Advisory Circular

CAA-AC-AWS010D

July 2018

RELIABILITY PROGRAMME

1.0 PURPOSE

1.1 The purpose of this Advisory Circular (AC) is to provide information and guidance in the development of Reliability Program.

2.0 REFERENCE MATERIAL

2.1.1 Regulation 70 of Civil Aviation (Air Operators Certification and Administration) Regulations, 2018.

2.1.2 KCAA Advisory Circular No. CAA-AC-AWS009C (Aircraft Maintenance Program Development).

2.1.3 FAA AC 120-17A as amended (Maintenance Control by Reliability Methods).

2.1.4 The Airline/Manufacturer Maintenance Program Planning Document, Maintenance Steering Group (MSG)-2/3 as amended.

3.0 INFORMATION AND GUIDANCE

3.1 Application for Approval

3.1.1 An operator who wishes to start a reliability program shall apply in writing and submit a reliability program for approval. This may either be a part of the aircraft maintenance program (AMP) or an independent program, with suitable reference in the AMP.

3.1.2 All reliability program(s) should be submitted by the Quality Manager to KCAA for approval.

3.1.3 Regulation 70(3) of the Civil Aviation (Air Operators Certification and Administration) Regulations, 2018, provides that an aircraft with maximum certificated takeoff mass authorised above 13,310kg shall include a reliability program in the Maintenance Program and approved by the Authority.

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

3.1.5 The addition of an Extended Diversion Time Operation (EDTO) to an existing Reliability Program, is subject to further approval by the Authority.

3.1.6 Approval of an Approved Single Engine Turbine Powered Aeroplanes (ASETPA) requires a confirmation that an associated reliability program will cover the aircraft engine, propeller and equipment required to conduct an ASETPA operation.

3.2 Evaluation, Review and Approval of the Reliability Program

3.2.1 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.).

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

a) Utilization (high/low/seasonal)

b) Fleet commonality

c) Alert level adjustment criteria

d) Adequacy of data

e) Reliability procedure audit

f) Staff training

g) Operational and maintenance procedures.

3.2.3 The program areas requiring KCAA approval include changes to the program that involve:

a) Any procedural and organizational changes concerning program administration

b) Adding or deleting aircraft types

c) Adding or deleting components/systems

d) Procedures relating to performance standards

e) Data collection system

f) Data analysis methods and application to the total maintenance program

g) Procedures for maintenance program amendment.

3.2.4 The Authority shall establish that the Program contains:

a)The significant terms and definitions applicable to the program.

b) Acronyms and abbreviations unique to the program defined.

c)the type, model, serial number and registration mark of the aircraft controlled by the program;

d) the name and address of the registered operator of the aircraft controlled by the program;

e)The organizational structure and the departmental responsibilities for the administration of the program should be stated which largely depend on the size of operations. Large or small, each reliability program should clearly identify (by office title or departmental responsibilities) in the Maintenance Control Manual (MCM) the individuals responsible for its administration. This include individuals and departments (Engineering, Production, Quality, Operations etc.) responsible for the administration of the reliability program together with the functions of any program control committees (Reliability Group).

f) 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 Authority should be invited to participate in such meetings.

g) As a minimum, the maintenance program tasks controlled by the program must be clearly identified in the program and be adequate for continuing airworthiness of the aircraft.

Where some items, such as aircraft structure, engines, and auxiliary power units, are controlled by a separate program, such as a manufacturer structural sampling or life development program, this must be referenced in the program.

h) *A description of the objective* of the reliability program. The applicable instructions for continuing airworthiness must be followed to establish the objective of the program. The extent of the objectives should be directly related to the scope of the program. A statement summarizing as precisely as possible the scope and prime objectives of the program. As a minimum it should include the following:

i) a recognition of the need for corrective action;
ii) establishment of the corrective actions needed; and
iii) a determination of the effectiveness of those actions.

i) The manufacturers Maintenance Planning Data (MPD) may give guidance on the objectives and should be consulted in every case. Where some items such as aircraft structure, engines, APU, etc. are controlled by separate programs, the associated procedures (e.g. individual sampling or life development programs and manufacturers structure sampling programs) should be cross- referenced in the program.

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

3.2.5 When approving a reliability program, the Authority will determine that the program includes procedures for providing reliability reports to the Authority. The periodicity for report submission would normally be on a monthly basis.

3.2.6 Identification of items controlled by the program. The aircraft parts, systems and structural elements controlled by the program must be clearly defined and identified in the program.

3.2.7 A description of the data collection system for the items controlled by the reliability program must be included in the program. Such a description must include the following:

a)identification of sources of data;

b) procedures for transmission and receiving of data from each source;

c)steps of data development from source to analysis;

d) organizational responsibilities for each step of data development.

3.2.8 **The data collected** must be: obtained from items functioning under operational conditions; and accurate and factual to support a high degree of confidence in any derived conclusion; and directly related to the established levels of performance.

