Chapter 7
AIRCRAFT MAINTENANCE

7.1 Air operator's maintenance responsibilities

7.1.1 Annex 6, Part I, 8.1 and Part III, Section II 6.1, requires operators ensure that each aircraft they operate is maintained in an airworthy condition. It also provides that the operational and emergency equipment necessary for an intended flight is serviceable, and that the certificate of airworthiness of each aircraft they operate remains valid. It also provides that an operator should:

a) operate an aircraft maintained and released to service by an AMO, or under an equivalent system, either of which should be acceptable to the State of Registry;
b) employ a person or group of persons to ensure that all maintenance is carried out in accordance with the procedures and policies in the MCM. The MCM should be acceptable to the State of the Operator and to the State of Registry; and
c) ensure that the maintenance of its aircraft is performed in accordance with the maintenance programme, approved by the State of Registry and acceptable to the State of the Operator.

Note. *— The air operator should monitor the compliance of its maintenance procedures by establishing a quality assurance system or equivalent.*

7.1.2 Annex 8, Part II, 4.2.3 requires the State of Registry determine the continuing airworthiness of an aircraft. This can be done by developing or adopting requirements to ensure the continuing airworthiness of the aircraft and adopting the mandatory information from the State of Design and ensuring the transmission to the State of Design of all MCAI originated from the State of Registry. For aeroplanes over 5 700 kg and helicopters over 3 175 kg MTOM, there exists a system whereby information on faults, malfunctions, defects and other occurrences is transmitted to the organization responsible for the type design of that aircraft.

7.1.3 The State of Registry responsibilities include the approval of maintenance programme, adoption of continuing airworthiness requirements, reporting of in-service occurrences, and maintaining the validity of the Certificate of Airworthiness. The State of Registry is also responsible for acceptance of procedures for the performance and certification of maintenance including modifications and repairs, maintenance release procedures and AMOs, procedures for maintenance record keeping and the mass and balance programme.

7.1.4 Annex 6, Part I, 8.1.2, provides that when the State of Registry considers the acceptance of an equivalent system in lieu of an AMO, the State of Registry should ensure that policies and procedures that govern and control the performance of maintenance are acceptable. The air operator's MCM should describe the maintenance procedures including the procedures for completing and signing a maintenance release when maintenance is performed under an equivalent system acceptable to the State of Registry. The MCM should include the scope of maintenance to be performed under this system.

7.2 Air operator's maintenance control manual (MCM)

7.2.1 Annex 6, Part I, 8.2 and Part III, Section II, 6.2 require operators to ensure that a MCM, acceptable to the State of Registry, is provided for the use and guidance of maintenance and operational personnel as applicable. The operator is accountable for the manual and also required to ensure that the manual is amended and revised as necessary by means of establishing appropriate revision control system and those copies of changes are distributed to holders of the manual. Additionally, Annex 6, Part III, Section II, 6.2 and Part I, 8.2.1 require that the design of this manual should observe the human factors principles. Some of the basic aspects requiring human factor optimization include:

a) written language, which involves not only vocabulary and grammar, but also the manner in which they are used;
b) typography, including the form of letters and printing and the layout, has a significant impact on the comprehension of the written material;
c) the use of photograph, diagrams, charts or tables replacing long descriptive text helps comprehension and maintain interest. The use of colour in illustrations reduces the discrimination workload and has a motivational effect;
d) the working environment in which the document is going to be used has to be considered when print and page size are determined.

7.2.2 Annex 6, Part I, 11.2 and Part III, Section II, 9.2 specify the information that should be included in the MCM. **The MCM** should contain the following information:

a) a description of the procedures required by air operators to ensure that:
   i) each aircraft is maintained in an airworthy condition;
   ii) the operational and emergency equipment necessary for the intended flight is serviceable; and
   iii) the Certificate of Airworthiness of each aircraft remains valid;

b) a description of the administrative arrangements between the air operator and the AMO, when applicable, including how to review the arrangements, when applicable;
c) a description of the maintenance procedures and the procedures for completing and signing a maintenance release when maintenance is based on a system other than that of an AMO, when applicable;
d) the names and duties of the person or group of persons employed to ensure that all maintenance is carried out in accordance with the MCM;
e) a reference to the maintenance programme for each aircraft type operated (refer to paragraph 7.3 of this chapter);
f) a description of the methods used for the completion and retention of the air operator's maintenance records (refer to paragraph 7.8 of this chapter);
g) in the case of aeroplanes over 5 700 kg or helicopters over 3 175 kg MTOM:
   i) a description of the procedures for monitoring, assessing and reporting maintenance and operational experience to the State of Registry;
   ii) a description of the procedures for complying with the service information reporting requirements of Annex 8, Part II, 4.2.3 f) and 4.2.4; and
   iii) a description of the procedures for assessing continuing airworthiness information and recommendations available from the organization responsible for the type design, and for implementing resulting actions considered necessary as a result of the assessment in accordance with a procedure acceptable to the State of Registry;
h) a description of the procedures for implementing action resulting from MCAI and if applicable, how their alternative means of compliance is requested and complied with;
i) a description of establishing and maintaining a system of analysis and continued monitoring of performance and efficiency of the maintenance programmes, in order to correct any deficiency in the programme;
j) a description of aircraft types and models to which the manual applies;
k) a description of procedures for ensuring that unserviceable systems and components affecting airworthiness are recorded and rectified;
l) a description of the procedures for advising the State of Registry of significant in-service occurrences; and
m) a description and procedures for completing and signing a maintenance release for aircraft and parts thereof that have undergone maintenance (*refer to 7.9 of this chapter*).

7.2.3 Additional procedures may be necessary to ensure the air operator's maintenance personnel responsibilities and aircraft maintenance programme requirements are met. The following additional procedures are recommended:

a) a description of the procedures to ensure the aircraft is maintained in accordance with the maintenance programme;
b) a description of the training programme for the maintenance personnel employed by the air operator applicable to their assigned duties and responsibilities;
c) a description of the air operator's safety management system;
d) a description of the procedure to ensure that modifications and repairs comply with the State of Registry airworthiness requirements; and
e) a description of the procedure used for the MCM revision and control.

Note. — *Where an operator's SMS is already addressed in some other document, an appropriate reference to such document together with its relevant interfaces with the MCM can be described instead. Guidance material on safety management systems can be found in Doc 9859 (Safety Management Manual).*

7.2.4 Annex 6, Part I, 8.2.4 and Part III, 6.2.4, requires the air operator provides the State of the Operator and the State of Registry with a copy of the air operator's MCM, together with all amendments and/or revisions to it and should incorporate in it such mandatory material as the State of the Operator or the State of Registry may require.

7.3 Maintenance programme

7.3.1 General

7.3.1.1 Annex 6, Part I, 8.3 and Part III, Section II, 6.3 require operators to provide a maintenance programme approved by the State of Registry for the use and guidance of maintenance and operational personnel. When the State of Registry is different from the State of the Operator, the review of the programme may be coordinated with the State of the Operator. Additionally, Annex 6, Part I, 8.3 and Part III, Section II, 6.3 require that the design and application of the air operator's maintenance programme observe the human factors principles as described in 7.2.1.

7.3.1.2 Annex 6, Part I, 11.3 for aeroplanes and Part III, Section II, 9.3.3 for helicopters also require that maintenance tasks and intervals that have been specified as mandatory in approval of the type design be identified as such.

7.3.1.3 Annex 6, Part I, 11.3.3 for aeroplanes and Part III, Section II, 9.3.3 for helicopters also contains a recommendation that the maintenance programme be based on information made available by the State of Design or by the organization responsible for the type design, and any additional applicable experience. For large aeroplanes, this information is normally issued in the form of a maintenance review board report for the particular aircraft type is one of the main sources for the maintenance programme.

