Barbados Civil Aviation Department

BCAD Document AAC-025

AIRWORTHINESS

ADVISORY

CIRCULAR

MAINTENANCE CONTROL BY RELIABILITY METHODS

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1. PURPOSE

1.1 This circular provides information and guidance material which may be used to design or develop maintenance control programmes utilizing reliability control methods.

1.2 Its primary objective is to provide guidance for development of programmes using reliability techniques. It expresses BCAD practice with regard to control programmes utilizing these techniques.

1.3 This circular encompasses the information and criteria contained in:

(a) Federal Aviation Administration AC 120-17A, Maintenance Control by Reliability Methods which is used as the Technical Source Documents for this AC.
(b) The Airline/Manufacturer Maintenance Programme Planning Document – **MSG-2 and 3, (as revised)** which establishes the criteria for classifying maintenance processes.

2. REFERENCES

This circular is appropriate for guidance of certificate holders who operate aircraft in accordance with Barbados Civil Aviation Regulations (Aircraft Operations), (Air Operator Certification and Administration), (Airworthiness), (Approved Maintenance Organisation) and (Instrument and Equipment).

3. AUTHORITY

The basis for civil aviation regulations is in section 10 of the Civil Aviation Act, 2005. For air operators and operators subject to the following Regulations, (Aircraft Operations), (Air Operator Certification and Administration), (Airworthiness), Approved Maintenance Organisation) and (Instrument and Equipment), this authority is exercised through AOC & Administration Regulation 85, Aircraft Operations Regulation 29, Instrument & Equipment Regulation 5, which require that operations specifications contain time limitations, or standards for determining time limitations, for overhauls, parts retirement, inspections, replacements, and checks of airframes, engines, propellers, rotors, appliances, and emergency equipment.

4. BACKGROUND

(1) The first generation of formal air operator maintenance programmes was based on the belief that each functional part of a transport aircraft needed periodic disassembly inspection. Time limitations were established for servicing, checks and inspections, and the entire aircraft was periodically disassembled, overhauled, and reassembled in an effort to maintain the highest level of safety. This was the origin of the first primary maintenance process discussed in this publication and referred to as "Hard-Time."

(2) As the industry grew, matured, and adopted more complex aircraft, literal application of the "Hard-Time" primary maintenance process became obsolete. The industry

came to realize that each component and part did not require scheduled overhaul on a fixed time basis, and a second primary maintenance process evolved, referred to as "On-Condition." It is assigned to components on which a determination of continued airworthiness can be made by visual inspections, measurements, tests or other means without disassembly, inspection or overhaul.

(3) Control of these programmes was previously accomplished by individual approval of the hard- time or on-condition check periods for the aircraft, engines, and components. The procedures used to adjust these periods were awkward and burdensome, often inhibiting logical adjustment. This method of control was oriented toward mechanical performance rather than to predicting failure wear out points, as was the case in the previous methods. The new method was entitled "reliability control" because its major emphasis was toward maintaining failure rates below a predetermined value; i.e., an acceptable level of reliability.

(4) The analytical nature of reliability control disclosed and emphasized the existence of components and systems that did not respond to the hard-time or on-condition processes. This led to a third process whereby no services or inspections are scheduled to determine integrity or serviceability. However, the mechanical performance is monitored and analyzed, but limits or mandatory action are not prescribed. This process is entitled "Condition-Monitoring."

5. RELIABILITY CONTROL FUNDAMENTALS

5.1 GENERAL

5.1.1 It is intended that characteristics of each operator, i.e., philosophy, consideration of operational and environmental factors, recordkeeping systems, etc., be reflected in his own programme. The extent and scope of each operator's application of reliability control is defined in his reliability programme document.

5.1.2 There are four general categories of an operator's maintenance programme.

(a) Systems/components.

(b) Powerplants/components.

(c) Aircraft/engine checks and inspections.

(d) Structural inspection/overhaul.

5.1.3 All four may be controlled by a composite programme, or each may be handled individually. The programme can encompass a select group of items from a category without affecting other controls for the remaining items of that category. For example, the basic engine might be maintained by a programme that does not include its accessories. The accessories could be on another programme or they could be under traditional operations specifications control.

