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AIRCRAFT MAINTENANCE RELIABILITY PROGRAM

GUIDANCE ON HOW TO COMPLY WITH THE REQUIREMENTS OF CAR OPS 1 AND CAR OPS 3 WITH RESPECT TO RELIABILITY PROGRAMS

1. APPLICABILITY

All operators of large aircraft (a multi-engine helicopter or an aeroplane with Maximum Take Off Mass of more than 5,700 kg), engaged in the commercial operations / commercial air transport, are required to have in place a reliability program, as part of the maintenance program for those aircraft; if any one of the following conditions is met:

(a) The aircraft's maintenance program is based on MSG-3 logic process; or

(b) The aircraft's maintenance program includes condition monitored components; or

(c) The aircraft's maintenance program does not contain overhaul time periods for all significant system components; or

(d) It is required by the Maintenance Review Board (MRB) report; or

(e) It is required by the manufacturer's Maintenance Planning Document.

For other operators of large aircraft, maintenance reliability programs (or equivalent programs which meet the intent), should depend on the size of the operator, type of operations and other factors.

2. INTRODUCTION:

The GCAA CAR-OPS 1–Subpart M (Aeroplanes) and CAR-OPS 3– Subpart M (Helicopters) require all UAE based operators satisfying the applicability criteria, to have in place a reliability program.

The guidelines contained in this Civil Aviation Advisory Publication (CAAP) are general in nature and offer one of the ways operators may show compliance with the GCAA regulatory requirements. Not all provisions of this CAAP will be applicable to all of the operators and a rational judgment should be used to pick the elements that will suit an operator's size and type of operations.

The term *"reliable"*, as used by the aviation industry, applies to the dependability or stability of an aircraft system or a part thereof under evaluation. A system or component is considered *"reliable"* if it follows an expected law of behaviour and is regarded *"unreliable"* if it departs from this expectation. These expectations differ greatly, depending upon how the equipment is designed and operated.

A reliability program is a set of procedures aimed at collecting data related to the failure (i.e. not able to perform the function they are designed for, when it is required) of the aircraft, its systems, sub-systems, components and parts. Further analysis of the data thus collected and making meaningful inferences using engineering judgement also forms part of the program.

The actions based on those inferences, to improve the maintenance program, is what makes a reliability program beneficial.

The intent of the reliability analysis should be to measure the effectiveness of the tasks within the maintenance program by alerting to the systems, components and structures whose performance digresses from their expected levels.

Reliability programs form an integral part of an operator's maintenance program, and are designed to supplement the operator's overall program for maintaining aircraft in a continuous state of airworthiness. Accordingly any operator submitting maintenance program for the GCAA approval must also provide relevant reliability program for assessment and approval.

Maintenance Management Exposition (MME) of an operator should provide an overview of the management of maintenance reliability program.

Please note that the actions resulting from a reliability program may be to alter, delete or add maintenance tasks, as necessary. Any change in a maintenance program because of the findings of a reliability program will also require the regulatory (GCAA) approval.

3. THE BENEFITS:

Properly designed and implemented maintenance reliability programs bring many benefits to the operator, for example:

- Compliance with the regulatory requirements
- An increase in the aircraft availability
- Elimination of redundant and ineffective maintenance practices
- Reduction in the number of no-fault-found occurrences
- Reduction in fleet maintenance costs
- Reduction in maintenance and down time

A reliability program may become an essential decision-making tool for the maintenance management team, because it will provide a summary of aircraft fleet reliability, reflecting on the effectiveness of the maintenance program and the way it is done. It will also help the operator discover real causes of recurrent equipment problems, planning issues, scheduling conflicts, and procedural difficulties.

Once the shortcomings are known then an improvement in the reliability may be achieved through changes to the maintenance program or to the practices for implementing it. The overall result of an effective reliability program is the better utilization of the available resources.

4. THE SALIENT FEATURES

A reliability program may either be a part of the aircraft maintenance program (AMP) or an independent program on its own, with suitable reference in the AMP.

For a reliability program to be acceptable to the GCAA, it should have the following salient features:

(a) The program should monitor reliability of power plant and other major / significant systems essential for the intended operation of the aircraft.

Note: for the purpose of this CAAP, a significant system is a system the failure of which could hazard the aircraft safety.

(b) The personnel engaged in reliability monitoring should be suitably qualified and trained.

(c) The reliability reports should be generated on quarterly basis at the least and should be presented during periodic audits or when required by the GCAA.

(d) The maintenance program should have provisions to respond to the findings of the reliability program. The changes to the maintenance program revised as such should be resubmitted to the GCAA for approval.

(e) For airlines and other large operators (with fleet size of six or more aircraft), periodic reliability meetings should be organised with an aim to address all events affecting aircraft reliability. The GCAA should be invited to participate in such meetings.

All reliability program(s) should be submitted by the operator(s) to their designated Airworthiness Inspector(s) for GCAA approval.

