Part 1 Airworthiness Procedures

Leaflet 1-1 Approval of Organisations

1 Introduction

Any design, production or maintenance organisation seeking an approval in order to satisfy regulatory requirements should in the first instance make contact with the appropriate address given below. Advice will be provided as to the method of application and fees required.

Design or Production

Approvals and Quality Assurance Section
1E Aviation House
Gatwick Airport South
West Sussex
RH6 0YR

Email: aqas@srg.caa.co.uk
Tel. +44 (0)1293 573151

Maintenance

Applications and Approvals Section
1E Aviation House
Gatwick Airport South
West Sussex
RH6 0YR

Email: aanda@srg.caa.co.uk

CAA Approved Organisations (CAP 475)

CAP 475 is now freely available on the CAA web site at www.caa.co.uk/publications where you may use the free subscription service to register for e-mail notification of future amendments. Paper copies will no longer be supplied free of charge but may be purchased from the CAA's publishers, whose details are given on the inside cover of this publication.

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Leaflet 1-2 Legislation and Requirements

This leaflet has been completely revised and should be read in its entirety.

1 Introduction

The purpose of this Leaflet is to provide guidance and advice on the legislation and requirements applying to the airworthiness of civil aircraft, particularly where these matters affect Licensed Aircraft Maintenance Engineers and Approved Maintenance Organisations. The current situation has changed with the establishment of the European Aviation Safety Agency (EASA) and the introduction of European Regulations. The following table summarizes the UK National System and the new European systems.

	United Kingdom	European Community
Legislation. Create and empower	UK Parliament Civil Aviation Act Civil Aviation Authority	**European Parliament** Council Regulation 1592/2002 European Aviation Safety Agency Annex I Essential Requirement Annex II Excluded Aircraft Council Regulation 1643/2003 Council Regulation 1701/2003
Requirements. Binding by law	UK Parliament Air Navigation Order	**European Commission** Commission Regulation 1702/2003 Part 21 Commission Regulation 2042/2003 Annex I Part M Annex II Part 145 Annex III Part 66 Annex IV Part 147
Acceptable Means of Compliance and guidance material. Not binding by law	British Civil Airworthiness Requirements	**European Aviation Safety Agency (EASA)** Certification Specification CS 23, CS 25, CS 27, AMC, GM, etc.

2 The International Civil Aviation Organisation

2.1 As a result of the International Civil Aviation Conference which took place in Chicago in 1944, the International Civil Aviation Organisation (ICAO) was set up in Montreal Canada, on 4 April 1947 by the international contracting states of which the United Kingdom was, and remains, a participating member.

2.2 One of the primary objectives of the Chicago Convention was to promote and develop the principles and techniques of international air navigation and air transport technical standards and recommended practices.

3 Civil Aviation Act 1982

3.1 The Civil Aviation Act 1982, which consolidated many earlier enactments, is now the principal Act of Parliament which regulates civil aviation activities in the United Kingdom.

3.2 Section 3 of the Act specifies the functions of the CAA, which include:

a) those functions conferred on it (by the Civil Aviation Act) with respect to:

i) the licensing of air transport;

ii) the licensing of the provision of accommodation in aircraft;

iii) the provision of air navigation services;

iv) the operation of aerodromes and the provision of assistance and information.

b) those functions conferred on it by, or under, the Air Navigation Order with respect to:

i) the registration of aircraft;

ii) the safety of air navigation and aircraft (including airworthiness);

iii) the control of air traffic;

iv) the certification of operators of aircraft;

v) the licensing of air crews and aerodromes.

3.3 To give effect to UK membership of ICAO, Section 60(2) of the Act states that:

'An Air Navigation Order may contain such provision as appears to Her Majesty in Council to be requisite or expedient:

a) for carrying out the Chicago Convention, any Annex thereto relating to international standards and recommended practices (being an Annex adopted in accordance with the Convention) and any amendment of the Convention or any such Annex made in accordance with the Convention; or

b) generally for regulating air navigation.'

4 The Air Navigation Order 2005

4.1 The ANO is the principal Statutory Instrument regulating air navigation. The ANO Section 1 comprises Parts (which are further divided into Articles) and 15 Schedules:

PART 1	Registration and Marking of Aircraft
PART 2	Air Operators' Certificates
PART 3	Airworthiness and Equipment of Aircraft
PART 4	Aircraft Crew and Licensing
PART 5	Operation of Aircraft
PART 6	Fatigue of Crew and Protection of Crew from Cosmic Radiation
PART 7	Documents and Records
PART 8	Movement of Aircraft
PART 9	Air Traffic Services
PART 10	Licensing of Air Traffic Controllers

	PART B	Records Required in Accordance with Article 125(4)(c)
	PART C	Matters to which the CAA May Have Regard in Granting an Approval of Apparatus Under Article 125(5)
Schedule 13	Aerodrome Manual	
Schedule 14	Penalties	
	PART A	Provisions Referred to in Article 148(5)
	PART B	Provisions Referred to in Article 148(6)
	PART C	Provisions Referred to in Article 148(7)
Schedule 15	Parts of Straits Specified in Connection with the Flight of Aircraft in Transit over United Kingdom Territorial Waters	

4.2 **Air Navigation General Regulations**

In addition, the ANO empowers the Secretary of State to make Regulations on specific subjects. For example, the Air Navigation (General) Regulations 2006 is a Statutory Instrument (SI) which amplifies the ANO with respect to:

a) Particulars of Load Sheets

b) Weighing Requirements - Passengers, Crew and Hand Baggage

c) Weighing Requirements - Hold Baggage and Cargo

d) Loading - Additional Provisions

e) Aeroplanes to which Article 44(5) Applies

f) Helicopters to which Article 45(1) Applies

g) Weight and Performance - General Provisions

h) Noise and Vibration Caused by Aircraft on Aerodromes

i) Pilots Maintenance - Prescribed Repairs or Replacements

j) Aeroplanes Flying for the Purpose of Public Transport of Passengers - Aerodrome Facilities for Approach to Landing and Landing

k) Reportable Occurrences - Time and Manner of Reporting and Information to be Reported

l) Mandatory Reporting of Birdstrikes - Time and Manner of Reporting and Information to be Reported

m) Minimum Navigation Performance and Height Keeping Specifications

n) North Atlantic Minimum Navigation Performance Specification Airspace

o) Airborne Collision Avoidance System

p) Mode S Transponder

q) Aeroplane Performance

r) Helicopter Performance

4.3 Although the ANO establishes in law the basis for the regulation of civil aviation, it does not provide the specific details of what is to be achieved, e.g. technical requirements. This information including the administration procedures is contained in such publications as British Civil Airworthiness Requirements (BCAR), EASA Certification Specifications – see paragraphs 6 and 7. For example, Article 23(1) of the ANO 2005 (as amended) prescribes that:

'Every flying machine and glider in respect of which a Certificate of Airworthiness issued or rendered valid under this Order is in force shall be weighed, and the position of its centre-of-gravity determined, at such times and in such manner as the CAA may require or approve in the case of that aircraft.'

The fulfilment of this provision is provided for in BCAR Section A for aircraft manufactured in the United Kingdom, Chapters A5–4 Weight and Balance of Aircraft and A7–10 Weight and Balance Report and for aircraft manufactured outside the United Kingdom, Chapters B5–4 Weight and Balance of Aircraft and B7–10 Weight and Balance Report.

4.4 The above illustrates, in basic terms, the system of airworthiness control which is accomplished in conjunction with Approved Organisations and Licensed Aircraft Maintenance Engineers.

NOTE: The ANO is frequently subject to amendment, therefore the current status of the ANO should always be checked prior to use.

5 The Civil Aviation Authority – Safety Regulation Group

5.1 The CAA was set up in 1972 to bring together the regulation of civil aviation within one body.

5.2 One of the primary responsibilities bestowed upon the CAA by the Civil Aviation Act and the Air Navigation Order, is the certification and approval of those aircraft and their constituent parts which are not covered by Regulation (EC) 1592/2002. This function is carried out by the Safety Regulation Group (SRG) based in Aviation House, Gatwick Airport South, West Sussex, RH6 0YR.

5.3 SRG comprises the following Divisions:

- Airworthiness Division - Aircraft Certification Department, Applications and Approvals Department, Engineering Department, Flight Department, Policy and Standards Department and Survey Department.
- Flight Operations Division - Flight Operations Inspectorate Department and Flight Operations Policy Department.
- Licensing Standards Division – Aerodrome Standards Department, Air Traffic Standards Department, Personnel Licensing Department, Safety Investigation and Data Department and Medical Department.

5.4 SRG also prescribes airworthiness procedures based on the current legislation, approves all organisations which fall outside Regulation (EC) 1592/2002 (see BCAR Section A, Sub-Section A8) and Maintenance and Production Organisations which fall within 1592/2002, and issues licences to Aircraft Maintenance Engineers (subject to examination), to whom privileges are given to certify work done and issue maintenance certificates on specified types of aircraft, engines and systems.

6 European Aviation Safety Agency

6.1 All aircraft and their constituent parts covered by Regulation (EC) 1592/2002 are subject to the implementing rules of the European Commission and the certification specifications of the European Aviation Safety Agency (EASA). These requirements were developed from the Joint Aviation Authorities regulations and address the same subjects.

6.2 All aircraft are covered by 1592/2002, except for those:

a) excluded from the EASA scope by Article 1 of 1592/2002, which comprises those engaged in military, customs, police or similar services; or,

b) excluded by Annex II of 1592/2002, which largely comprises historical aircraft which are also few in number, experimental aircraft, homebuilt aircraft, microlight aircraft, gliders of a very light weight and very light unmanned aircraft. For the complete definition see Appendix A; or,

c) those for which an EASA Type Certification basis has not been established up until 28 March 2007; or,

d) those to which any derogation to national regulations applies under European Commission Regulation (EC) No. 1702/2003 "the Certification Regulation"; or,

e) those to which any derogation to national regulations applies under European Commission Regulation (EC) No. 2042/2003 "the Continuing Airworthiness Regulation" established under Article 7 of the Regulation up until 28 September 2008.

NOTE: The list of "aircraft of historical relevance and research aircraft" that are not regulated by EASA through being excluded under Annex II paragraphs a) and b) to EC Regulation 1592/2002 is available on the CAA web site under Safety and EASA.

6.3 The applicable implementing rules are:

Part-21	Implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations
Part-66	Certifying Staff
Part-145	Maintenance Organisation Approvals
Part-147	Training Organisation Requirements
Part-M	Continuing Airworthiness Requirements

6.4 The applicable certification specifications are:

CS-25	Large Aeroplanes
CS-23	Normal, Utility, Aerobatic and Commuter Category Aeroplanes
CS-22	Sailplanes and Powered Sailplanes
CS-VLA	Very Light Aeroplanes
CS-29	Large Rotorcraft
CS-27	Small Rotorcraft
CS-VLR	Very Light Rotorcraft
CS-AWO	All Weather Operations
CS-ETSO	European Technical Standard Orders

CS-Definitions	Definitions and Abbreviations used in Certification Specifications for Products, Parts and Appliances
CS-E	Engines
CS-P	Propellers
CS-APU	Auxiliary Power Units
CS-34	Aircraft Engine Emissions and Fuel Venting
CS-36	Aircraft Noise

7 British Civil Airworthiness Requirements

7.1 BCAR comprise minimum technical requirements, and administrative procedures, that form the basis for: the manufacture of aircraft; the approval of equipment; the approval of design, manufacturing and maintenance organisations; the approval of personnel; certification and continued airworthiness procedures.

BCAR set out, within the framework of current aeronautical knowledge, mandatory, imperative, and permissive objectives to allow those concerned with the design, manufacture and maintenance of aircraft, to show possible alternative methods of compliance with the BCAR which would offer equivalent airworthiness.

7.2 BCAR are sub-divided as follows:

Section A	Airworthiness Procedures Where the CAA Has Primary Responsibility for Type Approval of the Product (CAP 553)
Section B	Airworthiness Procedures Where the CAA Does Not Have Primary Responsibility for Type Approval of the Product (CAP 554)
Section L	Licensing (CAP 468)
Section Q	Non Rigid Airships (CAP 471)
Section R	Radio (CAP 472)
Section S	Small Light Aeroplanes (CAP 482)
Section T	Light Gyroplanes (CAP 643)
Section VLH	Very Light Helicopters (CAP 750)
BCAR 31	Manned Free Balloons (CAP 494)

7.3 BCAR Sections (e.g. A, B, S and T) are amended by the issue of loose leaf amendments, applicable to that particular section.

7.4 Those Sections of BCAR which deal with design and testing of aircraft, comprise the minimum requirements which must be achieved to certificate an aircraft as airworthy against a background of up-to-date aeronautical knowledge. BCAR also incorporates the standards laid down by ICAO which must be satisfied for an aircraft to operate internationally.

NOTE: Further details regarding the equipment required for international operation of aircraft are contained in the ANO 2005 Schedules 4 and 5.

7.5 In some cases, there is a general approach to a specific requirement. An example of this is to be found in the various chapters of Sub-section A8 of Section A which prescribes the Requirements for the approval of organisations. Within these chapters there is a Requirement that 'Bonded and Quarantine stores shall be provided'. However, the general Requirement includes more than a storage room. Consideration would need to be given to providing suitable racks and bins, record systems, and methods of stock segregation and identification. It would also include other factors such as temperature and humidity control of the stores, all of which can only be decided according to the particular circumstances, but see CAAIP Leaflet 1–8.

8 Joint Aviation Requirements (JAR)

8.1 JAR is a common airworthiness code accepted by a number of European Aviation Authorities, including the CAA whose purpose is to prevent the proliferation of differing airworthiness codes within Europe.

8.2 In 1979 an arrangements document was signed in Paris by ten states, which later increased to 27 States. This document committed the Participating Authorities to maintain JAR, and set out the ground rules for acceptance by signatory states of products complying with JAR, and established the Joint Aviation Authorities. Twenty three JAR codes have previously been accepted by CAA as forming part of BCARs, although a number of those are now superseded by their equivalent EASA regulations.

8.3 **Amendments**

For JAR, proposed amendments and additions to the Requirements are issued as Notices of Proposed Amendments (NPAs) and are considered according to agreed European procedures. The wording adopted by the JAA committee is then issued as an Amendment, and constitutes part of the Requirements with effect from the date of publication.

8.4 JARs are sub-divided as follows:

JAR-1	Definitions and Abbreviations
JAR-21[6]	Certification Procedures for Aircraft and Related Products and Parts
JAR-22[1]	Sailplanes and Powered Sailplanes
JAR-23[2]	Normal, Utility, Aerobatic and Commuter Category Aeroplanes
JAR-25[3]	Large Aeroplanes
JAR-26	Additional Airworthiness Requirements for Operators
JAR-27	Small Rotorcraft
JAR-29[4]	Large Rotorcraft
JAR-APU	Auxiliary Power Units
JAR-AWO	All Weather Operations
JAR-E[5]	Engines
JAR-P[5]	Propellers
JAR-VLA	Very Light Aeroplanes
JAR-VLR	Very Light Helicopters
JAR-TSO[6]	Joint Technical Standard Orders

JAR-MMEL/MEL Minimum Master Equipment List/Master Equipment List

NOTES: 1 Replaced BCAR Section E on 1 November 1980.

2 Replaced BCAR–23 which itself replaced Section K on 11 December 1987.

3 Replaced BCAR Section D on 1 July 1979.

4 Replaced BCAR–29 which itself replaced BCAR Section G on 17 December 1986.

5 JAR–E and JAR–P replaced BCAR Section C on 1 January 1984.

6 Adopted as an optional code.

9 CAA Publications

9.1 The CAA produces various publications which provide information on technical and administrative matters concerning airworthiness, together with notification of mandatory requirements. Airworthiness Notice No. 6 gives general information, publication dates and latest issue numbers of all CAA publications. A summary of the publications pertinent to this Leaflet is given below.

9.2 **Mandatory Requirements for Airworthiness (CAP 747)**

CAP 747 brings together in one publication, all of those requirements which CAA has notified under Regulation 1592/2002 Article 10, for the convenience of those persons responsible for aircraft and products covered by 1592/2002 and its implementing rules: for certification - European Commission Regulation (EC) No. 1702/2003; and for continuing airworthiness – 2042/2003.

CAP 747 brings together:

a) a small number of UK CAA Mandatory Airworthiness Notices, previously published in CAP 455 'Airworthiness Notices' and;

b) a number of CAA additional requirements and special conditions previously published in CAP 480 'Additional Requirements and Special Conditions' and;

c) a number of CAA additional airworthiness directives, previously published in CAP 473 'Foreign Airworthiness Directives Volumes I and II, (CAA Additional Airworthiness Directives applicable to products and equipment of USA design)' and;

d) a number of CAA additional airworthiness directives, previously published in CAP 474 'Foreign Airworthiness Directives Volume III, (CAA Additional Airworthiness Directives applicable to products and equipment of non-USA design)'.

9.3 **Mandatory Aircraft Modifications and Inspections Summary (CAP 476)**

This publication summarises mandatory information which is required to be complied with by UK Operators in respect of aircraft, engines, propellers, aircraft radio stations, instruments and equipment of UK manufacture. In order that the Certificate of Airworthiness may remain in force, mandatory aircraft modifications and/or inspections must be incorporated or carried out as specified in the summary.

9.4 **Foreign Airworthiness Directives**

These publications deal with Airworthiness Directives relating to aircraft manufactured in foreign countries which are on the UK Register. Airworthiness Directives contain details of those modifications and inspections which have been classified as mandatory by the Aviation Authorities of the countries of origin. The Directives are published as follows:

a) Volume I – Applicable to aircraft (including engines, propellers and equipment), certificated in the USA, which do not exceed 5700 kg MTWA.

b) Volume II – Applicable to aircraft (including engines, propellers and equipment), certificated in the USA, which exceed 5700 kg MTWA.

NOTE: Volumes I and II are published and distributed by the USA Federal Aviation Administration (FAA) as a 'Summary of Airworthiness Directives'. The volumes and bi-weekly listings must be obtained from the Superintendent of Documents, Government Printing Office, P.O. Box 371954, Pittsburgh, PA 15250–7954 U.S.A.

c) Volume III (CAP 474) – Applicable to all aircraft (including engines, propellers and equipment) manufactured in foreign countries other than the USA (see also paragraph 9.5 b)).

9.5 **CAA Additional Airworthiness Directives**

These Airworthiness Directives contain details of additional UK mandatory requirements relating to aircraft manufactured in foreign countries which are on the UK Register. These Directives are published as follows:

a) CAA Additional Airworthiness Directives (CAP 473). This publication is a summary of the additional UK mandatory requirements relating to aircraft (including engines, propellers and equipment) manufactured in the USA and registered in the UK, as called for by the CAA and are associated with Volumes I and II of the FAA 'Summary of Airworthiness Directives'.

b) Foreign Additional Airworthiness Directives Volume III (CAP 474) contains a summary of the additional UK mandatory requirements as called for by the CAA relating to all aircraft (including engines, propellers and equipment) manufactured in foreign countries other than the USA and registered in the UK.

NOTE: CAP 473 and 474 contain requirements applicable to both EASA and non-EASA aircraft. For a concise list of those requirements applicable only to EASA Regulation 1592/2002 aircraft, consult CAP 747.

9.6 **Air Operators' Certificates – Arrangements for Engineering Support (CAP 360 Part Two)**

This publication provides information for use by applicants for, and holders of, Air Operators' Certificates (AOC), regarding the requirements which are to be met by the Operator's engineering support organisation, in order to obtain the grant, variation or continuation of an AOC.

9.7 **UK Additional Requirements and Special Conditions for Certification of Foreign Constructed Aircraft (CAP 480)**

This publication has beeen withdrawn. Please contact the Aircraft Certification Department at department.certification@srg.caa.co.uk for further information.

This publication contains details of the Special Conditions that are required by the CAA following design investigation of foreign manufactured aircraft types, which must be satisfied before UK certification can be granted.

NOTE: CAP 480 contains requirements applicable to both EASA and non-EASA aircraft. For a concise list of those requirements applicable only to EASA Regulation 1592/2002 aircraft, consult CAP 747.

9.8 Condition Monitored Maintenance: An Explanatory Handbook (CAP 418)

This publication provides general information and guidance on the concepts and practices of aircraft maintenance control by the use of Condition Monitoring.

9.9 Air Navigation – The Order and the Regulations (CAP 393)

This publication sets out the provisions of the Air Navigation Order and the regulations made thereunder. It has been prepared for those concerned with day-to-day matters relating to air navigation who require an up-to-date version of the Orders and Regulations and is edited by the Legal Adviser's Department of the CAA. Courts of Law will, however, only refer to the Queen's Printer's edition and therefore CAP 393 should not be regarded as authoritative. CAP 393 contains the following:

a) The Air Navigation Order 2005.

b) The Rules of the Air Regulations 1996.

c) The Air Navigation (General) Regulations 2006.

d) The Air Navigation (Cosmic Radiation) (Keeping Records) Regulations 2000.

e) Permanent Air Navigation (Restriction of Flying) Regulations.

f) The Civil Aviation Authority Regulations 1991.

g) The Air Navigation (Dangerous Goods) Regulations 2002.

9.10 Light Aircraft Maintenance (CAP 520)

This publication provides general guidance on the implementation of the Light Aircraft Maintenance Scheme (LAMS), for aircraft not exceeding 2730 kg MTWA, with a Certificate of Airworthiness in the Transport, Aerial Work, or Private Category.

9.11 Airworthiness Notices (CAP 455)

These Notices provide information on technical, mandatory and administrative matters concerned with airworthiness.

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Appendix A

ANNEX II to Regulation (EC) 1592/2002

Aircraft referred to in Article 4(2)

Aircraft to which Article 4(1) does not apply are aircraft for which a type-certificate or a certificate of airworthiness has not been issued on the basis of this Regulation and its Implementing Rules, and which fall in one of the following categories:

a) aircraft having a clear historical relevance, related to:

i) participation in a noteworthy historic event; or

ii) a major step in the development of aviation; or

iii) a major role played in the armed forces of a Member State;

and meeting one or more of the following criteria:

i) its initial design is established as being more than 40 years old;

ii) its production stopped at least 25 years ago;

iii) fewer than 50 aircraft of the same basic design are still registered in the Member States;

b) aircraft specifically designed or modified for research, experimental or scientific purposes, and likely to be produced in very limited numbers;

c) aircraft of which at least 51% is built by an amateur, or a non-profit association of amateurs, for their own purposes and without any commercial objective;

d) aircraft whose initial design was intended for military purposes only;

e) aeroplanes having no more than two seats, the stall speed or the minimum steady flight speed in landing configuration not exceeding 35 knots calibrated air speed (CAS), and a maximum take-off mass (MTOM) of no more than:

i) 300 kg for a land plane, single seater; or

ii) 450 kg for a land plane, two seater; or

iii) 330 kg for an amphibian or floatplane single seater; or

iv) 495 kg for an amphibian or floatplane two seater, provided that, where operating both as a floatplane and as a land plane, it falls below both MTOM limits, as appropriate;

f) 'gliders' with a structural mass of less than 80 kg when single seater or 100 kg when two seater, including those which are foot launched;

g) unmanned aircraft with an operating mass of less than 150 kg;

h) any other aircraft, with a total mass without pilot, of less than 70 kg.

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Leaflet 1-3 Occurrence Reporting and the Engineer's Role

1 Introduction

This Leaflet describes the Mandatory Occurrence Reporting (MOR) Scheme, explains the work of the CAA Safety Investigation and Data Department, and outlines the responsibilities of the Licensed Aircraft Maintenance Engineer in submitting reports on occurrences which could have airworthiness implications.

2 The Mandatory Occurrence Reporting Scheme

The Mandatory Occurrence Reporting Scheme was introduced by the CAA in 1976 with the following objectives:

a) to ensure that the CAA is advised of all hazardous or potentially hazardous defects and incidents (occurrences);

b) to ensure that all information concerning these occurrences is disseminated to operators and other interested parties;

c) to enable an assessment to be made of the safety implications of each occurrence;

d) to decide whether any corrective action needs to be taken.

2.1 Legislation concerning the MOR Scheme is contained in Article 142 of the Air Navigation Order 2005 (as amended), in Regulation 14 of the Air Navigation (General) Regulations 2006 (as amended), and in Regulation 9 of the CAA Regulations 1991 (as amended). Information and guidance on the Scheme is also published in CAP 382 Mandatory Occurrence Reporting Scheme – Information and Guidance.

2.2 The Scheme is applicable to all public transport aircraft registered in the United Kingdom, or a public transport aircraft not registered in the UK, but which is operated by a UK AOC Holder, or a UK registered aircraft which is turbine powered and which has a C of A. However, in the interests of aircraft safety, the CAA will also accept and process reports concerning aircraft which are not covered by these criteria.

2.3 Any organisation concerned with the operation, manufacture, repair or overhaul of aircraft, or of any items of equipment intended for use on an aircraft, aircraft commanders, air traffic controllers, and engineers signing Certificates of Maintenance, Release or Compliance in respect of such aircraft or equipment, who become aware of a reportable occurrence (paragraph 4), are required to submit a report to the CAA, either directly or using the appropriate company procedures.

2.4 In order not to deter individuals from submitting reports on occurrences which may have resulted from a breach of regulations, the CAA has stated (in CAP 382) its views on confidentiality and disciplinary measures, and also its concern that no action should be taken by employers which could inhibit full and free reporting under the Scheme.

2.5 The CAA considers that the exchange of information resulting from the submission of reports under the MOR Scheme can be of great benefit to aircraft safety and to all those concerned with aircraft maintenance by, for example, calling attention to various defects which have occurred on particular types of aircraft. Engineers are, therefore, encouraged to study the information distributed by the CAA as it relates to their particular field of concern, and to submit reports on occurrences, the knowledge of which could be of benefit to other engineers and to aircraft safety in general.

3 Safety Investigation and Data Department

All reports received under the MOR Scheme are processed by a section of the CAA, called the Safety Investigation and Data Department (SIDD), which is based in the Safety Regulation Group at Aviation House, Gatwick. Reports are directed from SIDD to the appropriate departments within the CAA for any necessary follow-up action.

3.1 SIDD operates an MOR database, in which it stores the information related to occurrences and accidents it considers should be recorded, and from which it extracts information for dissemination within the CAA, to the aircraft industry and other interested parties.

3.2 SIDD is responsible for providing to the airlines, manufacturers and others, the basic information contained in the reports, and summaries of this information. A summary of all occurrences is issued once a month. A 'General Aviation Safety Information Leaflet', relating to light aircraft, is distributed to the general aviation community every 3 months.

3.3 SIDD also analyses occurrences and accidents to establish trends and to determine where corrective action is desirable, and provides selected flight safety information to the industry on request.

NOTES: 1 Flight safety information disseminated by SIDD is generally free, but the provision, by request, of certain selected information may be the subject of a special charge.

2 Information may be provided to certain persons outside the aviation industry, in which case it is dis-identified and is subject to the payment of a fee.

4 Reportable Occurrences

A reportable occurrence is defined as any incident, malfunctioning or defect in an aircraft or its equipment, or in ground facilities intended for use in connection with the operation of an aircraft, which endangers, or if not corrected could endanger, the aircraft or its occupants or any other person. Reports are thereby required on occurrences which involve, for example, a defective condition or unsatisfactory behaviour or procedure which although not actually endangering the aircraft, could, if repeated in different circumstances, do so. These criteria should be used by all persons concerned with the MOR Scheme before submitting a report, since the reporting of minor occurrences will, by the volume of data produced, tend to obscure serious occurrences, and would also be costly to both the operator and the CAA. It is, however, probable that many persons required to submit reports will be unaware of the full implications of an occurrence or its connection to previous similar occurrences, and if any doubt exists a report should be submitted so that the CAA is informed of, and may take action on, any occurrences which could affect aircraft safety.

4.1 The majority of occurrence reports result from incidents occurring in flight, and the responsibility for reporting them will rest with the aircraft commander, with Air Traffic Control, or with the operator. Licensed Aircraft Maintenance Engineers will often be involved in supplying technical details or evidence in the investigation of these occurrences, but may also be responsible for reporting occurrences themselves. Paragraphs 4.1.1 to 4.1.6 list examples of occurrences which may be reportable by engineers under the MOR Scheme (or which, when involving aircraft not covered by the Scheme, could be reported in the same way). The decision on whether to report an occurrence will normally require judgement by the person concerned, who should consider whether the occurrence is covered by the reporting criteria (paragraph 4).

4.1.1 **Structural Damage.** Substantial damage incurred during flight constitutes a notifiable accident and should be reported to the Air Accidents Investigation Branch (AAIB), at the Department for Transport. Damage discovered during a routine inspection, which falls into any of the following categories may be reportable under the MOR Scheme:

a) Failure of aircraft primary structure.

b) Structural damage resulting from any cause, which requires a permanent repair before the aircraft can fly.

c) Serious defects in the aircraft structure such as cracks in primary structure or serious cracks in the secondary structure, corrosion or permanent deformation greater than expected.

d) Failure of a non-primary structure which endangers the aircraft.

4.1.2 **Injury.** Serious injury inflicted during flight constitutes a notifiable accident and should be reported as such (paragraph 4.1.1). Any injury to servicing personnel, resulting from a fault in the aircraft or from servicing procedures should be reported under the MOR Scheme.

4.1.3 **Aircraft System and Equipment.** Any fault discovered during routine servicing operations, which could have led to a hazardous situation during flight, should be reported. Faults in items included on the allowable deficiencies list should not normally be reported, since an alternative system is available if required, but the circumstances of the failure and its possible connection with other failures should be considered. The following are some examples of occurrences which might be discovered during routine servicing or when checking a snag reported by the flight crew, and which could be reportable:

a) Malfunction, stiffness, slackness or limited range of movement of any controls.

b) Inability to feather or unfeather a propeller, to shut down an engine or to control thrust.

c) Failure or malfunction of the thrust reverser system.

d) Fuel system malfunction affecting fuel supply and distribution.

e) Malfunction of the fuel jettison system.

f) Significant leakage of fuel, oil or other fluid.

g) Use of incorrect fuel, oil or other fluid.

h) Significant failure or malfunction of the electrical, hydraulic, pneumatic or ice-protection systems, or of the radio and navigation equipment.

i) Smoke, toxic or noxious fumes inside the aircraft.

j) Significant failure of wheels, tyres or brakes.

k) Incorrect assembly of components, causing possible malfunction.

l) On a multi-engined rotorcraft, loss of drive of one engine.

m) Operation of any rotorcraft transmission condition-warning system.

n) Operation of fire or smoke warning systems.

o) Failure or malfunction of ground equipment used for testing/checking aircraft systems or equipment.