3.2.9 Sources of data may include: pilot reports; unscheduled removals; confirmed failures; sampling inspections; workshop findings; functional checks; and bench checks.

3.2.10 Examples of Data Sources

Data	**Source**
Pilot Reports	Airplane Technical logbook, Cabin Log Book
Occurrence Reports	Air Safety Reports, Service Difficulty Reports ,Major Defect and occurrence reports
Delays and Cancellations	Operations Analysis and MCC Reports
Engine Removals	Airplane Log, MCC, Engine Shop Reports
In-Flight shutdowns	Airplane Log, MCC, Engine Shop Reports
Scheduled or Unscheduled Component Removals	Serviceable/Unserviceable Tags, MCC, On-board Maintenance System readouts, Airplane Technical logbook, confirmed failures.
Inspection Findings	Routine or Non-routine Cards, On-board Maintenance System readouts, Special Inspections, Airplane Technical logbook
Shop Findings	Component Shop and Engine Shop Reports
Other Sources	ETOPS, RVSM, CAT II/III operations

3.2.11 Pilot Report (Pirep)

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

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

3.2.13 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.

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

3.3 Aircraft Reliability Program Flow Chart

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

3.4.1 Identification of performance parameters indicative of aircraft reliability.

3.4.2 Collation of service data.

3.4.3 Analysis and reporting of service data.

3.4.4 Decisions made if performance standards are met.

3.4.5 Engineering investigates alerts and determining corrective actions.

3.4.6 A Reliability Control Committee approves corrective action. KCAA approves corrective action, if required (e.g. in proposed changes to maintenance program, training program).

3.4.7 Engineering issues an Engineering Order (EO) to correct the problem.

3.4.8 Maintenance accomplishes the Engineering Order.

3.4.9 The cycle repeats itself.

3.5 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 as follows:

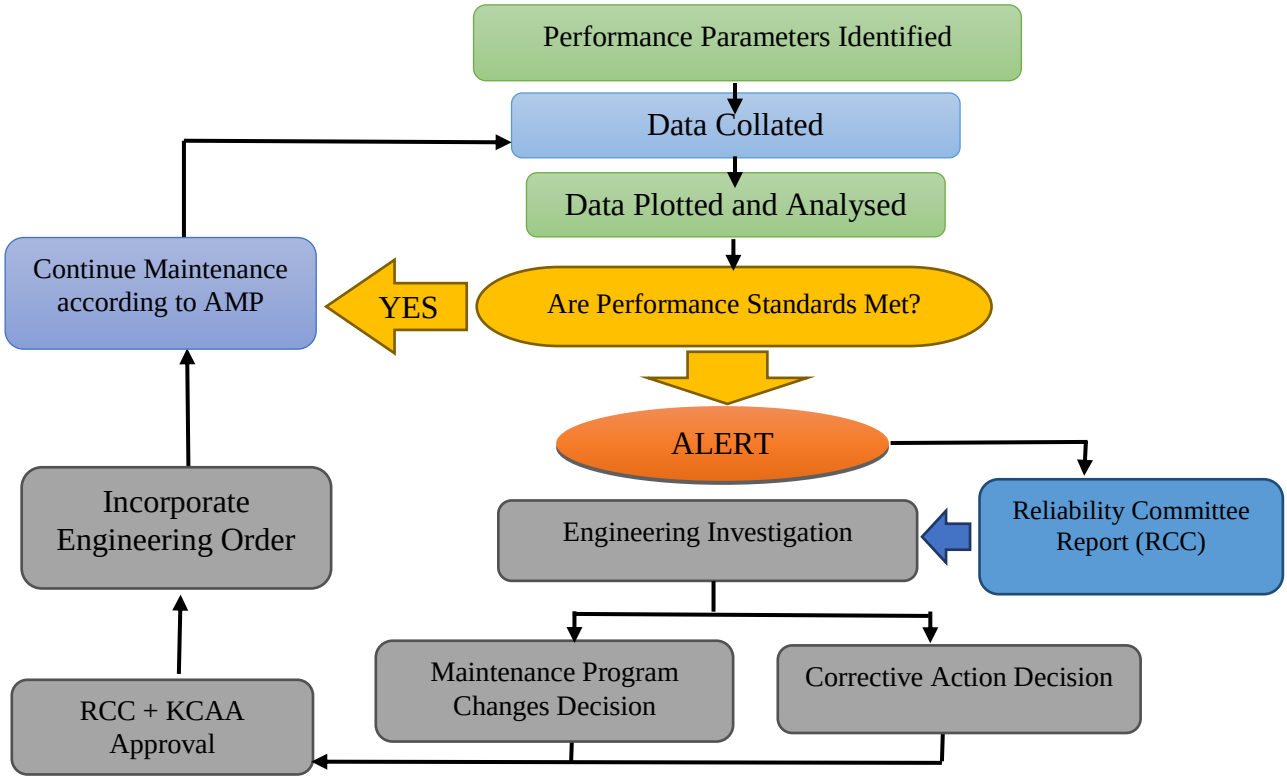


Figure 1: Aircraft Reliability Program Flow Chart

3.6 **Statistical type reliability programs** may be used to enable the use of alert rates, which may be shown on graphic charts (or equivalent displays) to identify areas where responsive action may be needed.

