



**Civil Aviation  
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*This publication is only advisory but it gives the CASA preferred method for complying with the Civil Aviation Regulations 1988 (CAR 1988).*

*It is not the only method, but experience has shown that if you follow this method you will comply with CAR 1988.*

*Always read this advice in conjunction with the appropriate regulations.*

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# Reliability Programs

## References

- Regulations 42L and 42M of the *Civil Aviation Regulations 1988* (CAR 1988)
- Regulation 132 of CAR 1988
- Civil Aviation Order (CAO) 20.7.1B

## Who this CAAP applies to

- Certificate of Registration holders
- Air Operator's Certificate (AOC) holders
- Maintenance Controllers
- Approved Maintenance Organisations

## Why this publication was written

This CAAP provides information and guidance material that may be used to design, develop and manage reliability programs. It expresses practices that are acceptable to the Authority with regard to maintenance program management utilising reliability methods.

## Status of this CAAP

This is the first CAAP to be written on this subject.

## For further information

Contact CASA Office nearest to you.

## 1. Introduction

1.1 The overall maintenance program development process has two distinct processes within it. The initial maintenance program development (baseline) is the actual preparation of the aircraft maintenance specifications, and the reliability analysis (living process) collects data associated with the aircraft operating on the maintenance program. This process then measures the effectiveness of those maintenance tasks by alerting to systems, components and structures whose performance digresses from their expected levels.

1.2 A reliability program 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 program or to the practices for implementing it. Actions resulting from a reliability program may be to escalate or de-escalate, delete or add maintenance tasks, as necessary. This amendment will involve the approval of the Authority unless the operator has been approved to amend the maintenance program without direct involvement of the Authority. In simpler words, a reliability program enhances safety of flight operation and optimises maintenance costs.

## 2. Who is required to have a reliability program

2.1 All operators of transport category aircraft engaged in commercial operations are required, as part of the system of maintenance (generally known as maintenance program) for those aircraft, to have in place a reliability program where:

- The aircraft's maintenance program is based on MSG-3 logic process; or
- The aircraft's maintenance program includes condition monitored components; or
- The aircraft's maintenance program does not contain overhaul time periods for all significant system components; or
- It is required by the Maintenance Review Board (MRB) report issued by the national airworthiness authority (NAA) responsible for type certification of the aircraft or the manufacturer's Maintenance Planning Document (MPD).

2.2 A reliability program is not required, where:

- The maintenance program is based on the MSG-1 or MSG-2 logic process, but only contains hard time or on condition items; or

- The aircraft's Maximum Take-off Weight is 5700 kg or below; or
- The aircraft maintenance program provides overhaul time periods for all significant system components

### **3. Engineering judgement**

3.1 Engineering judgement is itself inherent to reliability programs as no interpretation of data is possible without judgement. In approving the operator's maintenance and reliability program, the Authority expects that the organisation which runs the program (it may be the operator, or an approved maintenance organisation (AMO) under contract) hires sufficiently qualified personnel with appropriate engineering experience and understanding of reliability concepts.

3.2 Failure to provide appropriately qualified personnel for the reliability program may lead the Authority to reject the approval of the reliability program and therefore the aircraft maintenance program.

### **4. Reliability program document**

4.1 The operator should develop a document describing the reliability program. This document should include at least the following:

- A general description of the reliability program
- Application of the program by aircraft fleet type/model, aircraft registration marks, or serial numbers, as appropriate.
- The organisational structure, duties and responsibilities
- Procedures for establishing and reviewing performance standards
- Data collection system
- Methods of data analysis
- Data display and reporting
- Corrective action program
- Maintenance program amendment
- Definitions of significant terms used in the reliability program
- A copy and explanation of all forms, peculiar to the program
- Reliability program's revision control and approval of revisions to the document (e.g. List of Effective Pages, Table of Contents, etc.)

## 5. Reliability program elements

### 5.1 GENERAL

5.1.1 A reliability program, in practical terms, is 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.

5.1.2 A good reliability program should contain means for ensuring that the reliability which is forecast can actually be achieved. A program, which is only general, may lack the details necessary to satisfy the reliability requirement. It is not intended to imply that all of the following information should be contained in one program. It is realised that operating philosophy and program management practices, etc, for each operator are different; however, the following information could be applied to the specific needs of either a simple or a complex program. All associated procedures should be clearly defined.