5. STRUCTURE AND MANAGEMENT OF THE RELIABILITY PROGRAM

The details that follow discuss how the reliability program should be structured and how it should be managed.

Part one discusses the structure. Every operator is different in terms of the operations, fleet composition and operating environment therefore the operators may tailor the structure of their reliability program according to their own unique situation while meeting the intent of the requirement.

Part two discusses the operators with small fleet while part three discusses the possibility of outsourcing.

Part One: Structure of Reliability Program

An aircraft Maintenance Reliability Program should include the following elements:

- Reliability program's revision control and approval of revisions (e.g. List of Effective Pages, Table of Contents, etc.)
- A general description of the reliability program
- Definitions of significant terms used in 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
- A copy and explanation of all forms, relevant to the program

Some important elements which form part of a reliability program are discussed below:

1.01 Terms and Definitions

The significant terms and definitions applicable to the program should be clearly identified. Some of the terms are already defined in (Maintenance Steering Group) MSG-3, CARs and other GCAA publications. The number of terms and definitions should be kept to a minimum.

1.02 Objectives

A statement should be included in the program summarising the scope and prime objectives. As a minimum it should include the following:

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

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 also be consulted.

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.

1.03 Reliability Program Administration:

The organisation structure of the reliability program administration will largely depend on the size of operations. In small organisations, administration of a reliability program may be a shared responsibility while the large airlines may establish their own dedicated reliability group.

Large or small, each reliability program, however, should clearly define the individual by office title or departmental responsibilities for all phases of its administration, including policy enforcement, follow-ups and corrective actions.

A reliability program should also contain a procedure for the preparation, approval and implementation of its revisions.

The organisation personnel engaged in running reliability program should be suitably qualified and appropriately experienced.

A program administration should also ensure provision for the GCAA participation at periodic reliability meetings.

1.04 Identification of items:

The reliability program should state items being controlled, e.g. by ATA Chapters. Where some items (e.g. 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 main program.

1.05 Data Collection System

The data should be as factual as possible so that a high degree of confidence may be placed in any derived conclusion. In order to ensure accuracy, data should be obtained from units functioning under different operational conditions.

The data sources should be listed in the program and path for flow of information (including procedure for collecting and receiving the data) should be set out in detail.

The type of information to be collected should relate to the program objectives. Following are examples of the normal sources of reliability data:

- Pilots Reports.
- Technical Logs.
- Aircraft Maintenance Access Terminal / On-board Maintenance System readouts.
- Maintenance Worksheets.
- Workshop Reports / findings.
- Reports on Functional Checks.
- Unscheduled removals and confirmed failures.
- Reports on Special Inspections
- Stores Issues/Reports.
- Air Safety Reports / Service Difficulty Reports / Major Defect and occurrence reports.
- Reports on Technical Delays and Incidents.
- Other sources: ETOPS, RVSM, CAT II/III operations.

Some aircraft systems are redundant in design (i.e. function acceptably after specific component or sub-system failure). The reliability data associated with such systems should be recorded and assessed keeping that point in perspective.

In addition to the normal sources of information, due consideration should be given to the safety information promulgated by the type certificate holders and design organisations as well as by the type certificating aviation authority (NAA) of the state of design.

If the operator is reliant on contracted maintenance for an information input to the reliability program, the arrangements for availability and continuity of such information should be established and details should be included.

1.06 Performance Standards

A performance standard or reliability alert level is an indicator (expressed in mathematical terms), 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.

Performance standard or alert or equivalent title (e.g. Control Level, Reliability Index, Upper Limit etc.) require engineering judgement for their application.

Please note that alert levels are not minimum acceptable airworthiness levels. Similarly, 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.

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 (Pilot Reports) 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.

For structural or significant non-routine findings from major checks, a non-statistical review may identify an alert condition.

Due to the constantly changing technologies, no performance standard should be considered fixed and should be subject to change as reliability changes. Accordingly, the standards should be responsive and sensitive to the level of reliability experienced (i.e. should be "stable" without being "fixed").

If, over a period of time, the performance of a system improves to a point where even abnormal variations would not produce an alert, then the performance standard has lost its value and should be adjusted downward. Conversely, should it become evident that the standard is consistently exceeded in spite of taking the best known corrective measures to produce the desired reliability, then the performance standard should be re-evaluated and a more realistic standard should be established.

A Reliability Program should contain a section on the performance standards, describing what type of alert levels will be used, how the levels will be established, how the levels will be re-established if required, how the system would know if the levels have been exceeded and what corrective action(s) would be taken and how.

1.06.1 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 should be for one year at least, preferably more (2 – 3 years) depending on the fleet size and utilisation.

(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 initial period 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.

1.06.2 Re-calculation of alert levels

(a) Whenever 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 reliability program and the procedures, periods and conditions for re-calculation should also be defined.

1.07 Data Analysis System

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 or 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.

The range and depth of engineering analysis and interpretation should be related to the type and scope of operations. 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 literature such as Service Bulletins, SIL, SL, technical instructions, etc.

