Advisory Pamphlet

Maintenance Control by Reliability Method

AP 1.1.214A

[Air Operator Certification]

1. Purpose

1.1 The purpose of this Reliability Program guidance document is to inform applicants of those elements of a Reliability program deemed by the CAAI to be required to ensure that the Applicant's Maintenance Program is monitored for its effectiveness in maintaining the subject aircraft in an airworthy condition.

1.2 The guidelines contained in this Advisory Pamphlet are general in nature and offer one of the ways operators may show compliance with the CAAI regulatory requirements. Not all provisions of this AP 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.

2. Introduction

2.1 Modern commercial aircraft maintenance programs are based on MSG-3 (Maintenance Steering Group) analysis. All operators in the initial phase of new aircraft type operation use generic maintenance programs largely based on aircraft manufacturer’s recommendations.
Note: For more information on MSG-3 analysis and maintenance planning practices, refer to FAA AC 121-22 as revised.

2.2 The manufacturer’s recommendations are featured in a manual called the MPD – Maintenance Planning Document. While developing the MPD, the manufacturer assumes average operational conditions (climate, no geographical specifics, average annual utilization, average flight duration, standard operational procedures). However, a given operator's operating specifications, environment and profile often vary from the average conditions used to develop the generic Maintenance Program defined by the Manufacturer's MPD, and consequently adjustments to the Maintenance program are necessary to suit specific operating profile. The operator's actual Maintenance Program should reflect the relevant technical and operational environment specific to his operations.

2.3 To facilitate this requirement, the operator’s maintenance reliability program should be established.

2.4 Reliability is the measure of a system or component stability. The system or component is considered to be reliable if it is functioning within the designed or expected parameters. The system is not reliable when it is functioning outside the designed or expected parameters.

2.5 The maintenance reliability program can be defined as a set of organizational procedures and responsibilities dealing with obtaining and collecting data regarding the effectiveness of the maintenance program, performing an analysis (statistical or other) of the collected data, identifying negative trends, and determining the corrective actions needed to rectify negative trends.

2.6 The reliability program provides information about the reliability of each specific aircraft system and components covered by the program, as well as about the reliability of the aircraft type. Such information can be compared with the expected reliability data or, with such data collected for the world fleet of a certain aircraft type, in order to assess the effectiveness of the operator's maintenance process.

2.7 Statistical type reliability programs may be used wherever the frequency of events being monitored is sufficient. This type of program enables the use of alert rates, which may be shown on graphic charts (or equivalent displays) to identify areas where responsive action may be needed.

The statistical analysis of the collected relevant data derives statistical trends in reliability which can be positive or negative. Negative trends indicate that some system or component is not performing up to the expected standard and that the cause for this behavior has to be investigated, analyzed, determined and eliminated by proper corrective action.

2.8 Where the frequency of events is too low to provide valid statistical data, sampling inspection and defect analysis may be used to assess the relationship between operating time and the failure resistance of components. These types of programs are known as "non-alert" type programs.

2.9 In practice most reliability programs include elements of both techniques.

2.10 Older aircraft's maintenance programs could be based on MSG-2 analysis, which typically divide scheduled maintenance processes into 3 categories: hard time (HT), on condition (OC) and condition monitoring (CM);

2.10.1 Hard-Time (HT): a preventative primary maintenance process which requires that an appliance or part be periodically overhauled or removed from service. Time limits may only be adjusted based on operating experience or tests, in accordance with (IAW) procedures in the operator’s approved reliability program.

2.10.2 On-condition (OC): a preventative primary maintenance process which requires that an appliance or part be periodically inspected against some appropriate standard to determine whether it can continue in service. These standards may be adjusted based on operating experience or tests, as appropriate, IAW an air operator’s approved reliability program or maintenance manual

2.10.3 Condition-Monitoring (CM): a maintenance process for items that have neither HT nor OC maintenance as their primary maintenance process. For these items, the operator must control the reliability of systems or equipment based on knowledge gained through analysis of failures or

other indications of deteriorations.

2.11 According to regulation 131(a)(5) of the Air Navigation Regulations (Operation of Aircraft and Rules of the Air), 1981 (hereinafter – ANR.OPS) The reliability program, where applicable, should be included in the Maintenance Program approved by the CAAI.

2.12 The benefits

2.12.1 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 fleet maintenance costs

2.12.2 A reliability program can become an essential decision-making aid for the maintenance management team, as it provides a summary of aircraft fleet reliability and a structured method of examining the maintenance program and the way it is implemented. It can also help the operator discover real causes of recurrent equipment problems, planning issues, scheduling conflicts, and procedural difficulties.