7.3.1.4 A maintenance programme is applicable to aircraft, engines, propellers and parts. Annex 6, Part I, 8.3 and Part III, Section II, 6.3 requires each aircraft and helicopter to have a maintenance programme which should contain the following information:

a) maintenance tasks and the intervals at which these are to be performed, taking into account the anticipated utilization of the aircraft and operating environment of the aircraft. It is recommended that the maintenance programme be based on information made available by the State of Design or by the organization responsible for the type design and any additional applicable experience. The basic requirements for a maintenance programme include but are not limited to:
   i) inspection;
   ii) scheduled maintenance;
   iii) overhaul and repairs;
   iv) structural inspection; and
   v) maintenance tasks and intervals specified and identified as mandatory in approval of the type design.
b) when applicable, a continuing structural integrity programme (SIP) which at least includes:
   i) supplemental inspections;
   ii) corrosion prevention and control;
   iii) structural modification and associated inspections;
   iv) repair assessment methodology; and
   v) widespread fatigue damage (WFD) review;
c) procedures for changing or deviating from a) and b) above for tasks that do not have mandatory designations from the State of Design; and
d) when applicable, condition monitoring and reliability programme descriptions for aircraft systems, components and engines.

***Note**. — In the context of d) above, "when applicable" means that the condition monitoring and reliability programmes are only applicable to aircraft types where the maintenance programme was derived using the maintenance review board process*

7.3.2 Maintenance programme development basis

7.3.2.1 Air operators' maintenance programmes should normally be based upon the manufacturer recommended ICAs such as, but not limited to, the MRB report, where available, and the type certificate holder's maintenance planning document (MPD) and/or appropriate chapter in the maintenance manual (i.e., the manufacturer's recommended maintenance programme). The structure and format of these maintenance instructions may be required to be written in a format acceptable to the CAA for the issuance of the approval.

7.3.2.2 For a newly type-certificated aircraft, where no previously approved maintenance programme exists, it will be necessary for the air operator to comprehensively appraise the manufacturer's recommendations (and the MRB report where applicable), together with other airworthiness information, in order to produce a realistic programme for approval.

7.3.2.3 The following requirements for content of the maintenance programme should be considered by the State of Registry during the approval of the proposed maintenance programme.

a) MRB report approved by the State of Design;
b) MPD issued by the type certificate holder or manufacturer;
c) ALIs specified in the type certificate data sheet. These may include CMRs, safe life airworthiness limitation items, and damage tolerant ALIs;
d) specific operation requirements of the State of Registry and the State of the Operator. These requirements may relate to maintenance of additional configuration items required by these States for the type of operations approved and to any additional maintenance tasks required by national regulations. Examples include maintenance requirements relating to operations over uninhabited terrain, operations over water, EDTO, reduced vertical separation minima (RVSM) operations, all-weather operations (AWOPS) and navigation system requirements relating to polar operations and minimum navigation performance specifications (MNPS). Additional maintenance requirements relating to

extreme climates (temperature, humidity, salt spray, ice or dust) in the area of operations may also be required by national regulations. Also, these States may have specific maintenance requirements relating to the flight data recorder (FDR) system, the cockpit voice recorder (CVR) system, emergency equipment and other systems;

e) mandatory life limits for engine life-limited parts specified by the manufacturer;
f) engine and APU off-wing maintenance as specified in the engine and APU work scope planning guides; and
g) ICAs specified for air operator installed equipment or required by STC modifications, including emergency equipment.

All items in the maintenance programme should have the source document clearly identified and mandatory items (such as CMRs, ALIs and ADs) must be clearly distinguished from items that are subject to adjustments or changes based on operating experience.

7.3.2.4. The following provides some guidance on task intervals:

a) the task intervals are commonly specified in the MRB report in terms of relevant usage parameters such as cycles, flight hours or calendar time. For planning convenience, it is usual for the air operator (or the MRB) to group the tasks into packages or scheduled maintenance checks (for example, A-check or 150 hour check). When this is done, it is important to retain visibility of the original MRB recommended usage parameter for use when task and/or scheduled maintenance check interval adjustments are evaluated; and
b) some air operators prefer to accomplish scheduled maintenance checks in separate "phases" which combine to make up a complete check. This is acceptable provided that the interval between repetitions of tasks is not exceeded (this may require some phases to be accomplished long before they are due during the first cycle).

7.3.2.5 For existing aircraft types, it is permissible for the air operator to make comparisons with maintenance programmes previously approved. It should not be assumed that a programme approved for one air operator should automatically be approved for another air operator. The air operator should fit the maintenance programme around their expected utilization and operating environment. The State of Registry should evaluate the maintenance programme against the air operators' aircraft fleet utilization, landing rate and equipment fit. In particular, the experience of the air operator should be assessed. Where the CAA of the State of Registry is not satisfied that the proposed maintenance programme can be used as is by the air operator, the CAA should request the air operator to introduce appropriate changes to it, such as additional maintenance tasks, de-escalation of check intervals, or to develop the aircraft initial maintenance programme based upon the manufacturer's recommendations.

7.3.3 Maintenance programme approval

The legislation of the State of Registry should provide the CAA of the State the authority and responsibility for the approval of each air operator's aircraft maintenance programme. The approval of the maintenance programme establishes the maintenance tasks and intervals for the aircraft, engines, propellers and parts.

7.3.4 Updating the maintenance programme

7.3.4.1 Revisions to the approved programme should be raised by the air operator, in order to reflect changes in the type certificate holder's recommendations, modifications, service experience, or as required by the CAA of the State of Registry (in coordination with the State of the Operator where the two are different). Reliability programmes form one important method of updating approved programmes (see Chapter 7.4 of this manual).

7.3.4.2 The air operator may only vary the periods prescribed by the programme with the approval of the State of Registry (in coordination with the State of the Operator where the two are different). The CAA should not approve intervals escalations or task modifications related to MCAI, ALIs and CMRs without an appropriate coordination with the State of Design.

7.3.4.3 The air operator's approved aircraft maintenance programme should be subject to periodic review to ensure that all mandatory requirements are addressed. These include MCAI, ICAs, revisions to the MRB report and maintenance needs of the aircraft as identified by the reliability programme or other monitoring of in-service performance.

7.3.4.4 The State of Registry should ensure that the air operator has the necessary resources, organization and documented processes to perform the continuous assessment of the type certificate holder's latest recommendations and maintenance requirements of the aircraft as required by Annex 6, Part I, Chapter 8 and Part III, Section II, Chapter 6.

7.3.4.5 The air operator should review the content of the maintenance programme periodically for continued validity in view of operating experience and ensure that the programme is amended and revised as necessary by means of establishing appropriate revision and control system and that copies of all amendments to the maintenance programme should be furnished promptly to all organizations or persons to whom the maintenance programme has been issued.

7.4 Reliability programme

7.4.1 General

7.4.1.1 The State of Registry may require that the air operator develop a reliability programme in conjunction with the maintenance programme in order to ensure the continuing airworthiness of the aircraft. Specifically, the programme may be required in the following cases:

a) the aircraft maintenance programme is based upon MSG-3 logic; or
b) the aircraft maintenance programme includes condition monitored components; or
c) the aircraft maintenance programme does not include overhaul time periods for all significant system components; or
d) when specified by the Manufacturer's MPD or MRB report.

***Note** 1. — for the purpose of this paragraph 7.4.1.1, c) "significant system" is a system the failure of which could cause a hazard to the safe operation of the aircraft.*

***Note** 2. — Notwithstanding paragraph 7.4.1.1, an operator that is not required to develop a reliability programme however may develop its own reliability monitoring programme when it may be deemed beneficial from a maintenance point of view.*

***Note** 3. —Two primary maintenance procedures that have currently been utilized for the purpose of a maintenance programme: MSG-2 for maintenance processes, i.e. hard time (HT), on condition (OC) and condition monitoring (CM); MSG-3 for maintenance tasks, i.e. lubrication and servicing, operational and visual check, inspection and function and functional check, restoration and discard.*

7.4.1.2 The purpose of a reliability programme is to ensure that the aircraft maintenance programme tasks are effective and their recurrence at regular intervals is adequate. The reliability programme therefore may give rise to the optimization of a maintenance task interval, as well as the addition or deletion of a maintenance task. In this respect, the reliability programme provides an appropriate means of monitoring the effectiveness of the maintenance programme.

7.4.1.3 Reliability programmes are designed to supplement the operator's overall programme for maintaining aircraft in a continuous state of airworthiness. There are a number of maintenance reliability programmes now in operation that use new and improved maintenance management techniques. Although the design and methods of application vary to some degree, the basic goals are the same — by recognizing access and acting upon meaningful symptoms of deterioration before malfunction or failure in order to establish and monitor the MCM requirements.

