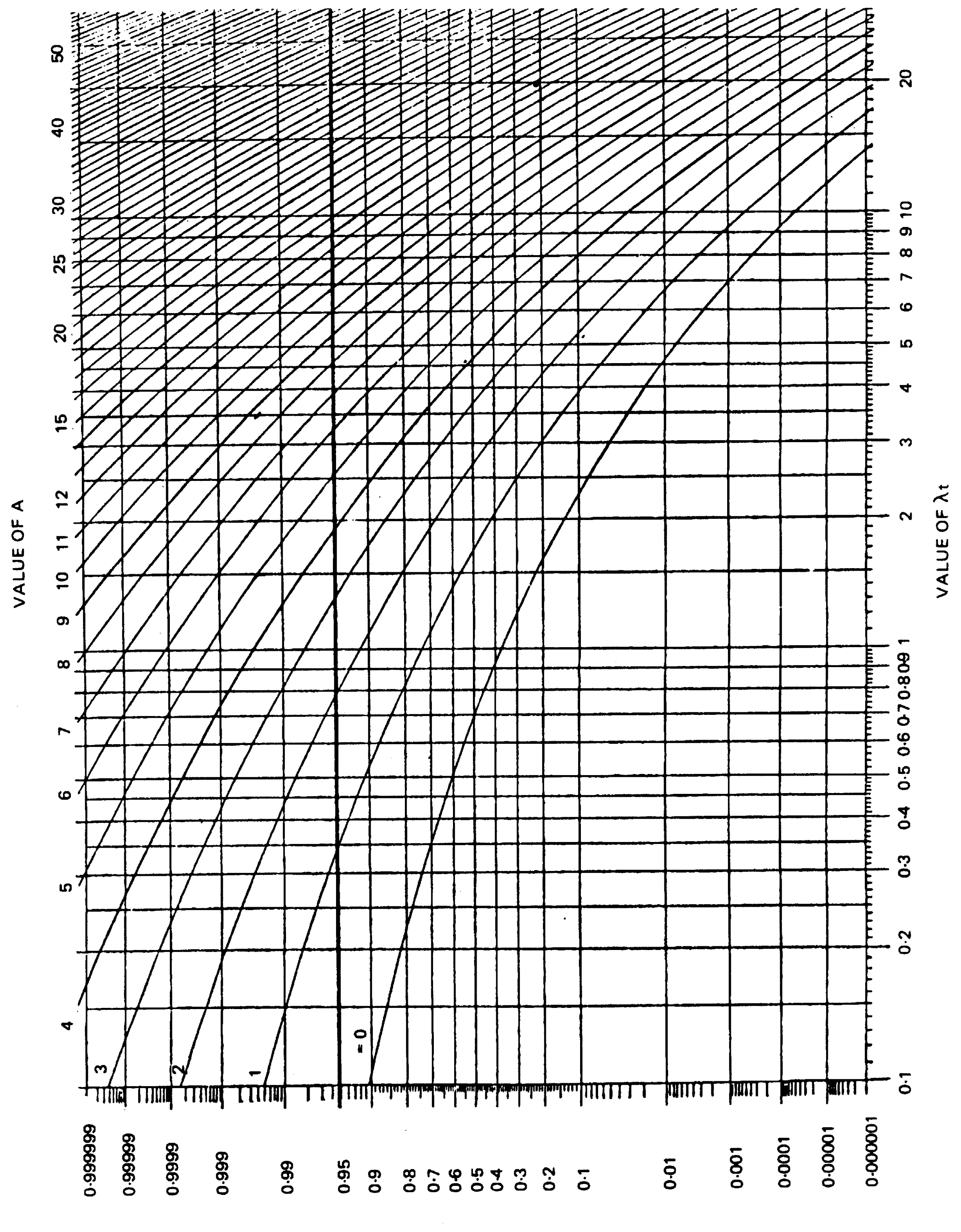


Fig. C1 Poisson Cumulative Probabilities

AIRCRAFT TYPE:		1976	1977												ACCUM TOTALS
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
NUMBER OF AIRCRAFT IN FLEET		6	6	6	6	6	6	6							6
NUMBER OF AIRCRAFT IN SERVICE		6	5	5	5	6	6	6							6
NO OF OPERATING DAYS (less checks)		1634	153	144	152	160	186	174							969
FLYING HOURS (hr:min)	Revenue —	13400:39	907	801	1068	1374	1571	1798							7519
	Non Revenue —	39:38	5	4	8	3	0:5	1							21:5
	Training —	97:24	—	24	25	32	12:5	1							94:5
	TOTAL	13537:41	912	828	1102	1409	1584	1800							7635
DAILY UTILIZATION (average/aircraft) (hr:min)		8:17	5:57	5:45	7:15	8:48	8:31	10:20							7:52
AVERAGE FLIGHT DURATION (hr:min)		2:32	2:52	2:43	2:42	2:36	2:23	2:23							2:36
LANDINGS	Revenue —	5277	316	293	395	528	658	752							2942
	Non Revenue —	45	5	2	2	5	2	3							19
	Training —	275	3	55	100	104	34	4							300
	TOTAL	5597	324	350	497	637	694	759							3261
TECHNICAL DELAYS — REVENUE (more than 15 mins)	Number of Movements —	5277	316	293	395	528	658	752							2942
	Number of delays —	134	8	6	9	17	13	16							69
	Total Delay Time —	310·32	38	13	9	27	22	33							142
	Average Delay (%)	2·54	2·53	2·04	2·27	3·22	1·97	2·12							2·35
TECHNICAL CANCELLATIONS		—	—	—	—	—	—	—							—
TECHNICAL INCIDENTS	Interrupted Flights —	7	Nil	Nil	Nil	Nil	Nil	Nil							Nil
	Engine Shut Downs —	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil
	Fire Warnings —	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil
	Fire Warnings (false) —	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil
	Fuel Dumpings —	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil
REMARKS															

Fig. D1 Fleet Reliability Summary

AIRCRAFT TYPE:	1976	1977											
%	Average	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
5													
4													
		3·80											