2.12.3 Once the fleet reliability shortcomings are identified, the Reliability program affords the operator a formal means of substantiating applications for approval of proposed amendments to the maintenance program and to the practices for implementing it, with the intent of improving fleet reliability, reducing maintenance costs and achieving a better utilization of available resources.

3. Reference Material

3.1 ICAO Annex 6 Para. 8.9.1,

3.2 FAR 121.373(a), FAR 135.431, JAR-OPS 1.035, AMC OPS 1.910a

3.3 Air Navigation Regulations (Operation of aircraft and Rules of the Air), 1981 (hereinafter – ANR.OPS) as amended: 131, 132, 418

3.4 Fourth attachment to ANR.OPS(3)(c)

3.5 Sixth Attachment to ANR.OPS

3.6 FAA AC 120-17A

3.7 EASA Continuing Airworthiness Requirements - Part M

3.7.1 M.A.302 Aircraft Maintenance Programme

3.7.2 AMC 20-6

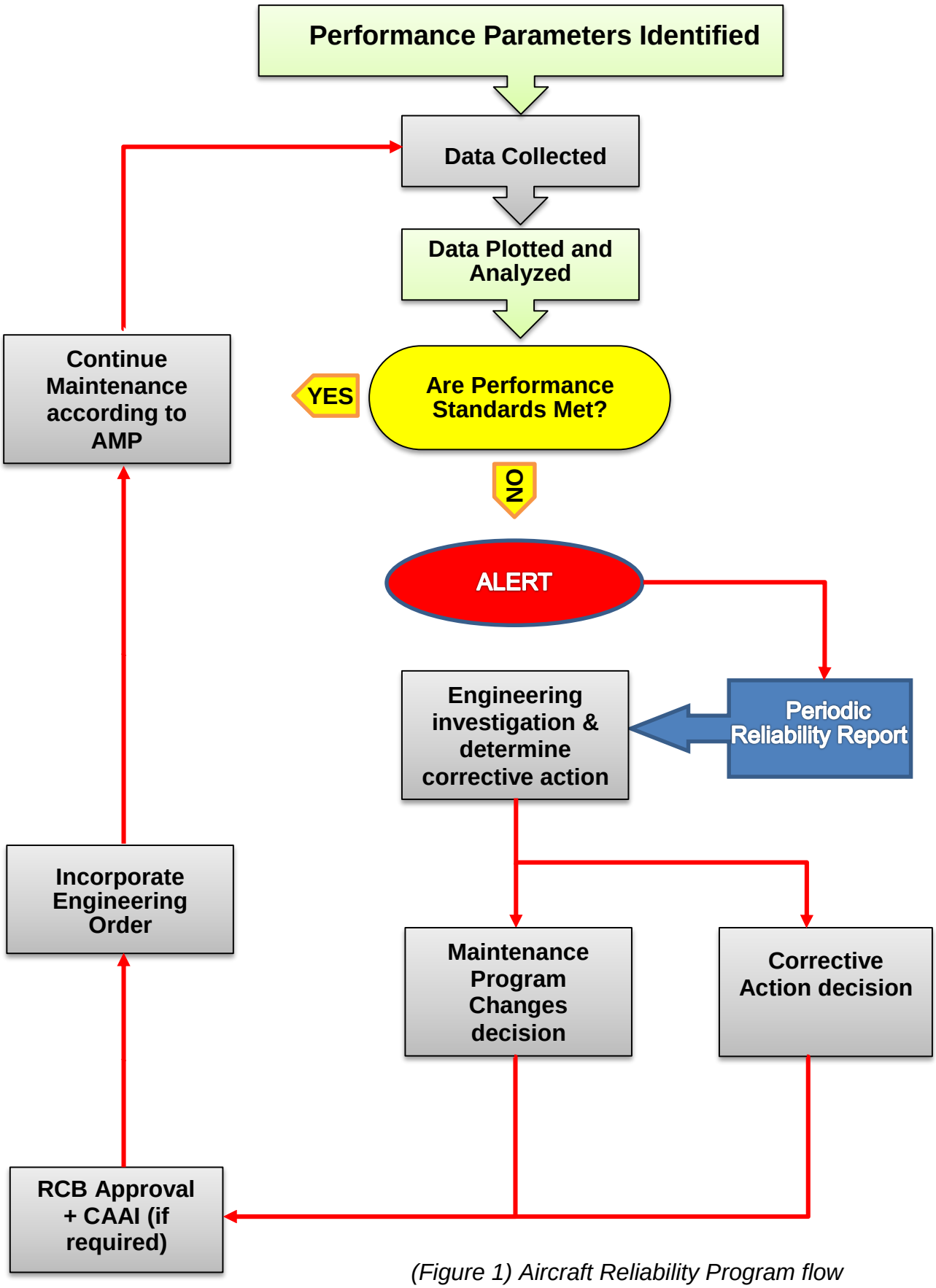
3.8 CASA AC 42-3(0)