5.1.4 Statistical analysis is most effective in its application to systems and components because the occurrence of failures can be readily reduced to meaningful statistics. When

alert rates are used in the analysis, graphic charts (or equivalent displays) show areas in need of corrective action. Conversely, statistical analysis of inspection findings or other abnormalities related to aircraft/engine check and inspection periods requires judgmental analysis. Therefore, programmes encompassing aircraft/engine check or inspection intervals might consider numerical indicators, but sampling inspection and discrepancy analysis would be of more benefit.

6. PRIMARY MAINTENANCE PROCESSES

6.1 The three primary maintenance processes utilized by maintenance programmes are:

(a) hard-time;

(b) on-condition, and;

(c) condition-monitoring.

6.2 Following are general descriptions of the three maintenance processes. Each programme should include specific definitions of the processes it uses and how they are applied. The detailed requirements for the condition-monitoring process are included in the Airline Manufacturer Maintenance Planning Document – **MSG-2 and 3 (as revised)**.

(a) **Hard-Time (HT).** This is preventive primary maintenance process. It requires that an appliance or part be periodically overhauled in accordance with the carrier's maintenance manual or that it be removed from service.

(b) **On-Condition (OC).** This is a preventive primary maintenance process. It requires that an appliance or part be periodically inspected or checked against some appropriate physical standard to determine whether it can continue in service. The purpose of the standard is to remove the unit from service before failure during normal operation occurs.

(c) **Condition-Monitoring (CM).** This is a maintenance process for items that have neither "Hard-Time" nor "On-Condition" maintenance as their primary maintenance process. CM is accomplished by appropriate means available to an operator for finding and solving problem areas. The detailed requirements for the condition-monitoring process are included in the Airline Manufacturer Maintenance Planning Document – **MSG-2 and 3 (as revised)**.

(i) Complex (multicell) units may be subject to control by two or even all three of the primary processes. The predominant process will determine its classification. For example, the B-747 Modular Package - Stabilizer Control has CM assigned as its primary maintenance process by the MRB report, but a leakage check, which is a conventional OC task, is also specified.

(ii) The basic engine has characteristics that involve all three primary maintenance processes.

(A) Programmes that control engine major overhaul intervals consider the engine as a hard-time unit. The overhaul standards are specified by

overhaul manuals or other publications that do not identify individual processes as such.

(B) Programmes controlling shop maintenance to a "conditional" standard (restoration, etc.,) may classify the engine as on-condition or as condition-monitoring depending on the characteristics of the programme. The applicable maintenance processes and their intervals should be designated in (or referenced by) the programme document. **MSG-2 and 3 (as revised)**, discusses the analysis method for assigning maintenance processes. This method was used in the maintenance review board activity for the engines of the wide-bodied jets. This analytical method, in conjunction with service experience, can be applied to earlier engines.

7. RELIABILITY CONTROL SYSTEMS.

7.1 Typical systems used in reliability control are:

(a) data collection;

(b) data analysis;

(c) corrective action;

(d) performance standards;

(e) data display and report;

(f) maintenance interval adjustment and process change, and;

(g) programme revision.

7.2 The intent of this section is not to provide a rigid specification but rather to explain the purpose of the systems which the operator can use as a framework for his particular programme. The following paragraphs discuss these systems:

(a) **Data collection system**. This system should include a specific flow of information, identity of data sources, and procedures for transmission of data, including use of forms, computer runs, etc. Responsibilities within the operator's organization must be established for each step of data development and processing. Typical sources of performance information are as follows, however, it is not implied that all of these sources need be included in the programme nor does this listing prohibit the use of other sources of information:

(i) Pilot reports.

(ii) In-flight engine performance data.

(iii) Mechanical interruptions/delays.

(iv) Engine shutdowns.

(v) Unscheduled removals.

(vi) Confirmed failures.

(vii) Functional checks.

(viii) Bench checks.

(ix) Shop findings.

(x) Sampling inspections.

(xi) Inspection writeups.

(xii) Service difficulty report Mechanical Reliability Reports (MRR).

(b) **Data analysis system**. Data analysis is the process of evaluating mechanical performance data to identify characteristics indicating a need for programme adjustment, revision of maintenance practices, hardware improvement (modification), etc. The initial step in analysis is the comparison of the data to a standard representing acceptable performance. The standard may be a running average, tabulations of removal rates for past periods, graphs, charts, or any means of depicting a "norm."