3													
			2·65										
2													
	1·73			1·98									
1													

BASE	NO. OF MOVEMENTS			NO. OF TECH. DELAYS			TOTAL DELAY TIME (hr:min)			AVERAGE DELAY (%)			REMARKS
	JAN	FEB	MAR	JAN	FEB	MAR	JAN	FEB	MAR	JAN	FEB	MAR	
Gatwick	171	159	174	9	4	4*	9:50	7:20	11:35	5·26	2·34	2·29	*1 Overseas
Manchester	44	46	17	1	3	0	0:30	2:51	—	2·27	6·52	—	
Berlin	127	59	111	3	—	2	13:19	—	4:21	2·36	—	1·80	
TOTALS	342	264	302	13	7	6	23:39	10:11	15:56	3·80	2·65	1·98	

Fig. D2 Aircraft Mechanical Delays/Cancellations

APPENDIX D

AIRCRAFT TYPE: / ENGINE TYPE:		1976	1977 JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	ACCUM TOTALS 1977	PREVIOUS 12 MONTHS TOTALS
	Total Engine Hours	40613	2735	2486	3306	4227	4752	5400							22906	45149
UNSCHEDULED REMOVAL	Total Unscheduled Removals	4	—	—	—	—	1	1							2	4
	Rate per 1000 Eng. Hours	0·10	—	—	—	—	0·21	0·18							0·08	0·08
REASON	Failure	4	—	—	—	—	1	1							2	4
	Suspect Failure	—	—	—	—	—	—	—							—	—
	External Causes	—	—	—	—	—	—	—							—	—
INVEST'N RESULTS	Basic Engine Failure	2	—	—	—	—	—	—							1	2
	Non Basic Engine Failure	—	—	—	—	—	—	—							—	—
	Unsubstantiated	1	—	—	—	—	—	—							1	2
FOLLOW UP ACTION	Rectification	3	—	—	—	—	1	—							1	3
	H.S.I.*	—	—	—	—	—	—	—							—	—
	Overhaul	—	—	—	—	—	—	1							1	1
SCHEDULED REMOVAL	Total Scheduled Removals	4	2	2	1	1	—	—							6	7
	H.S.I.* Time Expired	1	2	—	—	—	—	—							2	2
	Time Expired — Overhaul —	3	—	2†	1	1	—	—							3	5
	H.S.I.* Approved Life	5500	5500	5500	5500	5500	5500	5500							5500	5500
	Overhaul Approved Life	10500	10500	10500	10500	10500	10500	10500							10500	10500
UNSCHEDULED ENGINE SHUT-DOWN	Total Number	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil	Nil
	Rate per 1,000 Hours	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil	Nil
	Accumulative Rate	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil	Nil