5.1.3 An operator's reliability program requires approval from the Authority and its approval is indicated on the Revision Control Page of the reliability program document.

### 5.2 OBJECTIVES

5.2.1 A statement should be included summarising as precisely as possible the scope and prime objectives of the program. As a minimum it should include the following:

- To recognise the need for corrective action; and
- To establish what corrective action is needed; and
- To determine the effectiveness of that action

5.2.2 The extent of the objectives should be directly related to the scope of the program. The manufacturer's MPDs may give guidance on the objectives and should be consulted in every case. Where some items such as aircraft structure, engines, APU, etc. are controlled by separate programs, the associated procedures (e.g. individual sampling or life development programs, manufacturer's structure sampling programs) should be cross-referenced in the program.

5.2.3 In case of a MSG-3 based maintenance program, the reliability program should provide a monitor that all MSG-3 related tasks from the maintenance program are effective and their periodicity is adequate.

### **5.3 RELIABILITY PROGRAM ADMINISTRATION**

5.3.1 The organisational structure and the departmental responsibilities for the administration of the program should be stated. The responsibilities for individuals and departments (Engineering, Production, Quality, Operations etc.) in respect of the program, together with the information and functions of any program control committees (Reliability Group), should be defined. Participation of the Authority at periodic reliability meetings should be considered. This information should be contained in the operator's Maintenance Control Manual (MCM).

### **5.4 TERMS AND DEFINITIONS**

5.4.1 The significant terms and definitions applicable to the program should be clearly identified. Terms are already defined in MSG-3, CARs and CAOs. Other terms may be found in World Airlines Technical Operations Glossary (WATOG) or in mathematical statistics literature. However, their number should be kept to a minimum.

### **5.5 DATA COLLECTION SYSTEM**

5.5.1 Sources of information should be listed and procedures for the transmission of information from the sources, together with the procedure for collecting and receiving it, should be set out in detail.

5.5.2 The type of information to be collected should be related to the objectives of the program. Some aircraft systems function acceptably after specific component or sub-system failures. Reports on such failures in those systems, nevertheless, act as a source of data that may be used as the basis of action either to prevent the recurrence of such failures, or to control the failure rates. The following are examples of the normal prime sources:

- Pilots Reports.
- Technical Logs.
- Aircraft Maintenance Access Terminal / On-board Maintenance System readouts.
- Maintenance Worksheets.
- Workshop Reports.
- Reports on Functional Checks.
- Reports on Special Inspections
- Stores Issues/Reports.
- Air Safety Reports.

- Reports on Technical Delays and Incidents.
- Other sources: ETOPS, RVSM, CAT II/III operations.

5.5.3 In addition to the normal prime sources of information, due account should be taken of continuing airworthiness and safety information promulgated by NAAs, design organisations and manufacturers.

## 5.6 PERFORMANCE STANDARDS

- (a) Performance standard/alert require engineering judgement for their application and typically applies to component monitoring, Pilot Reports (PIREPS) etc. A reliability alert level (or equivalent title, e.g. Performance Standard, Control Level, Reliability Index, Upper Limit) 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 an assessment should be made to determine if corrective action should be taken. It is important to realise 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 should not be misunderstood that, as redundancy exists, an increase in failure rate can always be tolerated without corrective action being taken.
- (b) Alert levels can range from 0.00 failure rate per 1,000 hours both for important components, where failures in service have been extremely rare, and 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.
- (c) For structural or significant non-routine findings from major checks, a non-statistical review may identify an alert condition.