3.7 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 KCAA for approval.

4.0 Training

4.1.1 The personnel engaged in reliability monitoring should be suitably qualified and trained. Trained and experienced personnel enable correct interpretation of data analysis.

4.1.2 In approving the operator's maintenance and reliability program, KCAA 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.

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

4.2 Reliability control Committee

a) The operator will form a Reliability Control Committee (RCC) that is responsible for managing the overall operation of the program. The RCC is authorized to:

   i) Approve corrective actions developed by engineering or other departments.

   ii) 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 KCAA.

   iii) 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 KCAA approval.

b) A typical Committee will be composed of the following:

   i) Director of Maintenance -Chair ,

   ii) Reliability Engineer – Secretary,

   iii) Quality Manager ,

   iv) AMO Maintenance Manager ,

   v) Planning Officer,

   vi) Workshop Manager, where applicable

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

4.3 An operator /owner shall quarterly invite the Authority to attend reliability meeting. This notification shall be a month before the reliability meeting is held.

5.0 STRUCTURE OF THE RELIABILITY PROGRAM

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

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

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

5.1.3 Definitions of significant terms used in the reliability program;

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

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

5.1.6 Procedures for establishing and reviewing performance standards;

5.1.7 Data collection system;

5.1.8 Methods of data analysis;

5.1.9 Data display and reporting;

5.1.10 Corrective action program;

5.1.11 Procedures for Maintenance program amendment based on Reliability program;

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

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

7.5 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.

7.5.1 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.

7.6 Performance Standards

7.6.1 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.

7.6.2 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.

7.6.3 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.

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

7.6.5 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.

7.6.6 Establishing alert levels

a) 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 or for 20 removals of passenger entertainment units in a like period .

b) 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. They should be up-dated periodically to reflect operating experience, product improvement, changes in procedures, etc.

c) 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.

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

i) 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.

ii) 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.

iii) 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.

7.6.7 Re-calculation of alert levels

a) 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").

b) 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.

c) 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.

d) 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.

7.7.1 Upper control limits (alert values)

a) 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.

b) 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.

c) 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:

a) 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).

b) Analysis and interpretation of trends

c) The evaluation of repetitive defects

d) Confidence testing of expected and achieved results

e) Studies of component life-bands and survival characteristics

f) Reliability predictions

g) 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:

a) Flight defects and reductions in operational reliability Defects occurring at line and main base Deterioration observed during routine maintenance Workshop and overhaul facility findings

b) Modification evaluations Sampling programs

c) The adequacy of maintenance equipment and technical publications

d) The effectiveness of maintenance procedures Staff training

e) 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 following information should be included in the periodic reliability report:

a) Fleet reliability summary

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

i) Number of aircraft in fleet and Number of aircraft in service

ii) Number of operating days (less maintenance checks)

iii) Total number of flying hours

iv) Average daily utilization per aircraft, and average flight duration

v) Total number of cycles/landings

vi) Total number delays/cancellations

vii) Technical incidents

b) 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.

c) 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.

d) 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.

e) 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.

f) 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.

g) 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.

h) 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.

i) PIREPS

PIREPS should be reported to the Authority by ATA chapters in graphical and/or tabular form as a count and rate for the defined reporting period, and comparison thereof with the alert level.

j) Fleet reliability performance against the applicable worldwide rate.

k) Tracking and reporting of relevant events of the following events should be included in the reporting :

1) in-flight shutdowns or flameouts;
2) diversion or turn-back;
3) uncommanded power changes or surges;
4) inability to control the engine or obtain desired power; and
5) significant events or adverse trends with Non EDTO or EDTO significant systems.

This should also identify the following:

6) aeroplane identification;
7) engine identification (make and serial number);

8) total time, cycles and time since last shop visit;
9) for systems, time since overhaul or last inspection of the defective unit
10) phase of flight;
11) corrective action; and
12) resulting action by the flight crew (divert, return, continue, etc.).

l) EDTO specific operations

In addition to non-EDTO reliability reporting requirements, the following information should be provided for EDTO flights:

i) Number of EDTO flights during the defined reporting period.

ii) Aircraft /engine combination (AEC). involved in the program, e.g. B767/CF6-80C2.

iii) Identification details of aircraft and flights involved in the program during the reporting cycle.

iv) Average fleet utilization time and cycles during the reporting cycle.

v) EDTO critical component failures or malfunctions, by ATA chapter. However, EDTO critical system failure reporting may also be acceptable.

vi) Engine condition monitoring.