4.1.4 **Refuelling.** Significant spillage of fuel during refuelling or defuelling operations, the use of incorrect or contaminated fuel, or failure of automatic cut-off valves in pressure refuelling systems, could all be reportable.

4.1.5 **Cargo.** Incidents arising from the carriage of cargo could be reportable if they endangered the aircraft. These include incidents related to:

a) The carriage of hazardous or restricted material.

b) Incorrectly packed cargo.

c) Incorrectly stowed cargo.

d) Incorrectly secured cargo.

e) The carriage of livestock.

4.1.6 **Miscellaneous.** The following items are all examples of incidents which could occur during servicing and which could be reportable:

a) Fire or explosion.

b) Collisions between aircraft and vehicles or other ground equipment.

c) Jet blast incidents.

d) Damage resulting from adverse weather conditions.

5 Reporting Procedures

5.1 **Operators.** To ensure compliance with the requirements, most operators have set up systems for handling all types of occurrences, whether reportable or otherwise. The operator takes the responsibility for investigating all defects and incidents which occur to his aircraft, and deciding which are reportable occurrences under the MOR Scheme. Where the operator submits reports to the CAA, he must also inform the individual submitting the original report under company procedures, as to his course of action, and should also notify the appropriate manufacturer, overhauler or repairer, by letter or by documents accompanying components returned to them.

5.2 **Individuals.** An individual who is required to submit reports under the MOR Scheme (e.g. a Licensed Aircraft Maintenance Engineer) and who has submitted a report to his employer under company procedure which has not been passed on to the CAA, should consider whether to report the occurrence directly to the CAA. An individual employed by a company not using a defined reporting procedure, must submit such reports directly to the CAA.

5.3 **Manufacturers, Overhaulers and Repairers.** A manufacturer of aircraft components or equipment, is not expected to submit reports to the CAA, as a matter of routine, on occurrences concerning their own products which have already been reported by an operator; they should, however, submit reports on occurrences which they consider are reportable and which have not already been reported. The discovery during overhaul or repair of a serious defect, places the onus for reporting on the company concerned, even though its effect on the aircraft concerned may be difficult to assess. Similarly, the discovery of further significant information on a known or suspected defect should also be reported.

5.4 **Method of Reporting.** Reports on occurrences should be despatched to the CAA in writing within 96 hours of the occurrence coming to the notice of the person making the report; any information not known at the time of submission of the report being forwarded when it becomes available. Except in the cases of Airprox and birdstrike occurrences, and reports on air traffic control procedures, a report should normally be made on CAA Form CA 1673 (see paragraph 6 and Figure 1) or such other forms as are approved by the CAA, but a report by letter is acceptable if an official form is not available. Occurrences which are considered to be particularly hazardous and to require urgent attention should be notified in the first place by telephone, facsimile or telex before submission of a report. Occurrences involving a lesser degree of hazard need not be reported immediately if it is likely that further useful information will be available within the prescribed 96 hours.

5.5 **Supplementary Information**. Under the MOR Scheme, the CAA may request, and reporters are required to provide, additional information on particular occurrences, to enable the CAA to reach a satisfactory conclusion and take the appropriate action. Operators and manufacturers are also expected to provide any significant supplementary information which may have been discovered as a result of investigations they have carried out, to assist the CAA in providing a complete information service.

5.6 **Channels for Reports.** Reports should be forwarded to the CAA as outlined in paragraphs 5.6.1 to 5.6.3 according to their urgency.

5.6.1 Reports originating in the United Kingdom which are not considered urgent, should be sent to:

Safety Investigation and Data Department
Civil Aviation Authority
Aviation House
Gatwick Airport South
West Sussex RH6 0YR

5.6.2 Reports required to reach the CAA with the minimum of delay, and from overseas, should be sent by the following means:

a) Email: sdd@srg.caa.co.uk

b) Telex: No. 878753

c) Facsimile: 44 (0)1293 573972

5.6.3 Reports on particularly hazardous occurrences should be sent to the CAA as follows:

a) During normal working hours:

i) Aircraft defects – Safety Regulation Group Area Office (see Airworthiness Notice No. 29)

ii) Other occurrences – SIDD, telephone 44 (0)1293 573220

b) Outside normal working hours:

i) Aircraft defects – A Surveyor from Safety Regulation Group Area Office, or if not available, CAA Emergency Phone List 44 (0)1293 563344

ii) Other occurrences – CAA Emergency Phone List 44 (0)1293 563344.

6 Division of Responsibilities

6.1 The existence of the Occurrence Reporting Scheme to achieve the above objectives is not intended to replace or reduce the duties and responsibilities of all organisations and personnel within the air transport industry. The primary responsibility for safety rests with the management of the organisations involved (Manufacturers, Operators and Maintenance Organisations). The CAA's responsibility is to provide the regulatory framework within which the industry must work and thereafter to monitor performance to be satisfied that required standards are set and maintained. The Occurrence Reporting Scheme is an established part of the CAA's monitoring function and is complementary to the normal day to day procedures and systems (e.g. AOC, Company approvals, etc.); it is not intended to duplicate or supersede these. It is thus no less incumbent upon any organisation:

a) to record occurrences and

b) in conjunction with the appropriate organisation (e.g. Aircraft/Equipment Manufacturer, Operating Agency, Maintenance/Repair Organisation) and when necessary the CAA, to investigate occurrences in order to establish the cause sufficiently to devise, promulgate and implement any necessary remedial and preventative action.

6.2 In relation to all reported occurrences, including those raised by its own personnel, the CAA will:

a) evaluate each occurrence report received;

b) decide which occurrences require investigation by the CAA in order to discharge the CAA's functions and responsibilities;

c) make such checks as it considers necessary to ensure that operators, manufacturers, maintenance, repair and overhaul organisations, air traffic control services and aerodrome operators are taking any necessary remedial and preventative action in relation to reported occurrences;

d) take such steps as are open to it to persuade foreign aviation authorities and organisations to take any necessary remedial and preventative action in relation to reported occurrences;

e) assess and analyse the information reported to it in order to detect safety problems which may not be apparent to individual reporters;

f) make available the information derived from occurrence reports in accordance with the relevant CAA Regulations (see paragraph 4.3);

g) make available the results of studies of the data provided to those who will use them for the benefit of air safety;

h) where appropriate, issue specific advice or instructions to particular sections of the industry;

i) where appropriate, take action in relation to legislation, requirements or guidance, e.g. revisions of the Air Navigation Order (ANO), Joint Aviation Requirements (JAR), amendments to Flight Manuals and Operations Manuals, introduction of mandatory modifications and inspections, amendments to maintenance schedules, terms of approval, and licences, issue of Aeronautical Information Circulars, Airworthiness Notices, etc.

7 Report Forms

Because of the need to store a wide variety of facts concerning occurrences in automatic data processing equipment, and to retrieve selected data for the purpose of flight safety studies, it is essential that reports should contain sufficient information for the identification, classification and comparison of all pertinent facts. The best method of achieving standardisation and of facilitating storage and retrieval of information has been found to be the use of a specially devised report form. The CAA has devised such a report form specifically for occurrence reporting (Form CA 1673), which will cover most eventualities and which should be used whenever possible. Certain companies may wish to use forms more suitable to their own particular requirements, but these must be approved by the CAA to ensure compatibility with the data processing equipment.

7.1 An example of a completed Form CA 1673 is shown in Figure 1. Each form is intended to provide a report on a single occurrence, and the presentation of the 'box' headings is generally self-explanatory. For a report on an aircraft defect the blocks for Aircraft and Operator Identification (boxes 1 to 4), Narrative (box 24), Engineering Details (boxes 25 to 42) and non-technical information (boxes 43 to 53) should be completed, the boxes being used to insert the relevant details or to delete the inappropriate choices.

7.2 The narrative should contain a clear and concise description of the occurrence, and any immediate or subsequent action taken or proposed. It should include details of all associated information, including the relationship to other occurrences which have been reported, and any comments or recommendations which may assist the CAA in any subsequent investigations.

7.3 In the 'Engineering Details' section of the form, 'Maintenance Programme' (box 32), 'O.C.' means 'on condition', 'C.M.' means 'condition monitored', and 'H.T.' means 'hard time'. Box 41 should be used to identify items included in a CAA approved reliability programme and classified as Category A.

7.4 The completion of box 52 is optional, and should be used by individuals preferring to be contacted at their home address rather than through their employer.

UK Civil Aviation Authority

OCCURRENCE REPORT

When completed, please send to : Safety Investigation and Data Department (SIDD),
Civil Aviation Authority,
Safety Regulation Group,
Aviation House,
Gatwick Airport South,
West Sussex,
RH6 0YR

CAA Occurrence Number

If report is CONFIDENTIAL - mark clearly at the top and provide contact address/Tel no. Your wish will be respected.

Civil Aviation Authority

AIRCRAFT TYPE & SERIES	REGISTRATION	OPERATOR	DATE	LOCATION/POSITION/RW	TIME	DAY NIGHT TWILIGHT
					UTC	

FLIGHT CREW REPORT

FLIGHT NR	ROUTE FROM	ROUTE TO	FL/ALT/HT (FT)	IAS (KTS)	ETOPS	
					YES	NO

NATURE OF FLIGHT	PAX	FREIGHT	POSITIONING	FERRY	TEST	TRAINING	BUSINESS	AGRICULTURAL	SURVEY	PLEASURE	CLUB/GROUP	PRIVATE	PARACHUTING	TOWING

FLIGHT PHASE	PARKED	TAXYING	TAKE OFF	INITIAL CLIMB	CLIMB	CRUISE	DESCENT	HOLDING	APPROACH	LANDING	CIRCUIT	AEROBATICS	HOVER

ENVIRONMENTAL DETAILS

WIND		CLOUD			PRECIPITATION				OTHER METEOROLOGICAL CONDITIONS								RUNWAY STATE				
DIRN	SPEED (kts)	TYPE	HT (ft)	8th	RAIN	SNOW	SLEET	HAIL	VISIBILITY	ICING			TURBULENCE			OAT (°c)	DRY	WET	ICE	SNOW	SLUSH
					LIGHT	MOD	HEAVY		KM/M	LIGHT	MOD	SEVERE	LIGHT	MOD	SEVERE		CATEGORY	I	II	III	

BRIEF TITLE

DESCRIPTION OF OCCURRENCE

Continue on back as necessary

Any procedures, manuals, pubs (eg AIC, AD, SB etc) directly relevant to occurrence and (when appropriate) compliance state of aircraft, equipment or documentation.

GROUND STAFF REPORT

A/C CONSTRUCTORS NR	ENGINE TYPE/SERIES	ETOPS APPROVED		GROUND PHASE	AIRCRAFT BELOW 5700KG ONLY - MAINTENANCE ORGANISATION
		YES	NO	MAINTENANCE	
				GROUND HANDLING	
				UNATTENDED	TEL NO.

COMPONENT/PART	MANUFACTURER	PART NR	SERIAL NR	MANUAL REF	COMPONENT OH/REPAIR ORGANISATION

CA 1673 (April 2003)

Figure 1 Example of Occurrence Report

Leaflet 1-4 Weight and Balance of Aircraft

1 Introduction

1.1 **General.** The purpose of this Leaflet is to provide guidance on the weighing of aircraft to determine the Basic Weight and corresponding centre-of-gravity (c.g.). The need for accuracy when weighing aircraft is extremely important. Incorrect data could cause subsequent overloading of the aircraft resulting in an increase of structural loads and a reduction in performance. Subject headings are as follows:

1.2 **Definitions.** The following is a list of definitions of the terms used in this Leaflet:

a) **Basic Equipment** – is the unconsumable fluids (e.g. coolant and hydraulic fluid) and equipment which is common to all roles for which the operator intends to use the aircraft.

b) **Basic Weight** – is the weight of the aircraft and all its Basic Equipment, plus that of the declared quantity of unusable fuel and unusable oil. In the case of turbine-engined aircraft and aircraft, the Maximum Total Weight Authorised (MTWA) of which does not exceed 5700 kg (12 500 lb), it may also include the weight of usable oil.

c) **Variable Load** – is the weight of the crew and of items such as crew baggage, removable units, and other equipment, the carriage of which depends upon the role for which the operator intends to use the aircraft for a particular flight.

d) **Disposable Load** – is the weight of all persons (e.g. passengers) and items of load, including fuel and other consumable fluids carried in the aircraft, other than the Basic Equipment and Variable Load.

e) **Maximum Total Weight Authorised (MTWA)** – is the Maximum Total Weight Authorised for the aircraft and its contents, at which the aircraft may take off anywhere in the world, in the most favourable circumstances in accordance with the Certificate of Airworthiness or Flight Manual.

f) **Reaction** – is the load at each separate weighing point.

2 Requirements

2.1 The requirements relating to the weighing of aircraft and the establishment of a Weight and Balance Schedule are prescribed in British Civil Airworthiness Requirements (BCAR) Section A, Chapters A5–4, A6–4 and A7–10. An interpretation of those parts of the Chapters which are pertinent to this Leaflet are given below.

2.2 Aircraft must be weighed to determine the Basic Weight and the corresponding c.g. position when all the manufacturing processes have been completed. Aircraft exceeding 5700 kg (12 500 lb) MTWA must be re-weighed within 2 years after the date of manufacture and, after this, a check weighing must be carried out at intervals not exceeding 5 years and at such times as the CAA may require. Aircraft not exceeding 5700 kg (12 500 lb) MTWA must be re-weighed as required by the CAA.

2.3 In making decisions on weighing, the CAA considers the history of the aircraft, its flying performance, and the probable effect on the weight after a major overhaul, or embodiment of a modification, repair or replacement.

2.4 Certain types of aircraft may be weighed on a sampling basis (i.e. a representative aircraft, as weighed, would be acceptable for others of the same standard) by agreement with the CAA.

2.5 An alternative arrangement to the periodical check weighing of individual aircraft is for the operator to establish a fleet mean weight (i.e. Basic Weight) and fleet mean centre-of-gravity position. The initial fleet mean weight is based on the mean of the weights of all the aircraft of the same type in the fleet which is revised annually by sample weighing (see BCAR, Section A, Chapter A6–4).

2.6 When an aircraft is weighed, the equipment and other items of load such as fluid in the tanks must be recorded. This recorded load should not differ significantly from the Basic Equipment List associated with the Weight and Centre-of-Gravity Schedule (see paragraph 2.9). In circumstances where there is a significant difference between the Basic Weight of the aircraft and the operating weight (i.e. Basic Weight plus the Variable Load) not accountable to structural changes brought about by modifications/ repairs, the CAA may require that the actual weights of the Variable Load items be ascertained.

2.7 All records of the weighing, including the calculations involved, must be available to the CAA. The records are retained by the aircraft manufacturer, overhauler or operator, and when the aircraft is weighed again, the previous weighing records must not be destroyed but retained with the aircraft records. Operators must maintain records of all known weight and c.g. changes which occur after the aircraft has been weighed.

2.8 **Weight and Balance Report**

2.8.1 Before the CAA can issue a Certificate of Airworthiness for a prototype, variant (prototype modified) or series aircraft exceeding 5700 kg (12 500 lb) MTWA, a Weight and Balance Report must be prepared by a CAA Approved Organisation.

2.8.2 The Weight and Balance Report is intended to record the essential loading data to enable a particular aircraft to be correctly loaded, and to include sufficient information for an operator to produce written loading instructions in accordance with the provisions of the Air Navigation Order (ANO). The Weight and Balance Report applies to the aircraft in the condition in which it is to be delivered from the manufacturer to the operator.

2.8.3 The Weight and Balance Report must include the following items:

a) Reference number and date.

b) Designation, manufacturer's number, nationality and registration marks of the aircraft.

c) A copy of the Weighing Record.

d) A copy of the Weight and Centre-of-Gravity Schedule (see paragraph 2.9) including the Basic Equipment List if this is separate from Part A of the Schedule.

e) A diagram and a description of the datum points which are used for weighing and loading, and an explanation of the relationship of these points to the fuselage frame numbering systems and, where applicable, to the Standard Mean Chord (SMC).

NOTE: SMC is also referred to as the Mean Aerodynamic Chord (MAC).

f) Information on the lever arms appropriate to items of Disposable Load. This will include the lever arms of fuel, oil and other consumable fluids or substances in the various tanks (including agricultural material in hoppers), which, if necessary, should be shown by means of diagrams or graphs, lever arms of all passengers in seats appropriate to the various seating layout, mean lever arms of the various baggage holds or compartments.

g) Details of any significant effect on the aircraft c.g., of any change in configuration, such as retraction of the landing gear.

2.9 Weight and Centre-of-Gravity Schedule

2.9.1 A Weight and Centre-of-Gravity Schedule details the Basic Weight and c.g. position of the aircraft, the weight and lever arms of the various items of load including, fuel oil and other fluids.

The Schedule is normally divided into Part A – Basic Weight, Part B – Variable Load and Part C – Loading Information (Disposable Load).

a) A Weight and Centre-of-Gravity Schedule shall be provided for each aircraft, the MTWA of which exceeds 2730 kg (6000 lb).

b) For aircraft not exceeding 2730 kg (6000 lb) MTWA, either a Weight and Centre-of-Gravity Schedule shall be provided or alternatively, a Load and Distribution Schedule which complies with BCAR, Section A, Chapter A7–10 and Section B, Chapter B7–10.

c) For new aircraft exceeding 2730 kg (6000 lb) MTWA, but not exceeding 5700 kg (12 500 lb) MTWA, the information contained in Parts B and C of the Schedule may be given as part of the Weight and Balance Report.

2.9.2 A Weight and Centre-of-Gravity Schedule must provide the following. Each Schedule must be identified by the aircraft designation, the nationality and registration marks, or if these are not known, by the manufacturer's serial number. The date of issue must be on the Schedule and it must be signed by an authorised representative of a CAA Approved Organisation or a person suitably qualified and acceptable to the CAA, and if applicable, a statement shall be included indicating that the Schedule supersedes all earlier issues. It is also necessary to refer to the date or reference number (or both) of the Weight and Balance Report, or other acceptable information upon which the Schedule is based.

2.9.3 Operators must also issue a revised Weight and Centre-of-Gravity Schedule when it is known that the weight and c.g. has changed in excess of the maximum figure agreed by the CAA as applicable to a particular aircraft type. If the aircraft has not been re-weighed, the revised Weight and Centre-of-Gravity Schedule must state that it has been calculated on the basis of the last Weight and Balance Report and the known weight and c.g. changes. A record of the calculations involved should be retained for future reference.

2.9.4 A copy of the Schedule is to be retained by the operator with a further copy sent to the CAA Safety Regulation Group which shall include any related list of Basic Equipment. Furthermore, for aircraft not exceeding 5700 kg (12 500 lb) MTWA, a copy of the Weight and Centre-of-Gravity Schedule must be included in the Flight Manual. If a Flight Manual is not a requirement, the Schedule must be displayed or retained in a stowage which is identified in the aircraft. A similar arrangement is often used for larger types of aircraft.

2.9.5 A typical Weight and Centre-of-Gravity Schedule for an aircraft not exceeding 2730 kg (6000 lb) MTWA is shown in the Appendix to this Leaflet.

3 The Principles of Aircraft Weight and Balance

3.1 Principles of Balance

3.1.1 The theoretical principle of the weight and balance of aircraft is basically very simple and can be compared with that of the familiar scale (as depicted in Figure 1) which, when in balance, will rest horizontally on the fulcrum in perfect equilibrium provided that the two pans suspended from the beam are of equal weight and distance from the fulcrum.

3.1.2 In aeronautical terms the fulcrum can be equated to the aircraft c.g., and the weights, with the loads imposed thereof on the structure.

3.1.3 Because of the design tolerances built into aircraft, the Weight and Balance is not as critical as that of the scales in Figure 1. It is however important that they remain within those tolerances for reasons of safety, performance and economy.

3.1.4 From Figure 1 it can be understood that the influence of weight, in relation to balance, is directly dependent upon the distance of the weight from the fulcrum.

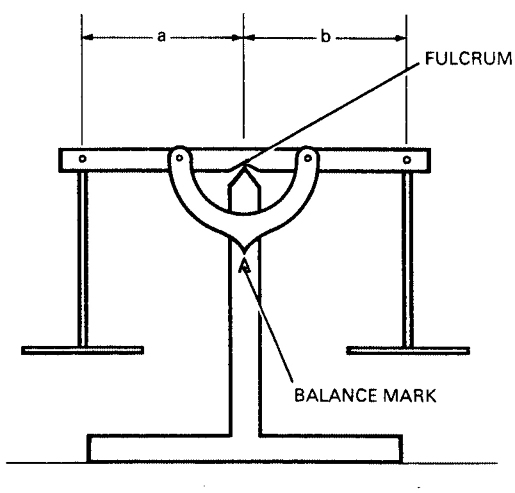

Figure 1 Simple Scale

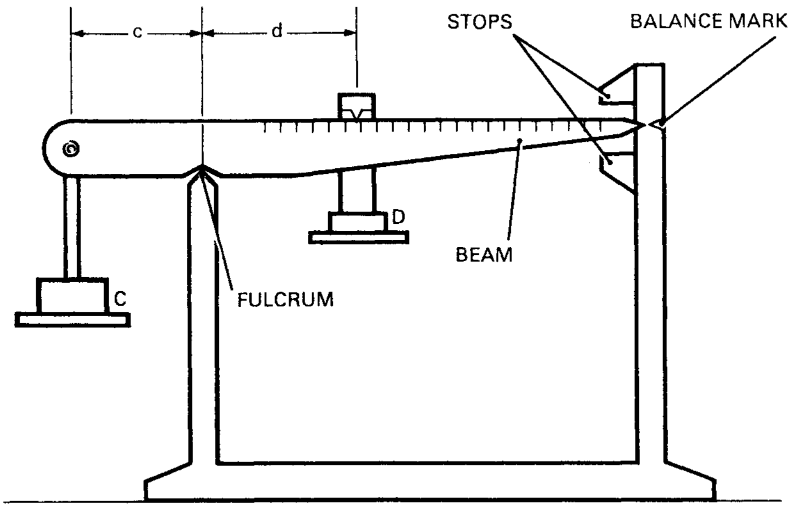

Figure 2 Steelyard

3.1.5 Unlike the scales in Figure 1, aircraft (apart from some helicopters), cannot practicably be suspended in such a way as to determine the relative weight, balance and c.g. However, it can be achieved mathematically.

3.1.6 The steelyard shown in Figure 2 has a known weight 'D' and a known weight 'C' set at a specific distance 'c'. Under normal circumstances to determine the distance required to balance 'C', the known weight 'D' is moved along the beam until the weight of 'D' and its accompanying lever arm are equal to the weight of 'C' therefore aligning the beam with the balance mark. Once achieved the distance 'd' can then be read from the graduated scale.

3.1.7 Mathematically the distance can be found as follows:

$$d = \frac{Cc}{D}$$

Where C = 50 lb

c = 10 inches

D = 20 lb

$$\frac{Cc}{D} = \frac{50 \times 10}{20}$$

d = 25 in

3.2 Moments

3.2.1 The distance from the fulcrum is called the 'arm' and this distance, multiplied by the weight, is the turning effect or 'moment' about the fulcrum. The c.g. of the balanced system is the position at which the weight resting on the fulcrum may be taken to act, and will lie in a plane drawn vertically through the fulcrum. The conventional signs which are applied to arms and moments in relation to their direction from the c.g. datum are as follows:

a) **Horizontal** (–) forward and (+) aft of the datum.

b) **Vertical** (–) below and (+) above the datum.

c) **Transverse** (–) right and (+) left of the datum.

3.2.2 In a similar way to the balancing of weights, the horizontal c.g. of a system of weights can be found by calculating the moment of each weight from a selected position (e.g. reference datum) and dividing the total moment by the total weight.

NOTE: In aeronautical terms all arms forward of the reference datum are designated negative (–) and all arms aft of the datum are designated positive (+).

3.2.3 Illustrated in Figure 3 is a constant cross-section beam 80 in long and weighing 8 lb, upon which have been placed 5 loads weighing 2 lb, 6 lb, 1 lb, 4 lb and 3 lb respectively, which are 5 in, 20 in, 30 in, 60 in, 70 in, from the left-hand end of the beam, which in this example is the c.g. reference datum. It should be noted however, that although any plane normal (i.e. perpendicular) to the beam's horizontal axis could have been selected as the reference datum, the position chosen is one of convenience, and therefore all moment arms in this example are positive (+). As the beam is of a constant cross-section, the c.g. of the loaded beam in Figure 3 can be found as follows by:

a) calculating the moment of each load, i.e. multiplying the weight by arm (distance from the reference datum),

b) calculating the total weight by adding together the weight of each load,

c) adding together the moment of each load, and

d) dividing the total moment by the total weight.

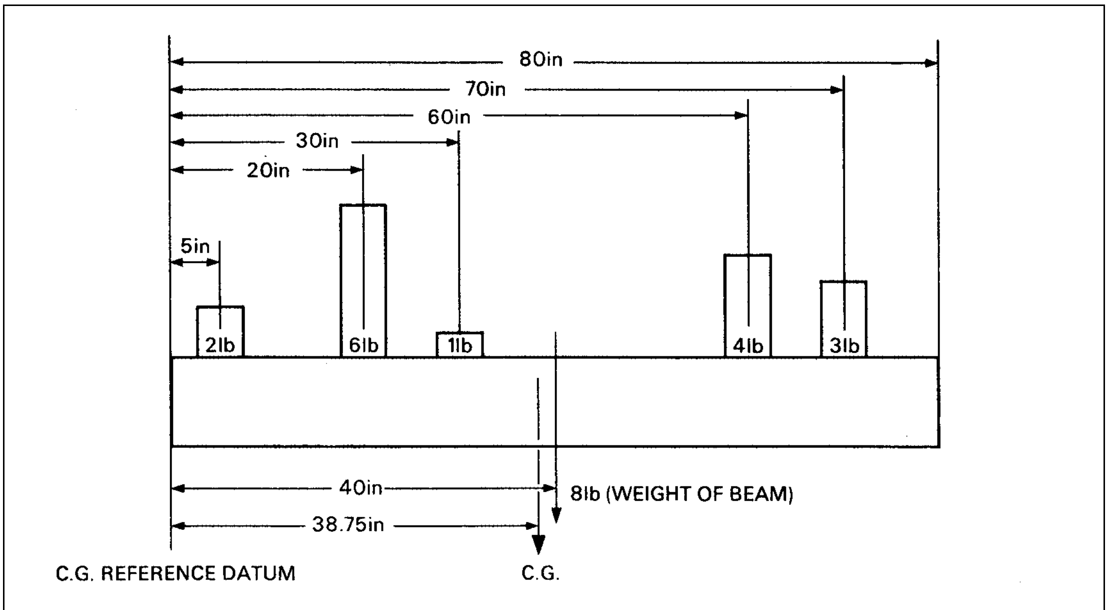

Figure 3 Centre-of-Gravity of Beam

Item	Weight (lb)	Arm (in)	Moment (lb in)
Beam	8	40	320
1st load	2	5	10
2nd load	6	20	120
3rd load	1	30	30
4th load	4	60	240
5th load	3	70	210
TOTALS	24		930

$$\therefore \frac{930 \text{ lb in}}{24 \text{ lb}} = 38.75 \text{ in}$$

$\therefore$ the c.g. of the loaded beam is 38.75 in from the reference datum.

NOTES: 1) The arm of the beam is taken as half its length.

2) The units of weight, arm and moment used in this and subsequent paragraphs are the pound (lb), inch (in) and pound inch (lb in) respectively. Other units, such as the kilo-gramme (kg) and metre (m) may be used where this is more convenient for the operator but, whichever units are used, it is essential that the same units are used throughout the calculations.

3.3 **Aircraft Weight and Centre-of-Gravity**

3.3.1 The weight and c.g. of an aircraft is calculated in the same way as for the loaded beam in Figure 3. The Basic Weight and c.g. of the aircraft corresponds to the weight and c.g. of the beam, and, the Variable and Disposable Loads correspond to the beam loads. Before each flight the total weight and moment of these items must be determined, and the c.g. of the aircraft calculated to ensure the aircraft remains within the approved limits. If for example, the c.g. was too far forward, it would result in a nose-heavy condition which could be potentially dangerous (particularly during take-off and landing), cause a general reduction in the performance of the aeroplane, and effect an increase in fuel consumption as a result of the drag caused by excessive balancing of the elevator trim. Where rotorcraft are concerned, a c.g. too far forward could result in excessive strain on the main rotor shaft and a general lack of control. The c.g. too far aft results in a tail-heavy condition which, with the tendency of the aeroplane to stall, makes landing more difficult, may result in a reduction in performance, and cause an increase in fuel consumption. In the case of rotorcraft it will reduce the forward speed and also the range of effective control.

3.3.2 The operational limitations for the fore and aft positions of the c.g. are defined in the aircraft Flight Manual or other document associated with the Certificate of Airworthiness, such as the Owner's Manual. Where no such document exists, the limitations are specified in the Certificate of Airworthiness.

3.3.3 Fortunately it is not necessary for an aircraft to be perfectly balanced to achieve stable flight, i.e. to an exact c.g. position. The permissible variation is called the Centre-of-Gravity Range. This is specified by the manufacturer for each aircraft type and is determined by the need to comply with various airworthiness design requirements.