† 1 removed for disc mod

*Hot Section Inspection

Fig. D3 Engine Removals and Unscheduled Shut-downs

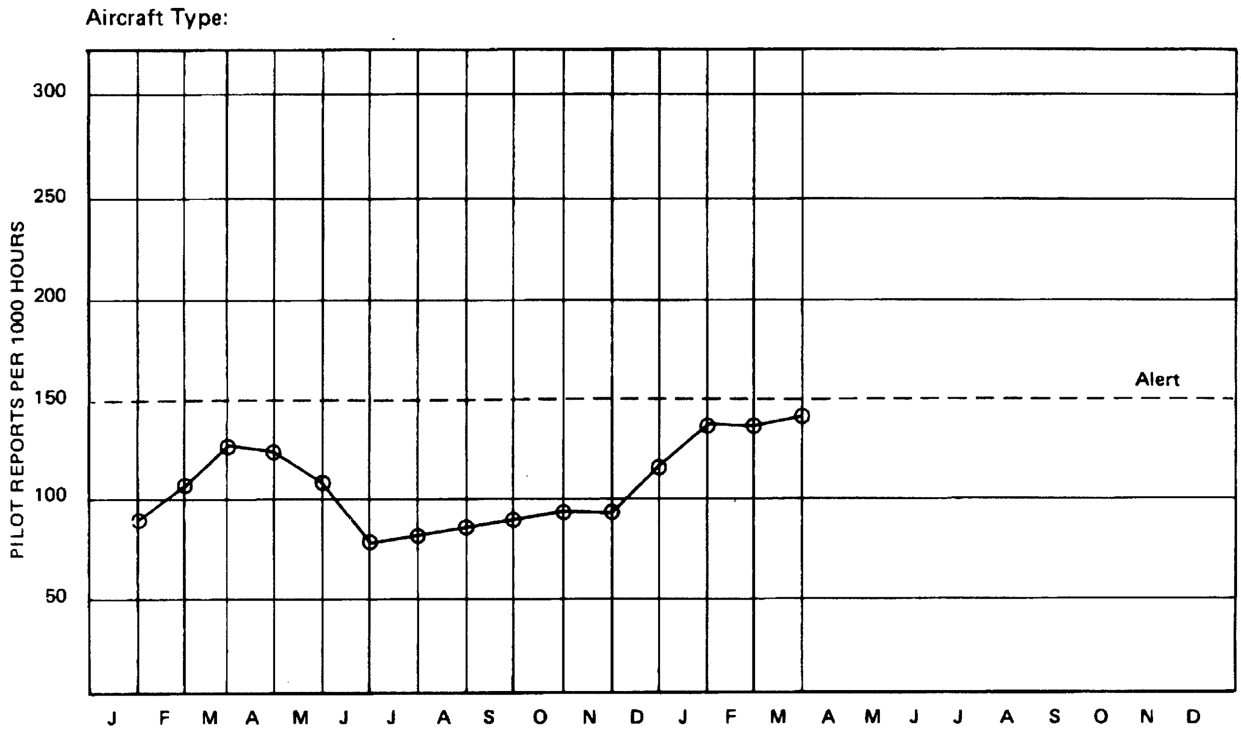


Fig. D4 Fleet Pilot Reports

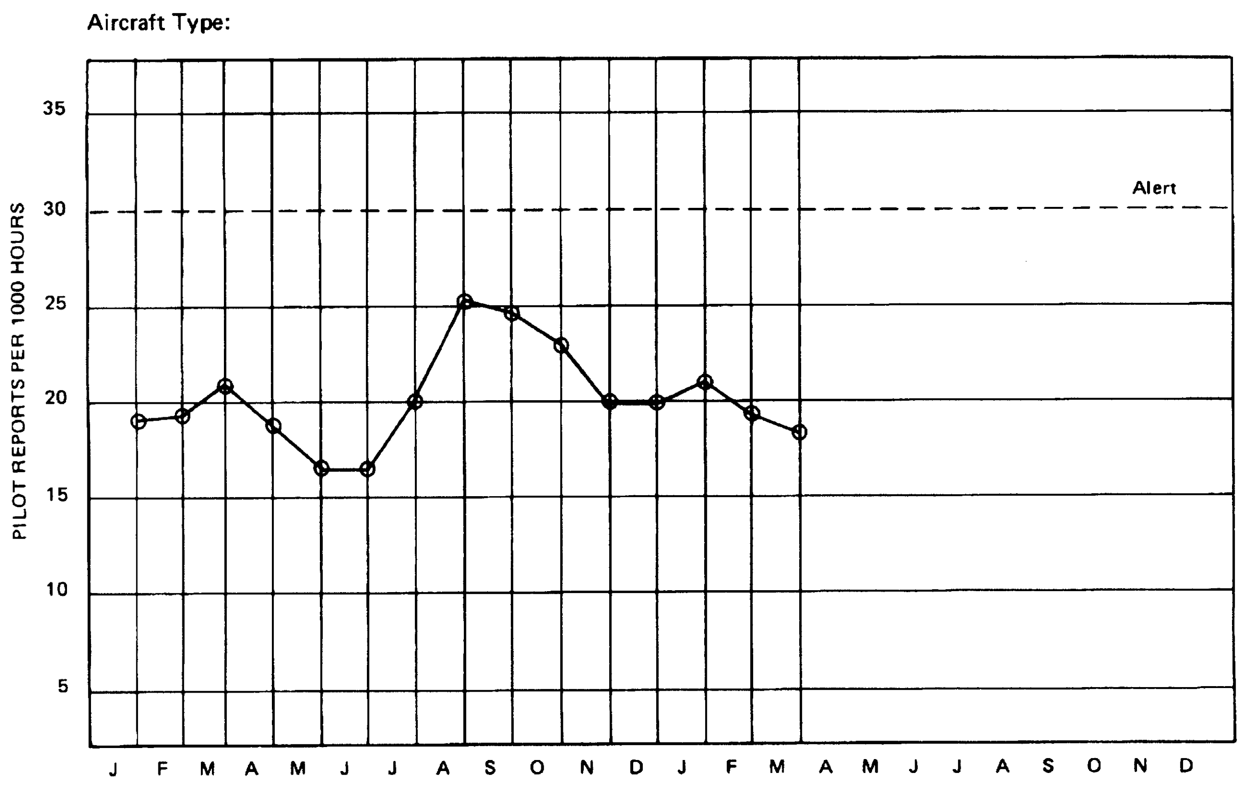


Fig. D5 Pilot Reports ATA 21 — Air Conditioning System

APPENDIX D

SCH. REF.	PART NUMBER	NO PER A/O	COMPONENT (FLYING HOURS / PERIOD)	13408 / 1975 A*	B*	C*	2495 / 1st Qtr 1976 A*	B*	C*		A*	B*	C*	ALERT LEVEL	ACCUMULATIVE COMPONENT CONFIRMED FAILURES SINCE 1.1.74 A*	B*	MTBF†
30/4	131046-1	1	Manual Pressure Controller	—	—	—	2	0·80	—	X*				—	2	0·06	16000
30/5	102518-3-1	1	Auto Cabin Pressure Controller	4	0·29		—	—	—					0·60	9	0·28	3555
30/6	10-3280-5-1	2	Cabin Outflow Valve	9	0·26	2	1	—	1					0·50	9	0·14	7110
51/1	178040-2-1	4	Heat Exchanger	3	0·05		—	—	—					0·15	5	0·04	25601
51/2	204050-10-1	2	Air Cycle Machine	2	0·07		—	—	—					0·30	4	0·06	16000
51/5	129150-2-1	2	35° Thermostat Pack Anti-icing	1	0·03		—	—	—					0·30	1	0·015	64020
51/6	321674-3-1	2	Valve — Pack Shut-Off	5	0·11	2	—	—	—					0·30	5	0·08	12800