1.08 Data Display and Reporting System

The reliability program should detail how reliability data will be displayed and reported.

While the data collected may have several internal uses for the operator, the information provided in the reliability report should provide the operator and the GCAA with a clear indication of aircraft fleet's reliability. Accordingly, the format, frequency of preparation and the distribution of displays and reports should be fully detailed in the program.

The rules governing any discarding of information prior to incorporation into reliability displays and reports should also be stated. Similarly, the reliability reports / displays should include provisions for "nil returns" to help the examination of the total information.

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

1.09 Presentation of Reliability Information:

A reliability program, when being submitted to the GCAA for initial approval, should also contain following information:

- The format and content of routine reports (A sample report would be preferred).
- The time scales for the production of reports together with their planned distribution list
- The format and content of reports supporting request for increases in periods between maintenance (escalation) and for amendments to the approved maintenance program (Again, a sample report would be preferred).

The sample reports should contain sufficient detailed information to enable the Authority to make its own evaluation where necessary.

1.10 What should be included in the Periodic Reliability Reports:

Each operator is unique in terms of type / scope of operations, the operating environment, operations network, type of aircraft fleet etc and accordingly what should or should not be included in the periodic reliability reports should be decided by the maintenance management to reflect most accurate picture of the actual reliability or effectiveness of its maintenance operations.

The GCAA suggests following information to be included in the periodic 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 and Number of aircraft in service

◊ Number of operating days (less maintenance checks)

◊ Total number of flying hours

◊ Average daily utilisation per aircraft, and 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 should 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. This information should be presented in such a way as to show the long-term trend.

- *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 Mandatory Occurrence / Difficulty Reporting (MODR) System, a summary of all in-flight technical diversions should be provided in the periodic reliability report.

- *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. 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 long-term trend.

- *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. When dealing with small numbers of such incidences, this information should be presented in such a way as to show the long-term trend.

- *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. When dealing with small numbers of unscheduled engine removals, this information should be presented in such a way as to show the long term trend.

- *Component unscheduled removal*

All unscheduled removal of maintenance significant components, by ATA chapter, during the defined reporting period should be reported. 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 GCAA 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.

1.10.1 What else should be included: The periodic reliability report may also 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.

1.11 Availability of Reliability Reports when Required

The operator is required to make available all reliability reports during audits or when required by the GCAA. The Reliability program should therefore specify the procedure for periodic distribution of the reports as well as for their storage at a safe place and retrieval, when required.

1.12 Corrective Actions:

The procedures and time scales both; for implementing corrective actions and, for monitoring the effects of corrective actions should be fully described in the reliability program. An assessment of the time permitted should be commensurate with the severity or safety impact of the problem.

Corrective actions should correct any reduction in reliability revealed by the program and could take the form of:

- Changes to the 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 task intervals, addition or modification or deletion of maintenance tasks, etc.
- 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.

Some of the above corrective actions may need the GCAA's approval before implementation.

If despite having a signal / alert for the need of corrective action generated by the maintenance reliability system, and the operator opts not to change the maintenance program or implement a correction, that decision should be justified objectively and documented.

1.13 Evaluation, Review and Changes:

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

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.

The program areas requiring GCAA'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.

Part Two: An operator with a small fleet:

Note: For the purpose of this CAAP, a small fleet of aircraft is a fleet of less than six aircraft of the same type.

The volume of reliability related data generated by a small operator may be too low and slow to offer meaningful insight into the effectiveness of its maintenance program. Accordingly, 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, stage length, utilisation and maintenance procedures applied must be substantially the same.

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, stage length (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 utilization), etc.
- Maintenance factors, such as aircraft age, maintenance procedures; maintenance standards, applicable lubrication/servicing procedures, MPD revision or escalation applied or maintenance program applicable, etc.

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. Where an operator wishes to pool data in this way, the GCAA approval should be sought prior to any formal agreement being signed between operators.

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

Whereas the above paragraph addresses 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 GCAA is satisfied that the manufacturer manages a reliability program that complies with the intent of this CAAP.

Part Three: Delegation to a Third Party Organisation:

The GCAA regulations require that the operator manage and present the aircraft maintenance program which includes the associated reliability program. Keeping associated costs in perspective, the GCAA understands that a small operator may prefer to delegate certain functions to an approved CAR 145 organisation or an approved Continuing Airworthiness Management Organisation (CAMO) under contract.

If an operator outsources continuing airworthiness management functions to an approved Continuing Airworthiness Management Organisation (CAMO) or CAR 145 approved maintenance organisation, the operator should ensure that the agreement also includes function of establishing and monitoring reliability programs.

The reliability related functions that may be delegated 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.

Please note that despite the above, the decision to implement a corrective action (or the decision to request from the GCAA the approval to implement a corrective action) remains the operator's responsibility. If an operator decides not to implement a corrective action (proposed by a CAMO / CAR 145 Organisation) then that decision should be justified and documented.

The arrangement between the operator and the CAMO / CAR 145 Organisation should be specified in the maintenance contract and the relevant manuals.