(i) **Programmes incorporating statistical performance standards (alert type programmes)**. Reliability programmes previously developed, utilize parameters for reliability analysis such as delays per 100 departures for an aircraft system. They incorporate performance standards which define acceptable performance. When compared with a running graphical or tabular display of current performance they depict trends as well as show out-of-limits conditions. The system performance data is usually reinforced by component removal or confirmed failure data. The condition-monitoring process can be readily accommodated by this type of programme.

(ii) **Programmes using other analysis standards (nonalert type programmes)**. Data that is compiled to assist in the day-to-day operation of the maintenance programme may be effectively used as a basis for continuous mechanical performance analysis. Mechanical interruption summaries, flight log review, engine monitoring reports, incident reports, engine and component analysis reports are examples of the types of information suitable for this monitoring method. For this arrangement to be effective, the number and range of inputs must be sufficient to provide a basis for analysis equivalent to the statistical standard programmes. The operator's organization must have the capability of summarizing the data to arrive at meaningful conclusions. Also, actuarial analysis should be periodically conducted to ensure that current process classifications are correct.

(iii) **Summary.** The objective of data analysis is to:

(A) Recognize the need for corrective action,

(B) Establish what corrective action is needed, and

(C) Determine the effectiveness of that action.

(c) **Corrective action system**. The actions to be taken are a reflection of the analysis and should be positive enough to effectively restore performance to an acceptable level within a reasonable time. The system must include notification to the organizational element responsible for taking the action. The system should provide periodic feedback until such time as performance has reached an acceptable level. The mechanics of the corrective action system normally encompass methods that have been established for the overall maintenance programme such as work forms, special inspection procedures, engineering orders, technical standards, etc. Special provisions should be included for critical failures; i.e., failures in which loss of the function or secondary effects of the failure impair the airworthiness of the aircraft.

(d) **Statistical performance standards system**. A performance measurement expressed numerically in terms of system or component failures, pilot reports, delays or some other event (bracketed by hours of aircraft operation, number of landings, operating cycles, or other exposure measurement) serves as the basis for the standard. The development of control limits or alert values is usually based on accepted statistical methods such as standard deviation or the poisson distribution. However, some applications use the average or base line method. The standard should be adjustable with reference to the operator's experience and should reflect seasonal and environmental considerations. The programme should include procedures for periodic review of, and either upward or downward adjustment of, the standards as indicated. It should also include monitoring procedures for new aircraft until sufficient operating experience is available for computing performance standards.

(e) **Data display and report system**.

(i) Operators with programmes incorporating statistical performance standards (alert type programmes) should develop a monthly report, with appropriate data displays, summarizing the previous month's activity. The report should cover all aircraft systems controlled by the programme in sufficient depth to enable the BCAD and other recipients of the report to evaluate the effectiveness of the total maintenance programme. It should highlight systems which have exceeded the established performance standards and discuss what action has been taken or planned. The report should explain changes which have been made or are planned in the aircraft maintenance programme, including changes in maintenance and inspection 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 programmes.

(ii) Programmes using other analytical standards (nonalert type programmes) should consolidate or summarize significant reports used in controlling their programme to provide for evaluation of its effectiveness. These reports may be in the form of computer printouts, summaries, or any intelligible form. A typical programme of this type reports the following information:

(A) Mechanical Interruption Summary (MIS).

(B) Mechanical Reliability Reports (MRR).

(C) Listing of all maintenance process and interval assignment. (Master specification)

(D) Weekly update to letter (c) above.

(E) Daily Repetitive Item Listing (by aircraft).

(F) Monthly Component Premature Removal Report (includes removal rate).

(G) Monthly Engine Shutdown and Removal Report.

(H) Quarterly Engine Reliability Analysis Report.

(I) Engine Threshold Adjustment Report.

(J) Worksheets for maintenance process and interval changes (not provided to BCAD, but BCAD approves process changes).

(K) Maintenance interval adjustment and process change system. A major characteristic of reliability control programmes is that they afford the operator a formal means of adjusting maintenance/inspection/overhaul intervals without prior BCAD approval. This does not relieve the operator or BCAD of their responsibility for the effects of the programme on safety. Procedures for adjusting maintenance intervals should be included in the programme.

(f) **Maintenance interval adjustments** should not interfere with an ongoing corrective action. Special procedures for escalating systems or components whose current performance exceeds control limits should be provided.

(i) Typical considerations for adjusting hard-time and on-condition intervals are as follows; however, it is not implied that all these factors be considered for each case:

(A) Sampling.

(B) Actuarial studies.

(C) Unit performance.