52/2	541248-2-1	2	Actuator — Ram Air	1	0·03		—	—	—					0·30	2	0·03	32000
52/7	207562-1	2	Fan Cooling Pack	2	0·07		—	—	—					0·30	8	0·13	8000
58/3	18801-5	1	Detector — Air Flow Sensor	—	—	—	—	—	—					—	1	0·03	32000
61/1	321402-1-1	2	Valve/Actuator — Control Mix	—	—	—	1	0·20	—					0·30	5	0·08	12809
61/2	548376-5	1	Controller — Air Temp	1	0·07		—	—	—					0·60	2	0·06	16000
61/9	67321-10-190	3	Temperature Sensor	—	—	—	—	—	—					0·15	1	0·01	96061
62/2	163BL501	2	Indicator — Pack Temp.	—	—	—	—	—	—					0·30	1	0·015	64020
30/7	132322-2-1	1	Fan Venturi	2	0·14		1	0·40	—					0·60	4	0·13	8000
61/3	548392-1-1	2	Cabin Temp. Sensor	1	0·03		—	—	—					0·30	1	0·015	64020
42/1	32-2684-002	1	Cargo Outflow Valve	—	—	—	1	0·40	—					0·60	2	0·06	16000
58/8	123266-2-1/ 123544.1.1	2	Hot Air Check Valve	—	—	—	1	0·20	—					0·30	1	0·015	6402
23/1	500702-4620	2	Gasper Fan	—	—	—	—	—	—					0·60	4	0·06	16000
51/3	178050-2-1	2	Water Separator	—	—	—	—	—	—					0·60	2	0·03	32001
51/4	10-60506-4	2	35° Valve Pack Anti-icing Cont	—	—	—	—	—	—					0·30	—	—	—