The EDTO operator should implement an engine condition monitoring programme to detect deterioration at an early stage to allow for corrective action before safe operation is affected, and to ensure internal limit margins (e.g. rotor speeds, exhaust gas temperatures) are maintained to support single-engine diversion scenarios. Engine margins preserved through this programme should also account for the effects of additional engine loading demands (e.g. anti-icing, electrical) which may be required during the single-engine flight phase associated with the diversion.

At a minimum, the programme should record these parameters consistently during a benign part of flight, typically at cruise, and record them electronically or manually. These parameters can be defined by the engine manufacturers but could typically include N1, N2, N3, FF, EGT, oil pressure and oil temperature.

vii) Oil consumption monitoring.

The oil consumption monitoring programme is required to allow operators to detect unexpected oil consumption that could be the result of an oil leak or unforeseen engine wear which can impact the EDTO dispatch capability of the aircraft. This oil consumption monitoring programme for EDTO should define a baseline consumption rate (normal usage) and detect oil consumption based on the previous flight results. This oil consumption or loss must not exceed the manufacturer's maximum allowable usage rate and is defined in the aircraft maintenance manual.

viii) APU in-flight start monitoring programme.

The purpose of the APU in-flight start monitoring programme is to demonstrate and/or confirm that the APU is able to start at altitude while in flight. This in-flight verification is necessary as the capability of the APU to start at altitude can usually not be demonstrated while the aircraft is on ground. The requirement for APU in-flight start monitoring in the frame of EDTO is usually an operational requirement. The reliability objective for APU high-altitude relight should be defined in the applicable national regulation. Usually a 95 per cent success rate is expected to be demonstrated. An APU in-flight start attempt should be classified as "successful" when the APU is started within three start attempts.

ix) Propulsion system monitoring

The IFSD rate is a statistical indicator commonly used to assess the reliability of the concerned engine model versus the target rate set. The IFSD rate is a reliability figure calculated by dividing the chargeable number of in-flight shutdowns by the total engine operating hours accrued during the same period. The IFSD rate is usually computed over a 12-month rolling average basis for the concerned Aircraft /engine combination (AEC). It is, therefore, the count of IFSD(s) over the total engine hours cumulated during the last 12 months. The assessment of propulsion systems' reliability for the EDTO fleet should be made available to the Authority (with supporting data) in accordance with the approved EDTO maintenance control system.

x) EDTO significant system related occurrences reporting.

m) 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 Authority. 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:

a) Change of task interval in maintenance program or change in the work content;

b) Revision of certain scheduled maintenance tasks;
c) Additional inspections fleet wide with incentive to determine the condition of critical systems or components;
d) Fleet wide modification of aircraft;
e) Change in maintenance and/or operational procedures;
f) 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.

8.0 APPLICATION TO AN OPERATOR WITH A SMALL FLEET

Note: For the purpose of this AAC, 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:

a) Certification factors, such as aircraft type certificate data sheet (TCDS) compliance (variant)/modification status, including SB compliance

b) 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.

c) 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 KCAA 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 KCAA 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 KCAA is satisfied that the manufacturer manages a reliability program that complies with the intent of this AC.

9.0 OPERATOR MAINTENANCE PROGRAM ADJUSTMENT BASED ON RELIABILITY PROGRAM OUTPUT

9.1 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.

9.2 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.

9.3 Volume of data needed to substantiate Maintenance program adjustment

9.3.1 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.

9.3.2 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.

9.3.3 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.

9.4 Adding, and deleting a maintenance task:

9.4.1 Air operators must review manufacturer’s and vendor’s recommendations published through service bulletin (SB), service letter (SL), all operators letter (AOL), and other documents such as CMM revisions. These recommendations may result in changes in the maintenance program.