4 Weighing Equipment

4.1 General

The main types of weighing equipment for use in the weighing of aircraft are weighbridge scales, hydrostatic weighing units and electrical and electronic weighing equipment based on the strain gauge principle. Since considerable errors can arise if small loads are checked with equipment designed for heavy loads, whereby scales may be calibrated in increments too coarse for accurate calculation, the capacity of the weighing equipment should be compatible with the load.

NOTE: All weighing apparatus should be checked, adjusted and certified by a competent authority at periods not exceeding 1 year and, in addition, the zero indication should be checked for accuracy before any weighing is commenced.

4.2 Weighbridge Scales

This equipment consists of a separate weighing platform for each wheel or bogey on the aircraft, the weight at each reaction point being recorded directly on the balance arm. On some equipment a dial indicator is also provided. Large aircraft are normally weighed in a hangar, using either portable weighbridge scales or weighbridges set permanently into the floor at appropriate positions with their platforms level with the floor. The aircraft may then be rolled directly onto the platforms without the need for special equipment.

NOTES: 1) Care should be taken when moving portable weighbridge scales to prevent them becoming out of balance.

2) It is advisable to set the approximate load on each balance arm before releasing it. Failure to do this could cause damage to the knife edge.

4.3 Hydrostatic Weighing Units

4.3.1 The operation of these units is based on the hydraulic principle that the fluid pressure in a cylinder in which a piston is working, depends on the area of the piston and the load applied to it. The units are interposed between the lifting jacks and the aircraft jacking points, the weight at each position being recorded on a pressure indicator. The indicator may record directly in units of weight or may be a multi-rotational type where the readings are converted to weight by means of a conversion table peculiar to each particular unit.

4.3.2 It is important that the lifting jacks are exactly vertical and the units correctly positioned, otherwise side loads may be imposed on the weighing units and may affect the accuracy of the readings.

4.4 Electrical Weighing Equipment

Equipment of this type incorporates three or more weighing cells, each of which contains a metallic element of known electrical resistance. Aircraft load is measured with the variation in resistance with elastic strain by means of a galvanometer, the scale of which is calibrated in units of weight. As with the hydrostatic weighing units, the weighing cells are interposed between the lifting jacks and the aircraft jacking points and similarly care is necessary to ensure that no side loads are imposed upon them. (See paragraph 4.3.2.)

4.5 Electronic Weighing Equipment

4.5.1 This type of weighing equipment combines elastic strain load cells as described in paragraph 4.4 into weighbridge-type platforms which are placed either as a single unit or combination of units beneath the wheels of the aircraft undercarriage.

4.5.2 Each platform, is electrically connected to an instrumentation unit, which digitally displays the selected platform load. The number of platforms required to weigh an aircraft by this method is determined by the size of the aircraft. For example, a very large transport aircraft may require as many as 18 or more platforms to accommodate the wheel multiples of the undercarriage. The number of units that can be used is, however, limited by the terminal facility of the instrumentation unit.

4.5.3 As there is generally a requirement for aircraft weighing equipment to be portable, the platforms are normally manufactured of high strength lightweight materials, with the load cells interposed between the platform table, and the base unit. Where a platform is unevenly loaded (because of structural movement or undercarriage positioning), a greater load imposed on one side of the platform will be automatically compensated for by the lesser load on the other side.

NOTE: The displayed load (or reaction) on the instrumentation unit for each platform, is a dedicated computation of all load cell inputs from that particular platform.

4.5.4 The positioning of aircraft onto electronic weighbridge platforms may be accomplished by one of the following methods:

a) by towing the aircraft directly onto platforms permanently set into the hangar floor (sometimes in specific appropriate positions),

b) by supporting the aircraft on jacks and, where facilities allow, lowering the hangar floor, positioning the platforms below the extended undercarriage and then raising the hangar floor until all the weight of the aircraft is supported by the platforms, or

c) by towing the aircraft up purpose-made ramps (approximately 6%) onto the platforms.

4.5.5 The function of the instrumentation unit is to:

a) Compute and display the loads imposed upon each platform.

b) Provide a facility for the fine calibration of the platforms to a zero datum.

c) Record and print out the indicated data.

NOTE: Some instrumentation units (subject to the necessary inputs) also have the capability to compute both the total weight and the relative c.g. of the aircraft.

5 Determination of Basic Weight and Centre-of-Gravity

5.1 General

Modern aircraft may be weighed using any of the equipment described in paragraph 4. Arms from the c.g. datum are predetermined distances and therefore physical measurement is seldom required. However, when weighing certain types of aircraft on their wheels, it may be necessary to take measurements due to the possibility of landing gear compression or deflection altering the length of the lever arm. Furthermore, before weighing is commenced, reference should be made to the manufacturer’s recommended weighing procedures.

NOTE: It is important for large fixed-wing transport aircraft to be level in both the longitudinal and lateral planes when being weighed. However, for light fixed-wing aeroplanes the emphasis is normally on the longitudinal plane.

5.2 Preparation for Weighing

5.2.1 The aircraft should be in the condition described in the Weight and Centre-of-Gravity Schedule, fluids such as engine oil, or fuel being partially or completely drained in accordance with the manufacturer's requirements, and equipment positioned at its normal operational location.

5.2.2 It is important to carry out the weighing of aircraft inside a closed hangar, and where possible, it is recommended that the aircraft is positioned in the hangar several hours before weighing so that it can assume an even temperature and be free from moisture. If weighing in the open is unavoidable, it should be carried out on a firm level site when wind force is at a minimum with the aircraft completely dry (i.e. not affected by frost or dew) and several readings should be taken at each reaction point to obtain a reliable average figure. Also particular care should be exercised if plumb bobs are to be used for taking measurements.

5.2.3 In order to obtain consistent results from different weighings, it is essential that an aircraft is placed in the 'rigging' position (i.e. with the longitudinal axis parallel to the floor). Jigged positions are normally built into an aircraft structure for levelling purposes and these may be used in conjunction with a spirit level or plumb bob and scale. Instructions supplied by the relevant aircraft manufacturer on levelling procedures and the positioning of equipment should be carefully followed and adhered to.

5.2.4 It should be noted, however, that some light aeroplanes with tail-wheel landing gear, have a negative load on the tail when in the rigging position as a result of the c.g. being forward of the main wheel centres. In such cases, and where it is not possible to use a jack at the nose of the aeroplane, a spring balance should be anchored securely to the ground and attached to the tail wheel axle to determine the extent of the negative reaction. Since this is a minus load, it should be deducted from the total weight, and must be treated as a minus quantity when calculating the c.g. position.

NOTES: 1) The weight of the spring balance, and any rope used to secure it to the aircraft, must be added to the spring balance reading.

2) Two position weighings, i.e. datum horizontal and nose up or down, are sometimes used when necessary to determine the vertical c.g. position, but this is not normally carried out by operators.

5.3 Weighing on Weighbridge Scales or Platforms

5.3.1 This is normally carried out with the aircraft resting on its wheels, but is often necessary to jack the aircraft at either the nose or tail to level it longitudinally. In the circumstances where the normal aircraft attitude is almost level, the manufacturer may recommend that the tyres or oleo struts are partially deflated to obtain the corrected position. The weight of any equipment used for levelling must be deducted from the weight recorded at the particular scale. The example given in Figure 4 is a nosewheel aircraft on which, because of landing gear deflection, it is required to measure the distance between reaction points.

5.3.2 **Electronic Platform Weighing Equipment.** To achieve the degree of accuracy possible with this type of equipment, careful preparation is important and this will include:

a) Checking and adjusting the platforms to a horizontal level in the longitudinal and lateral planes.

b) Switching on the instrumentation unit prior to weighing to allow for temperature stabilisation of electronic circuits as specified by the relevant equipment manufacturer.

c) Adjusting and setting each platform to zero datum point through the instrumentation unit.

d) Correcting the aircraft's longitudinal level.

e) Ensuring the hangar is free from destabilising draughts, e.g. hangar doors ajar, warm/cold air blowers, etc.

NOTE: After the aircraft has been weighed and removed from the platforms, a platform zero datum check at the instrumentation unit should be repeated.

5.3.3 With the main wheels located centrally on the weighbridge platforms and wheels checked, the wheel brakes should be released and the nose raised or lowered until the fuselage is longitudinally level. Plumb bobs should be suspended from the centrelines of the main wheel axles on the inner side of the wheels, and the two positions marked on the floor (see Figure 5). The midway point between these two marks represents the rear reaction point. A plumb bob suspended from the centrelines of the nose-jacking point will enable the distance between the front and rear reaction points to be measured (see Figures 4 and 5).

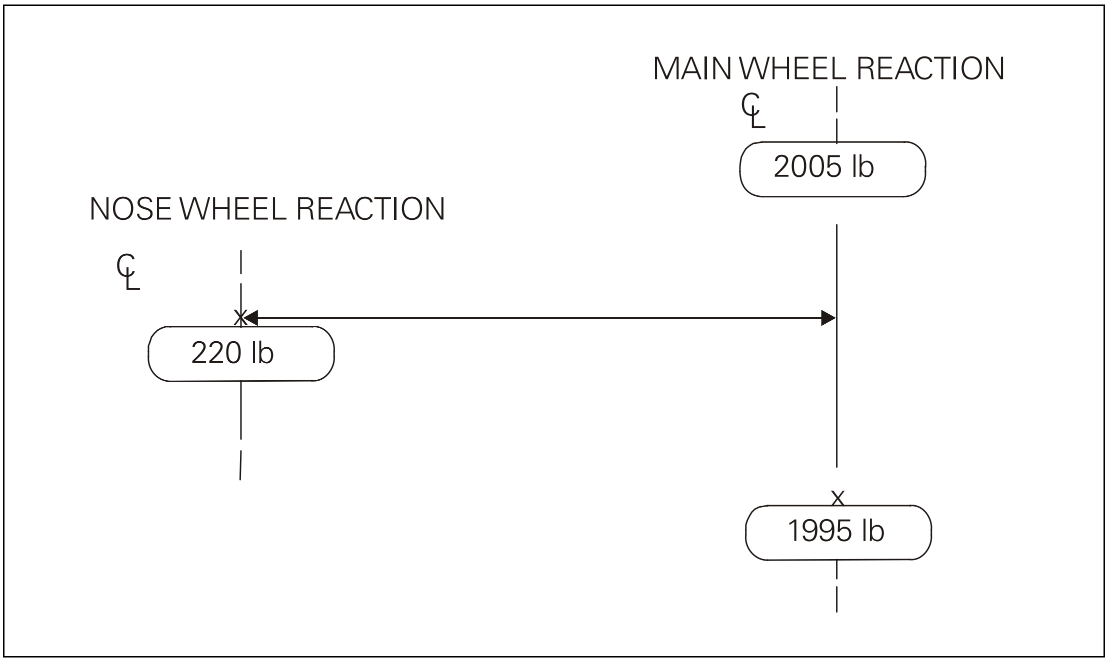

Figure 4 Light Aircraft

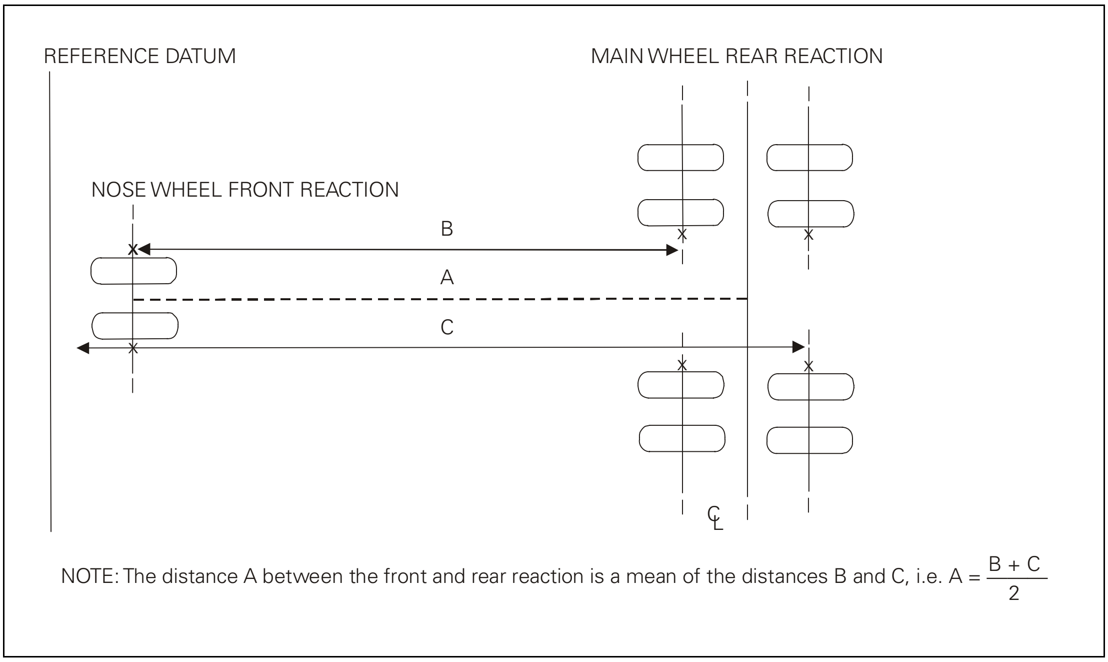

Figure 5 Heavy Aircraft

5.3.4 The c.g. can then be found by the following formula:

$$\frac{A \times W_1}{W_2}$$

Where A = distance between front and rear reactions

W_1 = weight at the nose or tail wheel

W_2 = Basic Weight

For example:

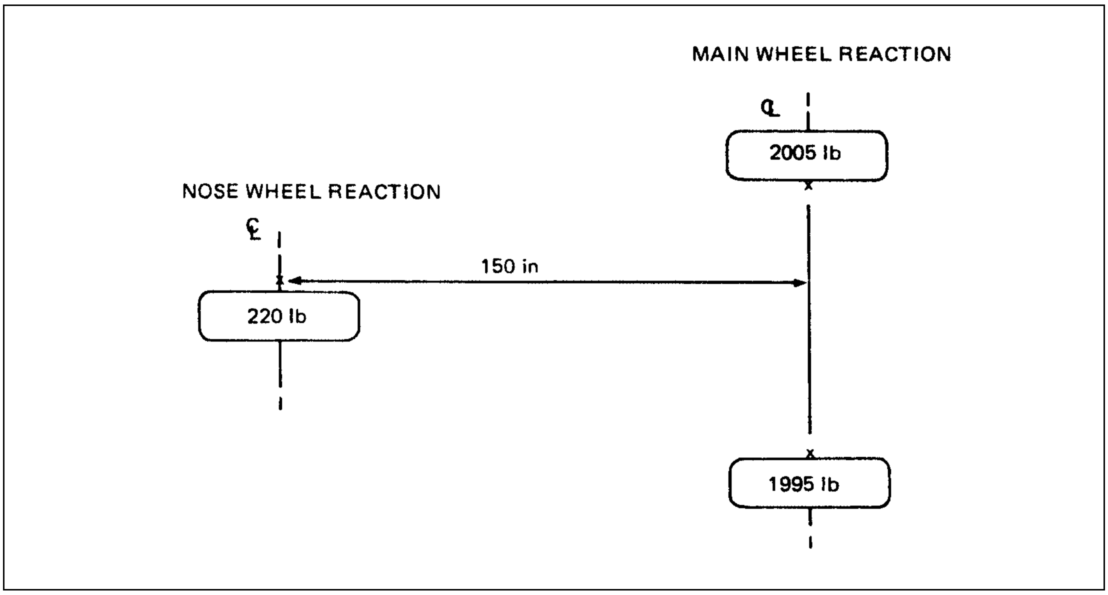

Figure 6 Centre-of-Gravity Relative to the Main Wheels

$A = 150$ in

$W_1 = 220$ lb

$W_2 = 4220$ lb (i.e. 220 + 1995 + 2005)

$$\text{Thus:} \quad \frac{A \times W_1}{W_2} = \frac{150 \times 220}{4220 \text{ lb}}$$

$$= \frac{33\,000 \text{ lb in}}{4200 \text{ lb}}$$

$$= 7.82 \text{ in}$$

∴ the c.g. is 7.82 in forward of main wheel centreline.

5.4 Reference Datums

5.4.1 Whenever a c.g. distance is reference to the main wheel centreline, it should always be corrected to relate to the reference datum, and its associated moment calculated. The purposes of this correction are twofold. Firstly, in terms of measurement, it relates the c.g. to the reference datum. Secondly, in terms of total moment (and Basic Weight), it establishes the necessary mathematical datum point for subsequent calculations with regard to the operation and maintenance of the aircraft.

5.4.2 Centre-of-Gravity correction to the reference datum is achieved by:

a) suspending a plumb bob from the reference datum,

b) measuring the distance, parallel to the aircraft's longitudinal centreline, from the reference datum to the main wheel reaction point centreline and,

c) either adding or subtracting this measurement to or from the distance of the c.g. from the main wheel centreline.

Example 1:

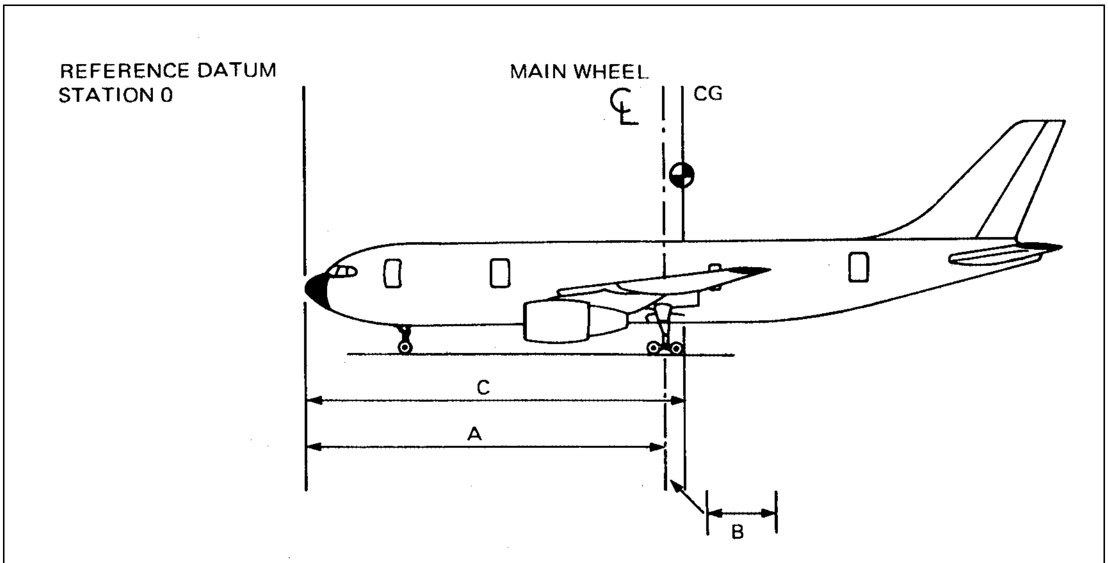

Figure 7 Centre-of-Gravity Correction to the Reference Datum

A	=	626 in forward of the main wheel reaction
B	=	50 in aft of the main wheel reaction
C	=	A + B

∴ the c.g. is 676 in aft of the reference datum

Example 2:

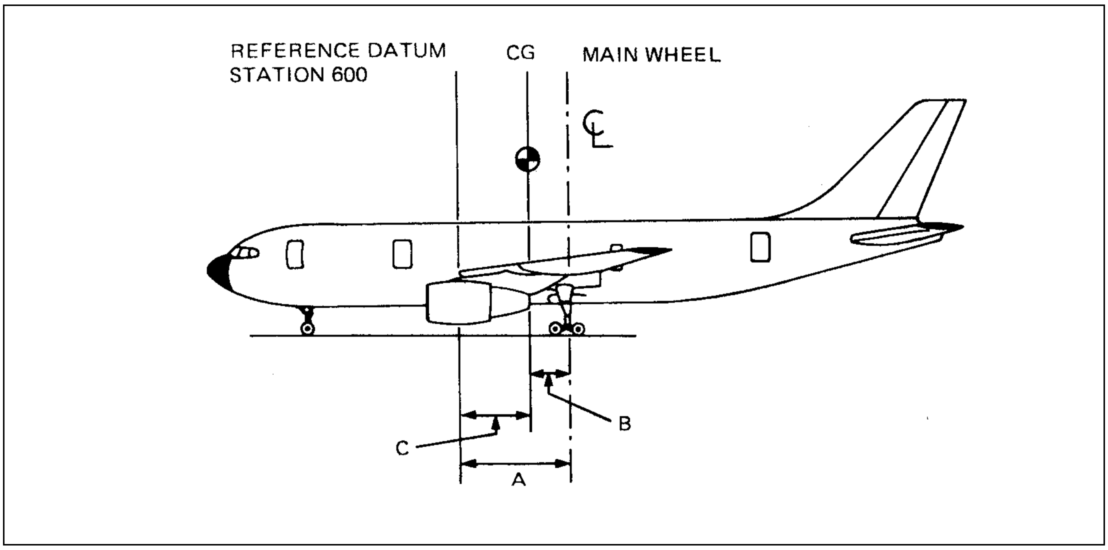

Figure 8 Centre-of-Gravity Correction to the Reference Datum

A	=	260 in forward of the main wheel reaction
B	=	100 in forward of the main wheel reaction
C	=	A – B

∴ the c.g. is 160 in aft of the reference datum

5.4.3 Total moment can then be found by the following calculation:

Arm of the c.g. from the reference datum x Basic Weight.

For example, if a hypothetical Basic Weight of 84 000 lb is attached to the aircraft shown in Figure 7, the calculation would be as follows:

Arm of the c.g. from reference datum	=	676 in
Basic Weight	=	84 000 lb
	=	84 000 x 676
Total Moment	=	56 784 000 lb in

Accordingly the Weight and Centre-of-Gravity Schedule will state:

Basic Weight	:	84 000 lb
Centre-of-Gravity	:	676 in aft of the reference datum
Total Moment about the datum	:	567 840 lb in/100

NOTE: Once the c.g. and its related moment have been established, any subsequent changes to the aircraft in terms of loading, fuel uplift or modification, etc. can be re-calculated from the original Basic Weight and moment (see paragraph 6 for further details).

5.4.4 The most commonly used reference datum adopted by the majority of aircraft manufacturers is, at, or forward of, the nose of the aircraft (e.g. fuselage station zero), for the following reasons:

a) All items of equipment whether basic or additional, will be preceded by a '+' sign (i.e. aft of the datum) thereby simplifying weight and balance computations.

b) Offers an accessible point for the purposes of measurement and as such the moment of any item can be easily calculated by its weight and distance relative to its fuselage station.

c) Provides a common location for future 'series' aircraft, of the type.

5.5 **Tail-wheel Aircraft**

5.5.1 Illustrated in Figure 9, is a typical tail-wheel aircraft positioned in a level attitude on weighbridge type platforms with a reference datum aft of the main wheel centreline.

NOTE: When it is not possible to suspend a plumb bob from the nose-jacking point, due, for example, to the jack or the trestle being in the way, a measuring point should be found by suspending the plumb bob at a predetermined distance from the jacking point, this distance being used to determine the distance between the reaction points.

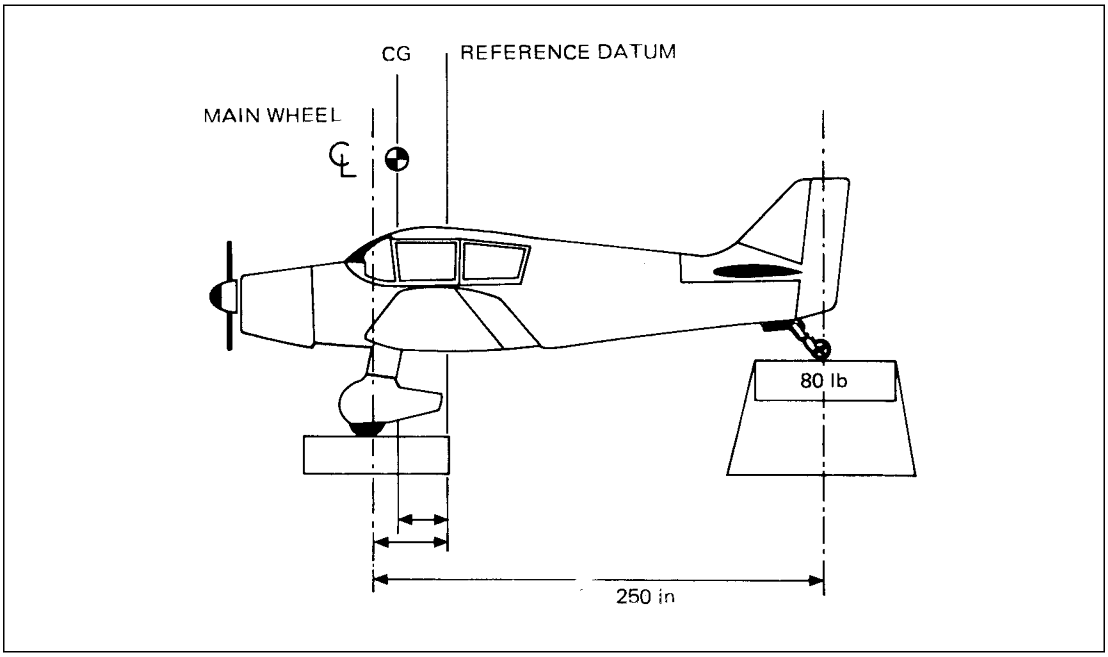

Figure 9 Tail-Wheel Aircraft

The weight at the right main wheel reaction	698 lb
The weight at the left main wheel reaction	702 lb
The weight at the tail wheel reaction	80 lb
TOTAL WEIGHT	1480 lb

5.5.2 To locate the c.g. of this type of aircraft the formula described in paragraph 5.2.4 can be adopted, i.e. tail-wheel distance A is multiplied by the tail-wheel weight, the result of which is divided by the basic weight as follows:

$$c.g. = \frac{A \times W_1}{W_2}$$

Where: A = 250 in

W_1 = 80 lb (weight at the tail wheel)

W_2 = 1480 lb

$$= \frac{250 \times 80}{1480 \text{ lb}}$$

$$= \frac{2000}{1480}$$

$$= 13.513 \text{ in}$$

∴ the c.g. is 13.513 in aft of the main wheel reaction, or alternatively 18.487 in forward of the reference datum (i.e. 32 in minus 13.513 in).

Or alternatively (see paragraph 5.6),

$$c.g. = \frac{\text{Total Moment (TM)}}{\text{Total Weight (TW)}}$$

	Weight (lb)		Arm (in)		Moment (lb in)
Right main wheel	698	x	(–) 32	=	(–) 22336
Left main wheel	702	x	(–) 32	=	(–) 22464
SUB TOTAL	1400				(–) 44800
Tail wheel	80	x	(+) 218	=	(+) 17440
				=	(–) 44800
					(+) 17440
TOTAL	1480				(–) 27360

$$c.g. = \frac{TM}{TW} = \frac{27360}{1480}$$

$$= (-)\ 18.487 \text{ in}$$

∴ the c.g. is 18.487 in forward of the reference datum.

5.6 **An Alternative Method of Weight and Balance Calculation**

5.6.1 There are various alternative methods to calculate the c.g. and moment of aircraft to that prescribed in the preceding paragraphs, once the basic weights and measurements have been established.

5.6.2 In the following example, the aircraft graphically described in Figure 10, is identical to that shown in Figure 6 except for the added reference datum. The method of calculation is the same as that used in paragraph 5.7, except that the subject aircraft has, as appropriate to this section, been weighed on platforms as opposed to aircraft jacks.

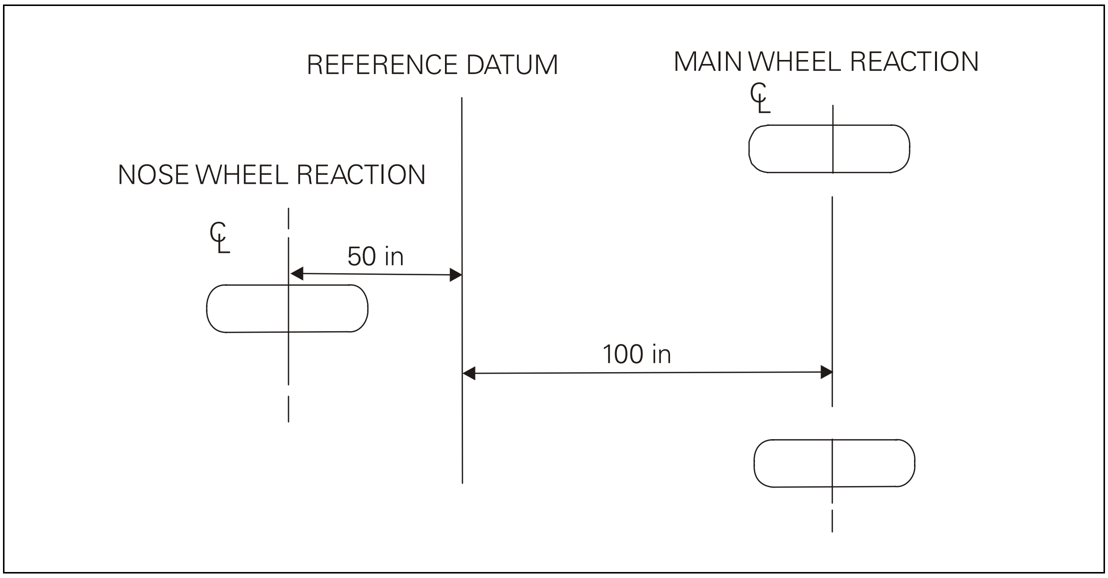

Figure 10 Centre-of-Gravity Relative to the Reference Datum

$$\text{c.g.} = \frac{\text{Total Moment (TM)}}{\text{Total Weight (TW)}}$$

	Weight (lb)		**Arm (in)**		**Moment (lb in)**
Left main wheel	1995	x	(+) 100	=	(+) 199 500
Right main wheel	2005	x	(+) 100	=	(+) 200 500
SUB TOTAL	4000				(+) 400 000
Nose wheel	220	x	(–) 50	=	(–) 11 000
TOTALS	4220				(+) 389 000

$$\frac{TM}{TW} = \frac{389\,000 \text{ lb in}}{4220 \text{ lb}}$$

= (+) 92.180 in aft of the reference datum.