7.4.1.4 Performance standards (e.g. alert value) are established by actuarial study of service experience using statistical methods coupled with application of technical judgment. These standards are used to identify trends or patterns of malfunction or failures experienced during programme operation. Even though reliability programmes vary, they should provide means for measurement, evaluation, and improvement predictions. The programme should contain the following elements:

a) an organizational structure;
b) a data collection system;
c) a method of data analysis and display;
d) procedures for establishing performance standards or levels;
e) procedures for programme revision;
f) procedures for time control; and
g) a paragraph containing definitions of terms used in the programme.

7.4.1.5 It is intended that the specific needs of operators, in terms of operating philosophy, and record keeping practices be reflected in their reliability programmes. The extent of statistical and data processing required for programme operation is entirely dependent on the character of the particular programme. Programmes may be simple or complex, depending on the size of the operator and other factors. The smaller as well as the larger operators may develop maintenance reliability programmes to meet their own specific needs.

7.4.2 Reliability programme criteria

7.4.2.1 The word "reliable" is a broad term meaning dependable or stable. The term, as used by the aviation industry, applies to the dependability or stability of an aircraft system or part thereof under evaluation. A system or component is considered "reliable" if it follows an expected law of behaviour and is regarded "unreliable" if

it departs from this expectation. These expectations differ greatly, depending upon how the equipment is designed and operated.

7.4.2.2 Reliability programmes should describe the techniques used for measuring the performance and calculating the remaining service life of the component sufficiently in advance in order to take corrective maintenance action prior to failure or reaching an unacceptable performance level. Essentially, reliability programmes are used for the control of maintenance by establishing performance levels for each type of unit and/or system individually or as a class. Generally, reliability programmes depend on the collection of data which can be analyzed and compared to previously established programme goals.

7.4.2.3 A good reliability programme should contain means for ensuring that the reliability which is forecast is actually achieved; a programme which is very general may lack the details necessary to satisfy this requirement. It is not intended to imply that all of the following information should be contained in one programme, since the operating philosophy and programme management practices for each operator are different. However, the following information could be applied to the specific needs of either a simple or a complex programme.

7.4.3 Organizational structure

7.4.3.1 The programme should contain an organizational chart which includes:

a) a diagram of the relationship of key organizational blocks;

b) a listing of the organizational elements by title responsible for the administration of the programme. The organizations responsible for instituting changes to maintenance controls and maintenance programmes should be clearly defined;

c) a statement describing lines of authority and responsibility. The programme should identify the organization responsible to management for the overall reliability functions. It should define the authority delegated to these organizations to enforce policy and assure necessary follow-up and corrective actions;

d) a procedure for the preparation, approval and implementation of revisions to the programme; and

e) a description of reliability board or committee membership and meeting frequency, as appropriate.

7.4.4 Data collection system

7.4.4.1 It is important that the data should be accurate and factual to support a high degree of confidence for any derived conclusion. It should be obtained from units functioning under operational conditions and should relate directly to the established level of performance. Typical sources of information are: unscheduled removals, confirmed failures, pilot reports, sampling inspections, functional checks, shop findings, bench checks and SDRs, flights cancellation and delays and other sources the operator considers appropriate. The data should be collected at specific intervals and should be sufficient to appropriately support the analysis.

7.4.5 Data analysis and display

7.4.5.1 Data display and reporting provide a timely and systematic source of information that is necessary for correcting existing deficiencies. Reporting is not an end objective, but rather a necessary link in the chain of events leading to system improvement. The principal reason for gathering reliability data is to use it for making various determinations and predictions. Among these are such items as failure rate of parts and components, serviceability, and maintainability. Root cause analysis is also frequently required as a pre-requisite to determining effective corrective action. Data analysis is the process of evaluating mechanical performance data to identify characteristics indicating a need for programme adjustment, revising maintenance practices, improving hardware, and equipment. The first step in analysis is to compare or measure data against acceptable performance levels. The standard may be a running average, tabulation of removal rates for past periods, graphs, charts, or any other acceptable means of establishing a norm.

7.4.5.2 In general, almost any desired information can be extracted from these data if they are obtained in a planned and organized manner and carefully recorded and collated. The methods used to analyse the results should also be made clear. The programme should provide the information necessary to properly evaluate the graphic presentations submitted in support of the programme.

7.4.6 Performance standard

7.4.6.1 Each reliability programme should include a performance standard expressed in mathematical terms. This standard becomes the point of measure of maximum tolerable unreliability. Thus, satisfactory reliability trend measurements are those which fall at or preferably below the performance standard. Conversely, a reliability trend measurement exceeding the performance standard is unsatisfactory and calls for some type of follow-up and corrective action.

7.4.6.2 A performance standard may be expressed in terms of system or component failures per thousand hours of aircraft operation, number of landings, operating cycles, departure delays, or of other findings obtained under operational conditions. In some instances, an upper and lower figure may be used. This is known as a reliability band or range and provides the standard by which equipment behaviour may be interpreted or explained.

7.4.6.3 When the performance standard is not met, the programme should provide for an active investigation which leads to suitable corrective action.

7.4.6.4 A description of the types of action appropriate to the circumstances revealed by the trend and the level of reliability experience should be included in the programme. This is the core of maintenance control by reliability measurement. It is the element that relates operating experience to maintenance control requirements. Statistical techniques used in arriving at reliability measurements presented in support of maintenance control actions should be described. Appropriate corrective actions might be:

a) verify that engineering analysis is appropriate on the basis of collective data in order to determine the need to change the maintenance programme;
b) actual maintenance programme changes involving inspection frequency and content, functional checks, or overhaul times;
c) aircraft system or component modification, or repair; or
d) other actions peculiar to the condition that prevails.

7.4.6.5 The results of corrective action programmes should become evident within a reasonable time from the date of implementation of corrective action. An assessment of the time permitted should be commensurate with the severity or safety impact of the problem. Each corrective action programme should have an identified completion date.

7.4.6.6 Due to the constantly changing state-of-the-art, no performance standard should be considered fixed – it is subject to change as reliability changes. The standard should be responsive and sensitive to the level of reliability experienced. It should be "stable" without being "fixed". If, over a period of time, the performance of a system or component 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 established. Each programme should contain procedures to accomplish, when required, such changes to the prescribed performance standards.

7.4.7 Establishing initial standards

7.4.7.1 In order to establish the initial standards for structural components, engines and systems, the past operating experience with the same (or, in the case of new aircraft, similar) equipment should be reviewed in sufficient depth to obtain a cross-section of the subject system's performance. Normally, a period of six months to one year should be sufficient. For a system common to a large fleet of aircraft, a representative sample may be used, while small fleet systems may require 100 per cent review. Examples of industry experience are past and present individual operator's industry experience of similar equipment and performance analysis of the similar equipment currently in service. Operators introducing a new aircraft into service may establish their alert values by using this available data. If industry experience is used in establishing a reliability programme performance standards, the programme should include a provision for reviewing the standards after the operator has gained one year of operating experience.

7.4.7.2 Due to different operating conditions and system design, it is necessary to use different measuring devices (either singly or combined) to obtain satisfactory performance criteria. As stated before, there are various methods used to evaluate and control performance – aircraft diversions, mechanical interruptions in flight, delays and flight cancellations and component unscheduled removal rates.

7.4.7.3 The following are typical examples of methods that can be used to establish and maintain alert values. It should be understood that the methods of evaluation given below are only illustrative and that other suitable methods of evaluation could be used:

a) pilot reports per 1 000 aircraft departures:
    i) some operators have selected pilot reports as related to the number of departures as the primary measure of aircraft systems performance reliability. The reference base for the computation of alert values is a cumulative rate of the previous calendar years' experience. This provides a large statistical base and takes into consideration the extremes in seasonal effects. The baseline for each system is initially calculated by compiling the number of pilot reports logged for the previous twelve-month period times 1 000 divided by the number of aircraft departures for the same twelve-month period.