3.9 Maintenance Program Optimization Guidance Material (IATA 2007 Edition)

4. Aircraft Reliability Program Flow Chart

4.1 The Aircraft Reliability Program is a closed loop cycle, accomplished by applying the following steps:

1. Identification of performance parameters indicative of airplane reliability
2. Collection of service data.
3. Analysis and reporting of service data.
4. Decisions made if performance standards are met.
5. Engineering investigates alerts and determines corrective actions. Other departments may also be involved in corrective action development.
6. A Reliability Control Board approves corrective action. CAAI approves corrective action, if required (e.g. in the case of proposed changes to maintenance program, training program, etc.).
7. Engineering issues an Engineering Order (EO) to correct the problem.
8. Maintenance accomplishes the Engineering Order.
9. The cycle repeats itself.



(Figure 1) Aircraft Reliability Program flow

5. Applicability

5.1 The CAAI requires that an air operator develop a reliability program in conjunction with its maintenance program in order to ensure the continuing airworthiness of the aircraft it operates. Specifically, the program may be required in the following cases:

5.1.1 The aircraft maintenance program is based upon MSG-3 logic;

5.1.2 The aircraft maintenance program includes condition monitored components;

5.1.3 The aircraft maintenance program does not include overhaul time periods for all significant system components;

5.1.4 When specified by the Manufacturer's maintenance planning document or MRB.

5.1.5 The aircraft's maintenance program is subject to an Extended Diversion Time Operation (EDTO) approval issued by the CAAI.

5.2 A reliability Program need not be developed in the following cases:

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

5.2.2 For aeroplanes - the aeroplane is not a large aeroplane;

5.2.3 The aircraft maintenance program provides overhaul time periods for all significant system components.

6. The salient features of an approved reliability program

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

6.2 For a reliability program to be approved by the CAAI, it should have the following salient features:

6.2.1 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 AP, a significant system is a system the failure of which could hazard aircraft safety.

6.2.2 The personnel engaged in reliability monitoring should be suitably qualified and trained.

6.2.2.1 In approving the operators maintenance and reliability program, CAAI expects that the organization which runs the program (it may be the operator, or an approved maintenance organization (AMO) under contract) employs or contracts the services of

sufficiently qualified personnel with appropriate engineering experience and understanding of reliability concepts.

6.2.2.2 Trained and experienced personnel enable the interpretation of the data analysis to be made correctly.

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

6.2.3 The reliability reports should be generated on a quarterly basis at the least and should be presented during periodic audits or when required by the CAAI.

6.2.4 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 CAAI for approval.

6.2.5 For large air Operators (with fleet size of six or more aircraft), periodic reliability meetings should be organized with an aim to address all events affecting aircraft reliability. The CAAI should be invited to participate in such meetings.

6.3 All reliability program(s) should be submitted by the operator(s) to their designated Principle Maintenance Inspector for CAAI approval.

7. Structure of the Reliability Program

7.1 An aircraft Maintenance Reliability Program should include the following elements:

7.1.1 Reliability program's revision control and documented approval of revisions (e.g. List of Effective Pages, Table of Contents, etc.);

7.1.2 A general description of the reliability program, including a statement of its objectives;

7.1.3 Definitions of significant terms used in the reliability program;

7.1.4 Application of the program by aircraft fleet type/model, aircraft registration marks, or serial numbers, as appropriate;

7.1.5 The organizational structure, duties and responsibilities of the Air operator's employees involved in the program;

7.1.6 Procedures for establishing and reviewing performance standards;

7.1.7 Data collection system;

7.1.8 Methods of data analysis;

7.1.9 Data display and reporting;

7.1.10 Corrective action program;

7.1.11 Procedures for Maintenance program amendment based on Reliability program;

7.1.12 A copy and explanation of all forms relevant to the program.

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

7.2 Terms and Definitions

7.2.1 The significant terms and definitions applicable to the program should be clearly identified. Possible sources of definitions are (Maintenance Steering Group) MSG-3 documents, ANR.OPS regulations and other CAAI publications.

7.2.2 Acronyms and abbreviations unique to the program must also be defined.

7.2.3 The number of terms and definitions should be kept to a minimum.

7.3 Program Objectives

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

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

7.3.2 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 also be consulted.