AIRCRAFT TYPE: Air Conditioning/Pressurization (ATA 100, Chapter 21)

*A — No. of unscheduled removals
*B — Failure Rate per 1,000 hours
*C — Non-confirmed Defects
*X — Failure Rate above Alert Level
†MTBF — Mean Time Between Failures

Fig. D6 Component Unscheduled Removals and Confirmed Failures

AIRCRAFT TYPE:		JANUARY 1971			1970 FIRST HALF			1970 LAST HALF		
ATA 100 CHAPTER	ALERT LEVEL	UR*	URR†	FR‡	UR*	URR†	FR‡	UR*	URR†	FR‡
21 — Air Conditioning	·35	2	·53	·33	14	·34	·32	15	·36	·31
22 — Auto-pilot	·80	4	1·33	·33	16	·98	·29	19	·98	·32
23 — Communications	·92	2	·67	·48	10	·57	·48	8	·56	·37
24 — Electric Power	·20	2	·08	·02	8	·06	·02	9	·07	·03
27 — Flight Controls	·30	1	·20	·09	7	·12	·10	6	·10	·08
28 — Fuel	·23	0	·00	·00	2	·64	·30	1	·09	·06
29 — Hydraulic	·38	1	·42	·40	2	·26	·18	4	·46	·22
30 — Ice & Rain Protection	·15	0	·00	·00	2	·14	·08	2	·14	·08
31 — Instruments	·65	4	·63	·34	20	·61	·31	16	·57	·20
32 — Landing Gear	·33	1	·04	·02	7	·05	·03	9	·09	·04
34 — Navigation	·73	3	·66	·21	20	·69	·24	24	·71	·29
35 — Oxygen	·30	2	·66	·32	11	·65	31	9	·64	·30
36 — Pneumatic	·20	0	·00	·00	2	·01	·01	4	·02	·02
38 — Water/Waste	·24	1	·09	·06	6	·16	·15	7	·17	·16
49 — APU	·48	1	·33	·32	7	·34	·34	4	·26	·29
73 — Engine Fuel & Control	·39	0	·00	·02	4	·10	·06	2	·06	·05
75 — Engine Air	·28	1	·17	·16	5	·16	·14	3	·12	·12
77 — Engine Indicating	·30	5	·42	·17	26	·46	·18	22	·44	·17
79 — Oil	·22	0	·00	·00	2	·04	·02	3	·06	·04
80 — Starting	·50	1	·17	·11	6	·18	·12	3	·09	·10

*UR — Unscheduled Removals
†URR — Unscheduled Removal Rate
‡FR — Confirmed Failure Rate (3 months cum. av.)

Fig. D7 Component Unscheduled Removals and Confirmed Failures

AIRCRAFT TYPE:				
SERIAL NO.	AIRCRAFT & POSITION	HRS RUN	DEFECT	RESULTS OF WORKSHOP INVESTIGATION & ACTION TAKEN
1170109	G—	848 TSR* 9375 TSN†	Losing altitude in turns	Test wing levelling not operative; recalibrated.
0290329	G—	11110 TSR 16771 TSN	Rolls rapidly to right when heading hold engaged.	Various internal outputs were drifting and distorted. Replaced tacho, roll CT and resolver, servo amp and valve amplifier.
0920575	G—	99 TSR 4014 TSN	Altitude hold sloppy in turns.	Roll computer out of calibration limits. Mod D to Lateral Path Coupler embodied to improve interface between Sxxxx equipment and Cxxxx receiver.
1280330	G—	36 TSR 7664 TSN	A/C will not maintain heading — ends up with 30° bank.	No fault found but extensive investigation revealed A3A1A2B output 1·5V — should be zero volts.

CONCLUSIONS	REMEDIAL ACTION
All channel assemblies are now sent to Manufacturer for investigation. Histories are reviewed and any channels which have previous 'NFF'‡ findings are being extensively tested to isolate components which may be drifting out of tolerance. This should result in improved MTBF§, but will probably show more confirmed failures for a while.	