Accordingly, the Weight and Centre-of-Gravity Schedule will state:

Basic Weight	:	4220 lb
Centre-of-Gravity	:	92.180 in aft of the reference datum
Total Moment about the datum	:	3890 lb in/100.

5.7 Weighing on Aircraft Jacks

5.7.1 It is important when weighing aircraft on jacks to strictly observe the procedures specified by the relevant aircraft manufacturer. Reference should also be made to Leaflet 10–1 – Aircraft Handling. Suitable adapters should be fitted to the aeroplane jacking points and the weighing units of adequate capacity fitted to jacks. The jacks should then be positioned under each jacking point, and the zero indication of the weighing units verified. The attitude of the aeroplane should then be checked by means of levels or plumb bobs as appropriate. The aeroplane wheel brakes should then be released and the jack situated at the lowest jacking point raised until the aeroplane is level. The remaining jacks may then be raised to contact their respective jacking points. All jacks should then be raised slowly together (maintaining a level attitude) until the aircraft wheels are clear of the ground. When final adjustments have been made to level the aircraft, readings should be taken from each weighing unit, after which the aircraft may then slowly be lowered to the ground. To ensure that representative readings are obtained when using hydrostatic units or load cells, it is essential that a second weighing is carried out.

NOTE: When electrical weighing cells are being used it is often recommended that they should be switched on 30 minutes before commencing weighing operations, in order that the circuits have time to stabilise.

5.7.2 The weight and c.g. of the aeroplane can then be calculated as in the example given below, for an aircraft whose c.g. reference datum is quoted as fuselage station zero and on which the jacking points are situated at 50 and 180 in aft of the datum.

$$\text{c.g.} = \frac{\text{Total Moment (TM)}}{\text{Total Weight (TW)}}$$

		Weight (lb)		Arm (in)			Moment (lb in)
a)	Left jack reaction	1995	x	(+) 50	=	(+)	99750
b)	Right jack reaction	2005	x	(+) 50	=	(+)	100250
c)	Tail jack reaction	900	x	(+) 180	=	(+)	162000
TOTAL		4900				(+)	362000

$$\text{c.g.} = \frac{\text{Total Moment (TM)}}{\text{Total Weight (TW)}} = \frac{362\ 000\ \text{lb}}{4900\ \text{lb}}$$

$$= 73.88\ \text{in}$$

Accordingly, the Weight and Centre-of-Gravity Schedule will state:

Basic Weight	:	4900 lb
Centre-of-Gravity	:	73.88 in aft of the reference datum
Total Moment about the datum	:	3620 lb in/100.

5.8 Weighing Rotorcraft

5.8.1 Rotorcraft are normally weighed in a similar way to fixed-wing aircraft, four jacking points being located in the fuselage near the wheels. The c.g. datum is, however, normally located on the vertical line through the centroid of the main rotor and is marked on the side of the fuselage. Moments may therefore be either positive or negative and the permissible c.g. range extends either side of the datum.

5.8.2 The hydrostatic weighing of rotorcraft by the single point method can be used when permitted by the manufacturer. The process consists of suspending the craft from a single hydrostatic weighing unit at the rotor head. The c.g. is determined by measuring defined angles, and then entering the results into tables supplied by the manufacturer.

5.8.3 To ensure that the rotor blades are symmetrically located about the rotor axis, it is usually necessary to fit locks to the rotor head. The weight of these locks must be taken into account when calculating the c.g. position.

5.8.4 On some rotorcraft it may also be necessary to determine the vertical and transverse positions of the c.g., and the manufacturer's instructions regarding the method of calculation should be followed.

5.9 Standard Mean Chord

Since the c.g. is an aerodynamic consideration, its position is sometimes additionally specified as a percentage of the Standard Mean Chord (SMC) of the wing, measured aft from the leading edge (see paragraph 2.8.3 e)). The percentage SMC may be calculated as follows:

$$\frac{A - B}{C} \times 100$$

Where A = distance of the c.g. from the reference datum

B = distance of the SMC leading edge from the reference datum

C = the length of the SMC.

For example:

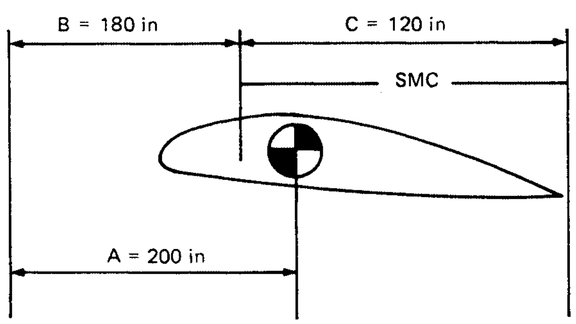

Figure 11 Standard Mean Chord

$$\therefore \frac{A - B}{C} \times 100 = \frac{200 - 180}{120} \times 100$$

$$= \frac{20}{120} \times 100$$

$$= 16.6\%$$

6 Change in Basic Weight

6.1 General

When an item of Basic Equipment is added, removed or repositioned in an aircraft, calculations must be made to determine the effect on both Basic Weight and c.g. This information should then be used to prepare a revised Weight and Centre-of-Gravity Schedule – Part A (see paragraph 2.9).

6.2 Modifications

Where the total weight and moment for additional equipment is not quoted in the appropriate Modification Leaflet, the equipment, and any parts used for attachment purposes, such as brackets, nuts, bolts, rivets, sealant, etc. must be accurately weighed. The position of the additional material must then be determined, and its moment calculated relative to the c.g. datum.

6.3 In order to find the new Basic Weight and moment of the aircraft, the weight and moment of the equipment added or removed must be considered in relation to the original Basic Weight as follows:

a) When equipment has been added the weight must be added to the original Basic Weight; if the arm of the new equipment is positive (i.e. aft of the c.g. reference datum) then the moment must be added to the original moment, whereas if the arm is negative (i.e. forward of the c.g. reference datum) then the moment must be subtracted from the original moment.

b) When equipment has been removed the weight must be deducted from the original weight; if the arm of the equipment was positive then the moment must be deducted from the original moment, whereas if the arm was negative then the moment must be added to the original moment.

c) The new c.g. position is calculated by dividing the new total moment by the new basic weight.

NOTE: It may be found convenient to use mathematical signs to confirm the final action in the above calculations. For example, if equipment is added '+' and its arm is positive (+), since + x+=+, then its moment must be added to the original moment, but if equipment is removed "–" and its arm was positive (+), since –x+=–, then its moment must be subtracted from the original moment.

6.4 Examples of Alterations to Basic Weight

6.4.1 The following examples are for an aeroplane whose:

a) Basic Weight is 15 700lb,

b) c.g. reference datum is at fuselage station 105, i.e. 105 in aft of fuselage station zero,

c) c.g. is at station 130 i.e. + 25 in aft of the reference datum.

6.4.2 **Example 1**

A radar system is installed in the aeroplane which comprises:

a) a radar set which weighs 32 lb and is located aft of the reference datum at fuselage station 125, with

b) a controller which weighs 2 lb and is located at fuselage station 65, forward of the reference datum, and

c) a scanner which weighs 25 lb and is located at fuselage station 12, forward of the reference datum.

			Weight (lb)	**Arm (in)**	**Moment (lb in)**
Original aircraft			15700	(+) 25	(+) 392500
Added items	(a)	+	32	(+) 20	(+) 640
	(b)	+	2	(–) 40	(–) 80
	(c)	+	25	(–) 93	(–) 2325
Revised Basic Weight and moment		+	15759		(+) 390735

With the revised Basic Weight and moment the c.g. can be calculated as follows:

$$\text{c.g.} = \frac{TM}{TW}$$

$$= \frac{390\ 735}{15\ 759}$$

$$= 24.79 \text{ in.}$$

Accordingly, the Weight and Centre-of-Gravity Schedule will state:

Basic Weight	:	15 759 lb
Centre-of-Gravity	:	24.79 in aft of the reference datum
Total Moment about the datum	:	3096 lb in/100.

6.4.3 **Example 2**

The aeroplane's heating and air conditioning unit is removed from fuselage station 65 to fuselage station 180.

	Weight (lb)	**Arm (in)**	**Moment (lb in)**
Original aircraft	15700	(+) 25	(+) 392500
Item removed	– 120	(–) 40	(+) 4800
Item replaced	+ 120	(+) 75	(+) 9000
Revised Basic Weight and moment	+ 15700		(+) 406300

With the Basic Weight unchanged and a revised moment the calculations are as follows:

$$\text{c.g.} = \frac{TM}{TW}$$

$$= \frac{406\ 300}{15\ 700}$$

$$= 25.87 \text{ in.}$$

Accordingly, the revised Weight and Centre-of-Gravity Schedule will state:

Basic Weight	:	15 700 lb
Centre-of-Gravity	:	25.87 in aft of the reference datum
Total Moment about the datum	:	4063 lb in/100.

7 Loading of Aircraft

7.1 General

In accordance with the Air Navigation Order, the Commander of an aircraft registered in the United Kingdom, must be satisfied before the aircraft takes off, that the load carried is of such weight and so distributed and secured, that it may safely be carried on the intended flight. To ensure this, the Variable and Disposable Loads must be added to the Basic Weight and c.g. of the aircraft and the total weight and c.g. determined. If the aircraft exceeds 5700 kg MTWA or has a seating capacity of 12 or more persons, the loading is based on assumed weights for persons and baggage, otherwise the actual weights must be used. For further information see Air Navigation Order (General) Regulations.

7.2 Small Aircraft

7.2.1 On small aircraft the calculations are fairly simple since the only item which alters appreciably during flight is the fuel quantity. Calculations should include all the variable and disposable items, at both maximum and minimum fuel states, to ensure that the c.g. will remain within the limits as fuel is used up.

NOTE: To minimise the calculations involved, some aircraft Operating Manuals include a graph of the c.g. limitations in the form of a weight/moment envelope.

7.2.2 On some aircraft the loadings which will give the maximum forward and aft c.g. positions are included in the weight and balance data. For example, on most four seat aircraft the maximum forward c.g. position is reached with the pilot only, no baggage and minimum fuel, and the maximum aft c.g. is normally obtained with pilot and two rear seat passengers, maximum baggage and maximum fuel. Provided these loadings are within limits it will not normally be necessary to calculate weights and moments before each flight. However, in the fully laden condition the maximum weight or aft c.g. limits may be exceeded, therefore, it may be necessary to offload passengers, baggage or fuel, depending upon requirements of a particular flight.

7.3 Large Passenger and Cargo Aircraft

7.3.1 With large aircraft the moment of items such as fuel, passengers and cargo are considerable and the procedures for determining a particular loading become complicated. In addition to the longitudinal c.g. calculation it is also usually necessary to ensure that distribution of fuel and cargo is satisfactory in a transverse (lateral) direction. Most airlines employ a specialist section dealing with loading calculations, whose responsibility it is to produce a load sheet for each flight.

7.3.2 The main item of variable moment during flight is the fuel, and although correct management of the fuel system will minimise c.g. movement, some variations will remain due to the impracticability of locating all fuel near the c.g. on modern swept-wing aircraft. The critical points in the c.g. envelope are caused by fuel usage and variations in specific gravity, these variations are calculated and applied to the envelope to curtail its boundaries.

7.3.3 The c.g. limitations are further curtailed by fixed allowances for other variable items such as the following:

a) Seating allowance, which is calculated to provide for out-of-balance seating loads resulting from empty seats or passenger weight variation.

b) Flight allowance, which is provided to allow for the normal movement of crew and passengers during flight.

c) Moment changes due to operation of the landing gear or flaps.

7.3.4 Weights and moments of passengers and cargo are then calculated, the cargo being arranged within the fuselage or holds in such a way that the total weight and moment of the loaded aircraft fall within the curtailed limitations. The heavier pieces of cargo or pallets are normally located close to the c.g. to restrict their effect, due attention being paid to floor loading limitations, strength and number of lashing points, etc.

7.3.5 On some aircraft it is also necessary to predetermine the order of loading fuel, cargo and passengers, in order to ensure that the structural limits are not exceeded, by excessive out-of-balance forces tending to tip the aircraft on its tail.

7.3.6 A Load Sheet, similar to the one shown, is prepared for each flight, the weights and moments with zero fuel and maximum fuel being entered in the c.g. envelope to ensure satisfactory balance and performance throughout all phases of flight, i.e. take-off, climb, cruise and landing.

Table 1 Typical Load Sheet

		Weight (lb)	Arm (in)	Moment (lb in/1000)	CG (% SMC[1])
Basic Weight		100 000	210	21 000·00	29·2
Variable Load					
Pilot		165	100	16·50	
Navigator		165	100	16·50	
Engineer		165	120	19·50	
Steward		165	300	49·50	
Crew baggage		100	110	11·00	
Passenger seats,	50 1st class	450	170	76·50	
	100 tourist	600	280	168·00	
Drinking water		250	130	32·50	
Liferaft		300	410	123·00	
Emergency transmitter		30	120	3·60	
Service equipment (food, etc.).		200	400	80·00	
Operating Weight		102 590	211	21 596·60	30·0
Disposable Load					
Passengers	1st class (35)	5 775	160	924·00	
	Tourist (83)	13 695	270	3 697·65	
Cargo	No. 1 hold. .	500	100	50·00	
	No. 2 hold. .	450	200	90·00	
	No. 3 hold. .	500	280	140·00	
	No. 4 hold. .	400	350	140·00	
Zero Fuel Weight.		123 910	215	26 638·55	33·3
Fuel	Nos 2 and 4 tanks	10 000	150	1 500·00	
	Nos 1 and 3 tanks	10 000	200	2 000·00	
	Reserve tanks	5 000	240	1 200·00	
Take-off Weight		148 910	210	31 338·55	29·22

1. SMC is explained in paragraph 5.9. In this example % SMC is derived from the formula. $\frac{(c \cdot g \cdot arm - 175) \times 100}{120}$ (i.e. length of the SMC is 120 in and its leading edge is 175 in aft of fuselage station zero).

APPENDIX

Typical Weight and Centre-of-Gravity Schedule

Reference	:	NAL/286
Produced by	:	Loose Aviation Ltd
Aircraft Designation	:	Flynow 2E
Nationality and Registration Marks	:	G-BZZZ
Manufacturer	:	FLY Co Ltd
Manufacturer's Serial	:	44
Maximum Total Weight Authorised (MTWA)	:	7300 lb
Centre-of-Gravity Limits	:	Refer to Flight Manual Reference Number 90/946

Part 'A' Basic Weight

The Basic Weight of the aircraft (as calculated from Weight and Balance Report/Weighing Record NAL/W/95[1] dated 31 August 1977) is	:	5516 lb
The c.g. of the aircraft (in the same condition at this weight and with the landing gear extended) is	:	127 in aft of datum
The total moment about the datum in this condition in lb/100 is	:	7015

NOTE: The datum is at fuselage station 0 situated 114 in forward of the wing leading edge. This is the datum defined in the Flight Manual. All lever arms are distances in inches aft of datum.

The Basic Weight includes the weight of 5 gallons of unusable fuel and 1 gallon of unusable oil and the weight of the following items which comprise the list of Basic Equipment:

Item	Weight (lb)	Lever Arm (in)
2 Marzell propellers type BL-H3Z30	127 each	76
2 engine driven 100 ampere alternators	27 each	117
1 13 Ah Ni-Cd battery CB-7 etc.	31 etc.	153 etc.

Part 'B' Variable Load

The weight and lever arms of the Variable Load are shown below. The Variable Load depends upon the equipment carried for the particular role.

Item	Weight (lb)	Lever Arm (in)	Moment (lb in/100)
Pilot (one)		108	
De-icing fluid $1^1/_2$ gal	12	140	17
Life-jackets (seven)	14	135	19
Row 1 passenger seats (two)	60	173	104
Row 2 passenger seats (two)	60	215	129
Row 3 passenger seats (two)	60	248	149
Table	8	256	20
One stretcher and attachments (in place of seat rows 2 and 3)	45	223	100
Medical stores	15	250	37

1. Delete as appropriate

Part 'C' Loading Information (Disposable Load)

The total moment change when the landing gear is retracted in lb in/100 is: –18. The appropriate lever arms are:

Item	Weight (lb)	Lever Arm (in)	Capacity (imp gal)
Fuel in tanks 1 and 2	1368[1]	145	190
Engine oil	50[1]	70	5.5
Forward baggage		21	
Rear baggage		261	
Passengers in Row 1 seats		171	
Passengers in Row 2 seats		213	
Passengers in Row 3 seats		246	
Patient in stretcher		223	

1. Densities – Petrol 7.2 lb/imp gal; kerosene 8.1 lb/imp gal; Oil 9.0 lb/imp gal.

NOTE: To obtain the total loaded weight of the aircraft, add to the Basic Weight and the weights of the Variable and Disposable Load items to be carried for the particular role.

This Schedule was prepared (date)....................and supersedes all previous issues.

Signed .... Inspector/Engineer

on behalf of ....

Approval reference ....

NOTE: (Not part of the Example Schedule). In Part 'B' Variable Load of this Schedule, the actual weight of the pilot is required in accordance with the Air Navigation (General) Regulations for aircraft the (MTWA) of which does not exceed 5700 kg or with less than 12 persons seating capacity. Hence the pilot’s weight and moment are omitted in the example.

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Leaflet 1-5 Aircraft, Engine and Propeller Log Books

1 Introduction

The Air Navigation Order (ANO), prescribes that a separate log book must be kept for each aircraft registered in the United Kingdom, for each engine and for each variable-pitch propeller fitted to such aircraft. The ANO also prescribes the information which must be recorded, the timescales within which the record must be made and the person responsible for keeping the log books. Also included in the ANO are the requirements for the retention of records, and details concerning acts in connection with log books which constitute offences under the Order.

2 Purpose

It is intended that a log book should constitute a history of the aircraft, engine or propeller to which it refers in terms of, as appropriate:

- Manufacturer;
- Date of Manufacture;
- Manufacturers No./Serial No.;
- Aircraft Registration;
- Type;
- Aircraft/engine to which fitted;
- Operator;
- Flying hours/cycles, etc;
- Maintenance;
- Continued compliance with mandatory requirements.

3 Source and Format of Log Books

3.1 For aircraft not exceeding 2730 kg MTWA, the CAA requires that all log books shall be CAA approved. CAA publications CAP 398, 399 and 400 meet this requirement for aircraft, engines and propellers respectively in this category and are intended to comprise a self-contained record of the item to which they refer.

3.2 For aircraft exceeding 2730 kg MTWA, the log book can take any form acceptable to the CAA. CAA publications CAP 388, 391 and 408 are suitable log books for propellers, engines and aircraft respectively in this category.

3.3 **Alternative Form of Log Book**

To enable acceptance of an alternative technical record system the following features should be taken into account:

a) Compliance with the requirements of the ANO must be shown;

b) The record must be kept in indelible hard copy form or in the form of a computer memory acceptably safeguarded against erasure and available when required as a printed-out hard copy;

c) Any computer system used must be capable of a total quarantine of the record for a particular aircraft, engine or variable-pitch propeller on command and must be capable of a subsequent print-out of data in a form acceptable to the CAA;

d) Safeguards against erasure of any computer memory must include adequate defences against fraud, malpractice, incompetence and accidents such as power failure. Any erase function must be unavailable once data is committed to the memory;

NOTE: The requirements of Article 94 of the ANO 2005 (as amended) apply to all forms of technical record and must be satisfied.

e) Any recording system offered for acceptance must be capable of maintaining the required timescale for updating;

f) On any occasion requiring the transfer of responsibility for the upkeep of a technical record system the form taken by the system must lend itself to removal without loss of content;

g) In a computer system the information comprising the log book in the terms of the requirements should, when printed out, be in a coherent format and legible to the user without a need for in-depth knowledge of computer language. In addition, to enable the efficient conduct of investigations the required data should, when printed out, preferably be discrete from other data stored in excess of the requirements.

NOTE: Any extension of the log book in the form of files, appendices, subsidiary records held elsewhere such as by Non-Destructive Testing (NDT) specialists or Test Houses are deemed in a legal sense to be part of the subject log book and must be treated accordingly, including the retention of a clear cross-references association with the basic log book.

4 Timescale Limitations for the Upkeep of Records

4.1 Apart from those entries shown in paragraph 4.2, each entry should be made as soon as is practicable after the occurrence to which it relates, but in no event more than seven days after the expiry of any Certificate of Maintenance Review (CMR) in force at the time of the subject occurrence. (See BCAR Section A, Chapter A6–2 for information on CMR.)

4.2 In engine and variable-pitch propeller log books, where the operator has chosen to record total aggregated flying time accrued since the last issue of a Certificate of Release to Service (CRS), each entry related to flight time must be made on the occasion of any work which will require the issue of the next CRS. (See BCAR Section A, Chapter A6–2 for information on CRS.)

4.3 There are aircraft which do not necessarily require a CMR or a CRS by virtue of their Certificate of Airworthiness (C of A) Category and MTWA (see paragraph 5.1.5). The operators of such aircraft should however, bear in mind that the validity of any C of A depends on continued compliance with any applicable Approved Maintenance Schedule and with all applicable mandatory requirements. It follows that a regular review of maintenance and adherence to proper standards are essential even when certifications to that effect are not legally required.

5 Information to be Recorded

5.1 Information which must be Recorded

The following is, in part, quoted from the ANO.

5.1.1 Aircraft Log Book

The following entries shall be included in the aircraft log book:

a) the name of the manufacturer, the type of the aircraft, the number assigned to it by the manufacturer and the date of the manufacture of the aircraft,

b) the nationality and registration marks of the aircraft,

c) the name and address of the operator of the aircraft,

d) the date of each flight and the duration of the period between take-off and landing, or, if more than one flight was made on that day, the number of flights and the total duration of the periods between take-off and landings on that day,

e) particulars of all maintenance work carried out on the aircraft or its equipment,

f) particulars of any defects occurring in the aircraft or in any equipment required to be carried therein by or under the ANO, and of the action taken to rectify such defects including a reference to the relevant entries in the technical log required by the ANO, and

g) particulars of any overhauls, repairs, replacements and modifications relating to the aircraft or its equipment.

NOTE: Entries are not required to be made under sub-paragraphs e), f) and g) in respect of any engine or variable-pitch propeller (see respectively paragraphs 5.1.2 and 5.1.3).

5.1.2 Engine Log Book

The following entries shall be included in the engine log book:

a) the name of the manufacturer, the type of the engine, the number assigned to it by the manufacturer and the date of the manufacture of the engine;

b) the nationality and registration marks of each aircraft in which the engine is fitted;

c) the name and address of the operator of each such aircraft;

d) either,

   i) the date of each flight and the duration of the period between take-off and landing or, if more than one flight was made on that day, the number of flights and the total duration of the periods between take-offs and landings on that day; or

   ii) the aggregate duration of periods between take-off and landing for all flights made by that aircraft since the immediately preceding occasion that any maintenance, overhaul, repair, replacement, modification or inspection was undertaken on the engine;

e) particulars of all maintenance work done on the engine;

f) particulars of any defects occurring in the engine, and of the rectification of such defects, including a reference to the relevant entries in the technical log required by the ANO; and

g) particulars of all overhauls, repairs, replacements and modifications relating to the engine or any of its accessories.

5.1.3 **Variable-Pitch Propeller Log Book**

The following entries shall be included in the variable-pitch propeller log book:

a) the name of the manufacturer, the type of the propeller, the number assigned to it by the manufacturer and the date of the manufacture of the propeller;

b) the nationality and registration marks of each aircraft, and the type and number of each engine, to which the propeller is fitted;

c) the name and address of the operator of each such aircraft;

d) either;

i) the date of each flight and the duration of the period between take-off and landing or, if more than one flight was made on that day, the number of flights and the total duration of the periods between take-offs and landings on that day; or

ii) the aggregate duration of periods between take-off and landing for all flights made by that aircraft since the immediately preceding occasion that any maintenance, overhaul, repair, replacement, modification or inspection was undertaken on the propeller;

e) particulars of all maintenance work done on the propeller;

f) particulars of any defects occurring in the propeller, and of the rectification of such defects, including a reference to the relevant entries in the technical log required by the ANO; and

g) particulars of any overhauls, repairs, replacements and modifications relating to the propeller.

5.1.4 A clear record of continued compliance with all applicable mandatory requirements is required.

5.1.5 Each record of work done should, when required, be covered by a CRS unless the certification has been made elsewhere, in which case it must be cross-referred to in the log book (BCAR Section A, Chapter A6–7 and Section B, Chapter B6–7 refers). Currently a CRS is required for all types of work except on aircraft in the Special Category not exceeding 2730 kg MTWA, and aircraft in the Special or Private categories of similar weight, when the work done comes within the provisions of the Air Navigation Regulation which specifies work which can be carried out personally by the owner or operator if he is a licensed pilot. In all such cases the work done should be recorded and signed for in the log book by the person carrying out the work. There may be cases when the CAA will direct that a CRS is to be issued under exceptional circumstances. In such cases the C of A will be endorsed to that effect.

5.1.6 Whenever a Certificate of Fitness for Flight is issued in accordance with BCAR Section A, Chapter A3–8 and Section B, Chapter B3–8, the aircraft log book should be endorsed with the reason for its issue including the condition being invoked (i.e. the specific 'A' Condition), and a copy included in the log book.

5.1.7 Duplicate inspections certified in accordance with BCAR Section A, Chapter A6–2 must be recorded in the appropriate log book except that, if made elsewhere such as in the Technical Log, they may be cross-referred to in the log book.

5.1.8 For aircraft exceeding 2730 kg MTWA, it is required that a separate Modification Record Book be maintained. A suitable book is available from the CAA (CAP 395).

5.2 **Information Recording Practice**

5.2.1 **General**

a) Maintenance and Inspection (including routine inspections)

i) When maintaining the record of compliance with mandatory requirements, all sources of such requirements must be complied with. The primary source is the regulatory authority of the country of design certification of the aircraft, engine, propeller or items of equipment, in addition to which there may be CAA Additional Directives imposed and CAA Airworthiness Notices of a mandatory nature.

ii) When a mandatory requirement is of a repetitive nature it is important to highlight this fact so that it will not be confused with once-only requirements.

iii) Inspections of an optional nature, if adopted, should be recorded. It is recommended that such inspections, when strongly recommended by the manufacturers, should either be adopted or the justification for non-adoption be recorded.

iv) When a mandatory requirement can be complied with via a choice or combination of options, the method of compliance must be recorded, and where compliance is by a series of progressive actions the extent of compliance must be kept accurately on record.

v) When raising log books for imported aircraft, engines or propellers, a copy of the C of A for Export should be attached. After C of A renewal, the cut-off point used in the review of the technical record should be highlighted. Usually, in log books this is achieved by ruling off the affected page, recording totals for each column and continuing on a fresh page. In order to facilitate any maintenance review required by the ANO, it is essential that the record is kept in a form and location readily accessible to the person carrying responsibility for the review.

vi) When considering adjustable-pitch propellers in relation to the requirements for log books it would be sensible to deem such a propeller to be of variable pitch, resulting in a need for a log book. The alternative approach would be to treat it as any other major part with no log book, i.e. all information to be included in the Aircraft Log Book.

b) Overhauls

Details of any overhauls should be included in the relevant log book except that where the details are contained in another document such as an Approved Certificate or equivalent foreign certification acceptable to the CAA, it is only necessary to make a cross-reference in the log book to identify the document. Such documents should be retained as part of the record.

c) Replacements

i) Details of any replacements should be included in the relevant log book. Where any component is the subject of a life control system, it must be possible to readily establish the status of such components relative to the life control system.

ii) Various methods are available to prove component status but two are perhaps more common, i.e. component listings and component cards. These cards must include the date and aircraft hours or other parameter(s) at which the item was fitted and the remaining life available on the item. Note that lives can be expressed in a number of parameters apart from hours flown, and the record must be made in terms of whatever parameter is specified by the manufacturer. Particular care must be exercised where a component is the subject of a mandatory requirement to ensure that the component fitted is always in compliance with the requirement.

iii) Where component life control is by on-condition monitoring then the performance control parameter(s) should be recorded (where possible in a way that shows any deterioration progressively) and the record kept must be compatible with the statistical system in use. In all cases the record of component changes, or the history of rectification of a system defect should show the precise identity of items removed and fitted and all known detail of life available and expended, in addition to the reason for the work.

iv) When a major component such as an engine, wing flap, etc. is changed, a record of all parts or accessories transferred from the removed item to the fitted item should be made, showing when necessary, remaining life available. Any serviceable items being re-used without re-lifing should follow a similar procedure. The information recorded should include the origin and prior location of the item. It is thus clearly vital that parts recovered from out-of-use aircraft or major assemblies for possible future re-use must at the time of recovery only be considered acceptable if their history of use is genuinely known and on record and their condition established by a person or organisation approved for the purpose. Where a component has been recovered from an aircraft involved in an incident/accident, reference must be made to CAAIP Leaflet 11-28.

d) Repairs

i) A summary of any repair must be recorded including the reason for the work, with reference to supporting documentation, and must be accompanied by a CRS made by a person appropriately authorised in relation to the scope of the repair.

ii) The log book record must include proof of origin of all materials and parts used unless the organisation concerned is CAA Approved and operates a system under the Approval for the control of procurement and use of materials or parts.

iii) Any record of repair involving welding should include the welder's Approval number, in addition to a CRS which must be issued by the person taking responsibility for the work.

e) Modifications

i) All modifications must be recorded in the appropriate log book and when required, in the Modification Record Book, quoting the title and the authorisation. The latter can take the form of an Airworthiness Approval Note (AAN) number issued by the CAA, a CAA Form AD 261 reference number issued by the CAA, an Alert Service Bulletin, Service Bulletin or other document issued by an organisation taking design responsibility for the modification under a CAA Approval or by a foreign authority acceptable to the CAA. All supporting documents such as drawings, Supplemental Type Certificate, etc. should be listed or, if kept separately, cross-referred to.

ii) When the modification is satisfying a mandatory requirement the record should highlight this fact and should be cross-referred to in the separately maintained record of compliance with mandatory requirements, showing clearly the extent of compliance.