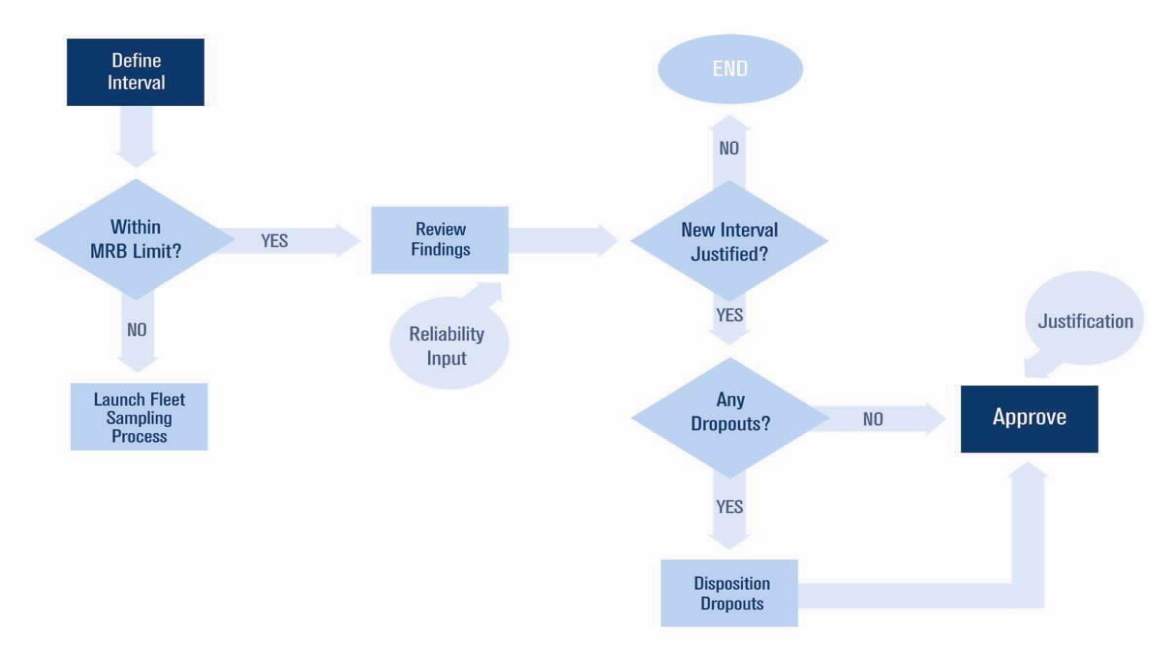
9.4.2 Changes which involve the deletion of a task, must be subjected to the same analysis that was used to establish the initial program basis. This is sometimes referred to as the internal MRB procedure.

9.4.3 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.

9.4.4 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 KCAA requirements.

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

9.5.1 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.

a) 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.

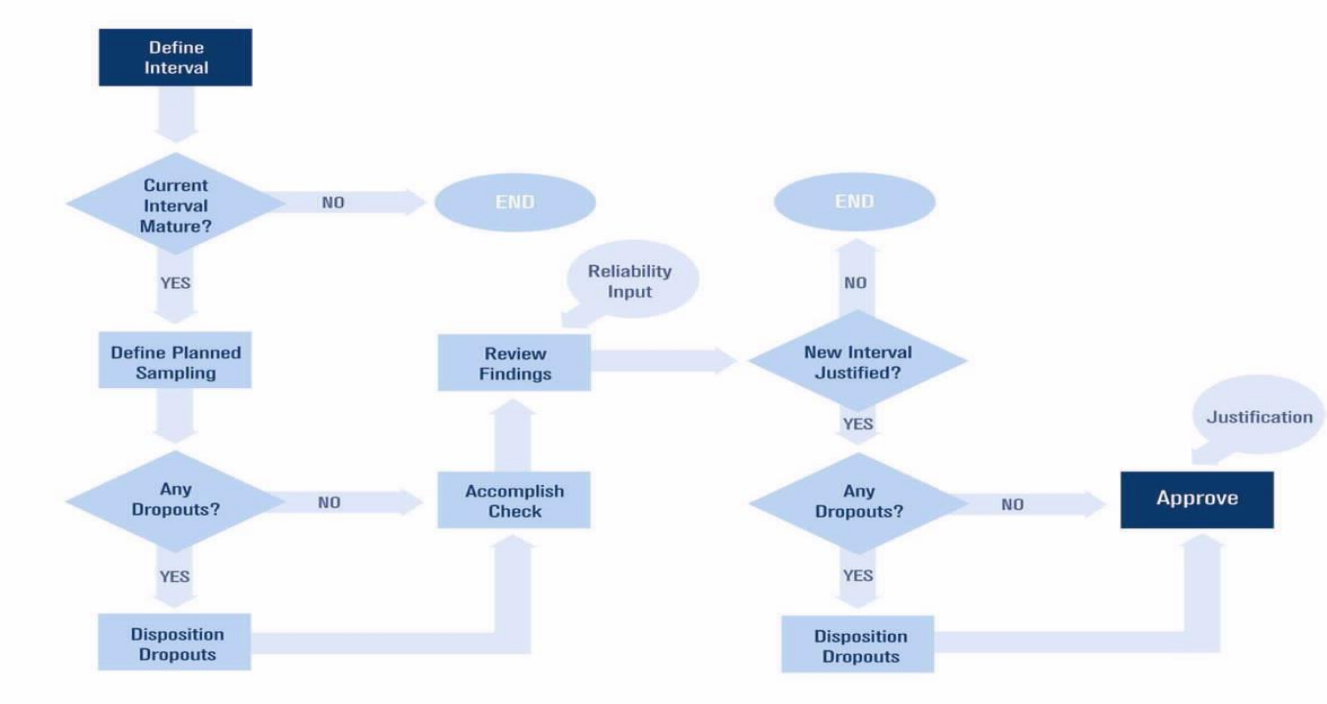
b) If a task/check that is subject to an escalation per an approved MRBR revision has never been performed by the air operator because the interval for its performance has not yet been reached, the new MRBR interval can be approved.

