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CASAS ADVISORY PAMPHLET

Subject: AIRCRAFT MAINTENANCE RELIABILITY PROGRAMS

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AIRCRAFT MAINTENANCE RELIABILITY PROGRAM APPROVAL PROCEDURE

1. INTRODUCTION

CARS 9.4.1.12 requires operators to have in place a reliability program when the requirement there for has been determined by the CASAS. The determination by the CASAS will be made on the basis of the requirements as detailed in the “Applicability” section here below.

This CASAS Advisory Pamphlet provides guidance to AOC holders for developing Aircraft Reliability Programs as part of the Aircraft Maintenance Program.

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 judgment also forms part of the program. The actions based on those inferences should lead to an improved maintenance program tailored to those conditions specific to the aircraft fleet and those specific to the operator.

2. GENERAL

The analysis of data collected under a reliability program should result in measuring 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 shall be designed to supplement the operator's overall program for maintaining aircraft in a continuous state of airworthiness. Accordingly any operator submitting a maintenance program for the CASAS approval must also provide the relevant reliability program, if applicable, for assessment and approval. The Maintenance Control Manual (MCM) as required by CARS 9.4.1.4 for AOC holders shall contain an overview of the management of the maintenance reliability program.

Note that any actions resulting from the analysis of data collected under a reliability program may impact the contents of the maintenance program approved by the CASAS. As required by CARS 9.4.1.12 (a) any change in a maintenance program will require the CASAS approval prior to its implementation.

3. APPLICABILITY

As noted in the Introduction section of this Advisory Pamphlet, the CASAS will determine the requirement for an AOC holder to have a Reliability Program in place for the aircraft operated by her.

This determination will be based on the following criteria:

- 1) The aircraft operated shall be "Large" type aircraft (A multi-engine helicopter or an aeroplane with a Maximum Take Off Mass (MTOM) of more than 5,700 kg), and
- 2) The aircraft's maintenance program shall be based on MSG-3 logic process; or
- 3) The aircraft's maintenance program includes condition monitored components; or
- 4) The aircraft's maintenance program does not contain overhaul time periods for all significant system components; or
- 5) The Maintenance Review Board (MRB) report requires a Reliability Program to be in place; or
- 6) The manufacturer's Maintenance Planning Document (MPD) requires a Reliability Program to be in place.

4. RELIABILITY PROGRAM CONTENT

For a reliability program to be acceptable to the CASAS, the following features shall be included:

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

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

- (b) The requirement for suitably qualified and trained Personnel that will be tasked with the management and monitoring of the program.

- (c) The generation of Reliability reports on at least a quarterly basis which shall be presented during periodic audits or when required by the CASAS.
- (d) Provisions to respond to the findings of the reliability program. The changes to the maintenance program revised as such shall be resubmitted to the CASAS for approval.
- (e) The organization of periodic reliability meetings with the aim to address all events affecting aircraft reliability. The CASAS 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 CASAS 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 organizational 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 CASAS publications. The number of terms and definitions should be kept to a minimum.

1.02 Objectives

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

- To recognize 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 organization structure of the reliability program administration will largely depend on the size of operations. In small organizations, 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 organization personnel engaged in running reliability program should be suitably qualified and appropriately experienced.

A program administration should also ensure provision for the CASAS 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 organizations 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 behavior 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 judgment 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 utilization.
- (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 utilized 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 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 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 reassessed 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 CASAS 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 CASAS 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 CASAS 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 utilization 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 CASAS 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 utilization 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 CASAS. 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 CASAS' 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.

- Utilization (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 CASAS' approval may include changes to the program that involve:

- Any procedural and organizational 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.