NOTE: Further information on modification procedure is contained in BCAR Section A, Chapter A2–5.

5.2.2 **Aircraft Log Books**

a) The identity of the engine and where appropriate, any propellers should be included. In the case of fixed-pitch propellers for which no log book is required, the Aircraft Log Book is likely to be the only location of such information.

b) It is usual to make provision for a range of rigging information with datums and tolerances, the completion of which would normally be the responsibility of the manufacturer or the person who initially issues the log book.

5.2.3 **Engine Log Books**

a) The installed location of the engine and the identity of the aircraft to which it is fitted should be shown. The Engine Inspection and Test Certificate should be fixed into the log book. This certificate should carry the data set out in BCAR Section A, Chapter A4–2 and include the date and reference of the CAA Approval Letter, or the latest issue of the Engine Type Certificate Data Sheet, the category of release (i.e. Experimental Flight, Transport Category – Passenger etc.), reference to inspection and test records and a list of parts subject to individual life control (overhaul, ultimate etc.).

b) For engines of modular manufacture, a log must be maintained for each module and the log must be treated as part of an engine's technical record for as long as it is installed on the particular engine. The module record should include full identity details, history of use, a record of flight times and cycles and maintenance and rectification work carried out. All life-limited components must be identified with their limiting parameters shown, e.g. the maximum permitted number of thermal cycles and proportion of life remaining. The log for that module which carries whole-engine identity and the Data Plate should in addition carry a record of module changes with identities as well as all the information normally required in an Engine Log Book. Each module record should have attached the manufacturers or overhaulers document approximating to the Engine Inspection and Test Certificate issued for a whole engine.

5.2.4 **Variable-Pitch Propellers**

The basic pitch setting should be recorded whenever it has been set, altered or verified. The identity of individual blades should be included initially and then maintained, since the log book associates with the hub.

6 The Upkeep of Log Books

6.1 Permanent legibility is the keynote. Handwritten entries must be made in ink or indelible pencil. Any document kept in or with the log book should be either securely attached or kept in an attached pocket but should not prevent reference to the page to which it is attached.

6.2 Initiation of a continuation log book is the responsibility of the user and he should transfer sufficient data for continuity and should number the log books consecutively.

6.3 Each completed column of figures should be totalled and carried forward.

6.4 Any error should be corrected but remain legible. The corrections should be signed. In a machine system errors discovered after the data has been inserted into the memory should be corrected by a new entry not an erasure and the correct entry annotated as a correction with an authorisation code.

6.5 All record keepers must remain aware of those actions which constitute offences under the ANO.

7 Transfer of Responsibilities for Upkeep of a Log Book System

7.1 After a log book or records system changes hands, it remains the responsibility of the previous operator or keeper to retain the existing record intact except that if the new operator or keeper demands custody of the existing records, it is a requirement that the previous keeper complies with the demand, at which time full responsibility for the record is also transferred. A new operator should ensure that the records reflect the new situation and any change of ownership if applicable.

7.2 Where an alternative form of Technical Records system was being utilised, continuation by a new owner, operator, or maintenance organisation, or the introduction of any other system may not be made without the prior approval of the CAA.

7.3 All log books and associated records must be retained until two years after the aircraft engine or propeller is destroyed or permanently withdrawn from use, whoever may be the custodian of the records.

Leaflet 1-6 The Problem of Bogus Parts

(Previously issued as AN 19)

1 The CAA is becoming increasingly concerned about the quantity and variety of unapproved parts which are finding their way on to UK registered aircraft, in particular helicopters. Evidence indicates that these counterfeit and/or fraudulently identified parts are being imported, largely from North America; however, the CAA also has evidence of such bogus parts originating from the UK and also other foreign sources.

1.1 Manufacturing and/or marketing bogus parts is not endemic to the United Kingdom but evidence of the falsification of release documentation (Form One or equivalent) has been observed.

1.2 Installing bogus parts onto aircraft has serious airworthiness implications; to illustrate just how serious, the following two examples are quoted involving aircraft which are available in the international market place:

a) A helicopter main rotor blade complete with release documentation was traced as having been scrapped by the manufacturer during the manufacturing process.

b) An engine mount described as fitted new to an aircraft in 1979 was traced as having been factory installed in 1966.

2 **UNAPPROVED PART** For the purpose of this Leaflet an Unapproved part is a part or material intended for installation on a type certificated product/aircraft, which has been neither manufactured according to approved procedures, nor conforms to an approved type design; or it fails to conform to declared specifications or accepted industry standards (i.e. standard parts).

2.1 Unapproved parts include, but are not limited to:

a) Parts specified in the illustrated parts catalogues (IPC) of a type certificated aircraft, but which have been manufactured, reclaimed or reworked and then marked by an unauthorised source and provided with documents which indicate falsely that the part(s) are genuine and conform to the approved type design, or meet a particular industry standard and are offered for use as conforming with an aircraft manufacturer's authorised IPC.

b) Parts shipped directly to users by manufacturers, suppliers, or distributors who do not themselves hold appropriate production approvals for the parts, and have not been authorised to make direct shipments to users or stockists by the Type Certificate holder, who alone has production approval, e.g. production overruns. This is a particular phenomenon in the United States.

c) Parts which have not been maintained, overhauled or repaired in accordance with the requirements of approved airworthiness data and/or statutory requirements, or that have been maintained, overhauled or repaired by persons not authorised to perform and certify these functions.

3 FAA SUSPECT UNAPPROVED PARTS NOTIFICATIONS

3.1 The FAA and CAA have intensified efforts to educate the public regarding the potential safety threat posed by aeronautical parts that do not meet applicable design, manufacturing or maintenance requirements. To achieve this, the FAA established a Suspect Unapproved Parts programme (SUPs) and issued guidance in an Advisory Circular 21-29B.

3.2 Suspect Unapproved Parts Notifications can be found on FAA Internet site: www.faa.gov/about/office_org/headquarters_offices/avs/offices/sup/

4 Because of the increased activity being undertaken in the United States against suspect unapproved parts, it is likely that the vendors of these parts will direct their activities towards Europe and other parts of the world because of the reduced risk of detection.

5 MANDATORY OCCURRENCE REPORTING PROCEDURES

5.1 Users of aircraft components and spares are reminded that suspected unapproved parts should be reported to the CAA through the Mandatory Occurrence Reporting (MOR) procedures.

5.2 Although the MOR procedure does not extend to piston engined aircraft used for Aerial Work or privately operated, and any aircraft with a Permit to Fly, users of aircraft parts or material for this class of aircraft are encouraged to use the procedure where suspect parts are identified.

5.3 On receipt of an MOR, and where appropriate, the CAA will pass the details to the FAA SUPs office by the submission of a SUPS Report. In addition to assisting the FAA, who are implementing a vigorous campaign against unapproved parts, this procedure will enable the CAA to establish the dimensions of the problem as it affects the United Kingdom.

5.4 To assist in tracing unapproved parts or material, persons raising an MOR should, as far as possible, provide the following information on their report:

a) The name of the suspected unapproved part.

b) Part number, or any other number on the part.

c) Serial number of part.

d) List next higher assembly that suspected unapproved part is assembled into (i.e. fuel pump, engine, landing gear) and list part number, if known.

e) Quantity of suspected unapproved parts found or identified.

f) Make and model number of the aircraft or component that the suspected unapproved part is applicable to.

g) The identification of the commercial source of the suspected unapproved part. If the part is identified with Part Manufacturer or Distributor marking, this should be quoted.

h) Describe any pertinent facts relating to the suspected unapproved part and identify where part may be inspected (provide photos, invoices, etc., if available).

i) The date suspected unapproved part was discovered.

j) Name and address in full or the location where suspected unapproved part(s) was discovered.

5.5 In accordance with normal protocol for confidentiality any SUPS report submitted to the FAA would not give details of the MOR reporter.

6 Foreign aircraft and approved component manufacturers can be contacted by users through their UK agent or direct, for verification that specific serial numbered items purported to be manufactured by them are in fact recorded in their archives. As an example, this process was used to verify that a particular helicopter main rotor head was in fact bogus.

7 THE CERTIFYING PERSON AND USER RESPONSIBILITY

7.1 The Certifying Person (User) can be either the Approved Organisation, a person authorized in accordance with that organisation's Exposition, or an appropriately CAA Type Rated Licensed Engineer, who issues the Certificate of Release to Service for installation of an aircraft part into an aircraft, its engine(s), propeller(s) or equipment.

7.2 The User of an aircraft part is responsible for ensuring that the part is serviceable and conforms to the standard determined by the appropriate Type Certificate holder as being suitable for the intended application. In order to discharge this responsibility to the satisfaction of the CAA/EASA, the user must, when obtaining an aeronautical part from a supplier:

a) Ensure that the purchase order contains accurate definition of the aircraft parts and full details of the quality control and certification requirements to be met by the supplier in satisfying the order;

b) Take all necessary steps to verify that the supplier is meeting the requirements of the purchase order. This may require the user visiting the supplier's facilities.

7.3 In order to contain the serious problem of unapproved parts, Commercial Air Transport Operators and associated Maintenance organisations who are users of aircraft spares should ensure that their aircraft spares purchasing policy and procedures are unequivocally stated in their company expositions/engineering procedural documents. They should also ensure that any deviation from that policy must be approved by the quality manager in accordance with procedures acceptable to the CAA.

7.4 Other organisations and private owners who purchase aircraft parts or materials can only be advised to exercise extreme caution and remember they will have to convince the user of the authenticity of such spares.

8 Airworthiness Notice Numbers 11, 16, 17 and 18 provide further information on the acquisition of parts and materials for use in aircraft.

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Leaflet 1-7 Condition Monitored Maintenance

1 Introduction

1.1 This Leaflet gives general information on the concepts and practices of aircraft maintenance control by the use of Condition Monitored Maintenance, and is derived directly from Civil Aviation Publication CAP 418. Definitions of the terms and abbreviations used in this Leaflet are given in paragraph 5.

NOTE: Defined terms are given an initial capital letter in the text.

1.2 Confidence in continued airworthiness has long been based on the traditional method of maintaining safety margins by the prescription of fixed component lives and by aircraft 'strip-down' policies. The call for changes to the basic philosophy of aircraft maintenance has been greatly influenced by the present day economic state of the industry as well as by changes in aircraft design philosophy allied to progress in engineering technology. These changes have in turn, resulted in the necessity for the management and control of expensive engineering activities to take a new and more effective form.

1.3 It is from this background that a maintenance process known as Condition Monitoring has evolved. Condition Monitoring is not a separate activity but a complete process which cannot be separated from the complete maintenance programme. It is not just an identification of a single maintenance action but is a basic maintenance philosophy.

1.4 Maximum use can be made of the Condition Monitoring process (which includes a statistical reliability element, see paragraph 3.3), when it is applied to aircraft meeting the following criteria:

a) Modern, multi-engined, Transport Category aircraft which incorporate in their design safeguards against the complete loss of the function which a system is intended to perform.

NOTE: These safeguards are provided by the provision of either Active Redundancy or Standby Redundancy. In simple terms the safeguards take the form of more than one means of accomplishing a given function. Systems (or functions within systems) beyond those necessary for immediate requirements are installed. These are so designed that with an Active Redundancy philosophy all the redundant Items are operating simultaneously and, in simple terms, sharing the load to meet the demand. Thus in the event of failure of one of the redundant Items, the demand will continue to be met by the remaining serviceable redundant Items; this process continues up to the extent of the Redundancy provided. The extent of the Redundancy provided, within practical limits, is related to the consequences of complete loss of the system function. (The term 'multiplicity of system function' is sometimes used in this context). With a Standby Redundancy philosophy only one redundant system is functioning at a time. If a function loss occurs, it is necessary to select (or activate) the functions provided by the 'standby' system(s). The principle is the same as for Active Redundancy and the term 'system redundancy' is sometimes used in this context.

b) Aircraft for which the initial scheduled maintenance programme has been specified by a Maintenance Review Board and to which a Maintenance Steering Group Logic Analysis[1] has been applied.

1. Should fuller details of the current Maintenance Steering Group process, or the process used in respect of a specific aircraft be required, these would have to be obtained from the regulatory authority responsible for the initial certification of that aircraft, or responsible for any subsequent Maintenance Review Board revisions employing a logic process.

NOTE: For an aircraft type introduced into service by Maintenance Review Board and Maintenance Steering Group procedures and where Condition Monitoring tasks are prescribed, a Condition Monitored Maintenance Programme (the Programme) will have to be established, even for a single aircraft.

1.5 Items which are not directly controlled by Condition Monitoring may be maintained by the traditional Hard Time or On-Condition processes, but the statistical reliability element of Condition Monitoring may, nevertheless, be applied for the purpose of monitoring their performance (but not be prescribed in the Maintenance Schedule as a primary maintenance process).

NOTE: For a statistical reliability element of a programme to be effectively used, a fleet minimum of five aircraft is normally necessary, but this can vary dependent upon the aircraft type and utilisation.

2 Primary Maintenance

2.1 The CAA recognises three primary maintenance processes. They are Hard Time, On-Condition and Condition Monitoring. In general terms, Hard Time and On-Condition both involve actions directly concerned with preventing failure, whereas Condition Monitoring does not. However, the Condition Monitoring process is such that any need for subsequent preventative actions would be generated from the process.

2.2 **The Processes**

2.2.1 **Hard Time**

This is a preventative process in which known deterioration of an Item is limited to an acceptable level by the maintenance actions which are carried out at periods related to time in service (e.g. calendar time, number of cycles, number of landings). The prescribed actions normally include Servicing and such other actions as Overhaul, Partial Overhaul, Replacement, in accordance with instructions in the relevant manuals so that the Item concerned is either replaced or restored to such a condition that it can be released for service for a further specified period.

2.2.2 **On-Condition**

This also is a preventative process but one in which the Item is inspected or tested, at specified periods, to an appropriate standard in order to determine whether it can continue in service (such an inspection or test may reveal a need for Servicing actions). The fundamental purpose of On-Condition is to remove an Item before its failure in service. It is not a philosophy of 'fit until failure' or 'fit and forget it'.

2.2.3 **Condition Monitoring**

This is not a preventative process, having neither Hard Time nor On-Condition elements, but one in which information on Items gained from operational experience is collected, analysed and interpreted on a continuing basis as a means of implementing corrective procedures.

2.3 Where a Maintenance Steering Group Logic Analysis has not been applied to a particular aircraft to establish and allocate the primary maintenance processes for each Item, the considerations of a), b) and c) will be applied separately to all Items to determine the acceptability of the primary maintenance process.

a) Hard Time

i) Where the failure of the Item has a direct adverse effect on airworthiness and where evidence indicates that the Item is subject to wear or deterioration.

ii) Where there is a Hidden Function which cannot be checked with the Item in-situ.

iii) Where wear or deterioration exists to such an extent as to make a time limit economically desirable.

iv) Where component condition or 'life' progression sampling is practised.

v) Where limitations are prescribed in a Manufacturer's Warranty.

b) **On-Condition.** Where an inspection or test of an Item to a prescribed standard (frequently insitu) will determine the extent of deterioration, and hence the 'condition', i.e. any reduction in failure resistance.

c) **Condition Monitoring.** Where a failure of an Item does not have a direct adverse effect on operating safety, and where a) and b) are not prescribed and no adverse age reliability relationship has been identified as the result of analysis of the data arising from a formalised monitoring procedure or programme.

3 Condition Monitored Maintenance

3.1 Introduction

Condition Monitored Maintenance, as a programme, is the formalised application of the maintenance processes Hard Time, On-Condition and Condition Monitoring to specific Items as prescribed in the Approved Maintenance Schedule. The controlling activity of Condition Monitored Maintenance is Condition Monitoring irrespective of whether Condition Monitoring is prescribed as a primary maintenance process in the Approved Maintenance Schedule or not. Condition Monitoring is repetitive and continuous, the key factor in its use being the introduction of aircraft embodying failure tolerant designs, which allow for replacement of some traditional failure preventative maintenance techniques by non-preventative techniques. Condition Monitoring is not a relaxation of maintenance standards or of airworthiness control; it is, in fact, more demanding of both management and engineering capabilities than the traditional preventative maintenance approaches. Each Condition Monitored Maintenance Programme is required to be approved by the CAA.

3.2 Maintenance Activities

3.2.1 There are three types of maintenance activity:

a) Maintenance applied at specified periods of time regardless of condition at that time. The maintenance activity may be a periodic overhaul, a bearing change, re-work, repaint, calibration, lubrication, etc. These result from Hard Time requirements;

b) Periodic examinations, mostly at specified periods of time, but sometimes on an opportunity basis (e.g. when an Item is removed for access) to determine not only the extent of deterioration but also that the deterioration is within specified limits. These result from On-Condition requirements;

c) Actions applied in response to the analysis of condition clues produced by monitoring inflight, hangar, workshop and other types of condition information sources. These result from Condition Monitoring requirements.

3.2.2 Condition Monitoring uses data on failures as items of 'condition' information which are evaluated to establish a necessity for the production or variation of Hard Time and On-Condition requirements, or for other corrective actions to be prescribed. Failure rates and effects are analysed to establish the need for corrective actions. Condition

Monitoring can be used in its own right to identify the effects of deterioration, in order that steps may be taken to maintain the level of reliability inherent in the design of the Item. Although Condition Monitoring accepts that failures will occur, it is necessary to be selective in its application. The acceptance of failures may be governed by the relative unimportance of the function, or by the fact that the function is safeguarded by system Redundancy.

3.2.3 Maintenance of a particular Item could well be some combination of the three primary maintenance processes (Hard Time, On-Condition and Condition Monitoring). There is no hierarchy of the three processes; they are applied to the various Items according to need and feasibility. Maintenance Schedules which are based on the Maintenance Steering Group principles will have Hard Time, On-Condition, or Condition Monitoring specified as the primary maintenance process for specific systems and sub-systems as well as for individual Maintenance Significant Items. Condition Monitoring can, therefore, be the primary maintenance process prescribed for an Item, in which case it has also to be used for controlling the availability of those functions which are not directly controlled by a prescribed On-Condition or Hard Time process; this control is provided by the statistical reliability element of Condition Monitored Maintenance. Items for which Hard Time and On-Condition are prescribed may, however, have the statistical reliability element of Condition Monitored Maintenance applied, not as a primary maintenance process, but as a form of Quality Surveillance.

3.3 **Statistical Reliability Element**

3.3.1 The assessment of defect/removal/failure rate trend, of age bands at which Items fail, or the probability of survival to a given life are, in most cases, used to measure the effect of suitability of the primary maintenance processes applied to Items. The assessment is made by examination of rates of occurrence of events such as in-flight defects, incidents, delays, use of Redundancy capability, engine unscheduled shut-downs, air turn-backs, etc. which are reported in accordance with the procedure associated with the reliability element of Condition Monitored Maintenance.

3.3.2 A statistical reliability programme, as an element of Condition Monitoring, is, in practical terms, the continuous monitoring, recording and analysing of the functioning and condition of aircraft components and systems. The results are then measured or compared against established normal behaviour levels so that the need for corrective action may be assessed and, where necessary, taken.

3.4 **The Condition Monitored Maintenance Programme**

3.4.1 A maintenance programme which provides for the application of Hard Time, On-Condition and Condition Monitoring is known as a Condition Monitored Maintenance Programme. A Programme has two basic functions. Firstly, by means of the statistical reliability element, to provide a summary of aircraft fleet reliability and thus reflect the effectiveness of the way in which maintenance is being done. Secondly, to provide significant and timely technical information by which improvement of reliability may be achieved through changes to the Programme or to the practices for implementing it.

3.4.2 A properly managed Programme will contribute not only to continuing airworthiness, but also to improvement of fleet reliability, to better long-term planning, and to reduced overall costs.

3.4.3 The fundamental factors of a successful Programme are the manner in which it is organised and the continuous monitoring of it by responsible personnel. Because of differences in the size and structure of the various airlines, the organisational side of any Programme is individual to each operator. Hence, it is necessary to detail the organisation and responsibilities in the Programme control documentation.

3.5 **Programme Control Committee**

3.5.1 Every Programme is required to have a controlling body (usually known as the Reliability Control Committee) which is responsible for the implementation, decision making and day-to-day running of the Programme. It is essential that the Reliability Control Committee should ensure that the Programme establishes not only close co-operation between all relevant departments and personnel within the Operator's own Organisation, but also liaison with other appropriate Organisations. Lines of communication are to be defined and fully understood by all concerned. The Programme objectives and a typical Organisation and Data Flow Chart are shown in Appendix A.

3.5.2 The Reliability Control Committee is responsible for, and will have full authority to take, the necessary actions to implement the objectives and processes defined in the Programme. It is normal for the Quality Manager or the Engineering Manager to head the Committee and to be responsible to the CAA for the operation of the Programme.

3.5.3 The formation of the Committee and the titles of members will vary between Operators. The structure and detailed terms of reference of the Committee and its individual members will be fully set out in the documentation for each Programme. The Committee will usually comprise the Quality or Engineering Manager, the Reliability Engineer or Co-ordinator, the Chief Development Engineer, and the Chief Production Engineer.

3.5.4 The Committee should meet frequently to review the progress of the Programme and to discuss and, where necessary, resolve current problems. The Committee should also ascertain that appropriate action is being taken, not only in respect of normal running of the Programme, but also in respect of corrective actions.

3.5.5 Formal review meetings are held with the CAA at agreed intervals to assess the effectiveness of the Programme. An additional function of the formal review meeting is to consider the policy of, and any proposed changes to, the Programme.

3.6 **Data Collection**

3.6.1 Data (or more realistically, collected information) will vary in type according to the needs of each Programme. For example, those parts of the Programme based on data in respect of systems and sub-systems will utilise inputs from reports by pilots, reports on engine unscheduled shut-downs and also, perhaps, reports on mechanical delays and cancellations. Those parts of the Programme based on data in respect of components will generally rely upon inputs from reports on component unscheduled removals and on workshop reports. Some of the larger Programmes embrace both 'systems' and 'component' based data inputs in the fullest of detail.

3.6.2 The principle behind the data collection process is that the information to be collected has to be adequate to ensure that any adverse defect rate, trend, or apparent reduction in failure resistance, is quickly identified for specialised attention. Some aircraft systems will function acceptably after specific component or sub-system failures; reports on such failures in such systems will, nevertheless, act as a source of data which may be used as the basis of action either to prevent the recurrence of such failures, or to control the failure rates.

3.6.3 Typical sources of data are reports on delays, in-flight defects, authorised operations with known defects (i.e. equipment inoperative at a level compatible with the Minimum Equipment List), flight incidents and accidents, air turn-backs; the findings of line, hangar and workshop investigations. Other typical sources include reports resulting from On-Condition tasks and in-flight monitoring (Airborne Integrated Data Systems); Service Bulletins; other Operators' experience, etc. The choice of a source of data, and the processes for data collection, sifting and presentation (either as individual events or as rates of occurrence) should be such as to permit adequate condition assessment to be made relative both to the individual event and to any trend.

3.6.4 **Pilot Reports**

a) Pilot Reports, more usually known as 'Pireps', are reports of occurrences and malfunctions entered in the aircraft Technical Log by the flight crew for each flight. Pireps are one of the most significant sources of information, since they are a result of operational monitoring by the crew and are thus a direct indication of aircraft reliability as experienced by the flight crew.

b) It is usual for the Technical Log entries to be routed to the Reliability Section (or Engineer/Co-ordinator) at the end of each day, or at some other agreed interval, whereupon each entry is extracted and recorded as a count against the appropriate system. Pireps are thus monitored on a continuous basis, and at the end of the prescribed reporting period are calculated to a set base as a reliability statistic for comparison with the established Alert Levels (see paragraph 3.8) e.g. Pirep Rate per 1,000 hr, Number of Pireps per 100 departures, etc.

c) Engine performance monitoring can also be covered by the Pirep process in a Programme. Flight crew monitoring of engine operating conditions is, in many Programmes, a source of data in the same way as reports on system malfunctions.

3.6.5 **Engine Unscheduled Shut-downs**

a) These are flight crew reports of engine shut-downs and usually include details of the indications and symptoms prior to shut-down. When analysed, these reports provide an overall measure of propulsion system reliability, particularly when coupled with the investigations and records of engine unscheduled removals.

b) As with Pireps, reports on engine unscheduled shut-downs are calculated to a set base and produced as a reliability statistic at the end of each reporting period. The causes of shutdowns are investigated on a continuing basis, and the findings are routed via the Reliability Section to the Powerplant Development Engineer.

3.6.6 **Aircraft Mechanical Delays and Cancellations**

a) These are normally daily reports, made by the Operator’s line maintenance staff, of delays and cancellations resulting from mechanical defects. Normally each report gives the cause of delay and clearly identifies the system or component in which the defect occurred. The details of any corrective action taken and the period of the delay are also included.

b) The reports are monitored by the Reliability Section and are classified (usually in Air Transport Association of America, Specification 100 (ATA 100) Chapter sequence), recorded and passed to the appropriate engineering staffs for analysis. At prescribed periods, recorded delays and cancellations for each system are plotted, usually as events per 100 departures.

3.6.7 **Component Unscheduled Removals and Confirmed Failures**

At the end of the prescribed reporting period the unscheduled removals and/or confirmed failure rates for each component are calculated to a base of 1,000 hours flying, or, where relevant, to some other base related to component running hours, cycles, landings, etc.

NOTE: Reports on engine unscheduled removals, as with reports on engine performance monitoring, are also a source of data and are reported as part of the Programme.

a) **Component Unscheduled Removals.** Every component un-scheduled removal is reported to the section which monitors reliability (the 'Reliability Section') and will normally include the following information:

i) Identification of component.

ii) Precise reason for removal.

iii) Aircraft registration and component location.

iv) Date and airframe hours/running hours/landings, etc. at removal.

v) Component hours since new/repair/overhaul/calibration.

Completed reports are routed daily to the Reliability Section for recording and for continuous monitoring for significant trends and arisings. Components exhibiting abnormal behaviour patterns are brought to the attention of the engineering staff responsible, so that detailed investigations may be made and corrective action may be taken.

b) Component Confirmed Failures

i) With the exception of self-evident cases, each unscheduled removal report is followed up by a workshop report in which the reported malfunction or defect is confirmed or denied. The report is routed to the Reliability Section. Workshop reports may be compiled from an Operator’s own 'in-house' findings and/or from details supplied by component repair/overhaul contractors.

ii) Where an unscheduled removal is justified the workshop reports will normally include details of the cause of the malfunction or defect, the corrective action taken and, where relevant, a list of replacement items. Many Programmes utilise the same type of report to highlight structural and general aircraft defects found during routine maintenance checks.

3.6.8 **Miscellaneous Reports**

Dependent upon the formation of individual Programmes, a variety of additional reports may be produced on a routine or non-routine basis. Such reports could range from formal minutes of reliability meetings to reports on the sample stripping of components, and also include special reports which have been requested during the investigation of any Item which has been highlighted by the Programme displays and reports.

3.7 **Statistical Reliability Measurement**

To assist in the assessment of reliability, Alert Levels are established for the Items which are to be controlled by the Programme. The most commonly used data and units of measurement (Pireps per 1,000 hours, Component Removals/Failures per 1,000 hours, Delays/Cancellations per 100 departures, etc.) have been mentioned in paragraph 3.6. Too much importance should not be placed upon the choice of units of measurement, provided that they are constant throughout the time the Programme runs and are appropriate to the type and frequency of the event. The choice of units of measurement will depend on the type of operation, the preference of the Operator and those required by the equipment manufacturer.

3.8 **Reliability Alert Levels**

3.8.1 A reliability alert level (or equivalent title, e.g. Performance Standard, Control Level, Reliability Index, Upper Limit) hereinafter referred to as an 'Alert Level', is purely an 'indicator' which when exceeded indicates that there has been an apparent deterioration in the normal behaviour pattern if the Item with which it is associated. When an Alert Level is exceeded the appropriate action has to be taken. It is important to realise that Alert Levels are not minimum acceptable airworthiness levels. When Alert Levels are based on a representative period of safe operation (during which failures may well have occurred) they may be considered as a form of protection against erosion of the design aims of the aircraft in terms of system function availability. In the case of a system designed to a multiple Redundancy philosophy it has been a common misunderstanding that, as Redundancy exists, an increase in failure rate can always be tolerated without corrective action being taken.

3.8.2 Alert Levels can range from 0·00 failure rate per 1,000 hours both for important components and, where failures in service have been extremely rare, to perhaps as many as 70 Pireps per 1,000 hours on a systems basis for ATA 100 Chapter 25 – Equipment/Furnishings, or for 20 removals of passenger entertainment units in a like period.

3.8.3 **Establishing Alert Levels**

a) Alert Levels should, where possible, be based on the number of events which have occurred during a representative period of safe operation of the aircraft fleet. They should be updated periodically to reflect operating experience, product improvement, changes in procedures, etc.

b) When establishing Alert Levels based on operating experience, the normal period of operation taken is between 2 and 3 years dependent on fleet size and utilisation. The Alert Levels will usually be so calculated as to be appropriate to events recorded in one-monthly or three-monthly periods of operation. Large fleets will generate sufficient significant information much sooner than small fleets.