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

d) 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.

9.5.2 Air Operators check interval escalation above MRB approved limit

a) 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.

i) As a prerequisite requirement, the escalation and sampling program must conform to the interval and program limitations approved by the Authority.
ii) 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.
iii) 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.
iv) Minimum two aircraft should be selected as sample to evaluate the effect of the new target interval before it is approved.
v) To be eligible as samples, checks should achieve at least 90% of the target interval.

10.0 An Approved Single Engine Turbine Powered Aeroplanes

An Approved Single Engine Turbine Powered Aeroplanes programme shall include the following:

10.1 Engine Trend Monitoring Document

The Operator should develop a document describing the Engine trend monitoring including at least the following:

a) A general description of the Engine trend monitoring including definitions of significant terms used in the Engine trend monitoring.

b) Application of the program by aircraft fleet type/model, aircraft registration marks, or serial numbers, as appropriate.
c) The organisational structure, duties and responsibilities.
d) Procedures for establishing and reviewing performance standards.
e) Data collection system.
f) Methods of data analysis.
g) Data display and reporting.
h) Corrective action program.
i) A copy and explanation of all forms, peculiar to the program.

10. 2 Identification and applicability of the program

The Engine trend monitoring must contain the following information:

a) the type, model, serial number and registration mark of the aircraft controlled by the program;
b) the name and address of the registered operator of the aircraft controlled by the program;
c) the name and approval certificate reference number of the Operator responsible for the program organisational structure and the departmental responsibilities for the administration of the program should be stated.
d) The responsibilities for individuals and departments (Engineering, Production, Quality, Operations etc.) in respect of the program, together with the information and functions of any program control committees (Reliability Group), should be defined.
e) An oil consumption monitoring programme based on manufacturers' recommendations;
f) An engine condition monitoring programme describing the parameters to be monitored, the method of data collection and the corrective action process; this should be based on the manufacturer's recommendations. The monitoring is intended to detect turbine engine deterioration at an early stage to allow for corrective action before safe operation is affected.

This information should be contained in the operator's Maintenance Control Manual.

10.3 Objective of the program

10.3.1 The objective of the Engine trend monitoring must be described in the program.
10.3.2 The applicable instructions for continuing airworthiness must be followed to establish the objective of the program.
10.3.3 As a minimum, the Engine trend monitoring must provide a means of ensuring maintenance program tasks are effective and their periodicity is adequate for continuing airworthiness of the aircraft.

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

a) a recognition of the need for corrective action;
b) establishment of the corrective actions needed; and
c) a determination of the effectiveness of those actions.

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

10.4 Identification of items controlled by the program

10.4.1 The aircraft parts, systems and structural elements controlled by the Engine trend monitoring must be clearly defined and identified in the program.

10.4.2 The maintenance program tasks controlled by the program must be clearly identified in the program.

10.4.3 Where some items, such as aircraft structure and engines, are controlled by a separate program, such as a manufacturer structural sampling or life development program, this must be referenced in the program.

10.5 Administration of the program

The individuals responsible for the administration of the Engine trend monitoring must be identified and their responsibility must be described in the program.

10.6 Personnel Qualification

10.6.1 In approving the operator's maintenance and reliability program, the Authority expects that the operator employs sufficiently qualified personnel with appropriate engineering experience and understanding of reliability concepts.

10.6.2 The qualified personnel is required to have attended a Engine Condition Trend Monitoring Course from training organization acceptable to the Authority. The personnel should be able the interpretation of the data analysis to be made correctly.

10.6.3 An approved reliability program can include full or partial utilization of the services of aircraft manufacturers. Such utilization needs to be described with the reliability program.

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

10.7 Analysis and interpretation of information

10.7.1 The Engine trend monitoring must provide for the regular analysis and interpretation of information generated by the program.

10.7.2 The method employed for analysing and interpreting the information must be explained in the program.

10.7.3 The methods used must:

a) Enable the performance of the items controlled by the program to be measured; and
b) Facilitate recognition, diagnosis and recording of significant problems.

10.7.4 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:

a) comparisons of operational reliability with established or allocated standards (in the initial period these could be obtained from in-service experience of similar equipment of aircraft types);
b) analysis and interpretation of trends;
c) the evaluation of repetitive defects;

d) confidence testing of expected and achieved results;
e) studies of life-bands and survival characteristics;
f) reliability predictions; and
g) other methods of assessment.

10.8 Investigation and corrective action

10.8.1 The program must provide for an active investigation and, if applicable, implementation of corrective action when a performance standard is exceeded.

10.8.2 If upper and lower limits are used to express performance standards, the follow up requirements for each limit must be fully described in the program.

10.8.3 The procedures for implementing corrective actions and for monitoring the effectiveness of the corrective actions must be described in the program.