### 5.6.1 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 up-dated 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 utilisation. The alert levels should 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 information much sooner than small fleets.
- (c) Where there is insufficient operating experience, or when a program for a new aircraft type is being established, the following approach may be used:
- For a new aircraft type, during the first two years of operation, alert levels should be established in conjunction with the aircraft type certificate holder and operators experience if appropriate and should be closely monitored for effectiveness during the induction period. Program data should still be accumulated for future use.
  - For an established aircraft type with a new operator, the experience of other operators may be utilised until the new operator has accumulated a sufficient period of own experience. Alternatively, experience gained from operation of a similar aircraft model may be used.
  - While setting alert levels for the latest aircraft designs, computed values based on the degree of system and component in-service expected reliability assumed in the design of the aircraft might also be used. These computed values are normally quoted in terms of Mean Time Between Unscheduled Removals (MTBUR) or Mean Time Between Failure (MTBF), for both individual components and complete systems. These initial predictions should be replaced when sufficient in-service experience has been accumulated.
- (d) There are several recognised methods of calculating alert levels, any one of which may be used provided that the method chosen is fully defined in the operator's program documentation.

### 5.6.2 Re-calculation of alert levels

- (a) Both the method used for establishing an alert level, and the associated qualifying period, apply 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 should be re-assessed and revised on the data subsequent to the change.

- (b) Procedures for changes in alert levels should be outlined in the approved reliability program and the procedures, periods and conditions for re-calculation should be defined in each program.

## 5.7 DATA ANALYSIS SYSTEM

5.7.1 The procedures for data analysis should be such as to enable the performance of the items controlled by the program to be measured. They should also facilitate recognition, diagnosis and recording of significant problems. The whole process should be such as to enable a critical assessment to be made of the effectiveness of the program as a total activity. Such a process may involve:

- Comparisons of operational reliability with established or allocated standards (in the initial period these could be obtained from in-service experience of similar equipment of aircraft types).
- Analysis and interpretation of trends
- The evaluation of repetitive defects
- Confidence testing of expected and achieved results
- Studies of life-bands and survival characteristics
- Reliability predictions
- Other methods of assessment.

5.7.2 The range and depth of engineering analysis and interpretation should be related to the particular program and to the facilities available. The following should be taken into account:

- Flight defects and reductions in operational reliability
- Defects occurring at line and main base
- Deterioration observed during routine maintenance
- Workshop and overhaul facility findings
- Modification evaluations
- Sampling programs
- The adequacy of maintenance equipment and technical publications
- The effectiveness of maintenance procedures
- Staff training
- Service Bulletins (SB), technical instructions, etc.

5.7.3 Where the operator relies upon contracted maintenance and/or AMOs as an information input to the program, the arrangements for availability and continuity of such information should be established and details should be included.

## **5.8 DATA DISPLAY AND REPORTING**

5.8.1 The displayed information should provide the operator and the Authority with an indication of aircraft fleet's reliability. The rules governing any separation or discard of information prior to incorporation into these displays and reports should be stated.

5.8.2 The format, frequency of preparation and the distribution of displays and reports should be fully detailed in the program documentation.

5.8.3 Displays should include provisions for "nil returns" to aid the examination of the total information.

5.8.4 Where "standards" or "alert levels" are included in the program, the displayed information should be oriented accordingly.

## **5.9 PRESENTATION OF INFORMATION TO THE AUTHORITY**

5.9.1 The following information should be submitted to the Authority for initial approval of the reliability program:

- The format and content of routine reports
- The time scales for the production of reports together with their distribution
- The format and content of reports supporting request for increases in periods between maintenance (escalation) and for amendments to the approved maintenance program. These reports should contain sufficient detailed information to enable the Authority to make its own evaluation where necessary.

### **PERIODIC REPORTING**

5.9.2 The following information as agreed with the Authority should be included in the reliability report:

- Fleet reliability summary

This summary relates to all aircraft of the same type, and should contain the following information for the defined reporting period:

- ◇ Number of aircraft in fleet

- ◇ Number of aircraft in service
- ◇ Number of operating days (less maintenance checks)
- ◇ Total number of flying hours
- ◇ Average daily utilisation per aircraft
- ◇ Average flight duration
- ◇ Total number of cycles/landings
- ◇ Total number delays/cancellations
- ◇ Technical incidents
- Dispatch reliability (Aircraft technical delays/cancellations)

All technical delays more than 15 minutes and cancellation of flight(s), due to technical malfunction, are required to be reported. The report should include the delay/cancellation rate for the defined reporting period, the three-monthly moving average rate and, where appropriate, the alert level. The operator should present the information for a minimum period of 12 consecutive months, but need not repeat the occurrences in descriptive form. This information should be presented in such a way as to show the trend over a 2 to 3 year period.