The purpose of multiplying the pilot reports by 1 000 is to arrive at a figure that expresses the rate per 1 000 departures;

ii) in order for this to be a cumulative or rolling rate for the immediately previous twelve month period, it should be recalculated each month. The data for the first month of the existing twelve month data set is dropped, and the data compiled for the last month is added; i.e. if the initial calculation was from March 1998 to February 1999, the next month's calculation would cover the period from April 1998 to March 1999;

iii) when the base line is computed for a particular system, an alert value is established at a point above the base line equal to, say, five pilot reports per 1 000 aircraft departures. The alert values assigned to each system represent the maximum rate of pilot-reported malfunctions considered to deviate sufficiently from the base line to require investigation;

b) pilot reports per 1 000 aircraft hours:

i) for the purpose of measuring reliability, pilot reports per 1 000 aircraft flight hours may be selected as the indicator of aircraft systems performance. Performance standards in terms of pilot reports per 1 000 hours are established for each of the aircraft systems. Several programmes in current use utilize two performance numbers, an "alert" number and a "target" number. A review and evaluation of a minimum of six to twelve months' history of pilot reports are done to establish the initial alert and target numbers. Established alert and target numbers are valid for a six-month period, at the end of which all alert and target numbers are reviewed and adjusted as necessary;

ii) the alert number is defined as the three-month moving (running) average which is considered to indicate unsatisfactory performance;

iii) historically, alert numbers show seasonal variations. To provide a more realistic alert number, the year is divided into six-month periods. One period encompasses the winter months, the other, the summer months. When reviewing a particular six-month period to ascertain if the alert number is still practical, it is important that the comparison is made between similar periods;

iv) the target number is defined as the operator's goal and predicted level of performance at the end of a six-month period. Target numbers are set to specify the operator's desires and expectations for future system performance. The target number is established in the same manner as the alert number; the difference being that the alert number is the upper limit of the range and, when exceeded, indicates unsatisfactory performance. The target or the lower limit is set as a goal which represents a level that the operator believes is attainable;

v) each month a three-month running average for each system is calculated. First, a three month average is obtained by compiling and analysing data for three consecutive months – the total pilot reports for three months are divided by the number of aircraft hours flown during the same three-month period. To maintain a running average, each month the first month's data is deleted and the data for the current month added. Any system which either exceeds the alert or which has a trend indicating the target will not be met is considered to be in need of special attention.

7.4.8 Establishing alert values statistically (alert type)

7.4.8.1 Many programmes establish alert values by reviewing past performance and establishing the numerical value for the alert. Some operators prefer the statistical or mathematical approach. The development of alert values may be based on industry accepted statistical methods such as standard deviations, or the Poisson distribution. Some programmes use the average or base line method. The standard should be adjustable with reference to the operator's experience and should reflect seasonal and environmental considerations. The programme should include procedures for periodic review of, and either upward or downward adjustment of the standards as indicated. It should also include monitoring procedures for new aircraft until sufficient operating experience is available for computing performance standards. All methods, however, require a sufficient quantity of accurate data to be available for analysis.

***Note**. — Poisson distribution is a discrete probability distribution that expresses the probability of a number of events occurring in a fixed period of time if these events occur with a known average rate and independently of the time since the last event.*

7.4.8.2 In order to establish system alert values, an evaluation is made of the operational performance of each system to be controlled by the programme. The yardsticks covering failure performance are clearly defined in the programme. Using these definitions, the failure data for each system are extracted from pilot-reported malfunctions for at least a 12-month period. The "mean" and the "standard deviation" are then computed from those data and each system's alert value is established equal to the mean plus three standard deviations.

7.4.8.3 The current performance level of each system is computed on a monthly basis as a three-month cumulative performance rate. This rate is computed by multiplying the number of in-flight malfunctions for a three-month period by 1 000 and dividing by the total aircraft flight hours for the same period. Maintaining a

cumulative rate requires that the first month's data be deleted and the data for the current month are added to the sum of the previous two months. When a trend of deteriorating system performance is detected, or if a system is over the alert value, an active investigation is conducted to assess the causes of the change in system performance and to develop an active corrective programme, if required, to bring the system performance under control.

7.4.9 Establishing standards using other analysis (non-alert type)

Data that is compiled on a day to day basis of the maintenance programme may be effectively used as a basis for continuous performance analysis. Mechanical interruption summaries, flight log reviews, engine monitoring reports, incident reports, and engine & component analysis reports are some examples of the types of information suitable for this monitoring method. For this arrangement to be effective the quantity and range of information should be satisfactory enough to provide a basis for analysis equivalent to that of a statistical standards programme. The operator's organization should have the capability of evaluating the information and summarizing the data to arrive at a meaningful conclusion. Actuarial analysis should be periodically performed to ensure that current process classifications are correct.

7.4.10 Condition-monitored maintenance programmes

7.4.10.1 Other techniques are used which monitor the functional condition of systems or components without disturbing them in their installed environment. These programmes are based on the establishment of acceptable performance as base line data. Internal and external leakage, functional testing, and unit teardown analysis are the factors used to determine the base line. The results from these tests and analysis become a part of the aircraft's permanent record. The point to be established is that the tests and analysis accurately and conservatively identify discrepancies before operational reliability is degraded.

7.4.10.2 This type of programme lends itself readily to components. It has also proven very successful in monitoring the functional condition of aircraft systems such as hydraulics, air conditioning and pneumatics (the system primarily utilizing this type of programme is hydraulics). The various tests perform the function of system or subsystem interrogation to determine the presence or absence of component degradation. Internal leakage rates serve as the criteria to evaluate wear and rigging effect on component performance while pressures are used to determine certain component functional responses.

7.4.10.3 During the test, individual parts, components and subsystems are evaluated by selective positioning of the various system controls and isolation points. From the comparison of the response produced by sequential steps to the established tolerance, the general location or the specific location of the faulty unit can be determined.

7.4.10.4 Additional advantages include:

a) analysis of the data is not required before departure unless functional tests indicate a need for immediate corrective action;
b) results of the test do not require immediate replacements of units showing deterioration provided the functional tests of the subsystem or component are satisfactory; and
c) evaluation of these test data can be used to schedule component replacement at a subsequent inspection or check.

7.4.11 Monitoring by age/reliability relationship

7.4.11.1 Some operators may use an actuarial analysis technique as a basic requirement for making technical decisions concerning component reliability in their "on condition" overhaul and monitored maintenance reliability programmes. Components selected for these programmes are those on which a determination of continuing airworthiness may be made by visual inspection, measurements, tests or other means without a teardown inspection or periodic overhaul. Under these programmes, components are allowed to operate in service subject to meeting the established performance standard or the established "on-condition" base line data.

7.4.11.2 Initially, an actuarial analysis of each component is prepared to determine its reliability versus age characteristics. A component is considered acceptable for inclusion in the programme when the analysis shows that reliability does not deteriorate with increased time in service up to a predetermined point established by the operator. Normally, this cut-off point is considered to be the practical limit based on the amount of data collection and analysis required to qualify the component.

7.4.11.3 When the reliability of a component deteriorates to a value above the established performance standard, another actuarial analysis is made to determine the component's reliability versus age characteristics. Normally, this analysis will also include a determination of the reasons for the deterioration and the corrective

action required to bring the condition under control. This reliability analysis is a continuing process and reveals whether a component requires a different maintenance programme or is in need of a design change to improve reliability.

7.4.11.4 An actuarial analysis is also made when the observed performance of a component improves to the point where more components are reaching higher operating times without experiencing premature removal failures. With such an improvement in survival characteristics possible, it is desirable to make a reliability analysis to determine its age-to-reliability characteristics.

7.4.11.5 Premature removal rate and the subsequent analysis of the teardown findings in the shop are monitored. The introduction of the "on-condition" overhaul concept has made it increasingly important to gain more information about the operating performance of the components and to examine the relationship of this performance to the time in service. This need has fostered the development of actuarial analysis techniques.

7.4.11.6 This method of analysis requires, for a specified calendar period, that the following information be available for each component under study:

a) the time on each operating component at the beginning of the study;
b) the time on each component removed and installed during this period;
c) the reason for removal and disposition of each component; and
d) the time on each operating component at the end of the study period.