7.3.3 In case of an 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.

7.4 Organizational structure, duties and responsibilities

7.4.1 Program administration

7.4.1.1 The organizational 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 of a nominated post holder, while the larger air operators may establish their own dedicated reliability group.

7.4.1.2 An Aircraft Reliability Program is typically administered by a Reliability Department, which conducts the day-to-day operations of the program and reports directly to the QA Manager. The organization's personnel engaged in running a reliability program should be suitably qualified and appropriately experienced.

7.4.1.3 Large or small, each reliability program should clearly identify (by office title or departmental responsibilities) in the Maintenance Control Manual the individuals responsible for each phase of its administration.

7.4.2 Reliability control Board

7.4.2.1 The operator will typically also form a Reliability Control Board (hereinafter – RCB) who is responsible for managing the overall operation of the program.

7.4.2.2 The Reliability Control Board is authorized to:

- Approve corrective actions developed by engineering or other departments.
- Approve changes in the reliability program and its procedures, including changes in performance standards and alert levels as stipulated in the Reliability Program Document. Some of these changes have to be approved by the CAAI, as outlined in article 7.11.3 of this document.
- Evaluate and approve the proposed change of the maintenance program as a result of corrective action determined under the reliability program. Amendments to the maintenance program require CAAI approval, as outlined in AP -1.1.336A – Maintenance program Contents.

7.4.2.3 The RCB is composed of permanent and advisory members. A typical Board will be composed of the following:

- Reliability Control Board (RCB) – Chaired by QA Manager
  - Reliability department manager
  - Engineering Manager
  - Airplane Maintenance Manager
  - Overhaul Shops Manager
  - Representatives of the various Engineering and Production Units of the Maintenance and Engineering organization – advisory, non-voting members

A program administration should also ensure provision for the CAAI representative's participation at periodic reliability meetings.

7.4.2.4 In order to make decisions, a minimum number (as defined by the air operator) of Reliability Control Board members must attend the RCB meeting. The RCB members should be familiar with Reliability program and its procedures.

7.5 Identification of items

The reliability program should state which items are controlled by the program, 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 reliability program.

7.6 Data Collection System

7.6.1 The Data Collection System is one of the basic elements of an Aircraft Reliability Program. The Data Collection System should:

- Provide an adequate source of information
- Provide an adequate flow of information and describe the process of its collection
- Ensure that the data collected is:
  - Accurate and factual
  - Received from all maintenance stations and shops, and
  - Directly related to the reliability performance standard being measured

7.6.2 Examples of Data sources are:

Data	**Source**
Pilot Reports…….	Airplane Log Book, Cabin Log Book
Delays and Cancellations…..	Del/Can and MCC Reports
Engine Removals……	Airplane Log, MCC, Engine Shop Reports
In-Flight shutdowns……	Airplane Log, MCC, Engine Shop Reports
Component Removals……	Serv/Unserv Tags, MCC, Airplane Log
Inspection Findings…….	Non-routine Cards, Airplane Log
Shop Findings…….	Component Shop and Engine Shop Reports

7.6.3 Pilot Report example

The type of information normally extracted from this report includes:

- Airplane registration number
- Flight number
- Date and station
- Part number/Serial number of removed/installed components
- Problem description and corrective action taken
- Mechanic accomplishing the corrective action

7.6.4 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.

7.6.5 The type of information to be collected should relate to the program objectives.

7.6.6 In addition to the sources of information listed above, 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.

7.6.7 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.

7.7 Performance Standards

7.7.1 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.

7.7.2 When an alert level is exceeded an assessment should be made to determine if corrective action should be taken.

Note: alert levels are not minimum acceptable airworthiness levels. Rather, they are a means of identifying those increases in failure rate which fall outside the bounds of normal distribution and therefore warrant further investigation.
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.

7.7.3 An alert condition may not necessarily rely on statistics. For example, structural or other significant non-routine findings from major checks require a non-statistical review to determine an alert condition.

7.7.4 Alert levels should be revised periodically to reflect operating experience.

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

7.7.6 Establishing alert levels

7.7.6.1 Alert levels can range from zero (for critical components, and for those where failures in service have been extremely rare) to perhaps as many as 100 PIREPS per 1,000 hours for less critical systems, such as ATA 25 (equipment/ furnishings) items.

7.7.6.2 Wherever possible, alert levels should be based on the number of events which have occurred during a representative period of safe operation of the aircraft fleet.

7.7.6.3 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.