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

i) For a new aircraft type during the first 2 years of operation, all malfunctions should be considered significant and should be investigated, and although Alert Levels may not be in use, Programme data will still be accumulated for future use;

ii) For an established aircraft type with a new Operator, the experience of other Operators may be utilised until the new Operator has himself accumulated a sufficient period of his own experience. Alternatively, experience gained from operation of a similar aircraft model may be used;

iii) A recent concept to be applied in setting Alert Levels for the latest aircraft designs, is to use computed values based on the degree of system and component in-service expected reliability assumed in the design of the aircraft. These computed values are normally quoted in terms of Mean Time Between Unscheduled Removal (MTBUR) or Mean Time Between Failure (MTBF) for both individual components and complete systems. Although these levels tend to be theoretical, they are, of course, based on a considerable amount of testing and environmental engineering and design analysis. Being purely initial predictions they should be replaced when sufficient in-service experience has been accumulated.

d) There are several recognised methods of calculating Alert Levels, any one of which may be used provided that the method chosen is fully defined in the Operator's Programme documentation.

e) Typical acceptable procedures for establishing Alert Levels are described briefly in paragraphs i) to iii), and some detailed examples of the methods of calculation are shown in Appendix B. It will be seen that the resultant Alert Levels can vary according to the method of calculation, but this need not necessarily be considered to be of significance.

i) **Pilot Reports (Pireps).** For the following example calculations, a minimum of twelve-months' operating data has to be available, and the resultant Alert Level per 1,000 hours is:

Calculation 1. The three-monthly running average Pirep rate per 1,000 hours for each system (or sub-system), as in the Table of Example 1, is averaged over the sample operating period and is known as the Mean; the Mean is multiplied by 1·30 to produce the Level Alert for the given system. This is sometimes known as the '1·3 Mean' or '1·3 $\bar{x}$ ' method.

Calculation 2. The Mean, as in Calculation 1, plus 3 Standard Deviations of the Mean (as illustrated in Appendix B – Example 1).

Calculation 3. The Mean, as in Calculation 1, plus the Standard Deviation of the 'Mean of the Means', plus 3 Standard Deviations of the Mean (as illustrated in Appendix B – Example 2).

ii) **Component Unscheduled Removals.** For the following example calculations, a minimum period of seven quarters' (21 months') operating data has to be available, and the resultant Alert Level rate for the current quarter may be set in accordance with any one of the following:

Calculation 4. The Mean of the individual quarterly Component Unscheduled Removal rates for the period of seven quarters, plus 2 Standard Deviations of the Mean.

Calculation 5. The maximum acceptable number of 'Expected Component Unscheduled Removals' in a given quarter, as calculated using a statistical process in association with the Poisson Distribution of Cumulative Probabilities (as illustrated in Appendix B – Example 3).

Calculation 6. The Number of 'predicted Component Unscheduled Removals (or failures)' in a given quarter, as determined by the Weibull or other suitable statistical method.

iii) **Component Confirmed Failures.** The period of operating experience has to be as in ii) and the resultant Alert Level rate for the current quarter is the 'corrected' Mean of the individual quarterly Component Confirmed Failure rates for the period, plus 1 Standard Deviation of the Mean (as illustrated in Appendix B – Example 4).

3.9 Re-calculation of Alert Levels

a) Both the method used for establishing an Alert Level, and the associated qualifying period, apply also when the level is re-calculated to reflect current operating experience. However, if, during the period between re-calculation of Alert Levels, 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 would be re-assessed and revised on the data subsequent to the change.

b) All changes in Alert Levels are normally required to be approved by the CAA and the procedures, periods and conditions for re-calculation are required to be defined in each Programme.

3.10 Programme Information Displays and Reports

3.10.1 General

As soon as possible after the end of each defined reporting period of a Programme, the Operator is required to produce graphical and/or tabular displays. These displays have to reflect the fleet operating experience for the period under review. The compilation and production of these displays from the day-to-day records has to be such that the essential information for each Item is in accordance with the requirements of the Programme.

3.10.2 The main purpose of displaying the information is to provide the Operator and the CAA with an indication of aircraft fleet reliability in such a manner that the necessity for corrective actions may be assessed. The format, frequency of preparation and the distribution of displays and reports are fully detailed in the Programme documentation. Typical data displays are described in paragraphs 3.10.3 to 3.10.9 and some examples are illustrated in Appendix C.

3.10.3 Fleet Reliability Summary

This display (see Appendix C, Figure C1), which is related to all aircraft of the same type in the fleet, is usually produced in tabular form, and should contain the following minimum information for the defined reporting period:

a) Number of aircraft in fleet;

b) Number of aircraft in service;

c) Number of operating days (less checks);

d) Total number of flying hours;

e) Average daily utilisation per aircraft;

f) Average flight duration;

g) Total number of landings;

h) Total number of delays/cancellations;

i) Technical Incidents.

3.10.4 Aircraft Mechanical Delays/Cancellations

The purpose of this type of display is to indicate the aircraft systems which have caused delay to or cancellation of flights as a result of mechanical malfunctions. It is normal for each display to show the delays/cancellations as a total for all systems (to represent fleet overall reliability, as in Appendix C, Figure C2) as well as separately for the individual systems. The displays for the separate systems will usually show the delay/cancellation rate for the defined reporting period, the three-monthly moving average rate and, where appropriate, the Alert Level, and will present the information for a minimum period of 12 months.

3.10.5 Engine Unscheduled Shut-downs

This display (see Appendix C, Figure C3) is the prime indication of engine in-service reliability and also, to a large degree, of total powerplant reliability. Because of the high level of reliability of engines and the consequently relatively low numbers of unscheduled shut-downs per fleet, both the actual number of shut-downs and the shut-down rate per 1,000 hours for the defined reporting period as a three monthly running average, shown as a graphical display, will provide useful information in addition to that of Appendix C, Figure C3. To be of most use, where dealing with small numbers of unscheduled shut-downs, it is usual to present both types of information in such a way as to show the trend over a two-to-three-year period.

3.10.6 **Engine Unscheduled Removals**

This display is the supporting primary indication of engine reliability and is usually presented in a similar manner to unscheduled shut-downs. Many Operators show scheduled and unscheduled engine removals and unscheduled shut-downs on the same display; this is purely a matter of preference (see Appendix C, Figure C3).

3.10.7 **Pilot Reports (Pireps)**

Pireps are presented by system or sub-system (normally identified in accordance with the classifications in ATA 100) in graphical and/or tabular form as a count, or rate, per 1,000 flight hours or 100 departures for the defined reporting period, for comparison with the Alert Level (see Appendix C, Figure C5). Occasionally some Programmes include a Pirep presentation of Fleet Pilot Reports (see Appendix C, Figure C4). This presentation shows the total number of Pireps for all systems and sub-systems and thus gives an overall picture of the total Pireps for the fleet of one aircraft type.

3.10.8 **Component Unscheduled Removals and Confirmed Failures**

a) There are various methods of displaying component information (both graphically and tabular). The display may be on the basis of each individual component which has been prematurely removed (see Appendix C, Figure C6), or on the basis of the total number of affected components per system (see Appendix C, Figure C7). Experience has shown that a tabular presentation of unscheduled removals and confirmed failures on an individual component basis, preferably giving both numbers and rates per 1,000 hours, of the defined reporting period is the most useful.

b) The format of any display of component information should be such that:

   i) Both unscheduled removals and confirmed failure rates may be compared with the Alert Levels so as to identify when the Levels are likely to be exceeded.

   ii) Current and past periods of operation may be compared.

3.10.9 **Workshop Reports**

A summary of the results of defect investigations, based on the Workshop Reports (see Appendix C, Figure C8) is normally produced by component type for assessment by the Reliability Committee.

3.11 **Problem Identification**

Having collected the information, and having presented it in a timely manner it should now be possible to identify any problems and to assess the necessity for corrective actions. The information, having been sifted and categorised (normally in ATA 100 Chapter order) as individual events and/or rates of occurrence, can be analysed using engineering and/or statistical methods. The analysis can be made at various stages in the handling of the data to differing degrees. Initially, reports on flight defects, delay causes, engine unscheduled shut-downs, workshop and hangar findings, other operators' experience, etc. should be analysed individually to see if any immediate action is desirable. This initial individual analysis will highlight any need for immediate short term actions, e.g. the preparation of Mandatory Occurrence Reports, safety reports, fleet campaigns, with the long term corrective actions following after the later, collective, stages of analysis.

3.12 **Corrective Action**

3.12.1 The effectiveness of corrective action will normally be monitored by the very process which revealed the need for it – the Condition Monitoring process.

3.12.2 Corrective actions taken to improve the reliability of systems and components, and ultimately that of the fleet, will vary considerably and may typically include one or more of the following:

a) Changes in operational procedures or improvements in fault-finding techniques;

b) Changes to the scope and frequency of maintenance processes which may involve Servicing and inspection, system Tests or Checks, Overhaul, Partial Overhaul or bench testing or the introduction or variation of time limits, etc;

c) Modification action;

d) Non-routine inspections or adjustment;

e) Change of materials, fuels and lubricants;

f) Use of different repair agencies;

g) Use of different sources of spares;

h) Variations of storage conditions;

i) Improvements in standards of staff training and technical literature;

j) Amendments to the policy/procedures of the Programme.

3.13 **Threshold Sampling**

3.13.1 Threshold sampling is the process whereby a maintenance limitation prescribed in the Maintenance Schedule (e.g. Hard Time) is varied in the light of experience gained from any source (e.g. scheduled and unscheduled maintenance, unscheduled removals). The prescribed maintenance limitation is the 'threshold upper limit', and, dependent upon the experience gained, can be either substantiated or varied. Maintenance activities (e.g. time for removal, extent of restoration) are normally related to actual experience of the Item in service (known as 'the experience age band'). When it is considered that the prescribed maintenance activity may be varied, threshold sampling may be used as a means of establishing confidence in the proposal. If when the threshold upper limit is reached, the condition of the Item is such that a variation is justified, then a new threshold upper limit may be set.

3.13.2 In setting the number of samples and any other qualifying conditions, both engineering assessment of the design and service experience are taken into account. Evidence derived from other activities (e.g. unscheduled removals or removals scheduled for other purposes) will supplement scheduled sampling and the removal itself may, if representative, be substituted for a scheduled sampling removal.

3.13.3 When the optimum period for a particular workshop activity has been determined, threshold sampling will be discontinued and a Hard Time limitation for workshop activity (e.g. Overhaul) will be prescribed.

3.13.4 A typical example of the use of threshold sampling is the control of the 'release for service' periods of certain gas-turbine engines, where some of the units on the engines are subject to individual Hard Time limitations (e.g. turbine disc lives, refurbishing intervals). These individual limitations are, in most cases, established and varied by the process described in paragraphs 3.13.1 to 3.13.3. The outcome is that the engine release period for installation in the aircraft is then fixed by the expiration of the lowest unit Hard Time limitation.

3.14 Quality Management

3.14.1 With the major issues of airworthiness and the economical allocation of vast sums of money being involved, it is essential that Quality Control should be applied as an overall control of the Maintenance Programme. Each Programme will describe the managerial responsibilities and procedures for continuous monitoring of the Programme at progressive and fixed periods. Reviews, to assess the effectiveness of the Programme, will also be prescribed.

3.14.2 There are various methods, both engineering and statistical, by which the effectiveness of the Programme may be evaluated, and these include:

a) an assessment of the Programme Document (see paragraph 4) and any subsequent amendment (e.g. with a view to possible extra activities);

b) surveillance of the Programme activities by the Quality Management Departments;

c) review by the Programme Control Committee to confirm that corrective action taken are correctly related to the performance trends and to the reports produced;

NOTE: Generally there would be two levels of committee activity, functional and managerial; the functional activity covering the practicality of corrective actions, and the managerial activity covering the overall Quality management of the Programme.

d) Assessment of reports on incidents and accidents, as these could be potential criticisms of the effectiveness of the Programme.

3.15 Review of the Programme

It is normal for each Operator to review the effectiveness of his Programme, in conjunction with the CAA, at annual intervals. At this review consideration will be given to any proposed major changes in the Programme structure and policy so as to obtain the optimum benefits from the operation of the Programme.

4 The Programme Document

4.1 Approval

Approval of the Programme (as identified by the 'Document') will depend on the results of an assessment as to whether or not the stated objectives can be achieved. The approval of the Document then becomes a recognition of the potential ability of the Organisation to achieve the stated objectives of the Programme.

NOTE: The Quality Department of the Organisation, together with the CAA, monitors both the performance of the Programme in practice as well as its continuing effectiveness in achieving the stated objectives.

4.2 Essential Qualities of the Programme

Condition Monitored Maintenance Programmes can vary from the very simple to the very complex, and thus it is impractical to describe their content in detail. However, the Document has to be such that the considerations in a) to i) are adequately covered.

a) It generates a precise, specific and logical Quality assessment by the Operator of the ability of the Organisation to achieve the stated objectives.

b) It enables the CAA initially to accept, and, with subsequent continued monitoring, to have confidence in, the ability of the Organisation to such an extent that the CAA can renew Certificates of Airworthiness, approve changes to the maintenance schedules, etc. in accordance with evidence showing that the objectives of the Programme are being achieved.

c) It ensures that the Operator provides himself with Quality management of his Organisation.

d) It provides the Operator with a basis for the discharge of his moral and legal obligations in respect of the operation of aircraft.

e) It enables the CAA (as the Airworthiness Authority) to discharge its duties and legal obligations in respect of the maintenance aspects of airworthiness, and, where applicable, to delegate certain tasks to the Operator.

f) The manner of presentation has to be acceptable to the CAA.

g) With a) to f) in mind, it states the objectives of the Programme as precisely as is possible, e.g. 'maintenance of designated components by reliability management in place of routine overhaul', 'Condition Monitoring as a primary maintenance process'.

h) The depth of description of the details of the Programme is such that:

   i) The details can be understood by a technically qualified person.

   ii) Those factors which require formal CAA acceptance of any changes are clearly indicated.

   iii) All significant non-self-evident terms are defined.

i) In respect of individuals or departments within the Organisation:

   i) The responsibility for the management of the Document, and

   ii) The procedures for revision of the Document, are clearly stated.

4.3 **Compliance with BCAR**

a) The Document is required to contain at least the information prescribed in BCAR Section A, Chapter A6–2, Appendix No. 1.

b) The Document may either be physically contained within the Approved Maintenance Schedule, or be identified in the Approved Maintenance Schedule by reference and issue number, in such a manner that the Approved Maintenance Schedule could be deemed to contain it by specific statement and cross-reference.

4.4 **Assessment of Programme Document**

The following questions (not necessarily definitive) may assist in making a preliminary assessment of the adequacy of the Programme Document:

a) Is the Document to be physically contained within the Approved Maintenance Schedule? If it is to be a separate document, is it satisfactorily linked with, and identified within the Approved Maintenance Schedule?

b) Are the objectives of the Programme clearly defined? e.g. 'Maintenance of designated Items by reliability management in place of routine overhaul', 'Confidence assessment of overhaul periods', 'Condition monitoring as a primary maintenance process', 'Airworthiness/economic Quality management of maintenance'.

c) Does the Approved Maintenance Schedule clearly state to which Items the Programme is applicable?

d) Is there a glossary of terms associated with the Programme?

e) What types of data are to be collected? How? By whom? When? How is this information to be sifted, grouped, transmitted and displayed?

f) What reports/displays are provided? By whom? To whom? When? How soon following data collection? How are delays in publishing controlled?

g) How is all information and data analysed and interpreted to identify aircraft actual and potential condition? By whom? When?

h) Is there provision within the Organisation for implementation of corrective actions and is this identified within the Document? How are implementation time periods, effects and time for effect manifestation provided for?

i) Is there a requirement that the Approved Maintenance Schedule be amended, and is the method of doing so included in the Programme, e.g. variation of time limitations, additional checks?

j) Is there a requirement that Maintenance Manuals be amended, and is the method of doing so included in the Programme, e.g. maintenance practices, tools and equipment, materials?

k) Is there a requirement that the Operations Manual/Crew Manual be amended, and is the method of doing so included in the Programme, e.g. crew drills, check lists, defect reporting?

l) What provision is made for corrective action follow-up and for checks on compliance with original intention, e.g. those which are not working out in practice, spares provisioning, timetables for the incorporation of modifications?

m) Who is responsible for the management of the Document?

n) Is there a diagram of the relationship between the departments and groups concerned with the Programme and does it show the flow of Condition Monitoring data, its handling and the prescribed reaction to it?

o) Are all of the departments involved in the Programme included and are there any responsibilities not allocated?

p) What Quality management processes are contained within the Programme in respect of:

   i) Responsibility for the Document itself and the procedure for its amendment?

   ii) Monitoring of the performance of the Programme by statistical reliability and other methods?

   iii) Committee consideration of Programme implementation and monitoring of performance?

   iv) Consideration of reports on incidents and accidents and other events which can effect airworthiness?

   v) Programme management and discipline?

5 Defined Terms and Abbreviations

5.1 Introduction

Those terms and abbreviations in the text which have a specific meaning are defined in this paragraph 5.

5.2 Terms and Abbreviations

5.2.1 Analysis

The MSG Logic Analysis.

5.2.2 **ATA 100**

Air Transport Association of America, Specification 100.

5.2.3 **Check**

An examination to determine the functional capability or physical integrity of an Item.

5.2.4 **Condition Monitoring**

A primary maintenance process under which data on the whole population of specified items in service is analysed to indicate whether some allocation of technical resources is required. Not a preventive maintenance process, condition monitored maintenance allows failures to occur, and relies upon analysis of operating experience information to indicate the need for appropriate action.

NOTE: Failure modes of condition monitored items do not have a direct adverse effect on operating safety.

5.2.5 **Document**

The Condition Monitored Maintenance Programme document.

5.2.6 **Failure Mode**

The way in which the failure of an Item occurs.

5.2.7 **Hard Time Limit**

A maximum interval for performing maintenance tasks. This interval can apply to Overhaul of an Item, and also to removal following the expiration of life of an Item.

5.2.8 **Hidden Function**

An Item is considered to have a 'hidden function' if either of the following is applicable:

a) The Item has a function which is normally active whenever the system is in use, but there is no indication to the flight crew when that function ceases.

b) The Item has a function which is normally inactive, but there is no prior indication to the flight crew that the function will not be available when required.

5.2.9 **Item**

Any level of hardware assembly (i.e. part, sub-system, system, accessory, component, unit, material, portion of structure, etc.).

5.2.10 **Maintenance Significant Items**

Maintenance items that are judged to be relatively the most important from a safety, reliability or economic stand-point.

5.2.11 **Minimum Equipment List**

An approved list of Items which may be inoperative for flight under specified conditions.

5.2.12 **On-Condition/On-Condition Maintenance**

A primary maintenance process having repetitive inspections or tests to determine the condition of units, systems, or portions of structure with regard to continued serviceability (corrective action is taken when required by Item condition).

5.2.13 **Overhaul**

The restoration of an Item in accordance with the instructions defined in the relevant manual.

5.2.14 **Partial Overhaul**

The overhaul of a sub-assembly of an Item with a time controlled overhaul to permit the longer-lifed Item to achieve its authorised overhaul life.

5.2.15 **Pireps**

Pilot Reports.

5.2.16 **Programme**

Condition Monitored Maintenance Programme.

5.2.17 **Quality**

The totality of features and characteristics of a product or service that bear on its ability to satisfy a given need.

5.2.18 **Quality Control**

A system of programming and co-ordinating the efforts of the various groups in an organisation to maintain or improve quality, at an economical level which allows for customer satisfaction.

5.2.19 **Quality Surveillance**

Supervision by the customer, his representative, or an independent organisation of a contractor's quality control organisation and methods.

5.2.20 **Redundancy**

The existence of more than one means of accomplishing a given function. Each means of accomplishing the function need not necessarily be identical.

5.2.21 **Redundancy, Active**

That redundancy wherein all redundant Items are operating simultaneously rather than being activated when needed.

5.2.22 **Redundancy, Standby**

That redundancy wherein the alternative means of performing the function is inoperative until needed and is activated upon failure of the primary means of performing the function.

5.2.23 **Replace**

The action whereby an item is removed and another item is installed in its place for any reason.

5.2.24 **Scheduled Maintenance**

That maintenance performed at defined intervals to retain an item in a serviceable condition by systematic inspection, detection, replacement of wearout items, adjustment, calibration, cleaning, etc. Also known as 'Preventative Maintenance' and 'Routine Maintenance'.

5.2.25 **Servicing**

The replenishment of consumables needed to keep an Item or aircraft in operating condition.

5.2.26 **Test**

An examination of an item in order to ensure that the Item meets specified requirements.

APPENDIX A

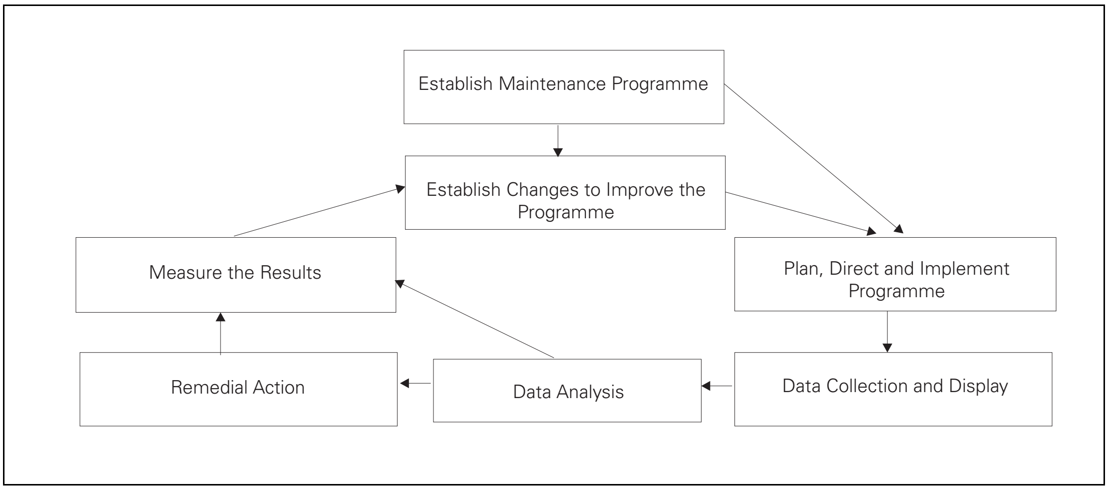

Figure A1 Programme Objectives

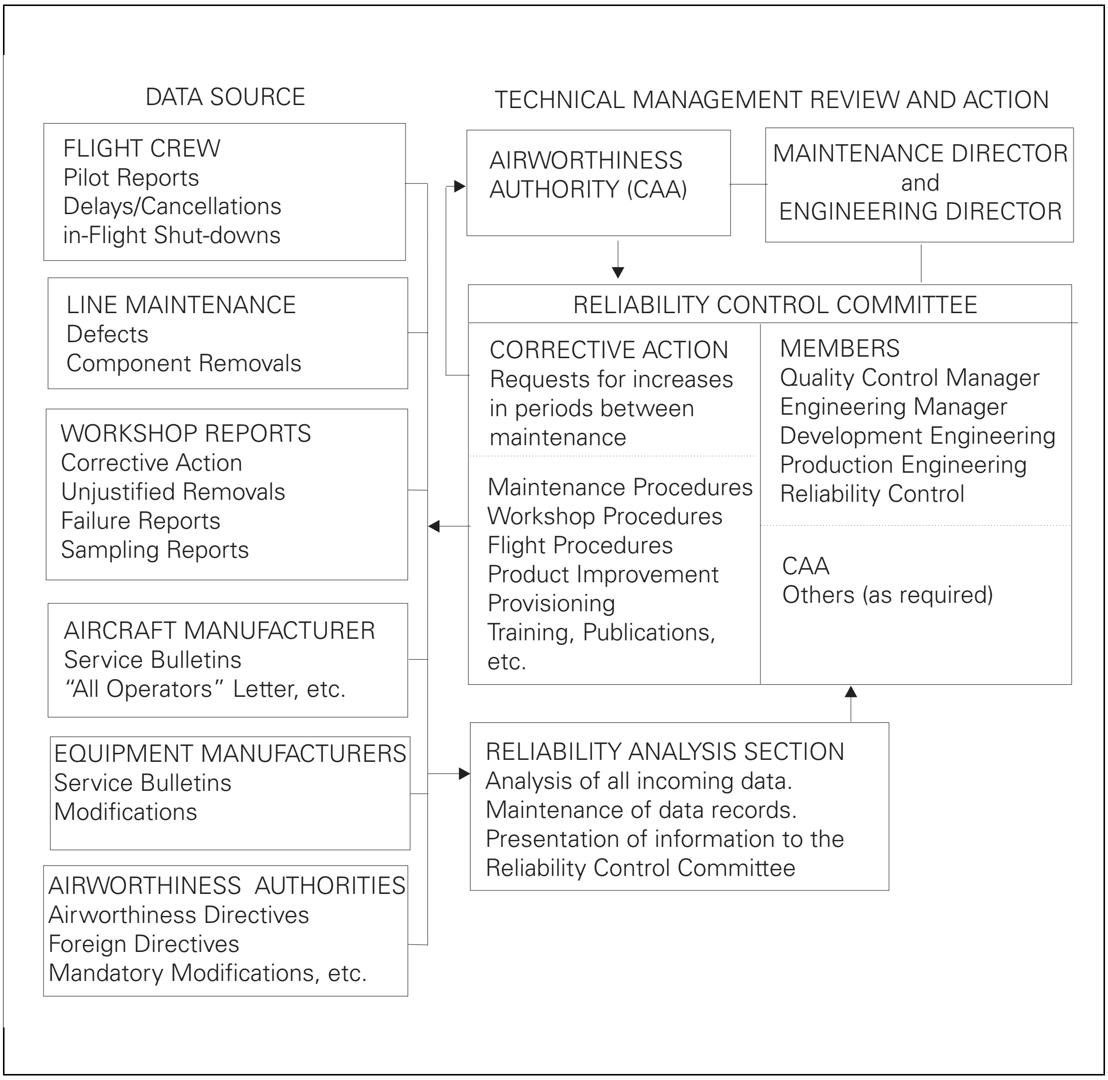

Figure A2 Typical Organisation and Data Flow Chart

APPENDIX B – Alert Level Calculations

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

Method: Alert Level per 1,000 flight hours = Mean of the 3 monthly Running Average 'Pirep' Rates per 1,000 flight hours (for past 12 months) plus 3 Standard Deviations.

Table 1 System: Aircraft Fuel System (ATA 100, Chapter 28)

Month	Pireps (monthly)	Pireps (3 months cumulative totals)	Flight Hours (monthly)	Flight Hours (3 months cumulative totals)	Pirep Rate per 1,000 hr (3 months running average) (x)
Nov	42	–	2,400	–	–
Dec	31	–	2,320	–	–
Jan	58	131	2,350	7,070	18
Feb	46	135	2,300	6,970	19
Mar	58	162	2,560	7,210	22
Apr	26	130	2,600	7,460	17
May	42	126	2,750	7,910	16
Jun	65	133	3,100	8,450	16
Jul	78	185	2,880	8,730	21
Aug	74	217	2,700	8,680	25
Sep	58	210	3,000	8,580	24
Oct	54	186	2,650	8,350	22
Nov	35	147	2,610	8,260	18
Dec	46	135	2,330	7,590	18

N(months)=12
Σ = Totals

(x)	$(x-\bar{x})$	$(x-\bar{x})^2$
18	-2	4
19	-1	1
22	2	4
17	-3	9
16	-4	16
16	-4	16
21	1	1
25	5	25
24	4	16
22	2	4
18	-2	4
18	-2	4
Σx = 236		$\Sigma(x-\bar{x})^2$ = 104

$$\text{MEAN}(\bar{x}) = \frac{\Sigma x}{N} = \frac{236}{12} = 19 \cdot 67 \text{ (rounded to 20)}$$

$$\text{STANDARD DEVIATION (SD)} = \sqrt{\frac{\Sigma(x-\bar{x})^2}{N}} = \sqrt{\frac{104}{12}} = \sqrt{8 \cdot 67} = 2 \cdot 94$$

3 SD = 8·82 (rounded to 9)

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

Example 2 – Pilot Reports (Pireps) by Aircraft System per 1,000 Flight Hours

Method : Alert Level per 1,000 flight hours = The Mean (as in Example 1), plus the Standard Deviation of the 'Mean of the Means', plus 3 Standard Devisions of the Mean.

Table 2 Aircraft Fuel System (ATA 100, Chapter 28)

Pirep Rate per 1,000 hr - 3 months runing Av. (x)	Mean of x (X)	Difference of X from $\bar{X}$ (D)	(D^2)
18			
19	18·5	1·3	1·69
22	20·5	0·7	0·49
17	19·5	0·3	0·09
16	16·5	3·3	10·69
16	16·0	3·8	14·44
21	18·5	1·3	1·69
25	23·0	3·2	10·24
24	24·5	4·7	22·09
22	23·0	3·2	10·24
18	20·0	0·2	0·04
18	18·0	1·7	2·89
	218·0=ΣX	23·7 = ΣD	74·79 = $\Sigma(D^2)$

N (months) now = 11 and thus $\bar{x}$ (the mean of the means) will = $\frac{\Sigma X}{N} = \frac{218}{11} = \underline{19 \cdot 8}$

Σ = Totals

STANDARD DEVIATION OF MEAN OF MEANS

$$= \sqrt{\frac{\Sigma(D^2)}{N} - \left(\frac{\Sigma D}{N}\right)^2} = \sqrt{\frac{74 \cdot 79}{11} - \left(\frac{23 \cdot 7}{11}\right)^2} = \sqrt{6 \cdot 80 - 4 \cdot 64} = \underline{1 \cdot 47}$$

Therefore ALERT LEVEL = MEAN $(\bar{x})$ + STANDARD DEVIATION OF MEAN OF MEANS $(\bar{X})$ + 3 SD

= 19·67 (as in Example 1) + 1·47 + 8·82 (as in Example 1)

= 29·96 (rounded to 30)

Example 3 – Component Unscheduled Removals by Individual Components in a Three-Monthly Period

Method : Alert Level = 95% cumulative probability of the Poisson Distribution based on past 21 months experience[1] to provide an Alert Level for use as a three-monthly period of comparison.

a) **Component: Auto-pilot Pitch Amplifier**

number of components per aircraft,	n = 1
number of unscheduled removals in past 21 months,	N = 62
fleet utilisation hours in past 21 months,	H = 36840
number of component running hours in past 21 months	T = (n x H) = 36840
fleet utilisation hours in current 3 months	h = 5895
number of component running hours in current 3 months,	t = (n x h) =5895
number of unscheduled removals in current 3 months	x = 12

Mean unscheduled removal rate $\lambda = \frac{N}{T}$ =0·00168

Expected number of unscheduled removals in current month

$= \lambda t$
= 0·00168 x 5895
= 9·9 (rounded to 10)

Referring to Figure B1 by entering the graph at λt = 10 the intersection with 0·95 (95% probability) gives the maximum acceptable number of unscheduled component removals (A value) for the 3 month period as 15.