	REPORT REF. NO.	PART NO.	ITEM
22-10-14/20 Sheet 1 of 1	1Q75-22-2H	2588812-901	Roll channel assy.

* Time since repaired
† Time since new
‡ 'No fault found'
§ Mean Time Between Failures

Fig. D8 Workshop Report

APPENDIX E - DEFINED TERMS AND ABBREVIATIONS

1 INTRODUCTION

Those terms and abbreviations in the text which have a specific meaning are brought together in this Appendix E for ease of reference. Where a definition has been derived from British Standard 4778 "Glossary of Terms used in Quality Assurance" or the "World Airlines Technical Operations Glossary", the source of the definition is indicated by the addition of "(BS)" or "(WATOG)" , as appropriate, at the end of the text.

2 TERMS AND ABBREVIATIONS

2.1 **Analysis.** The MSG Logic Analysis.

2.2 **ATA 100.** Air Transport Association of America, Specification 100.

2.3 **HKAR.** Hong Kong Aviation Requirements.

2.4 **CAD.** Hong Kong Civil Aviation Department

2.5 **Check.** An examination to determine the functional capability or physical integrity of an item. (WATOG).

2.6 **Condition Monitoring.** A primary maintenance process under which data on the whole population of specified items in service is analyzed to indicate whether some allocation of technical resources is required. Not a preventive maintenance process, condition monitored maintenance allows failures to occur, and relies upon analysis of operating experience information to indicate the need for appropriate action.

NOTE: Failure modes of condition monitored items do not have a direct adverse effect on operating safety. (WATOG).

2.7 **Document.** The CMM Programme document.

2.8 **Failure Mode**. The way in which the failure of an item occurs. (WATOG).

2.9 **Hard Time Limit.** A maximum interval for performing maintenance tasks. This interval can apply to Overhaul of an Item, and also to removal following the expiration of life of an Item.

2.10 **Item.** Any level of hardware assembly (i.e. part, sub-system, system, accessory, component, unit, material, etc.). (sic) (WATOG).

2.11 **Maintenance Significant Items.** Maintenance items that are judged to be relatively the most important from a safety, reliability or economic stand-point. (sic) (WATOG).

2.12 **Minimum Equipment List.** An approved list of items which may be inoperative for flight under specified conditions. (WATOG).

2.13 **On-Condition/ On-Condition Maintenance.** A primary maintenance process having repetitive inspections or tests to determine the condition of units, systems, or portions of structure with regard to continued serviceability (corrective action is taken when required by item condition). (WATOG).

2.14 **Overhaul.** The restoration of an item in accordance with the instructions defined in the relevant manual. (WATOG).

2.15 **Partial Overhaul.** The overhaul of a sub-assembly of an item with a time controlled overhaul to permit the longer-lifed item to achieve its authorized overhaul life. (WATOG).

2.16 **Pireps.** Pilot Reports.

2.17 **Programme.** Condition Monitored Maintenance Programme.

2.18 **Quality.** The totality of features and characteristics of a product or service that bear on its ability to satisfy a given need. (BS).

2.19 **Quality Control.** A system of programming and co-ordinating the efforts of the various groups in an organization to maintain or improve quality, at an economical level which allows for customer satisfaction. (BS).

2.20 **Quality Surveillance.** Supervision by the customer, his representative, or an independent organization of a contractor's quality control organization and methods. (BS).

2.21 **Redundancy.** The existence of more than one means for accomplishing a given function. Each means of accomplishing the function need not necessarily be identical. (WATOG).

2.22 **Redundancy, Active.** That redundancy wherein all redundant items are operating simultaneously rather than being activated when needed. (WATOG).

2.23 **Redundancy, Standby.** That redundancy wherein the alternative means of performing the function is inoperative until needed and is activated upon failure of the primary means of performing the function. (WATOG).

2.24 **Replace.** The action whereby an item is removed and another item is installed in its place for any reason. (WATOG).

2.25 **Scheduled Maintenance.** The maintenance performed at defined intervals to retain an item in a serviceable condition by systematic inspection, detection, replacement of wearout items, adjustment, calibration, cleaning, etc. Also known as "Preventative Maintenance" and "Routine Maintenance". (WATOG).

2.26 **Servicing.** The replenishment of consumables needed to keep an item or aircraft in operating condition. (WATOG).

2.27 **Test.** An examination of an item in order to ensure that the item meets specified requirements. (WATOG).

2.28 **WATOG.** World Airlines Technical Operations Glossary.

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