7.7.6.4 Where there is insufficient operating experience, or when a program for a new aircraft type is being established, the following approaches may be used:

- For a new aircraft type, during the first two years of operation all malfunctions may be considered significant (i.e. Alert level zero) while data is accumulated for future use.
- Alternatively, levels may be established based on the degree of system and component in-service reliability assumed in the design of the aircraft. These estimated values are normally quoted in terms of mean time between unscheduled removals (MTBUR) or mean time between failures (MTBF) for both individual components and complete systems. These initial predictions should be replaced by actual reliability figures when sufficient in-service experience has been accumulated.
- For an established aircraft type with a new operator, the alert levels of other operators may be utilized until the new operator has accumulated sufficient experience. Alternatively, experience gained

from operation of a similar aircraft model may be used.

7.7.7 Re-calculation of alert levels

7.7.7.1 Due to 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”).

7.7.7.2 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.

7.7.7.3 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.

7.7.7.4 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.

7.7.8 Upper control limits (alert values)

7.7.8.1 A performance standard may be determined using statistical methods. A reliability program using statistical methods will establish an Upper Control Limit (UCL) for each monitored parameter. The alert value is used to determine the acceptable deviation from the mean value and to recognize and react to the significant deviations from statistically acceptable limits in reliability.

7.7.8.2 It should be recognized that alert levels are not minimum acceptable airworthiness levels. Rather, they are a means of identifying those increases in failure rate which fall outside the bounds of normal distribution and therefore warrant further investigation.

7.7.8.3 An example of alert level calculation and procedures of establishing UCL can be found in APPENDIX 1 of this document.

7.8 Data Analysis System

7.8.1 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.

7.8.2 The whole process should be such as to enable a critical assessment to be made of the effectiveness of the maintenance 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 component life-bands and survival characteristics
- Reliability predictions
- Other methods of assessment.

7.8.3 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.

7.9 Data Display and Reporting System

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

7.9.2 The reliability program must provide for a format of display that allows easy identification of trends, events and when performance standards are exceeded. The display may be in graphical or in a tabular format or a combination of both.

7.9.3 The format, frequency of preparation and the distribution of displays and reports should be fully detailed in the program. The program should also include 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).

7.9.4 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.

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

7.9.6 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 the most accurate picture of the actual reliability or effectiveness of its maintenance operations.

The CAAI 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 of 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 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 due to technical failures, and removal rates, 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 failure 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 CAAI 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.

- *EDTO specific operations*

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

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. It should discuss continuing over-alert conditions carried forward

from previous reports and should report the progress of corrective action programs.

7.9.7 Availability of Reliability Reports when Required

The operator is required to make available all reliability reports during audits or when required by the CAAI. 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.

7.10 Corrective Actions

7.10.1 During the analysis of the negative trend, the engineering department finds out the cause of such deviations and recommends necessary corrective actions that will effectively return the observed parameter back to the normal stable level. Corrective actions must correct any reduction in reliability revealed by the program and may take the form of 1 or more of the following:

- *Change of task interval in maintenance program or change in the work content;*
- *Revision of certain scheduled maintenance tasks;*
- *Additional inspections fleet wide with incentive to determine the condition of critical systems or components;*
- *Fleet wide modification of aircraft;*
- *Change in maintenance and/or operational procedures;*
- *Training of maintenance personnel, flight crews or other operational staff.*

7.10.2 Where applicable, each corrective action must include a planned completion date.

7.10.3 The Reliability control board monitors the performance of corrective actions. At each meeting all the current corrective actions are reviewed and the status of each corrective action determined. If required, the corrective actions that have been delayed without any proper reason are enforced.

7.10.4 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.

7.11 Evaluation, Review and Changes to the Reliability Program

7.11.1 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 reliability maintenance control should also be detailed (e.g. progressive, monthly, quarterly, or annual reviews; or procedures following reliability alert levels being exceeded, etc.).

7.11.2 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.*

7.11.3 The program areas requiring CAAI's approval 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.*

8. Application to an operator with a small fleet

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

8.1 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, utilization and maintenance procedures applied must be substantially the same.

8.2 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, utilization, (e.g. low, high, seasonal, etc.), respective fleet size, operating rules applicable (e.g. EDTO, 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.*

8.3 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 CAAI approval should be sought prior to any formal agreement being signed between operators.

8.4 In case of a short-term lease agreement (less than 6 months) the CAAI may grant more flexibility against the above criteria to allow the operator to operate the leased aircraft under the operator's reliability program for the duration of the lease agreement.

8.5 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 CAAI is satisfied that the manufacturer manages a reliability program that complies with the intent of this AP.

9. Delegation to a Third Party Organization

9.1 Keeping associated costs in perspective, the CAAI understands that a small operator may prefer to delegate certain functions to an approved maintenance organization under contract.