7.4.11.7 An analysis is made of the performance of each component as its life progresses from one overhaul to another as follows:

a) a time and failure distribution chart is prepared showing the amount of operating time for each component and the failures experienced in each 100-hour time bracket for the specified study period. In conjunction with this chart, a digest of the causes of failure for each 100-hour time bracket is also prepared;
b) the next step is to develop failure rate and survival curves versus time since overhaul (TSO). A failure rate curve shows the failure rate per 1 000 hours for each component in each 100-hour time bracket. A survival curve shows the number of units remaining at any given time. The shape of the survival and failure rate curves are valuable when determining the deterioration of reliability. The operating time which can curve will show the probability of a component reaching a given time and the number of components expected to fail in a given time bracket.
c) the number of components that would probably fail in a given time bracket is obtained by taking the difference of the ordinates at the beginning and end of a given time bracket. This would also be a reflection of the slope of the survival curve at that point. The percentage of components which survive to a given time is also the probability of a single component operating to that time without failing; and
d) a still better evaluation is possible by developing a conditional probability curve. This curve will show the probability of failure of a component within a given time interval. Data for a conditional probability is obtained by dividing the number (or percentage) of components entering an interval by the number (or percentage) of components removed during an interval. It is considered that this curve best depicts the relationship between reliability and overhaul time.

7.4.11.8 Some advantages of this type of analysis are as follows:

a) a determination can be made as to whether failures are being prevented by the specification;
b) an indication is given statistically concerning the current limit and whether or not it has reached an optimum point;
c) an indication is provided as to what might occur to the overall premature removal rate if the limit were changed;
d) an indication will be provided of any unusual high rate of premature removals and/or failures that have occurred immediately after a check and repair or overhaul;
e) in some cases, an indication may be given that scheduled interim maintenance would result in an improvement of the overall premature rate;
f) other useful conclusions can be made concerning the relationship of the failure to the time in service, time intervals and engineering change accomplishment; and
g) this technique of in-service component reliability analysis readily lends itself to computer programming.

These advantages emphasize the value of such an analysis in determining a maintenance programme that is best for the component involved.

7.4.12 Control for adjusting time limitations

7.4.12.1 An operator may receive authorization from the CAA in its reliability programme to adjust time limitations without prior approval. Another operator's reliability programmes may require prior notification and

approval from the CAA before escalating time limitations for overhauls, inspection intervals and checks. Reliability programmes are unique to each operator and based on the operating environment and history of the operator. When considering the merits of a time extension, there are many different methods which may be used. The programme should identify these methods and the group responsible for the preparation of a substantiation report to justify the requested time extension. The programme should show that such action is approved by at least two separate organizational segments of the operator, one of which exercises inspection or quality control responsibility for the operator and the other organizational segment responsible for the performance of the function. When evaluating a particular programme, consideration should be given to the following:

a) are the specific parameters used to determine time extensions spelt out (i.e. sampling, functional checks and unscheduled removal)?;
b) if sampling is used, does it explain the method, number of samples required, when they will be taken, and at what time interval? Time on units or exhibits used as samples should be specified;
c) does the programme provide for time increase in overhaul times, periodic services, routine and service checks, phase checks and block overhauls?;
d) are provisions made for changing items having specified fixed time between overhaul to "on-condition"? If so, what are they, e.g. sampling, actuarial studies, unit performance, maintenance findings and pilot reports;
e) what substantiating data are provided to justify a time increase for emergency equipment which is not normally operated during routine flight?;
f) who establishes the increments of time increases, the sampling requirements, and other substantiation for each proposed action?;
g) are instructions available relative to manual revision concerning time increases and what will have to be accomplished prior to pursuing a subsequent time increase?; and

7.4.12.2 It should be ensured that the proposed time between overhauls (TBO) adjustment does not conflict with a corrective action programme established by a previous reliability analysis. A provision in the reliability programme should be made for CAA to be advised when increases of time limitations of system and/or components controlled by the programme occur. Operators should be encouraged where possible to include a graphic display of major system and/or component (engine/airframe) TBO escalation. Reliability programmes provide an operator with a method of adjusting maintenance, inspection and overhaul intervals without prior CAA approval. However, CAA's may require prior notification and approval before the operator may increase intervals for overhauls and inspections. It is important the operator strictly adhere to the approved reliability programme authorizations.

7.4.13 Interval adjustments and changes

The reliability programme should not allow for maintenance interval adjustment of any CMR items and ALIs. CMR items and ALI are part of the certification process and should not be escalated through the operator's reliability programme. The operator should not use its reliability programme as a basis for adjusting the repeat interval for its corrosion prevention and control programme. However, the operator may use the reliability programme for recording data for later submission to the CAA to substantiate subsequent repeat interval changes. Further, maintenance interval adjustments should not interfere with an on-going corrective action. The reliability programme should include procedures for the classification and assignment of maintenance processes and/or tasks and changing from one process and/or task to another. It may be necessary to contact with the aircraft manufacturer in order to reference the relevant MSG-2 methodology used for maintenance processes or MSG-3 methodology used for maintenance tasks. The programme should also include the authority and procedures for changing maintenance specifications and the related documents used to reflect changes to interval adjustments, processes and/or tasks.

7.4.14 Approval of programmes

7.4.14.1 As part of the maintenance programme approval process the operator should submit a reliability programme description that supports the effectiveness of the maintenance programme. The programme should be administered and controlled by the operators and monitored by the AID inspector. The document should contain the essentials of the systems operation and any other instructions required of the particular programme or character of maintenance organization involved.

7.4.14.2 The operator should submit the reliability programme and appropriate information to the CAA for evaluation and approval. The AID inspector should use all the information necessary in evaluating the reliability programme. Operator personnel should be available to answer questions or provide additional information concerning the reliability programme.

7.4.14.3 The procedures for implementing revisions to the programme should be described in sufficient detail to identify the isolated areas which require CAA approval. The operator should also identify the segment of the organization having overall responsibility for the approval of amendments to the programme. The areas involving reliability programme revision which require CAA approvals may include:

a) reliability measurement;
b) changes involving performance standards, including instructions relating to the development of these standards;
c) data collection;
d) data analysis methods and application to the total maintenance programme;
e) process or task changes:
i) for statistical alert type programmes, procedures for transferring components or systems from one primary maintenance process to another; and
ii) for non-alert type programmes, changing systems or components from one primary maintenance process to another;
f) procedures for adding or deleting systems, or components;
g) adding or deleting aircraft types;
h) procedural and organization changes affecting administration of the programme; and
i) procedures for transferring systems or components to other programmes.

7.4.14.4 When evaluating programme revision procedures, consideration should also be given to the following:

a) does the programme provide for periodic review to determine if the established performance standard is still realistic or in need of recalculation?;
b) what is the distribution circulation given to approved revisions?; and
c) are the overhaul and inspection periods, work content and rescheduled maintenance activities controlled by reliability methods reflected in the appropriate maintenance manuals?

7.4.14.5 Reliability programme evaluation and approval is one of the most complex duties an AID inspector will perform. Special attention should be given to every aspect of the proposed programme submitted by the operator. Previous experience with the type of equipment the operator proposes to include in the reliability programme is recommended. In States where adequate technical resources are not available the CAA may consider obtaining technical assistance from regional CAA's possessing experience in these areas, or the CAA of the State of Manufacture or State of Design.

7.4.14.6 All conclusions reached by the CAA should be addressed in writing to the operator with a copy kept in the CAA office operators file. Revisions to the reliability programme requiring formal CAA approval should be subject to the same consideration as initial approval.

7.5 Structural integrity programme

7.5.1 Annex 6, Part I, 11.3.1 b) and Part III, Section II, 9.3.1 b) requires the maintenance programme to contain, when applicable, a continuing structural integrity programme. Annex 8, Part II, 4.2 provides that the State of Design of an aircraft ensures that, in respect of aeroplanes over 5 700kg MTOM, a continuing structural integrity programme exists to ensure the airworthiness of the aeroplane. The programme should include specific information concerning corrosion prevention and control.

7.5.2. Service experience has indicated a need to have knowledge concerning the structural integrity of aircraft especially as they became older. Structural integrity is a concern to manufacturers and operators as fatigue cracking and corrosion are cycle and calendar time dependent respectively and knowledge concerning them can best be assessed on the basis of real time service experience. Increased operational demand, longer service life and strict safety standards indicated the need for a programme to ensure a high level of structural integrity. Structural integrity programme (SIP) development should be initiated by the type design organization and developed jointly with representatives of air operators and airworthiness authorities and approved by the State of Design of the aircraft

7.5.3 If the State of the Operator is not the State of Registry, it is recommended to contact the State of Registry to determine if SIP is applicable for the aircraft it operates. Contact with the manufacturer of the aircraft is also recommended to obtain information and advice on structural integrity programmes for the aircraft being operated.