10.8.4 The procedures must include provision of periodic feedback to the individual responsible for taking the corrective action until such time as performance has reached an acceptable level.

10.8.5 Corrective actions must correct any reduction in reliability revealed by the program and may take the form of one or more of the following:

a) changes to maintenance, operational procedures or techniques;
b) changes to maintenance program tasks, including escalation or de-escalation of tasks, addition, modification or deletion of tasks;
c) one-time special maintenance for the fleet;
d) initiation of modifications to aircraft and aeronautical products;
e) changes to provisioning of spare parts for maintenance;
f) changes to manpower and equipment planning for maintenance;
g) training of maintenance personnel.

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

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

a) 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 AMP;
b) amendments to approved manuals (e.g. Maintenance Manual, Crew Manual);
c) special inspections or fleet campaigns;

11.0 Reports to The Authority

11.1 When approving a Engine trend monitoring the Authority will require that the program includes procedures for providing reliability reports to the Authority .

11.2 The periodicity for report submission would normally be on a quarterly basis but other arrangements may be agreed. For a low use aircraft (eg some corporate aircraft) the report may be submitted on a yearly basis or as agreed with the the Authority field office responsible for the aircraft operator.

11.3 The report is required to be indicative of the fleet's reliability and overall effectiveness of the aircraft's maintenance program.

Kenya Civil Aviation Authority

APPENDIX 1 – ALERT LEVEL CALCULATIONS

Example – Pilot Report (Pireps) by Aircraft System per 1,000 Flight Hours

Method: Alert Level per 1, 000 flight hours = Mean of 3 months Running Average "Pirep" Rates per 1,000 flight hours (for the last 12 months) plus 3 standard Deviations.

System: Aircraft Fuel System (ATA 100, Chapter 28)

Month	Pireps (Monthly)	Pireps (3 monthly cumulative totals)	Flight hours (Monthly)	Flight Hours (3 months cumulative total)	Pirep rate per 1000 hour (3 months running average) (x)
Nov	42	-	2400	-	-
Dec	31	-	2320	-	-
Jan	58	131	2350	7070	18
Feb	46	135	2300	6970	19
Mar	58	162	2560	7210	22
Apr	26	130	2600	7460	17
May	42	126	2750	7910	16
Jun	65	133	3100	8450	16
Jul	78	185	2880	8730	21
Aug	74	217	2700	8680	25
Sep	58	210	3000	8580	24
Oct	54	186	2650	8350	22
Nov	35	147	2610	8260	18
Dec	46	135	2330	7590	18

N=12

x		**$(x- \bar{x})$**	**$(x- \bar{x})^2$**
18		-2	4
19		-1	1
22		2	4
17		-3	9
16		-4	16
16	Mean $(\bar{x}) = \bar{x}/N$	-4	16
21		1	1
25	=236/12	5	25
24		4	16
22	=19-67	2	4
18		-2	4
18	=20	-2	4
$\sum x$= 236			$\sum (x- \bar{x})^2$104

STANDARD DEVIATION = $\sqrt{\sum (x - \bar{x})^2 / N} = \sqrt{104/12} = \sqrt{8.67} = 2.94$