9.2 If an operator outsources continuing airworthiness management functions to an approved maintenance organization, the operator should ensure that the agreement also includes the function of establishing and monitoring reliability programs.

9.3 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.*

9.4 Please note that despite the above, the decision to implement a corrective action (or the decision to request from the CAAI 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 maintenance organization) then that decision should be justified and documented.

9.5 The arrangement between the operator and maintenance organization should be specified in the maintenance contract and the relevant manuals.

10. Operator Maintenance Program adjustment based on Reliability program output

10.1 A task should not be done more often than experience or other data suggests simply because it is easily accomplished, as doing tasks more often than necessary (or even performing an unnecessary task in the first place) increases the chance for maintenance-induced errors and may eventually have an adverse effect on reliability and safety.

10.2 The Reliability program, through its data collection and analysis activities, formalizes the operator's experience regarding the maintenance tasks and intervals listed in its maintenance program. Thus, the reliability program output may serve as substantiating evidence for proposed amendments to the maintenance program and to the practices for implementing it.

10.3 **Volume of data needed to substantiate Maintenance program adjustment**

10.3.1 The volume of data required to substantiate the extension of a maintenance interval, or the change or deletion of a maintenance task, will depend both on the frequency of the task, and on the reason for its inclusion in the initial program.

10.3.2 Task frequency: the minimum level of experience would normally approximate one year, or one complete interval between the events in question, whichever is the greater.

Thus, high frequency events, such as "A" check items, will require a relatively high volume of data, in the order of 25-50 events or more, while infrequent events, such as "D" check items, will usually require the operator to demonstrate satisfactory completion of at least one complete interval between the tasks under review.

10.3.3 Task origin / reason for inclusion in Maintenance program: changes to tasks introduced for safety reasons (e.g. in response to questions 5 or 8 of MSG-3) will require significantly more substantiating data than those included primarily for economic or operational efficiency reasons.

Note that changes to safety-related tasks will also require MRB authorization.

10.4 **Adding, and deleting a maintenance task:**

10.4.1 Air operators must review manufacturer's and vendor's recommendations published through inspection service bulleting (ISB), service letter (SL/SIL), all operators letter (AOL), and other documents such as CMM revisions. These recommendations may result in changes in the maintenance program.

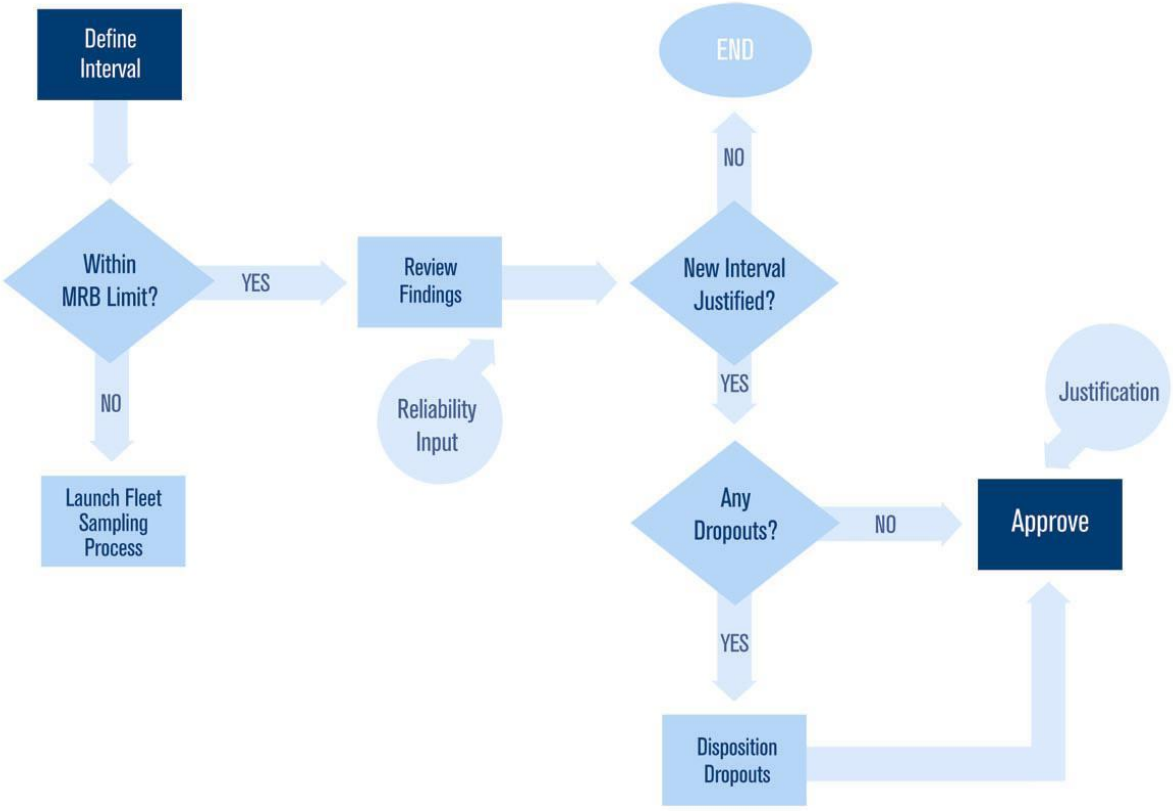
10.4.2 Changes which involve the deletion of a task, must be subjected to the same analysis that was used to establish the initial program basis. This is sometimes referred to as the internal MRB procedure.