7.5.4 A SIP should include:

a) an approved damage-tolerance based inspections and procedures for the aircraft structure susceptible to fatigue cracking that could contribute to a catastrophic failure. The purpose of the inspection programme

is to supplement the current inspection programme as necessary to ensure the safe operation of the aircraft type;

b) a corrosion prevention control programme with the objective of controlling corrosion in the aircraft's primary structure. The corrosion prevention control programme should include periodic inspections to detect and define levels of corrosion. Treatment of the corrosion is critical and limits the material loss and assists in maintaining the airworthiness of the aircraft;

c) maintenance programme procedures which addresses the adverse effects of fatigue cracking on critical structure and may include repetitive inspections of these areas to ensure structural integrity. The programme may also include modifications or replacement actions in areas where there is a known history or hazard of fatigue cracking. The modifications or replacement action may reduce or eliminate the need for repetitive inspections to maintain structural integrity. The type design organization may have issued SBs that contain terminating modifications to inspections and contact with the design organization is recommended;

d) a repair assessment programme to evaluate aircraft repairs. The programme ensures that existing repairs do not deteriorate due to accidental, fatigue or environmental damage beyond the remaining usage life of the aircraft. In order to establish the scope of the repair assessment programme contact with the type design organization of the aircraft may be necessary to determine if the aircraft was evaluated for damage tolerance during initial certification.

e) provisions for preventing widespread fatigue damage (WFD). Multiple site damage and multiple element cracks are typically too small initially to be reliably detected with normal inspection methods. Without intervention, these cracks can grow, link up and eventually compromise the structural integrity of the airplane, in a condition known as WFD. WFD is increasingly likely as the airplane ages, and is certain if the airplane is operated long enough without any intervention

7.5.5 The role of the State of Registry in the implementation of the SIP:

a) develop or adopt requirements to ensure the continuing airworthiness of the aircraft during its service life;

b) upon receipt of MCAI from the State of Design, adopt the mandatory information directly or assess the information received and take appropriate action; and

c) approve the structural integrity provisions contained in the maintenance programme.

7.5.6 The SIP developed and updated by the organization responsible for the type design under the responsibility of the State of Design (refer to Part V of this manual) is one important element of continuing airworthiness and it will include many specific items that are intended to be made mandatory. The programme should include damage tolerance based supplemental inspections, corrosion prevention and control, structural modifications and associated inspections, repair assessment; and WFD assessment as described in 7.5.4 above.

7.5.7 The State of Registry, in approving a maintenance programme, should therefore:

a) review and assess the latest SIP and all related continuing airworthiness information and, if appropriate, adopt the requirements in national regulations. All requirements made mandatory by the State of Design should also be assessed and made mandatory for all applicable aircraft on the State's Registry unless local operating conditions or operator experience provide a strong basis for deviation;

b) ensure that all the requirements of the SIP have been incorporated in the operator's maintenance programme before it is approved. It should be recognized that each operator should make an individual determination as to how the data that are in the continuing structural integrity programme should be incorporated in the maintenance programme owing to the differences in the various operators' maintenance programmes, operating environment and fleet modification status;

c) ensure that the air operator's maintenance programme procedures provide an adequate system for recording and reporting in a timely way to the type design organization (and to the State of Registry), the operational usage, the structural discrepancies experienced in service (including fatigue, wear, corrosion, accidental damage) and, where available, the results of initial analysis. These data should include a description and the location of the damage, identification of the aircraft, relevant data on its modification status and operating history, time since beginning operations, time since the last maintenance check, the means by which the discrepancy was detected and its probable cause. The operator's existing record keeping requirements still apply e.g. aircraft inspection status, and reports of major repairs and modifications, if applicable. A separate report to the State of Registry may be necessary should structural discrepancies that exceed repairable limits established by the type design organization are noted;

d) ensure that the air operator's MCM contains procedures for review of all recommended or mandatory changes to the SIP and will result in timely revision of the maintenance programme to include these changes;

e) ensure that the items in the SIP are accomplished on each aircraft for which it has issued a certificate of airworthiness within the time limits specified;
f) ensure that for each aircraft for which it has issued a certificate of airworthiness, the operator has good access to the records of all damage and repairs and modifications performed during the lifetime of the aircraft and has incorporated into the maintenance programme any specific structural inspections or life limits issued when the repair or modification was approved or when the damage was assessed; and
g) if the structural integrity programme issued by the organization responsible for the type design has a limit of validity (LoV) specified for the maintenance programme, the State of Registry should ensure that there is a system in the maintenance programme to identify when this validity limit is approaching and to stop flying if the limit is reached. The certificate of airworthiness is not valid beyond this LoV unless SIPs have been reviewed and that the results justify an extension of the maintenance programme.

7.6 Mass and balance programme

7.6.1 General

7.6.1.1 Annex 6, Part I, Chapter 5 for and Part III, Section 2, Chapter 3 requires that aeroplanes /helicopters be operated in accordance with a comprehensive and detailed code of performance in compliance with the applicable standards including mass limitations and center of gravity limitations as specified in the aircraft flight manual. To satisfy this requirement, operators are required to develop and maintain a mass and balance programme.

7.6.1.2 The primary purpose of aircraft mass and balance control is safety. A secondary purpose is to achieve the utmost in efficiency during operation of the aircraft. Improper loading reduces the efficiency of operating an aircraft and can be the cause of a failure to start or complete a flight. The empty mass and corresponding center of gravity of all civil aircraft is determined at the time of initial certification. The condition of the aircraft at the time of determining empty mass and center of gravity should be one that is well defined and can be easily repeated.

7.6.1.3 The mass and center of gravity of aircraft should be determined prior to the initial issuance of the Certificate of Airworthiness. In certain cases an updated determination of mass and center of gravity may not be required prior to the issuance of a Certificate of Airworthiness such as newly manufactured aircraft where the determination of mass and center of gravity has been previously determined by the manufacturer and recorded.
Another example where an aircraft may not require re-weighing pending issuance of a Certificate of Airworthiness is the importation of an aircraft where the aircraft has been previously weighed prior to importation with any changes to mass computed and recorded in the mass and balance report. Mass and balance control provides mathematical proof that the aircraft's mass and balance is within limits. Mass and balance information can be obtained from the aircraft specifications, aircraft operation limitations, aircraft flight manual and mass and balance report. The removal or addition of equipment affects the aircraft's empty mass and center of gravity limits and mass calculations are necessary to ensure the changes are within the aircraft's mass and balance limits.

7.6.1.4 The applicant for the issuance or renewal of certificate of airworthiness should be required to provide the current mass and balance report of the aircraft to the State of Registry. The mass and balance report is normally obtained by weighing. If the changes in mass and balance are negligible, computed and recorded, the accurate mass may continue to be obtained by calculation from the previous aircraft weighing. A sample of a mass and balance report is referenced in Attachment A to this chapter. Mass and balance records should be complete, current and maintain a continuous record of changes of empty mass, arm and empty center of gravity limits for each aircraft. The mass and balance record should contain details of all modifications affecting either the mass or balance of the aircraft.

7.6.2 Periodic determination of mass

7.6.2.1 Over period of time and use an aircraft will have a tendency to gain mass because of the accumulation of dirt, grease, and oil in areas of the aircraft not readily accessible for washing and cleaning. Other reasons include the repainting of aircraft, installation of new equipment and accomplishment of modifications and repairs. The mass gained in any given period of time will depend on the function of the aircraft, its hours in flight, atmospheric conditions, the type landing fields the aircraft operates from and their operating environment. For this reason, periodic aircraft weighing is desirable and usually required by their national regulations for operators. Operators are subject to standards that require their aircraft to be properly loaded and not to exceed the mass and balance limitations during operations. Therefore, operators normally require mass and balance instructions and periodic determinations of mass and balance to ensure safe and efficient operations. The aircraft should be re-weighed at periods determined by the CAA or as stipulated in the national regulations.