By comparing the current value of x = 12 one can see that an 'alert' situation does not exist for this component.

b) **Component: Temperature Control Value**

n = 3, N = 31, H = 36840, t = 3 x 36840 = 110520, h = 5895,
t = 3 x 5895 = 17685, x = 9

$\lambda = \frac{31}{110520}$ = 0·00028, λt =0·00028 x 17685 = 5·01 (rounded to 5)

from graph, acceptable a value = 8. Current value of x = 9, therefore Alert Level is exceeded.

1. For large fleets the past twelve months experience may be used with a one-monthly period of comparison.

Probability of Exact Value of A, or Smaller

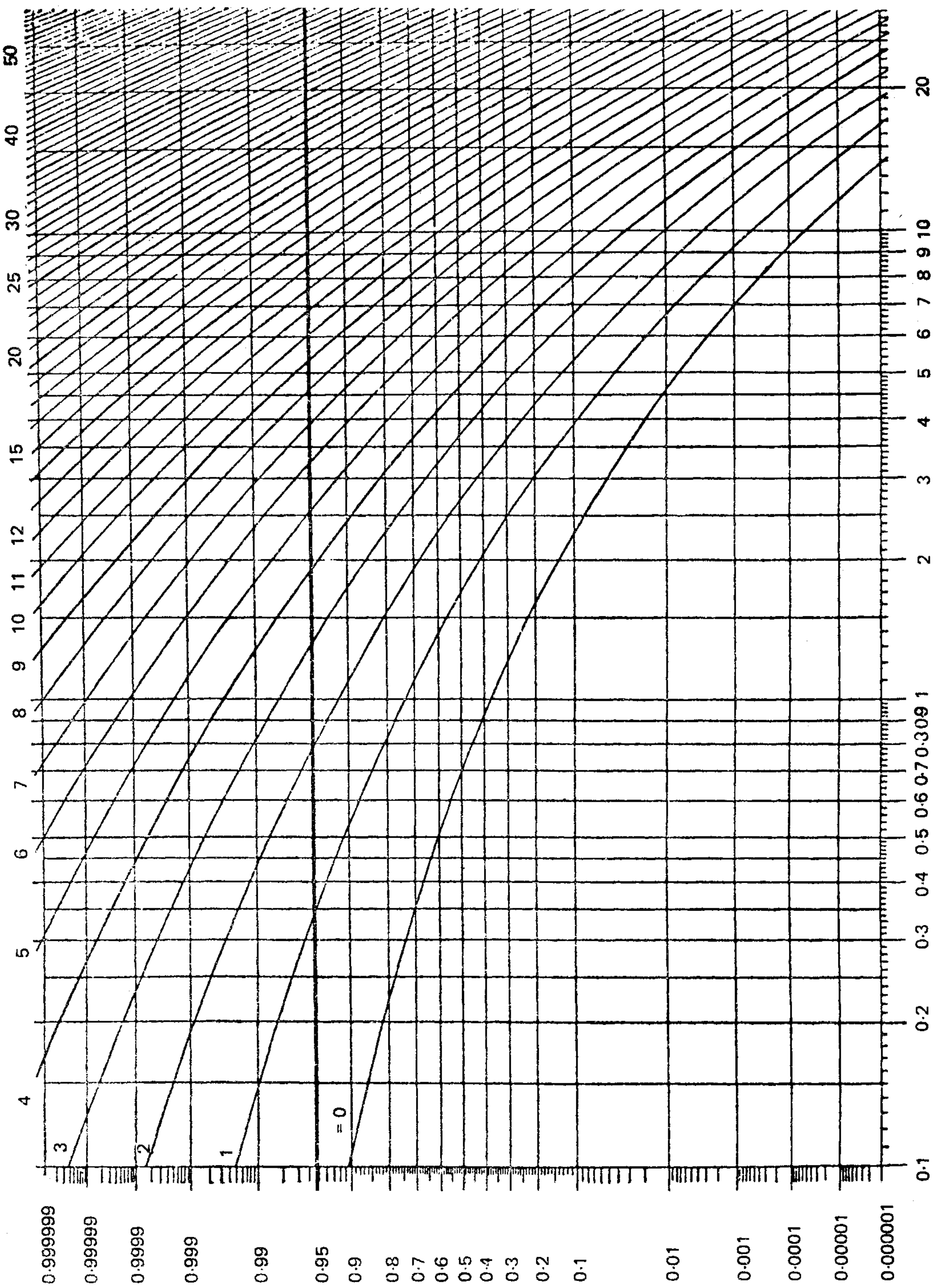

Figure B1 Poisson Cumulative Probabilities

Example 4 – Component Confirmed Failures by Individual Components in a Three-Monthly Period

Method: Alert Level = The 'corrected' Mean of the Quarterly Failure Rates plus 1 Standard Deviation of this mean, based on past seven calendar quarters of confirmed component failure rates per 1,000 hours to provide an Alert Level for use as a quarterly period of comparison.

Component: Main Generator

Table 3 Component Main Generator

Calendar Quarter	Quarterly Failure Rate (u)	Corrected Rate (C)	(C^2)
2/74	0·21	0·63[1]	0·397
3/74	0·38	0·38	0·144
4/74	0·42	0·42	0·176
1/75	0·84	0·84	0·706
2/75	0·59	0·59	0·348
3/75	0·57	0·57	0·325
4/75	1·38	0·63[1]	0·397
	$4 \cdot 39\Sigma(u)$	$4 \cdot 06\Sigma(C)$	$2 \cdot 493\Sigma(C^2)$

1

N(months)=7

Σ = Totals

QUARTERLTY MEAN FAILURE RATE = $\frac{\Sigma(u)}{N} = \frac{4 \cdot 39}{7} = 0 \cdot 63$

CORRECTED MEAN FAILURE RATE $\bar{C} = \frac{\Sigma C}{N} = \frac{4 \cdot 06}{7} = \underline{0 \cdot 58}$

STANDARD DEVIATION, SD $= \sqrt{\frac{\Sigma(C^2) - \frac{(\Sigma(C))^2}{N}}{N-1}}$

$= \sqrt{\frac{2 \cdot 493 - \frac{(4 \cdot 06)^2}{7}}{6}}$

$= \sqrt{\frac{2 \cdot 493 - 2.355}{6}}$

$= \underline{0 \cdot 15}$

ALERT LEVEL $= \bar{C} + 1SD = 0 \cdot 58 + 0 \cdot 15 = \underline{0 \cdot 73}$

1. Where an individual Quarterly Failure Rate falls outside plus or minus 50% of the uncorrected Quarterly Mean Failure Rate (0·63 in this case), then this Mean is to be used as a Corrected Rate in place of the uncorrected Quarterly Failure Rate.

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	Revenue -	13400:39	907	801	1068	1374	1571	1798							7519
(hr:min)	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 -	Number of Movements -	5277	316	293	395	528	658	752							2942
REVENUE (more than	Number of delays -	134	8	6	9	17	13	16							69
15 mins)	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	Interrupted Flights -	7	Nil	Nil	Nil	Nil	Nil	Nil							Nil
INCIDENTS	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															

Figure C1 Fleet Reliability Summary

APPENDIX C - Typical Data Displays

AIRCRAFT TYPE:	1976	1977											
%	Average	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
5													
4													
3		3·80											
2			2·65										
1	1·73			1·98									

BASE	NO. OF MOVEMENTS			NO.OF TECH. DELAYS			TOTAL DELAY TIME (hr:min)			AVERAGE DELAY (%)			REMARKS
	JAN	FEB	MAR	JAN	FEB	MAR	JAN	FEB	MAR	JAN	FEB	MAR	
Gatwick	171	159	174	9	4	4*	9:50	7:20	11:35	5·26	2·34	2·29	*1 Overseas
Manchester	44	46	17	1	3	0	0:30	2:51	-	2·27	6·52	-	
Berlin	127	59	111	3	-	2	13:19	-	4:21	2·36	-	1·80	
TOTALS	342	264	302	13	7	6	23:39	10:11	15:56	3·80	2·65	1·98	

Figure C2 Aircraft Mechanical Delays/Cancellations

AIRCRAFT TYPE: / ENGINE TYPE:			1976	1977 JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC	ACCUM TOTALS 1977	PREVIOUS 12 MONTHS TOTALS
		Total Engine Hours	40613	2735	2486	3306	4227	4752	5400							22906	45149
UNSCHEDULED REMOVAL		Total Unscheduled Removals	4	-	-	-	-	-	-							2	4
		Rate per 1,000 Eng. Hours	0·10	-	-	-	-	0·21	0·18							0·08	0·08
	REASON	Failure	4	-	-	-	-	1	1							2	4
		Suspect Failure	-	-	-	-	-	-	-							-	-
		External Causes	-	-	-	-	-	-	-							-	-
	INVEST'N RESULTS	Basic Engine Failure	2	-	-	-	-	-	-							1	2
		Non Basic Engine Failure	-	-	-	-	-	-	-							-	-
		Substantiated	1	-	-	-	-	-	-							1	2
	FOLLOW UP ACTION	Rectification	3	-	-	-	-	1	-							1	3
		H.S.I.[1]	-	-	-	-	-	-	-							-	-
		Overhaul	-	-	-	-	-	-	1							1	1
SCHEDULED REMOVAL		Total Scheduled Removals	4	2	2	1	1	-	-							6	7
		H.S.I.[1] Time Expired	1	2	-	-	-	-	-							2	2
		Time Expired - Overhaul -	3	-	2[2]	1	1	-	-							3	5
		H.S.I.[1] Approved Life	5500	5500	5500	5500	5500	5500	5500							5500	5500
		Overhaul Approved Life	10500	10500	10500	10500	10500	10500	10500							10500	10500
UNSCHEDULED ENGINE SHUT-DOWN		Total Number	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil	Nil
		Rate per 1,000 Hours	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil	Nil
		Accumulative Rate	Nil	Nil	Nil	Nil	Nil	Nil	Nil							Nil	Nil

1. Hot Section Inspection
2. 1 removed for disc mod

Figure C3 Engine Removals and Unscheduled Shut-Downs

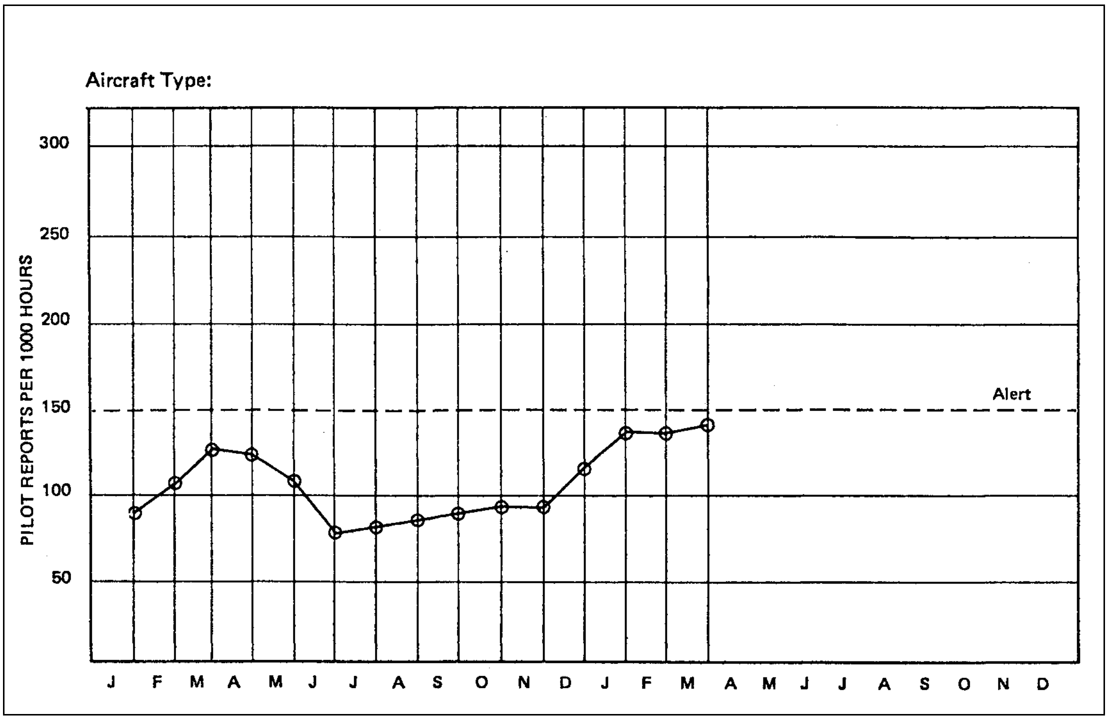

Figure C4 Fleet Pilot Reports

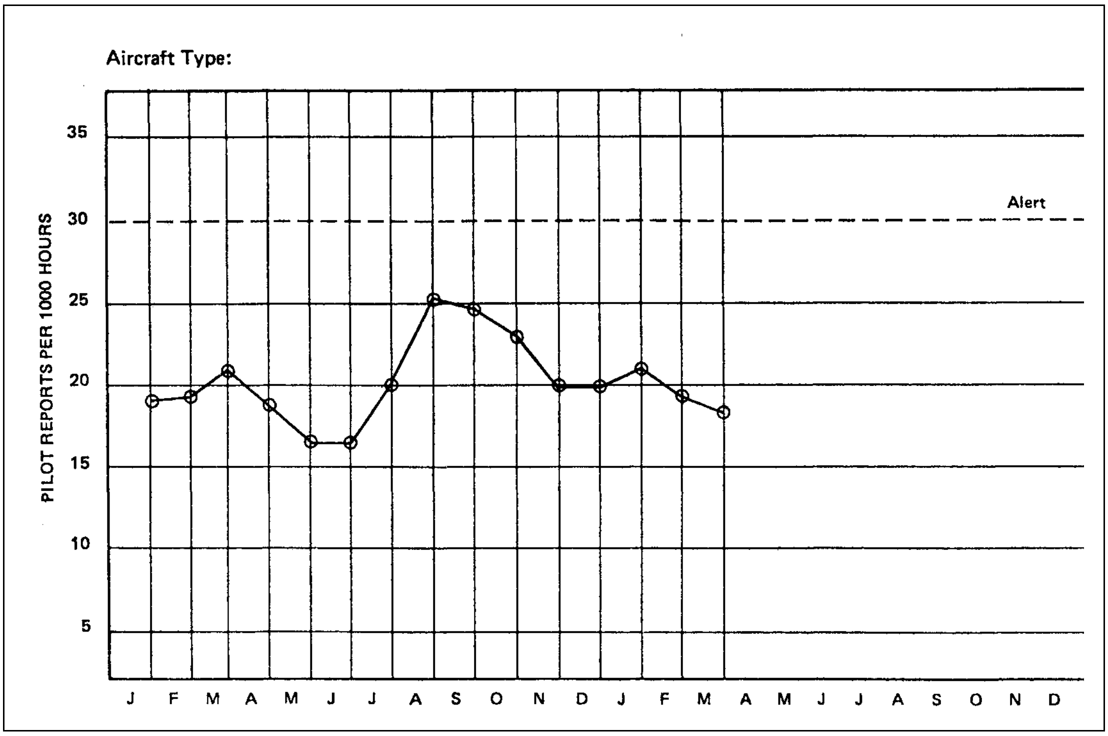

Figure C5 Pilot Reports ATA 21 - Air Conditioning System

AIRCRAFT TYPE:
Air Conditioning/Pressurisation (ATA 100 Chapter 21)

SCH. REF.	PART NUMBER	NO PER A/0	COMPONENT FLYING HOURS	13408				2495								ALERT LEVEL	ACCUMULATIVE COMPONENT CONFIRMED FAILURES SINCE 1.1.74		
			PERIOD	1975				1ST QTR 1976											
				A*	B*	C*		A*	B*	C*		A*	B*	C*			A*	B*	MTBF[1]
30/4	131046-1	1	Manual Pressure Controller	-	-	-		2	0·80	-	X*					-	2	0·06	16000
30/5	102518-3-1	1	Auto Cabin Pressure Controller	4	0·29			-	-	-						0·60	9	0·28	3555
30/6	10-3280-5-1	2	Cabin Outflow Valve	9	0·26	2		1	-	1						0·50	9	0·14	7110
51/1	178040-2-1	4	Heat Exchanger	3	0·05			-	-	-						0·15	5	0·04	25601
51/2	204050-10-1	2	Air Cycle Machine	2	0·07			-	-	-						0·30	4	0·06	16000
51/5	129150-2-1	2	35° Thermostat Pack Anti-icing	1	0·03			-	-	-						0·30	1	0·015	64020
51/6	321674-3-1	2	Valve - Pack Shut-Off	5	0·11	2		-	-	-						0·30	5	0·08	12800
52/2	541248-2-1	2	Actuator - Ram Air	1	0·03			-	-	-						0·30	2	0·03	32000
52/7	207562-1	2	Fan Cooling Pack	2	0·07			-	-	-						0·30	8	0·13	8000
58/3	18801-5	1	Detector - Air Flow Sensor	-	-	-		-	-	-						-	1	0·03	32000
61/1	321402-1-1	2	Valve/Actuator -Control Mix	-	-	-		1	0·20	-						0·30	5	0·08	12809
61/2	548376-5	1	Controller - Air Temp	1	0·07			-	-	-						0·60	2	0·06	16000
61/9	67321-10-190	3	Temperature Sensor	-	-	-		-	-	-						0·15	1	0·01	96061
62/2	163BL501	2	Indicator - Pack Temp.	-	-	-		-	-	-						0·30	1	0·015	64020
30/7	132322-2-1	1	Fan Venturi	2	0·14			1	0·40	-						0·60	4	0·13	8000
61/3	548392-1-1	2	Cabin Temp. Sensor	1	0·03			-	-	-						0·30	1	0·015	64020
42/1	32-2684-002	1	Cargo Outflow Valve	-	-	-		1	0·40	-						0·60	2	0·06	16000
58/8	123266-2-1/ 123544.1.1 }	2	Hot Air Check Valve	-	-	-		1	0·20	-						0·30	1	0·015	6402
23/1	500702-4620	2	Gasper Fan	-	-	-		-	-	-						0·60	4	0·06	16000
51/3	178050-2-1	2	Water Separator	-	-	-		-	-	-						0·60	2	0·03	32001
51/4	10-60506-4	2	35° Valve Pack Anti-Icing Cont	-	-	-		-	-	-						0·30	-	-	

*A - No. of unscheduled removals
*C - Non-confirmed Defects
*B - Failure Rate per 1,000 hours
*X - Failure Rate above Alert Level

1. MTBF - Mean Time Between Failures

Figure C6 Component Unscheduled Removals and Confirmed Failures

AIRCRAFT TYPE:		JANUARY 1971			1970 FIRST HALF			1970 LAST HALF		
ATA 100 CHAPTER	ALERT LEVEL	UR[1]	URR[2]	FR[3]	UR[1]	URR[2]	FR[3]	UR[1]	URR[2]	FR[3]
21 - Air Conditioning	·35	2	·53	·33	14	·34	·32	15	·36	·31
22 - Auto-pilot	·80	4	1·33	·33	16	·98	·29	19	·98	·32
23 - Communications	·92	2	·67	·48	10	·57	·48	8	·56	·37
24 - Electric Power	·20	2	·08	·02	8	·06	·02	9	·07	·03
27 - Flight Controls	·30	1	·20	·09	7	·12	·10	6	·10	·08
28 - Fuel	·23	0	·00	·00	2	·64	·30	1	·09	·06
29 - Hydraulic	·38	1	·42	·40	2	·26	·18	4	·46	·22
30 - Ice & Rain Protection	·15	0	·00	·00	2	·14	·08	2	·14	·08
31 - Instruments	·65	4	·63	·34	20	·61	·31	16	·57	·20
32 - Landing Gear	·33	1	·04	·02	7	·05	·03	9	·09	·04
34 - Navigation	·73	3	·66	·21	20	·69	·24	24	·71	·29
35 - Oxygen	·30	2	·66	·32	11	·65	·31	9	·64	·30
36 - Pneumatic	·20	0	·00	·00	2	·01	·01	4	·02	·02
38 - Water-Waste	·24	1	·09	·06	6	·16	·15	7	·17	·16
49 - APU	·48	1	·33	·32	7	·34	·34	4	·26	·29
73 - Engine Fuel & Control	·39	0	·00	·02	4	·10	·06	2	·06	·05
75 - Engine Air	·28	1	·17	·16	5	·16	·14	3	·12	·12
77 - Engine Indicating	·30	5	·42	·17	26	·46	·18	22	·44	·17
79 - Oil	·22	0	·00	·00	2	·04	·02	3	·06	·04
80 - Starting	·50	1	·17	·11	6	·18	·12	3	·09	·10

Figure C7 Component Unscheduled Removals and Confirmed Failures

1. UR - Unscheduled Removal
2. URR - Unscheduled Removal Rate
3. FR - Confirmed Failure Rate (3 months cum. av.)

AIRCRAFT TYPE:				
SERIAL NO.	AIRCRAFT & POSITION	HRS RUN	DEFECT	RESULTS OF WORKSHOP INVESTIGATION AND ACTION TAKEN
1170109	G-	848 TSR[1] 9375 TSN[2]	Losing altitude in turns	Test wing levelling not operative; recalibrated.
0290329	G-	11110 TSR 16771 TSN	Rolls rapidly to right when heading hold engaged.	Various internal outputs were drifting and distorted. Replaced tacho, roll CT and resolver, servo amp and valve amplifier.
0920575	G-	99 TSR 4014 TSN	Altitude hold sloppy in turns.	Roll computer out of calibration limits. Mod D to Lateral Path Coupler embodied to improve interface between Sxxxx equipment and Cxxxx receiver.
1280330	G-	36 TSR 7664 TSN	A/C will not maintain heading - ends up with 30° bank.	No fault found but extensive investigation revealed A3A1A2B output 1·5V - should be zero volts.

CONCLUSIONS	REMEDIAL ACTION
All channel assemblies are now sent to Manufacturer for investigation. Histories are reviewed and any channels which previous 'NFF'[3] findings are being extensively tested to isolate components which may be drifting out of tolerance. This should result in improved MTBF[4], but will probably show more confirmed failures for a while.	

	REPORT REF. NO.	PART NO.	ITEM
22-10-14/20 Sheet 1 of 1	1Q75-22-2H	2588812-901	Roll channel assy.

Figure C8 Workshop Report

1. Time since repaired
2. Time since new
3. 'No fault found'
4. Mean Time Between Failures

Leaflet 1-8 Storage Conditions For Aeronautical Supplies

1 Introduction

This Leaflet gives guidance and advice on acceptable conditions of storage which may be used, in the absence of manufacturer's recommendations, for specific aeronautical materials and parts. Subject headings are as follows:

1.1 The correct handling of materials, especially the high strength aluminium alloys, is of extreme importance. Great care is necessary during loading and unloading and storage at the consignee's works to ensure that the material is not damaged by chafing, scratching, bruising or indentation, and that it is not excessively strained by bending, otherwise the mechanical properties of the material may be seriously affected. Heavy forgings, extrusions and castings should be carried and stored singly, ensuring that there is adequate support to maintain the material in its intended shape without strain.

2 General Storage Conditions

The conditions of storage of aircraft supplies are important. The premises should be clean, well ventilated (see paragraph 3.13) and maintained at an even dry temperature to minimise the effects of condensation. In many instances the manufacturer will specify the temperature and relative humidity in which the products should be stored. To ensure that these conditions are maintained within the specified range, instruments are used which measure the temperature and relative humidity of the store room.

2.1 Temperature and Relative Humidity

When required, the temperature and humidity should be checked at regular intervals by means of a hygrometer which measures the amount of humidity in the atmosphere. The wall-type of hygrometer is normally used and consists of wet and dry 'bulbs'; the dry bulb records the actual temperature, and a comparison between this reading and that registered by the wet bulb, when read in conjunction with a table, will indicate the percentage of relative humidity present in the atmosphere.

2.2 Protective Materials for Storage Purposes

2.2.1 Vapour Phase Inhibitor (VPI)

This is a method of protection against corrosion often used for stored articles made of ferrous metals.

a) VPI protects by its vapour, which entirely covers any article in an enclosed space. Direct contact of the solid VPI with the metal is not required. Although moisture and oxygen are necessary for corrosion to take place, VPI does not react with or remove either of them, but operates by inhibiting their corrosive action.

b) The method most commonly used is treated paper or board, the article to be protected being wrapped in paper which has been treated with VPI or, alternatively, enclosed in a box made of VPI treated board, or lined with treated paper.

NOTE: Protection of parts by the VPI process should only be used where it is approved by the manufacturer of the part.

2.2.2 Protective Oils, Fluids, Compounds

Where oils, fluids or compounds are used as a temporary protection on metal articles, it should be ascertained that the material and the method of application is approved by the manufacturer of the article. Where protective oils, fluids or compounds have been used, deterioration of such fluids or compounds by handling can be minimised by wrapping in a non-absorbent material (e.g. polythene, waxed paper), which will normally increase the life of such temporary protectives by inhibiting drying out. When parts or components are stored for long periods they should be inspected at intervals to ensure that the condition of the coating is satisfactory.

2.2.3 **Desiccants**

The desiccants most commonly used in the protection of stored parts or components are silica-gel and activated alumina. Because of their hygroscopic nature these desiccants are capable of absorbing moisture either inside a packaging container or a component, thereby preventing corrosion.

a) Desiccants should be inspected and/or renewed at specified periods or when an airtight container has been opened. It is important when inspecting or changing a desiccant that the prescribed method is used to avoid the entry of moisture into a dry container.

b) **Tell-Tale Desiccant**. This indicating type of desiccant is prepared with a chemical which changes colour according to its moisture content. The following table gives guidance on the relative humidity of the surrounding air.

Colour	**Surrounding Relative Humidity (%)**	**Moisture Content of Silica-Gel %**
Deep Blue	0·5	0·2
Blue	10	5·5
Pale Blue	20	7·5
Pinkish Blue	30	12·0
Bluish Pink	40	20·2
Pink	50	27·0

c) Silica-gel and activated alumina can be reactivated by a simple heat treatment process. The time and temperature required to effectively dry the desiccant should be verified with the manufacturer, but a general guide is 135°C for at least 2 hours for silica-gel and 250°C for 4 hours for activated alumina. The desiccant should then be placed in a sealed container until it has cooled, after which it should be completely reactivated.

2.3 **Racks and Bins**

Open racks allow a free circulation of air and are preferable when the nature of the stock permits their use. The painted metal type of bins is more suitable than the wooden type, since with the latter there is a risk of corrosion due to mould or dampness. Polyethylene, rigid PVC, corrugated plastics or cardboard bins may also be used. Many moulded plastics bins can also be fitted with removable dividers which will allow for the segregation of small parts whilst making economic use of the space.

2.4 **Rotation of Issue**

Methods of storage should be such that batches of materials or parts are issued in strict rotation, i.e. old stock should be issued before new stock. This is of particular importance for perishable goods, instruments and other components which have definite storage limiting periods.

2.5 **Storage Limiting Period**

The manufacturers of certain aircraft units impose storage limiting periods after which time they will not guarantee the efficient functioning of the equipment. On expiry of recommended storage periods the parts should be withdrawn from stores for checking or overhaul as recommended by the manufacturer. The effective storage limiting periods of some equipment may be considerably reduced if suitable conditions of storage are not provided. Therefore, storage limiting periods quoted by manufacturers can only be applicable if the prescribed conditions of storage are in operation, and users should develop suitable limiting periods from their own experience.

2.6 **Flammable Materials**

All materials of a flammable nature, such as dope, thinners, paint, etc., should be kept in a store isolated from the main buildings. The precautions to be taken vary with the quantity and volatility of the materials, and such stores should comply with the requirements of HM Inspector of Factories and the Area Fire Authority.

2.7 **Segregation of Stock**

Care should be taken to segregate materials which may have deleterious effects on other materials, e.g. carboys of acid should not be placed in a store where escaping fumes may affect raw materials or finished parts; phenolic plastics should be segregated from cadmium-plated steel parts to prevent corrosion of the steel parts; magnesium alloys should not be stored in the vicinity of flammable materials.

2.8 **Packaging of Stock**

Stock should normally be packaged from the following:

a) **Materials.** Plastics film, 'Jiffy' bags, lanolin grease impregnated cloth, plastics film lined paper envelopes, etc.

b) **Methods.** Oiling and placing in jars or plastics bags, individual packaging of seals, etc.

NOTE: Magnesium fittings should not normally be kept in sacks, as the materials used in making the sacks may cause corrosion of the fittings.

2.9 **Materials in Long Lengths**

It is particularly important that long lengths of material, such as extrusions, tubes, bars, etc., should generally be stored vertically, which tends to reduce problems caused by bow and handling damage. Care should also be taken when placing the material in the storage racks to prevent indentations and scratches, especially when handling the high strength aluminium alloys.

3 Storage Conditions For Specific Materials and Parts

This paragraph gives guidance on recommended methods of storage for various materials and parts.

3.1 **Ball and Roller Bearings**

Ball and roller bearings should be stored in their original wrappings in dry, clean conditions with sufficient heating to prevent condensation caused by significant temperature changes.