10.4.3 An air operator may also decide to add new task(s) to their maintenance program, or to escalate/de-escalate individual tasks, based on reliability analysis and individual task findings.

10.4.4 In these cases it is recommended to also perform an MSG-3 logic analysis to determine the most effective new task or escalation/de-escalation of existing tasks. The reliability-based justification, together with the MSG-3 analysis can serve as justification for the new task and should be documented and approved in accordance with CAAI requirements.

10.5 **Escalating Task intervals:** the CAAI recognizes two main sources for initiating an escalation / de-escalation of a maintenance task interval.

10.5.1 **Air Operators check interval escalation with MRB approved limit** - A potential source of check interval escalation is a new MRB approved interval. Prior to accepting and implementing a new MRB interval an air operator shall undertake the following steps (see Figure 2):



(Figure 2) Interval escalation within MRB limits.

- The air operator shall review the check performance to date under the existing interval, including an assessment of the significance of findings generated at the check plus other relevant factors (i.e. air operator's experience and reliability data). In this case if results are positive (i.e the check findings at the current interval are of little or no significance) the new interval may be recommended for approval.

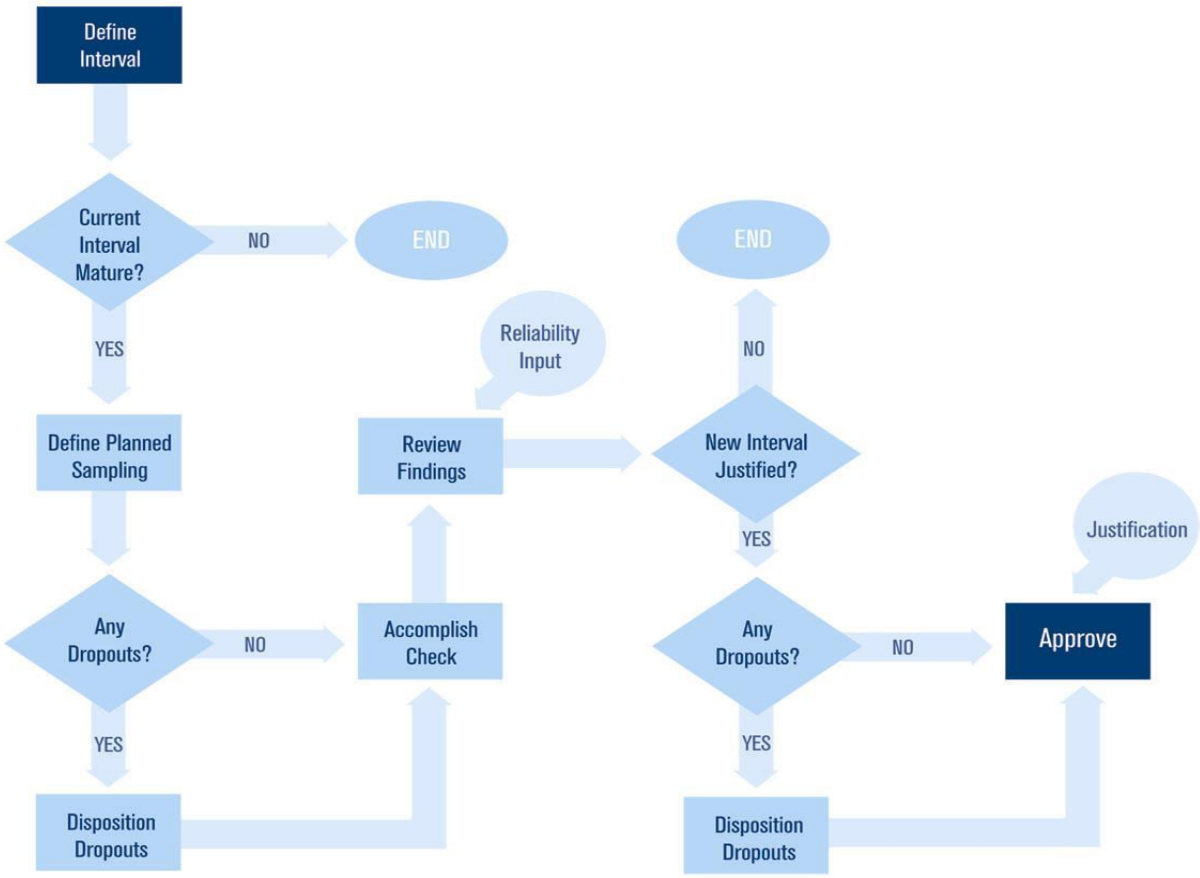
- If a task/check that is subject to an escalation per an approved MRBR revision has never been performed by the air operator because the interval for its performance has not yet been reached, the new MRBR interval can be approved.