- In-flight diversions due to technical malfunction or failures (known or suspected)

While all in-flight diversions due to technical malfunction or failures (known or suspected) should be reported through normal Service Difficulty Reporting (SDR) (Major Defect Reporting) System, a summary of all in-flight technical diversions should be provided with the 3 monthly report. If the summary references the SDRs, then it need not repeat the occurrences in descriptive form.

- Engine unscheduled shut-down or propeller feathering

All In-Flight Shut Down (IFSD) and IFSD rates or propeller feathering in flight, if applicable, listed by type of engine and aircraft for the reporting period should be reported and presented in graphical form. If this information references the SDRs, then it need not repeat the occurrences in descriptive form. When dealing with small numbers of IFSD, IFSD rate, or propeller feathering in flight, this information should be presented in such a way as to show the trend over a 2 to 3 year period.

- Incidents involving inability to control engine/obtain desired power

All incidents involving inability to control/obtain engine desired power during the reporting period should be reported and presented in graphical form. If this information references the SDRs, then it need not repeat the occurrences in descriptive form. When dealing with small numbers of such incidences, this information should be presented in such a way as to show the trend over a 2 to 3 year period.

- **Unscheduled engine removals due to technical failures**

All unscheduled engine removals and rates due to technical failures, listed by type of engine and aircraft for the reporting period should be reported and presented in graphical form. If this information references the SDRs, then it need not repeat the occurrences in descriptive form. When dealing with small numbers of unscheduled engine removals, this information should be presented in such a way as to show the trend over a 2 to 3 year period.
- **Component unscheduled removal**

All unscheduled removal of maintenance significant components, by ATA chapter, during the defined reporting period should be reported and presented in graphical form. Some operators may monitor hundreds of components and it may not be feasible for them to graph all data.

The format of component removal information should be such that:

  - ◇ Both unscheduled removals and confirmed failures rates should be compared with the alert levels; and
  - ◇ Current and past periods of operation should be compared.
- **Operation of aircraft with multiple Minimum Equipment List (MEL) items invoked**

A periodic reliability report should include trend reporting of dispatch of aircraft with multiple MEL items invoked and shall present the information for a minimum period of 12 months. The report need not repeat the occurrences in descriptive form.
- **PIREPS**

PIREPS should be reported to the Authority by ATA chapters in graphical and/or tabular form as a count and rate for the defined reporting period, and comparison thereof with the alert level. For certain types of aircraft pilot reported defects are not a valid

reliability indicator. In such situations, reporting of PIREPS will not be required.

- ETOPS specific operations
  - In addition to non-ETOPS reliability reporting requirements, the following information should be provided for ETOPS flights:
    - ◇ number of ETOPS flights during the defined reporting period
    - ◇ aircraft/engine type/combination involved in the program, e.g. B767/CF6-80C2
    - ◇ details of aircraft involved in the program during the reporting cycle
    - ◇ average fleet utilisation time and cycles during the reporting cycle
    - ◇ ETOPS critical component failures or malfunctions, by ATA chapter. However, ETOPS critical system failure reporting may also be acceptable.

5.9.3 The reports should explain changes, which have been made or are planned in the aircraft's maintenance program, including changes in maintenance and task intervals and changes from one maintenance process to another. It should discuss continuing over-alert conditions carried forward from previous reports and should report the progress of corrective action programs.

## 5.10 CORRECTIVE ACTIONS

The procedures and time scales both for implementing corrective actions and for monitoring the effects of corrective actions should be fully described. Corrective actions should correct any reduction in reliability revealed by the program and could take the form of:

- Changes to maintenance, operational procedures or techniques
- Maintenance changes involving inspection frequency and content, function checks, overhaul requirements and time limits, which will require amendment of the scheduled maintenance periods or tasks in the approved maintenance program. This may include escalation or de-escalation of tasks, addition or modification or deletion of tasks
- Amendments to approved manuals (e.g. Maintenance Manual, Crew Manual)
- Initiation of modifications

- Special inspections or fleet campaigns
- Spares provisioning
- Staff training
- Manpower and equipment planning.