3 x SD = 8.82 rounded to **9**

ALERT LEVEL = Mean + 3 SD = 20 + 9 = 29

APPENDIX II– TYPICAL DATA DISPLAY

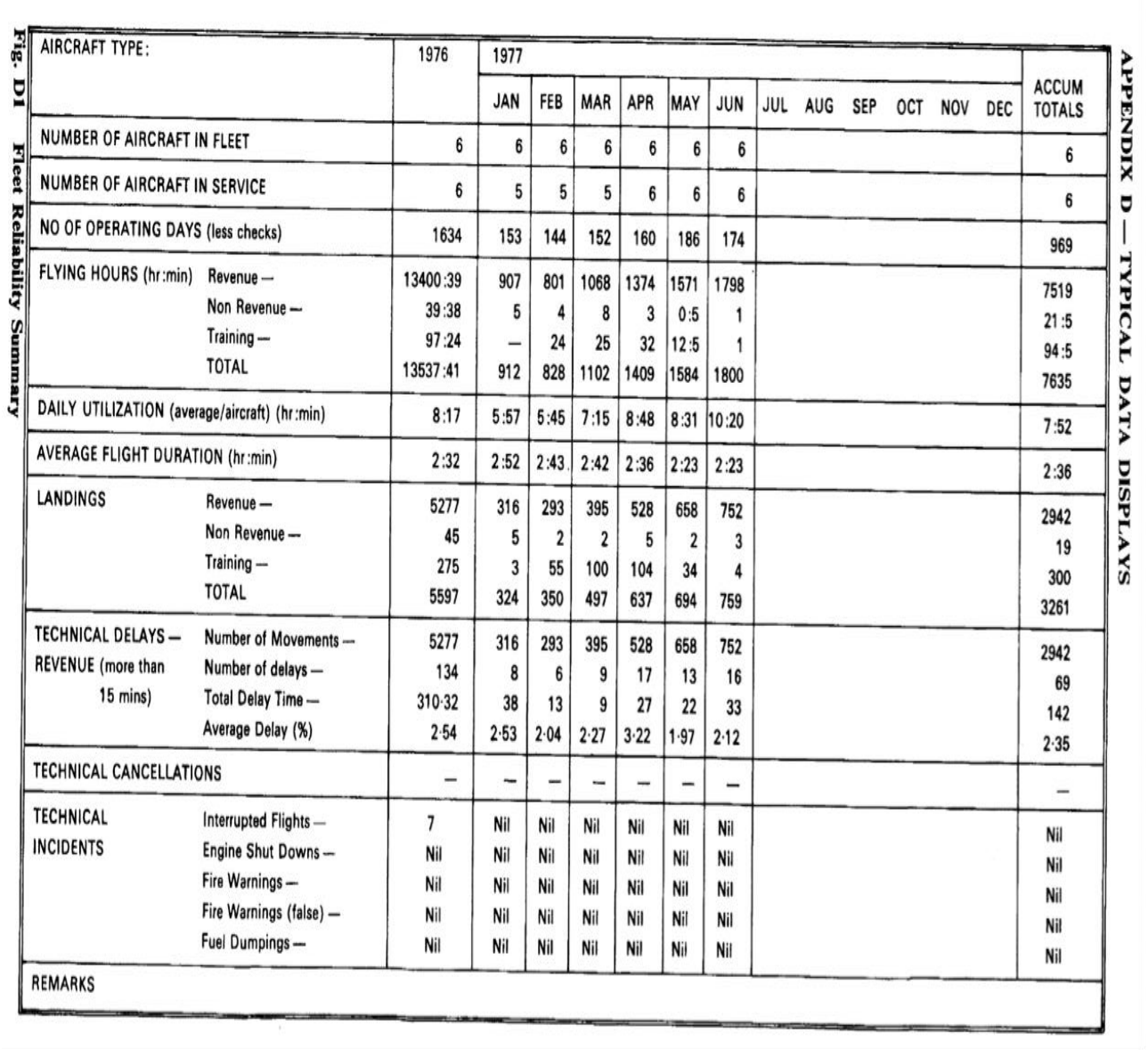


Fig. D1 Fleet Reliability Summary

APPENDIX D — TYPICAL DATA DISPLAYS

AIRCRAFT TYPE:		1976	1977												ACCUM TOTALS
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
NUMBER OF AIRCRAFT IN FLEET		6	6	6	6	6	6	6							6
NUMBER OF AIRCRAFT IN SERVICE		6	5	5	5	6	6	6							6
NO OF OPERATING DAYS (less checks)		1634	153	144	152	160	186	174							969
FLYING HOURS (hr:min)	Revenue —	13400:39	907	801	1068	1374	1571	1798							7519
	Non Revenue —	39:38	5	4	8	3	0:5	1							21:5
	Training —	97:24	—	24	25	32	12:5	1							94:5
	TOTAL	13537:41	912	828	1102	1409	1584	1800							7635
DAILY UTILIZATION (average/aircraft) (hr:min)		8:17	5:57	5:45	7:15	8:48	8:31	10:20							7:52
AVERAGE FLIGHT DURATION (hr:min)		2:32	2:52	2:43	2:42	2:36	2:23	2:23							2:36
LANDINGS	Revenue —	5277	316	293	395	528	658	752							2942
	Non Revenue —	45	5	2	2	5	2	3							19
	Training —	275	3	55	100	104	34	4							300
	TOTAL	5597	324	350	497	637	694	759							3261
TECHNICAL DELAYS — REVENUE (more than 15 mins)	Number of Movements —	5277	316	293	395	528	658	752							2942
	Number of delays —	134	8	6	9	17	13	16							69
	Total Delay Time —	310·32	38	13	9	27	22	33							142
	Average Delay (%)	2·54	2·53	2·04	2·27	3·22	1·97	2·12							2·35
TECHNICAL CANCELLATIONS		—	—	—	—	—	—	—							—
TECHNICAL INCIDENTS	Interrupted Flights —	7	Nil	Nil	Nil	Nil	Nil	Nil							Nil
	Engine Shut Downs —	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil
	Fire Warnings —	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil
	Fire Warnings (false) —	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil
	Fuel Dumpings —	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil
REMARKS															

APPENDIX III

10.0 INTRODUCTION

10.1 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.

10.2 The manufacturer's recommendations are featured in a Maintenance Planning Document (MPD). 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. To facilitate this requirement, the operator's maintenance reliability program should be established.

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

10.4 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);

10.4.1 *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.

10.4.2 *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

10.4.3 *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.