(D) Inspector or shop findings.

(E) Pilot reports

(ii) Methods for adjusting aircraft/engine check intervals should be included if the programme controls these intervals and sampling criteria should be specified.

(iii) The system should include procedures for initial classification of maintenance processes (HT-OC-CM) and for changes from one process to another. It should also include authority and procedures for changing maintenance specifications and related documents to reflect the interval adjustment or primary process change.

(g) **Programme revision system**. The programme should include a procedure for revision which is compatible with BCAD approvals discussed in chapter 4 of this circular. The procedure should identify organizational elements involved in the revision process and their authority. The programme areas requiring formal BCAD approval include any changes to the programme that involve-

(i) Procedures relating to reliability measurement/performance standards.

(ii) Data collection system.

(iii) Data analysis methods and application to the total maintenance programme.

(iv) Process changes:

(A) For programmes incorporating statistical performance standards (alert type programmes) procedures for transferring components or systems from one primary maintenance process to another.

(B) For programmes using other analysis standards (nonalert type programmes) changing systems or components from one primary maintenance process to another.

(v) Adding or deleting components/systems.

(vi) Adding or deleting aircraft types.

(vii) All procedural and organizational changes concerning administration of the programme.

8. PROGRAMME ADMINISTRATION

8.1 GENERAL

8.1.1 Administration of reliability programmes (as discussed in this circular) requires a specific organizational structure within the operator's maintenance organization. Participants should be drawn from appropriate elements of the organization and should be authorized to act on behalf of their elements. The highest maintenance official or his designee should participate in the administration of the programme. He should serve as the final authority for major activities and for programme changes requiring BCAD approval.

8.1.2 The makeup of the administration group may vary considerably from one operator to another. It may have a technical board that analyzes performance deteriorations and shop findings to make determinations that may be acted on by an administrative board. The two boards can be combined if this better serves the needs of the particular operator. The board type of administration should entail meetings scheduled for some specified interval and should provide for assembling a board at any time a decision is needed.

8.1.3 In lieu of a formal board, operators with sufficient organizational capability which should include a strong engineering function may administer their programme by assigning appropriate responsibilities to each organizational element. In this type arrangement,

responsibility for operation of the programme should be assigned to a specific element of the operator's organization.

8.1.4 Procedures for operating each of the systems described in chapter 2 of this publication are essential to the success of the programme. These procedures should be incorporated in appropriate sections of the operator's manual system. This will provide each organizational element, and individuals therein, instructions as to their part in the programme. Forms should be used, as necessary, to facilitate and document recurring transactions that involve several elements such as

(a) changes from one maintenance process to another
(b) analysis of substandard system or component mechanical performance,
(c) shop disassembly analysis for condition-monitoring purposes or overhaul frequency adjustment, etc., and
(d) sampling inspection for aircraft check or inspection adjustment.

9. RELIABILITY PROGRAMME DOCUMENT.

9.1 The operator should develop a document describing the application of reliability control methods.

9.2 This document should include at least the following:

(a) General description of the programme.

(b) Organizational structure, duties and responsibilities.

(c) Description of the individual systems.

(d) Derivation of performance standards (if used).

(e) Changes to the programme including designation of changes requiring BCAD approval.

(f) Copy and explanation of all forms peculiar to the system.

(g) Revision control and certification of revisions to the document.

9.3 The document should describe the workings of all systems in sufficient detail to provide for proper operation of the programme. It should include in detail how the three maintenance processes are applied. The document should describe the monthly report and any other reports relative to the programme, and include samples of these reports with instructions for their use. The organizational element(s) responsible for publishing reports should be identified and the distribution should be stated. Copies of pertinent reports should be provided to BCAD.

9.4 The document should also include definitions of significant terms used in the programme with particular emphasis on definitions of the three maintenance processes.

10. PROGRAMME APPROVAL

10.1 INITIAL APPROVAL.

10.1.1 The programme document and related data should be submitted to the BCAD in the form and manner prescribed. Guidance on the submission will be provided at the Pre-Application Meeting. Approval will be certified with the programme document for the Operations Specifications.

10.2 REVISION APPROVAL.

10.2.1 Revisions requiring formal approval (ref: chapter 2, section 3 sub-section 4. of this circular) will be subject to the same consideration as initial approval. The mechanics of the approval certification will be as defined in the document. If the revision concerns items listed in the operations specifications, the affected page(s) will be amended to reflect the revision.