*Note: Some of the above corrective actions may need the Authority's approval before implementation.*

5.10.2 The procedures for effecting changes to the maintenance program should be described, and the associated documentation should include a planned completion date for each corrective action, where applicable.

## **5.11 MAINTENANCE PROGRAM AMENDMENT**

5.11.1 The Authority may authorise the operator to implement maintenance program changes arising from the reliability program when satisfied that:

- The reliability program monitors the content of the approved maintenance program in a comprehensive manner, and
- The procedures associated with the functioning of the "Reliability Group" provide the assurance that the operator exercises appropriate control over the internal validation of such changes.

## **5.12 EVALUATION AND REVIEW**

5.12.1 Each program should describe the procedures and individual responsibilities in respect of continuous monitoring of the effectiveness of the program as a whole. The time periods and the procedures for both routine and non-routine reviews of maintenance control should be detailed (progressive, monthly, quarterly, or annual reviews, procedures following reliability "standards" or "alert levels" being exceeded, etc.).

5.12.2 Each program should contain procedures for monitoring and, as necessary, revising the reliability "standards" or "alert levels". The organisational responsibilities for monitoring and revising the "standards" should be specified together with associated time scales.

5.12.3 Although not exhaustive, the following list gives guidance on the criteria to be taken into account during the review.

- Utilisation (high/low/seasonal)
- Fleet commonality

- Alert level adjustment criteria
- Adequacy of data
- Reliability procedure audit
- Staff training
- Operational and maintenance procedures.

5.12.4 The program areas requiring Authority's approval may include changes to the program that involve:

- Any procedural and organisational changes concerning program administration
- Adding or deleting aircraft types
- Adding or deleting components/systems
- Procedures relating to performance standards
- Data collection system
- Data analysis methods and application to the total maintenance program
- Procedures for maintenance program amendment.

## 6. Pooling arrangements

6.1 In some cases, it may be desirable to "pool" data ( i.e. collate data from a number of operators of the same type of aircraft) for adequate analysis. For the analysis to be valid, the aircraft concerned, mode of operation, and maintenance procedures applied must be substantially the same. Variations in utilisation between two operators may fundamentally corrupt the analysis. Although not exhaustive the following list gives guidance on the primary factors, which need to be taken into account:

- Certification factors, such as aircraft type certificate data sheet (TCDS) compliance (variant)/modification status, including SB compliance
- Operational factors, such as operational environment/utilisation, e.g. low/high/seasonal etc /respective fleet size operating rules applicable (e.g. ETOPS/RVSM/ All Weather operations etc.)/operating procedures/MEL and MEL utilisation
- Maintenance factors, such as aircraft age, maintenance procedures; maintenance standards, applicable lubrication/servicing procedures, MPD revision or escalation applied or maintenance program applicable.

6.2 Although it may not be necessary for all of the foregoing to be completely common, it is necessary for a substantial amount of commonality to prevail. The Authority shall take decision on a case-by-case basis.

6.3 In case of a short-term lease agreement (less than 6 month) the Authority may grant more flexibility against the above criteria to allow the operator to operate the aircraft under the same program during the lease agreement.

6.4 Where an operator wishes to pool data in this way, the approval of the Authority will need to be sought prior to any formal agreement being signed between operators.

6.5 Whereas this paragraph is intended to address the pooling of data directly between operators, it is acceptable that the operator participates in a reliability program managed by the aircraft manufacturer, when the Authority is satisfied that the manufacturer manages a reliability program that complies with the intent of this CAAP.

## **7. Contracted reliability program**

7.1 While regulations require that the operator manage and present the aircraft maintenance program which includes the associated reliability program to the Authority, it is understood that the operator may delegate certain functions to an AMO under contract, provided this organisation proves to have the appropriate expertise.

7.2 The functions that may be delegated to an AMO are:

- Developing the aircraft maintenance and reliability programs
- Performing the collection and analysis of the reliability data
- Providing reliability reports; and
- Proposing corrective actions to the operator.

7.3 Despite the above the decision to implement a corrective action (or the decision to request from the Authority the approval to implement a corrective action) remains the operator's prerogative and responsibility. A decision not to implement a corrective action should be justified and documented.

7.4 The arrangement between the operator and the AMO should be specified in the maintenance contract and the relevant MCM and procedures manual of the AMO.

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