Reweighing of the aircraft is dependent on several factors, the date of last weighing, history of the aircraft or embodiment of modifications. Consultation with the CAA is recommended if clarification is needed on reweighing based on the history of the aircraft or incorporation of modifications

7.6.2.2 The common changes that occur during life of the aircraft are caused by repairs and modifications. The air operator is responsible to ensure the mass and balance records are updated whenever a change occurs to the aircraft mass and balance.

7.6.2.3 Further to the provisions above if the CAA or the operator is of the opinion that adequate mass control has not been exercised over an aircraft during the modification, the CAA may require that a new empty mass and empty center of gravity position should be determined for the aircraft.

7.6.2.4 For a fleet of the same model and configuration, an average operational fleet mass may be utilized if the operating mass and center of gravity (CG) position are within established limits acceptable to the CAA.

7.6.2.5 The following fleet weighing method is one of the means to establish an operator's fleet empty mass and CG. The operator should consult with the relevant CAA before establishing how many aircraft should be weighed in each weighing cycle. An air operator's fleet empty mass may be determined by weighting aircraft according to the following criteria:

a) for aircraft fleets of one to three aircraft, weigh all aircraft;
b) for fleets of four to nine aircraft, weigh three aircraft plus at least 50 per cent of the number of aircraft greater than three; and
c) For fleets of more than nine aircraft, weigh six aircraft plus at least 10 per cent of the number of aircraft greater than nine.

The aircraft in the fleet having the highest time since last weighing should be selected. Thereafter a rotation programme should be incorporated to ensure all aircraft in the fleet will be weighed periodically. Reestablishment of the air operator's empty fleet mass or operating fleet mass and CG may be accomplished by calculation based on the current empty mass and CG or weighing of aircraft at periodic intervals as approved by the CAA or established in the national regulations.

7.6.3 Procedures for determining mass

7.6.3.1 Aircraft mass determination should be performed by a person authorized to perform mass and balance calculations on behalf of the air operator or aircraft owner. Aircraft should be prepared for mass determination in accordance with manufacturer's instructions.

7.6.3.2 Two independent determinations should be made and the aircraft longitudinal datum line should be horizontal. The load should be completely removed from the weighing equipment between determinations. The aircraft gross masses as determined by the two measurements should be consistent. If not, the measurements should be repeated until the gross masses, as determined by two consecutive and independent measurements are consistent.

7.6.3.3 Prior to the initial issue of a Certificate of Airworthiness for each aircraft, a list of equipment included in the empty mass should be established. If an operating mass is used, a similar list of removable equipment and disposable load included in the operating mass should also be established. Where a change occurs in the items included in either the empty mass or, if applicable, the operating mass of an aircraft, the appropriate list should be amended by the operator.

7.6.3.4 Normal precautions, consistent with good practices in the mass determination procedures, should be taken, such as:

a) aircraft and equipment should be checked for completeness in accordance with 7.6.3.3 above;
b) fluids should be properly accounted for;
c) mass determination should be carried out in an closed building, to avoid the effect of wind; and
d) the scales used should be properly calibrated and used in accordance with the manufacturer's instructions.

7.6.3.5 An aircraft mass and balance report should be completed and certified by the person signing the report. Data recorded should be sufficient to enable the empty mass and empty mass center of gravity position to be accurately determined.

7.6.3.6 The empty mass and empty center of gravity position should be determined by the person determined in 7.6.3.1 or operator of the aircraft in accordance with the recorded results of the measurements.

7.6.4 Loading data

7.6.4.1 The loading schedule should be kept with the aircraft, forming a part of the aircraft flight manual.

It should include instructions on the proper load distribution such as filling of fuel tanks and oil tanks, passenger movement and distribution of cargo. A check should be made to determine if the schedule will allow computation of separate loading conditions when the aircraft is to be loaded in other than the specified conditions shown in the loading schedule.

7.6.4.2 Information on how to base records of mass and balance changes to the aircraft may be obtained from the pertinent aircraft specifications, aircraft flight manual and the aircraft mass and balance report. Operators should maintain records of all known mass and center of gravity changes which occur after the aircraft mass has been determined.

7.6.4.3 A mass and center of gravity schedule should be provided for each aircraft. Each schedule should be identified by the aircraft designation, nationality and registration marks. The date of issue of the schedule should be given and the schedule should be signed by an approved representative of the organization or a person suitably qualified or acceptable to the CAA. A statement should be included indicating that the schedule supersedes all earlier issues.

7.6.5 Preparation and approval of loading data

The loading data should be prepared by the air operator and acceptable to the CAA. Where the applicable aircraft flight manual pages are used as the load data sheet and to specify any required loading system, the completed pages should be also submitted to the CAA for approval and incorporation into the aircraft flight manual. The air operator is responsible for preparation of a load data sheet for each aircraft based on the empty mass and empty CG position. Unless otherwise approved by the CAA, the aircraft flight manual page titled "aircraft mass" should be used as the load data sheet in the case of aeroplanes of MTOM not greater than 5700kg. The air operator should be responsible for the preparation of a loading system for each aircraft based on the empty mass and empty CG position unless it can be shown that the aircraft cannot be loaded so that its CG falls outside the approved range.

7.6.6 Record of mass and balance

The mass and balance record system should include procedures that allow the air operator to update and maintain a current and continuous record of the mass and CG of the aircraft they operate. The records should reflect changes in mass and balance and list all modifications affecting the mass or balance of the aircraft. Revised empty mass and C.G. changes should be identified by the date, aircraft make, model and serial number. The revised mass and balance information should be signed by a qualified person. Where mass and balance programme information is generated by a computerized mass and balance control system, the operator should verify the accuracy of the output data. The operator should also ensure that amendments to the input data are validated and incorporated properly into the system. The operator should ensure the overall system is operating properly and the software updates are current. Some large aeroplanes have on-board mass weighing systems. When the aeroplane is on the ground the on-board mass system provides the flight crew with a continuous indication of the aircraft total mass and the location of the CG in per cent of the Mean Aerodynamic Chord (MAC). The operator should seek the approval from the CAA if he wishes to use an on-board mass and balance computerized system as a primary source for dispatch.

7.7 Maintenance arrangement

7.7.1 Maintenance organization

7.7.1.1 Annex 6, Part I, 8.1.2 and Part III, Section II, 6.1.2, provide that an operator should not operate an aircraft unless it is maintained and released to service by an organization approved in accordance with Annex 6, Part I, 8.7 or under an equivalent system, either of which should be acceptable to the State of Registry.

7.7.1.2 When the maintenance is not performed by an AMO, the State regulation has to identify and prescribe the requirements for the approvals of these organizations that will be considered an equivalent system.

7.7.1.3 Annex 6, Part I, 11.2 and Part III, 9.2, provides that the air operator's MCM includes a description of the administrative arrangements between the air operator and the AMO.

7.7.1.4 The maintenance organization should be approved by the State of Registry. The requirements and procedures for the approval of an AMO are found in Part III, Chapter 10 of this manual.

7.7.2 Guidance on contractual arrangements for maintenance

7.7.2.1 In accepting an operator contracted maintenance arrangement, the CAA should ensure that the following minimum requirements are satisfied:

a) the operator, subject to contractual maintenance arrangements will ensure each aircraft it operates is maintained in an airworthy condition;

b) the AMO contracted to perform the maintenance should have access to the operator's currently approved maintenance programme that includes the make and model of the aircraft subject to the contract and the operator's MCM;
c) an AMO performing maintenance for an operator under the terms of its organization certification should be appropriately rated and capable of performing the work contracted for, and that work should be performed in accordance with the air operator's approved MCM;
d) the AMO should have the facilities and capabilities to perform the work for which it has been contracted;
e) when an air operator contracts with an appropriately rated AMO, the air operator should have available the names of these organizations and the scope of the work contracted;
f) the contractor's manual may be used in part or in total for methods, techniques and standards provided the air operator's MCM describes the applicability and authority of the affected manuals. The same applies to work forms;
g) the air operator's MCM should also describe the policies and procedures for the evaluation and the air operator's approval of contractual arrangements;
h) a procedure for maintaining maintenance records and for transmitting related information regarding continuing airworthiness should be established.
i) The arrangements should clearly describe the operator's and AMO's responsibilities regarding the control, planning and scheduling of the maintenance tasks to be performed.