- The air operator must also examine all mandatory maintenance tasks, which are planned as part of the check program (i.e., ADs/CNs, Certification Maintenance Requirements (CMR), Airworthiness Limitations (ALS), ETOPS requirements and physical check of time expiry dates) and hard-time unit changes to ensure that they can withstand the interval escalation.

- The review described above may identify some tasks that will not tolerate the new interval. These "dropout" items may have to be controlled individually at the current interval or accomplished at a lower routine check.

10.5.2 Air Operators check interval escalation above MRB approved limit

- Prior to approving and implementing a new interval an air operator shall undertake the following steps (see Figure 3):



(Figure 3) Interval escalation above MRB limits.

- As a prerequisite requirement, the escalation and sampling program must conform to the interval and program limitations approved by the CAAI.

- In order to ensure that an air operator has gained sufficient experience with a fleet type at the current check interval prior to an interval escalation, it is desirable to develop criteria for minimum requirements for a corroborative sampling program. As a guideline

the corroborative sampling program will be performed on a minimum of two aircraft, both of which are at not less than 90% of the present task interval limit. Until the corroborative sampling is successfully completed, the present interval cannot be considered mature and the check interval cannot be further escalated.

- The target for interval escalation should be carefully set by the air operator and will be confirmed by a review of check findings on the sample aircraft before approving the new limit for the entire fleet. A too ambitious escalation may result in high number of dropout items, which may defeat the purpose of the interval escalation.

- Minimum two aircraft should be selected as sample to evaluate the effect of the new target interval before it is approved.

- To be eligible as samples, checks should achieve at least 90% of the target interval.

APPENDIX 1: Alert Level Calculation and Procedures of Establishing Upper and Lower Control Limits

Upper control limit is normally based on the statistical calculation of the standard deviation covering the recent twelve-month period.

a) There are several methods for calculating alert levels, all of them are well known as statistical error calculation. The most common are:

1. MEAN + 3 SD
2. MEAN + STANDARD DEVIATION OF MEAN OF MEANS + 3 SD
3. MEAN x 1.3
4. MEAN + 2 SD

……..

b) Calculation of the standard deviation:

This is the formula for Population Standard Deviation:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(xi - \mu)^2}$$

In the formula above μ (the Greek letter "mu") is the mean of all values.

The mean is just the average of the numbers

x_i = *monthly value of parameter in observed months,*

σ = standard deviation (SD),

N = number of observed months for which standard deviation is calculated.

Formula for Sample Standard Deviation:

$$s = \sqrt{\frac{1}{\mathrm{N}-1}\sum_{\mathrm{i}=1}^{\mathrm{N}}(\mathrm{xi} - \bar{\mathrm{x}})^2}$$

Where:

$\bar{x}$ = Mean = ∑ x / N

- The mean is now $\bar{x}$ (for sample mean) instead of μ (the population mean),
- And s (for Sample Standard Deviation) instead of σ.

When your data is the whole population the formula is: (The "Population Standard Deviation**"**)

When your data is a sample the formula is: (The "Sample Standard Deviation")

c) Calculation of Upper Control Limit – UCL:

$UCL = \bar{x} + k\,\sigma$ *or* $UCL = \mu + k\,\sigma$

k = deviation factor (normally between 2 and 3)

Updating UCL

The above calculation of upper control limit (UCL) should be repeated every 12 months. The upper control limit can be increased maximally by 10% compared to the previous UCL. The RCB can approve larger changes of UCL. However, it should be noted that the repeated increase of the alert value represents a negative trend which has to be stopped by the application of appropriate corrective action.