7.8 Maintenance records

7.8.1 Introduction

7.8.1.1 Annex 6, Part I, 8.2 and 11.2 and Part III, 6.2 and 9.2 provide that the State of Registry be responsible for the acceptance of the air operator's MCM. The MCM should, amongst others, include the policies and procedures relating to maintenance records. This paragraph covers the requirements for a maintenance records system. The State of Registry should verify that all these requirements are satisfied by the procedures in the air operator's MCM.

7.8.1.2 Annex 6, Part I, 8.4.1 and Part III, Section II, 6.4.1 require that an operator should ensure that the following records are kept:

a) the total time in service (hours, calendar time and cycles, as appropriate) of the aeroplane and all life-limited components;
b) the current status of compliance with all mandatory continuing airworthiness information;
c) appropriate details of modifications and repairs;
d) the time in service (hours, calendar time and cycles, as appropriate) since the last overhaul of the aeroplane or its components subject to a mandatory overhaul life;
e) the current status of the aeroplane's compliance with the maintenance programme; and
f) the detailed maintenance records to show that all requirements for the signing of a maintenance release have been met.

7.8.1.3 Annex 6, Part I, 8.4.2 and Part III, Section II, 6.4.2 provide that the records of 7.8.1.2 a) to e) above be kept for a minimum period of 90 days after the unit to which they refer has been permanently withdrawn from service, and the records of 7.8.1.2 f) above for a minimum period of one year after the signing of the maintenance release.

7.8.1.4 Annex 6, Part I, 8.4.3 and Part III, Section II, 6.4.3 provide that in the event of a temporary change of operator, the records be made available to the new operator. In the event of any permanent change of operator the records should be transferred to the new operator.

7.8.2 General

7.8.2.1 Maintenance records should give an overall picture of the maintenance status of the aircraft.

7.8.2.2 Operators should ensure that complete records associated with maintenance release by AMO are received so that the required records can be retained. In all cases, an AMO should record details of all work carried out.

7.8.2.3 When acceptable by the CAA, operators may arrange for a maintenance organization to retain maintenance records on their behalf. Operators are responsible for the transfer, preservation, and availability of the records. Operators should ensure the AMO maintains the records in compliance with the MCM and ensures the maintenance records are returned to the air operator upon their request. The CAA must have access to any maintenance records, whether kept by an air operator or an AMO.

7.8.2.4 The air operator is responsible to ensure a detailed description on maintenance record keeping is included in the MCM. The AMO is responsible to ensure a description on the completion of maintenance records

is included in the maintenance organization procedures manual to show that the requirements for the issuance of a maintenance release have been met.

7.8.3 Contents of records

7.8.3.1 Maintenance records are important documents that show if the aircraft is being maintained properly. The records should clearly indicate the status of applicable mandatory continuing airworthiness instructions, or if the aircraft is current with its maintenance programme requirements. Maintenance records can show if the aircraft has received all their required overhauls or any component have reached life limits. A thorough review of the maintenance records will help to determine if the aircraft's certificate of airworthiness is valid.

7.8.3.2 Maintenance personnel should make entries in the maintenance records to indicate a description of the work performed including a reference of the approved data used. The maintenance record entries should provide enough information to demonstrate that compliance to the airworthiness requirements has been met. A maintenance release should be completed and signed to certify that the maintenance work performed has been completed satisfactorily and in accordance with approved data.

7.8.3.3 The operator and AMO should develop detailed procedures in their manuals that address the form, content and information criteria necessary for completion and retention of the maintenance records.

7.8.3.4 When entering information in the maintenance record it is often necessary to include the following, as applicable:

a) the date;
b) the identification of the aircraft, or component to include make, model and where applicable registration and serial number;
c) the aircraft or component time since new (TSN), time since overhaul (TSO) and if applicable, cycles since new and cycles since overhaul;
d) the same information in d) is required for life-limited components, where applicable;
e) complete details of the work performed; and
f) the maintenance release, together with the name and identification (license or authorization number) of the certifying personnel.

7.8.3.5 Maintenance records and maintenance release record entries should contain a description of the work performed in enough detail to show that the requirements for the issuance of a maintenance release have been met. Annex 6, Part I, Chapter 8 and Annex 6, Part III, Section II Chapter 6 require that the following records be kept:

a) maintenance records:
    i) the total time in service (hours, calendar time, and cycles, as appropriate) of the aircraft and all life-limited components;
    ii) current status of compliance with all MCAI;
    iii) appropriate details of modifications and repairs;
    iv) the time in service (hours, calendar time and cycles, as appropriate) since the last overhaul of the aircraft and its component subject to a mandatory overhaul life;
    v) current status of aircraft's compliance with the maintenance programme; and
    vi) detailed maintenance records to show all requirements for signing a maintenance release have been met.
b) maintenance release:
    i) basic details of the work carried out including detailed reference of the approved data used;
    ii) date such maintenance was completed;
    iii) when applicable, the identity of the AMO; and
    iv) the identity of the person or persons signing the release.

7.8.3.6 Appropriately certificated persons in accordance with Annex 1 should accomplish the requirements contained in MCAI and is required to record compliance in the maintenance record. The air operator should ensure that maintenance personnel make appropriate entries in the maintenance records.

7.8.3.7 The maintenance records showing compliance with MCAI should include:

a) MCAI information (number and title), including revision or amendment numbers;
b) where the MCAI is generally applicable to the aircraft or component type but is not applicable to the particular aircraft or component being maintained, this should be identified in the maintenance record accordingly with an authorized signature;
c) the date when MCAI was accomplished;

d) for a multi-part instruction, which parts have been accomplished. If the entire MCAI was accomplished reference the entire instruction by title;
e) the method of accomplishment of the instruction together with the inspection result should be accurately described;
f) if the MCAI requires recurring action, the next recurring action interval should be indicated; and
g) certification by licensed personnel, in accordance with Annex 1, for the accomplishment of the MCAI.

7.8.3.8 Appropriate details of modifications and repairs should include records identifying any modification or repair, along with a reference to the approved data used and a description of the work performed with maintenance release information. Major modification and major repairs should be recorded in a form and manner as prescribed by the CAA.

7.8.3.9 Records about aircraft or component inspection status found during inspections should include information about defects or un-airworthy conditions, details of faults and any subsequent rectification, the total time in service as appropriate and the state of maintenance when it enters the AMO's facilities.

7.8.3.10 When operators wish to take advantage of modular design (e.g. modular assembled gas turbines where a specification of a true total time in service is not relevant), the total time in service and maintenance records for each module are to be maintained. The maintenance records as specified are to be kept with the module and should show compliance with any mandatory requirements pertaining to that module.

7.8.4 Record-keeping

7.8.4.1 The maintenance records required in Annex 6 should be kept in a form and manner acceptable to the State of Registry and the State of the Operator.

7.8.4.2 If a paper system is applied, legible entry should be made and the record should remain legible throughout the required retention period, irrespective of the medium.

7.8.4.3 If a computer system is used, it should have at least one back-up system. Each terminal should contain programme safeguards against unauthorized alteration of the database and should also have traceability features (e.g. requiring the use of a magnetic or optical card in conjunction with a personal identity number (PIN) known only to the individual concerned).

7.8.4.4 If optical or other high-density storage of maintenance records is used, the records should be as legible as the original record and remain so over the required retention period.

7.8.4.5 Maintenance records should be kept in such a way that they are protected from hazards such as fire, flood, theft or alteration. Computer backup disks, tapes and other storage mediums should be safely stored in a different location.

7.8.4.6 Records should be structured or stored in such a way as to facilitate auditing.

7.9 Maintenance release

7.9.1 General

7.9.1.1 Annex 6 provides that a maintenance release should be completed and signed to certify that the maintenance work performed has been completed satisfactorily. This should be done in accordance with the approved data and the procedures described in the maintenance organization's procedures manual or under an equivalent system.

7.9.1.2 It also provides that the MCM include a description of the procedures for preparing the maintenance release and the circumstances under which the release is to be signed.

7.9.2 Requirements of Maintenance Release

A maintenance release is a certification which includes:

a) details of the maintenance carried out including detailed reference of the approved data used. Where appropriate, a statement that all items required to be inspected was inspected by a qualified person who determined that the work was satisfactorily completed;
b) the date such maintenance was completed and the total flight hours and cycles;
c) when applicable, the identity of the AMO; and
d) the identity and authorization of the person signing the release.

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