3.1.1 If the wrapping has become damaged or if it is removed for inspection of the bearings, the bearing (providing it does not incorporate rubber seals) should be soaked and swilled in white spirit to remove storage grease and/or dirt. It is permissible to oscillate or turn the races slowly to ensure thorough cleaning, but the bearings should not be spun in this unlubricated condition because the working surfaces may become damaged. A forced jet of white spirit may be used to advantage but an efficient filter should be provided in the cleaning system.

3.1.2 In certain cases it may be preferable to clean very small bearings with benzene, but if this fluid is used, consideration should be given to the fire hazard and possible toxic effects.

NOTES: 1) There are certain proprietary light white spirits which are suitable for use with very small bearings and which eliminate some of the dangers associated with the use of benzene.

2) Miniature steel balls and special high precision balls are immersed in instrument oil contained in plastics phials with screw-on caps.

3.1.3 After cleaning, the bearings should be inspected for signs of corrosion and then re-protected with a compound of mineral oil and lanolin and wrapped in greaseproof paper. Many miniature bearings, especially those used in instruments, are susceptible to brinelling. When such bearings have become suspect or contaminated they should be discarded.

NOTE: In many instances orders for bearings are endorsed with a requirement that special grease should be applied by the manufacturer. If this grease is removed for any reason, it is essential that grease of the correct specification is re-applied.

3.2 **Aircraft Batteries**

3.2.1 **Lead-Acid Batteries**

A charged battery which is to be stored for any length of time should be in the "fully charged" condition. Before storing, the electrolyte levels should be checked and the battery bench-charged in accordance with manufacturer's instructions. When fully charged, the battery should be stored in a cool, dry, well ventilated store on an acid-resistant tray. Batteries may also be stored in the dry, uncharged state. Additional points to note are as follows:

a) Every 4 to 6 weeks (depending on manufacturer's instructions) the battery should be removed from storage and fully recharged, i.e. until voltage and specific gravity readings cease to rise.

NOTE: Damage to the battery will occur if it is allowed to stand idle beyond the period for charging specified by the manufacturer.

b) Regardless of periodic check charges, the battery should be given a complete charge and capacity check immediately before being put into service.

c) For new batteries, a complete capacity test to the manufacturer's instructions should be made every 6 months, but if the battery has been in service this test should be made every 3 months.

d) Every 12 months, or earlier if a leak is suspected, an insulation resistance test should be carried out to the manufacturer's instructions.

e) If the conditions mentioned in the previous paragraphs are observed, a battery may remain in storage up to 18 months. A battery should not be allowed to stand in a discharged condition, and electrolyte temperatures should not exceed 48.8ºC.

NOTE: Trickle charging at low rates is not recommended as damage will occur if idle batteries are subjected to this form of charging.

3.2.2 **Silver-Zinc Batteries and Silver-Cadmium Batteries**

These batteries should be stored in clean, dry, cool and well ventilated surrounds, not exposed to direct sunlight or stored near radiators.

a) New batteries will normally be supplied in the dry condition with the electrolyte contained in polythene ampoules. If possible, new batteries should be stored in their original packaging together with the related ampoules of electrolyte. For storage periods of more than 2 years, special instructions should be requested from the manufacturers.

b) Filled and formed batteries required for use at very short notice may be stored in the charged condition. Manufacturers normally recommend that such batteries should be discharged and recharged every 4 to 6 weeks. The manufacturer's schedule of maintenance should be applied to batteries stored in the charged condition.

c) Batteries to be stored out of use for protracted periods, should be discharged at the 40-hour rate until the voltage level measured while discharging, falls below the equivalent of 0·8 volt per cell.

d) Before storing batteries, the electrolyte level should be adjusted to near the maximum specified by topping up, using a potassium hydroxide solution of 1.300 sg.

e) The need for care in handling potassium hydroxide, because of its caustic content, is stressed.

After topping up or filling, the top of the batteries should be cleaned and the connections and terminals lightly smeared with white petroleum jelly. In no circumstances should sulphuric acid or acid contaminated utensils be used in close proximity to silver-zinc or silver-cadmium batteries.

3.2.3 Nickel-Cadmium Batteries

This type of battery can be stored for long periods without damage, in any state of charge, provided the storage place is clean and dry and the battery is correctly filled.

a) For the battery to be ready for use in the shortest possible time, it should be fully charged, correctly topped up and then discharged at normal rate for a period of 1 hour before storage.

b) The battery should be cleaned and dried and the terminals and connectors lightly smeared with pure mineral jelly.

c) The battery should be inspected at intervals of 6 to 9 months and topped up if necessary.

d) Before going into service, the battery should be given a double charge and capacity check as recommended by the manufacturer of the particular type of battery.

e) The battery should be stored on a shelf or rack, protected from dirt or dust, and where metallic objects such as bolts, hand-tools, etc., cannot drop onto the battery or touch the cell sides.

NOTE: The above refers to pocket plate nickel-cadmium cells and not to sintered plate nickel-cadmium cells, for which reference should be made to the manufacturer's instructions.

3.2.4 Precautions

It should be noted that sulphuric acid will destroy alkaline batteries; therefore, utensils which have been used for this acid should not be used with such batteries. It is also important to avoid any contamination from the fumes of lead-acid types of batteries. (See Leaflet 9–2).

3.3 **Braided Rubber Cord**

Braided rubber cord should be stored in a cool, dark place with an even temperature preferably not exceeding 18°C with relative humidity of approximately 65%. The cord should not come in contact with any radiant heat, grease, oil, water, organic solvents or corrosive materials.

NOTE: Storage at elevated temperatures may cause permanent deterioration of the rubber, and prolonged storage at low temperatures will cause temporary stiffening of the rubber.

3.3.1 **Storage Limiting Period**

Braided rubber cord has a storage limiting period of 4 years if stored in good conditions. Cord which has been issued from stores within the 4 year period from the date of manufacture may remain in service until the expiry of 5 years from that date.

a) The date of manufacture of cordage can be determined by the colour of the threads in the cotton outer casing; French Blue 1986; Night Black 1987; Nato Green 1988; Service Brown 1989 and Canary Yellow 1990. After 1990 the colours are repeated in the same sequence for a further 5 years and subsequently until further notice.

b) The number of coloured threads indicate the quarter of the year in which the cord was manufactured, e.g. one thread indicates the cord was made between 1st January and 31st March, two threads 1st April and 30th June inclusive.

NOTE: Further details are given in British Standard Specification (Aerospace Series) 2F 70 and 2F 71, Light Duty Braided Rubber Cord for Aeronautical Purposes.

3.4 **Compressed Gas Cylinders**

Stores which are used for storage of compressed gas cylinders should be well ventilated. The cylinders should not be exposed to the direct rays of the sun and no covering should be used which is in direct contact with the cylinders. Cylinders should not be laid on damp ground or exposed to any conditions liable to cause corrosion. Gas storage cylinders should normally be fitted with a transportation/storage cap over the shut-off valve to help prevent handling damage and contamination of parts which could cause a risk of explosion or fire. Portable gas cylinders (e.g. therapeutic oxygen, fire extinguishers) should be stored on racks and, where appropriate, control heads and gauges should be protected against impact.

3.4.1 No heating is required in stores where compressed gas cylinders are kept, unless specified by the manufacturer.

3.4.2 Lighting for stores containing combustible gas cylinders (i.e. acetylene) should be flameproof, or installed outside the building, lighting the interior through fixed windows.

3.4.3 Store rooms should be manufactured of fireproof materials and the cylinders so placed to be easily removable in the event of fire. The store should be at a distance from corrosive influences, e.g. battery charging rooms.

3.4.4 Full and empty cylinders should be stored in separate rooms, and appropriate notices displayed to prevent confusion.

3.4.5 Oxygen and combustible gases such as acetylene should not be stored together. Acetylene cylinders should be stored in the upright position.

3.4.6 Oxygen cylinders are generally rounded at the bottom, thereby making it unsafe to store in an upright position without suitable support. If cylinders are stacked horizontally special wedges should be used to prevent the cylinders rolling, and the stack of cylinders should not be more than four high.

3.4.7 Breathing oxygen and welding oxygen should be segregated and properly labelled to avoid confusion. In some cases welding oxygen may be used for testing oxygen components not installed in the aircraft, but welding oxygen should not be used in aircraft oxygen systems.

3.4.8 **Precautions**

If cylinders are exposed to heat, the gas pressure will increase and the cylinder walls may be weakened, causing a dangerous condition. Cylinders should be stored at some distance from sources of heat such as furnaces, stoves, boilers, radiators, etc.

a) Oil or grease will ignite in the presence of oxygen, and if the latter is under pressure an explosion may result. Cylinders should be kept away from sources of contamination, such as oil barrels, overhead shafting, hydraulic components or any container or component that may contain oil or grease.

b) Smoking, exposed lights or fires should not be allowed in any room where compressed gases are stored, and oily or greasy clothes or hands should be avoided when handling the cylinders.

c) Grit, dirt, oil and water should be prevented from entering the cylinder valves.

d) When returning any cylinder that may have been accidentally damaged or overheated, the supplier should be notified so that any necessary action may be taken before refilling.

3.5 **Electrical Cables**

Where electrical cables are stored in large reels it is necessary that the axis of the reels are in a horizontal position. If stored with the axis vertical there is a possibility that the cable in the lowest side of the reel will become crushed.

3.6 **Fabric**

Fabric and fabric covering materials (e.g. strips and thread) should be stored in dry conditions at a temperature of about 21°C away from direct sunlight. Discolouration, such as iron mould, is sufficient to cause rejection of the material and this may be caused by unsuitable storage conditions. Most synthetic fibre fabrics should be stored away from heat sources. Rubber proofed fabrics should be stored away from plasticised materials such as PVC as it is known, in some cases, for plasticisers to leach from some plastics and have an adverse affect on rubbers.

3.7 **Forgings, Castings and Extrusions**

All large forgings, castings and extrusions should be carefully and separately stored on racks to avoid superficial damage.

NOTE: The high strength aluminium alloys are susceptible to stress corrosion when in the solution treated condition, and it is important that parts so treated should be coated with a temporary protective such as lanolin.

3.7.1 Aluminium alloy forgings which are anodised normally need no protection in a heated store. Finished details should be protected in accordance with DEF STAN 03–2.

3.7.2 Aluminium alloy castings in store should not be contained in sacks or absorbent packages. It is not normally necessary to protect castings before machining, but finished details should be protected as for forgings in paragraph 3.7.1.

3.7.3 Aluminium alloy extrusions should be protected in store with a lanolin and mineral oil solution (DEF STAN 80–34) and as finished details with DEF STAN 03–2 as in paragraph 3.7.1.

3.8 **Instruments**

The smaller types of instruments are usually delivered in plastic envelopes and these should be used during storage to minimise the possible effects of condensation. The transit containers of the larger instruments contain bags of silica-gel (paragraph 2.2.3) to absorb moisture which may enter. The gel should be examined periodically, and if its colour has changed from blue to pink it should be removed, dried out and replaced, or renewed. It is essential that all instruments should be stored in a dry, even temperature, and that the storage limiting period recommended by the manufacturer is not exceeded.

NOTE: Whenever possible instruments should be kept in transit or similar cushioned containers until required for fitment to an aircraft.

3.8.1 In the absence of any specific recommendation by the manufacturer the storage limiting period for instruments should not exceed 3 years, and on completion of this time the item should be re-certified in accordance with the relevant Overhaul Manual. Additionally, any equipment containing gyro assemblies should be exercised and gyro wheels run for a period of 24 hours at the completion of periods not exceeding each 12 months of storage.

3.9 **Oil Coolers and Radiators**

Oil coolers and radiators are normally filled with an inhibiting fluid during storage; the fluid used should be in accordance with the manufacturer's instructions. The components should not be stored on the floor, but placed on raised wooden supports to permit a free circulation of air and minimise the possibility of damage to the matrices.

3.10 **Paints and Dopes**

For the storage of paint and related materials (i.e. all low flash point materials) it may be necessary to obtain a licence to comply with the requirements of the Petroleum Act. Paints should be kept in a dry store at a controlled temperature between 7° and 23°C.

3.10.1 Paint containers should be marked with the date of receipt so that the oldest batches may be used first, as pigments tend to 'settle out' when paint is stored. A simple method of avoiding settlement is to invert containers at regular intervals, e.g. once a month.

3.10.2 **Toxicity of Solvents**

If paints are handled or mixed in a confined space it is important to ensure adequate ventilation during such operations as the fumes from volatile liquids are harmful if inhaled in sufficient concentration.

NOTE: A point frequently overlooked in ventilating a paint store is that most solvents are heavier than air, so that ventilation is more efficient downwards than upwards.

3.10.3 Provided paints and dopes are suitably stored in their original sealed containers, the storage limiting period is normally 12 months in the United Kingdom, but this may vary elsewhere; for example, in tropical conditions the period is normally 6 months.

3.11 **Pipes**

Rigid pipes should be adequately supported during storage to prevent distortion. Flexible pipes should, unless otherwise stated by the manufacturer, be suitably wrapped, for example, in a sealed plastics sleeve before being stored in a darkened room, maintained at a temperature of approximately 15ºC. In hot climates, flexible pipes should be stored in cool places where air circulates freely, since high temperatures tend to accelerate surface hardening of the outer cover.

3.11.1 Flexible pipes should be stored in a completely unstressed condition and, where possible, should be suspended vertically (see also paragraph 3.13.14).

3.11.2 The ends of all pipes should be blanked, using a type of blank which does not allow it to be left in position when the pipes are fitted. The use of rags or paper for this purpose is prohibited. The blanks should not be removed until just prior to fitting the pipe.

3.11.3 Chloride based materials, such as Neoprene and glass fibre tape should not be used for the wrapping of Stainless Steel and Titanium pipes. Chloride based materials break down with heat (temperatures above 150ºC) to produce corrosive salts which will attack Stainless Steel and Titanium components resulting in premature failure. In addition it is also possible that smears of chloride material may be left on components which have been touched by PVC (Plasticised Polyvinyl Chloride) sheeting while covered over by, or packed in, such material.

3.12 **Pyrotechnics**

Pyrotechnics should be stored in a dry, well ventilated building and kept at constant room temperature. The building should conform to the local by-laws laid down by the Local Authority.

3.12.1 At the periods specified by the manufacturer, pyrotechnics should be examined for any signs of damp or other external damage.

3.12.2 With paper-cased items, such as signal cartridges, the effect of damp is usually indicated by softening or bulging of the outer case and evidence of staining.

3.12.3 With metal-cased items, the effects of damp may often be indicated by traces of corrosion or tarnishing of the case and/or staining of the instructions label.

3.12.4 All pyrotechnics gradually deteriorate in time, although such deterioration will vary with factors such as quality or type of composition, degree of protection afforded by the containers, etc. For this reason a proportion of the items should be proof-tested at regular intervals as specified by the manufacturer; the items will also have a maximum serviceable life, regardless of proof testing, which should not be exceeded.

NOTE: The most likely effect of storage deterioration is a loss of brightness and range.

3.13 **Rubber Parts and Components Containing Rubber**

The following storage conditions are generally acceptable for a wide range of components containing rubber in their manufacture or parts made of rubber. In many cases manufacturers make special recommendations and these should also be observed. (Further information can also be found in BS 3F 68 and 3F 69).

3.13.1 **Temperatures**

The storage temperature should be controlled between 10º and 21ºC and sources of heat should be at least 3 feet from the stored article (unless screened) to minimise exposure to radiant heat. Some special rubber materials (e.g. neoprene) may withstand a wider range of temperature satisfactorily, i.e. –12º to 26ºC, but before any rubber part is exposed to these temperatures the manufacturer's recommendations should be verified. This particularly applies to any special precautions necessary when thawing parts which have been subjected to the lower temperatures.

3.13.2 **Humidity**

The relative humidity in the store room should be about 75%. Very moist or very dry conditions should be avoided.

3.13.3 **Light**

Rubber parts should not be exposed to direct daylight or sunlight. Unless the articles are packed in opaque containers, store room windows or skylights should be screened or covered with a suitable transparent red or amber coating. Store rooms should be kept as dark as practicable. Use of artificial light which has a high ultra-violet level should be avoided.

3.13.4 **Oxygen**

Isolation from atmospheric oxygen greatly increases the storage limiting period of rubber parts. Where possible, parts should be packed in airtight containers or wrappings using talc or french chalk. Where parts are packed in airtight tins, the tins should be lined with wax paper or polythene to avoid direct contact with the metal.

3.13.5 **Ozone**

Exposure to air containing ozone even in minute quantities should be avoided.

Storage rooms should not contain any apparatus liable to generate ozone, such as high voltage electrical equipment, electric motors or other plant which may give rise to electrical sparks. Free access to outdoor air, which in temperate climates always contains ozone, should be avoided. Still indoor air is normally ozone-free because wall and ceiling coverings and organic materials rapidly destroy ozone.

3.13.6 **Deformation**

Rubber parts should be stored in a 'relaxed' position free from compression or distortion, with the least possible deformation. Deformation greatly aggravates the action of ozone and also leads to permanent changes in shape and dimensions. Articles received prepacked in a strain-free condition can, with advantage, be stored in their original packing, as long as they are clearly identified and labelled.

3.13.7 **Contamination**

Rubber parts should not come in contact with liquids or vapour concentrations during storage even though they may be subsequently used in contact with a similar fluid. Contact with copper, brass or corroded iron or steel, or with any compounds of manganese, should be avoided.

NOTE: If deterioration of seals is suspected, it can usually be verified by stretching the seals to 20% of their internal diameter. If cracks are visible under x10 magnification, the seals should be rejected.

3.13.8 **Hydraulic and Pneumatic System Components**

Hydraulic and pneumatic components generally have a nominal 7 year shelf life which may usually be extended for periods of 2 years by inspections.

NOTE: The maximum service life of seals is usually to be found in the approval Maintenance Schedule.

3.13.9 In many instances, hydraulic components are stored filled with hydraulic fluid which may leak slightly from the component; it is therefore important to ensure that fluid will not come into contact with other stored items.

3.13.10 If the stored component is filled with a fluid other than that used in the aircraft system (e.g. DTD 5540B is a hydraulic component storage fluid only) the component should be clearly labelled to ensure the removal of all traces of storage fluid prior to installation in the hydraulic system.

3.13.11 To avoid adhesion and to exercise the seals, it is in some cases recommended that the component be operated several times at three-monthly intervals. If the seals are square or rectangular, special care should be used in the initial operation as experience has shown that there is a tendency for seal stiction on its bearing surface and, if the part incorporating the seal is moved rapidly, the seal may tend to rotate and be damaged. This applies also where spring-loaded seals are concerned; growth of the rubber may result in damage to the sealing lip.

3.13.12 **Tyres**

Tyres should be stored vertically in special racks embodying support tubes, so that each tyre is supported at two points. Two-thirds of the tyre should be above the support tubes and one-third below. By this method the weight of the tyre is taken by the tread and distortion is reduced to a minimum. The tyres should be turned to a new position every 2 or 3 months. Where tyres are delivered in bituminised hessian wrappers, the wrappers should be left on during storage.

3.13.13 **Inner Tubes**

Inner tubes should be stored in the cartons in which they were received, but where this is not possible the tubes should be lightly inflated and stored inside covers of appropriate sizes to prevent damage. Tubes should not be secured in a fixed position (such as a tight roll) by rubber bands or tapes as this may cause the rubber to crack.

3.13.14 **Storage of Rubber Hose and Hose Assemblies**

Unless otherwise specified by the manufacturer, rubber hoses should be inspected and tested every 2 years; they should also be inspected and tested immediately prior to installation.

a) **Storage Conditions**. Hose and hose assemblies should be stored uncoiled and supported to relieve stresses. Air should circulate freely about the hoses unless they are contained in plastics envelopes. Temperatures in the store should be controlled as detailed in paragraph 3.13.1.

NOTE: Care should be taken to ensure that the plastics envelopes selected are compatible with the hose material, since some, including PVC, can have a deleterious effect on rubber.

b) **Sealing Blanks**. The correct sealing blanks should always be fitted to items in store. Plugs and caps conforming with AGS specifications are suitable but, where standard blanks cannot be fitted, the blanks used must be so designed that they cannot enter the pipe or be left in position when the assembly is coupled up. It is also important that the material used for blanking purposes will not 'pick-up' or leave small particles inside a coupling after long periods of storage. Tape, rag or paper should not be used.

c) **Bore Protection**. In some special cases, to prevent deterioration of the bore or inner lining of the hose, it may have to be stored filled with the liquid which it is intended to contain in service and instructions concerning this procedure are normally attached to the assembly. If a hose assembly is enclosed in an airtight plastics envelope, this should not be removed until the hose assembly is to be fitted. If this envelope becomes damaged during handling, it should be resealed or renewed after any desiccant inside has been checked for condition.

d) **Markings on Hose**. Various methods are employed to mark the date of manufacture on hoses. It is sometimes stencilled on the external surface, or impressed on a tab or band secured to the hose. In instances where the external surface is of cotton braid, some of the 'picks' are woven in black and some in colour which indicates the month and year of manufacture, as required by the appropriate Specification.

3.13.15 **Cleaning**

Any cleaning of rubber parts and components containing rubber, after storage, should be done with water, soap solution or methylated spirits. If synthetic detergents are used, care should be taken to select those that are not harmful to rubber. Petrol (or other petroleum spirit), benzene, turpentine, etc., should not be used, nor may cleaning be carried out with sharp or abrasive objects such as wire brushes or emery cloth. Disinfectants should not be used. After cleaning, articles should be rinsed in water and dried at a distance from any direct heat.

3.14 **Sheet, Bar and Tube Metal**

It is recommended that sheet material should be stored on edge in racks; care being necessary to prevent the bending of single sheets. Flat stacking is not recommended (unless suction pads are used to lift the sheets) since sheets are almost invariably slid from the stack, often resulting in detrimental scratches on the sheet removed and on the adjacent sheet. Where vertical storage is employed, the material should be kept clear of the floor to prevent possible damage by scraping, splashing from disinfectants used for floor cleaning (which may cause corrosion) and the possibility of edge corrosion, which can occur with light alloy materials when in contact with composition floors. Temporary protectives, such as grease, paper or plastics coating, should be left in position until the material is required for use. If the temporary protective becomes damaged or partially removed, it should be restored without delay, and a periodic inspection of stock should be made.

3.14.1 There may be some merit in storing the sheet material in the transit cases. After the initial checking of the sheets, the case should be closed to eliminate dust/dirt which can cause surface scratching during handling operations.

3.14.2 Metal bars should be stored in racks either horizontally or vertically, well supported along the length when stored horizontally to prevent bending under weight. Metal tubing is normally stored in racks, well supported, the smaller diameter tubing being wired along the length, in bundles, to prevent damage.

NOTE: Floor cleaning fluids containing chlorides should not be allowed to contact metallic materials, particularly austenetic steel as a brittle fracture may eventually result.

3.15 **Sparking Plugs**

The plugs should be treated with light oil or other suitable corrosion inhibitor. The inhibitor should not come into contact with the plug screen, but the electrode end of the plug may be filled with oil and then emptied prior to fitting the caps. Plugs receiving this treatment should be washed out with tricloroethylene or carbon tetrachloride before use. Protector caps should be screwed on both ends of the plugs to prevent the ingress of moisture or foreign matter. The plugs should be stored in a warm dry place, preferably in a heated cupboard, as an additional precaution against the ingress of moisture.

3.16 **Survival Equipment**

Survival equipment should be stored in a room which can be maintained at a temperature between 15° and 21°C, and which is free from strong light and any concentration of ozone.

3.16.1 **Preparation for Storage**

The manufacturer's instructions should be carefully followed when preparing survival equipment for storage. These instructions normally include: ensuring that the component is completely deflated; removing easily detachable components; fitting protection blanks or pads to inflation valves and other connections; dusting the component with french chalk and folding it loosely; wrapping in waterproof paper; and placing it on a shelf above the floor.

3.16.2 A tie-on label should be attached to the wrapping stating:

a) The type, serial number and part number of the equipment;

b) Date of inspection and inflation tests;

c) Date of overhaul;

d) Date of component overhaul;

e) Date of next inspection and/or test.

NOTE: The components should be stored with the equipment but it is preferable that any CO_2 cylinders be fitted with a transit cap and stored separately.

3.16.3 Under no circumstances should life-jackets or liferafts be stored one on top of the other without a separation of corrugated paper or similar shock absorbing material.

a) In the case of liferafts, not more than three should be stored on top of each other.

b) In the case of life-jackets, up to ten may be stored on top of each other.

c) Owing to the light texture of life-jackets, it is important that they should be handled with care to avoid damage.

3.16.4 **Storage Limiting Period**

The period is normally 6 months if packed and stored in accordance with the manufacturer's instructions. At the end of this period survival equipment should normally be:

a) Opened up and inspected before further storage;

b) Inspected, tested and overhauled prior to being operationally packed for stowage in aircraft.

3.16.5 Liferafts and life-jackets not operationally packed and placed in storage for more than 10 days after the last test should be re-tested before installation in an aircraft.

3.17 **Tanks (Flexible)**

The precautions to be taken during storage will depend on the type of tank and the packaging method (if any) used. Some manufacturers of flexible tanks specify that the tanks should be coated with a special preparation if they are to remain empty for more than 2 or 3 days, and that this preparation should be removed before the tanks are put into service.

3.17.1 Manufacturers also specify a 'long term' or 'short term' storage procedure contingent upon special requirements.

3.17.2 'Short term' storage is the period between transport of the tanks from the manufacturer's works and delivery for immediate installation by the aircraft firm.

3.17.3 'Long term' storage covers the period during which the tanks are held following receipt by the aircraft firm before installation, or shipment to locations at home or abroad, involving an extended period of storage prior to installation.

3.17.4 Flexible tanks can be divided into two categories for packaging and storage purposes:

a) Tanks that can be folded, e.g. those not fitted with rigid internal members, heavy coverings or fittings which would preclude satisfactory folding.

b) Tanks with heavy protective coverings, or fitted with rigid internal members, anti-surge valves, gauge units, etc.

3.17.5 **Folding and Packing**

When packing a tank for storage purposes it is important to fold it in such a way that no strain or creasing is imposed on the folded areas, and in many instances folding diagrams are provided. All openings should be sealed with the specified blanks and corrugated cardboard interposed between the folds.

a) After folding, the tank should be encased in an airtight wrapping, such as a polythene bag, and sealed.

b) The tank in its airtight envelope should then be placed in a cardboard box which should also be sealed.

c) Flexible tanks which are unsuitable for folding because of internal or external fittings, etc., are often packed in an air-inflated state suitably supported in sealed cases. This method of packing is used only for short term storage. For long term storage of this type of tank, the manufacturer’s instructions should be followed which will vary with the shape and type of tank concerned.

3.17.6 **Storage Conditions**

Generally, flexible tanks should be stored in the original airtight containers supplied by the manufacturer and if this is not possible a similar airtight storage container should be used. The manufacturer’s instructions should be observed closely. The tanks should be stored in cool, dry, draught-proof conditions, at a temperature not exceeding 25ºC and preferably below 15ºC.

3.18 **Tanks (Rigid)**

Rigid tanks should be carefully cleaned and any moisture dried out before storage. All apertures should be sealed with closely-fitting blanks. A silica-gel cartridge attached to a blank and placed inside the tank assists in preventing internal condensation and subsequent corrosion.

3.19 **Timber**

Plywood panels should be stored flat, away from all sources of heat or damp. Other timber sections should be stacked with spacers between each section to permit the free circulation of air. The timber should be checked periodically for moisture content. (See Leaflet 2–3.)

3.20 **Transparent Acrylic Panels**

Acrylic sheets should be stored on edge, with the protective paper left in position as this will help to prevent particles of grit, etc., becoming embedded in the surfaces of the sheets. When this is not possible, the sheets should be stored on solid shelves, and soft packing, such as cotton wool, should be placed between each sheet. The pile of sheets should be kept to a minimum and not exceed 12 sheets.

3.20.1 Curved panels should be stored singly with their edges supported by stops to prevent 'spreading'. There are several proprietary lacquers available for the protection of acrylic panels and shapings during handling and storage, including those complying with specifications DTD 900/5592.

3.20.2 Protective paper may also be used and, to prevent deterioration of the adhesive between the protective paper and the sheet, store rooms should be well ventilated, cool and dry. The material should not be placed near steam pipes or radiators as hot conditions will cause the adhesive to harden and make the subsequent removal of the paper difficult.

3.20.3 Material in storage should not be exposed to strong sunlight, particularly when the light shines through a glass window. This could cause a 'lens' formation resulting in local overheating to the detriment of the material.

3.20.4 Acrylic materials should not be stored with certain other materials because of the adverse effects which may arise from the vapours given off. A typical list of these materials is as follows:

Acetone	Dopes
Ammonia Vapour	Ethyl Alcohol
Amyl Acetate	Glacial Acetic Acid
Aviation Gasoline	Methyl Alcohol
Aviation Turbine Fuel	Nicotine
Benzene	Rust Remover
Butyl Acetate	Skydrol 500, and similar (Phosphate Ester) fluids
Carbon Tetrachloride	Synthetic Finishes
Cellulose Paints	Thinners
Cresol	Trichloroethylene
Deoxidine Materials	

3.20.5 When sheets are handled or moved they should be lifted off (not drawn from) the adjacent sheet. The vulnerability of transparent plastics to surface damage by scratching and bruising should be impressed on all personnel handling the material.

3.21 Windscreen Assemblies

All types of windscreen panels should be carefully protected from scratches, abrasions or other damage as small scratches or abrasions may considerably weaken the panels and impair their optical qualities. The manufacturer’s recommendations relating to packaging or protective wrapping for storage purposes should be carefully followed.

3.21.1 Glass Panels and Windscreen Assemblies

All types of glass panels should be carefully protected from scratches, abrasions or other external damage.

3.21.2 Sandwich Type Windows

Sandwich type windows should be stored vertically in dry conditions, each window having its own desiccant cartridge attached, which should be inspected and renewed at specified periods. Spare windows are usually despatched with desiccant cartridges attached and these should not be removed until the window is to be connected to the aircraft desiccation system.

a) Windows in transit should be allowed to 'breathe', this being particularly important when windows are transported by air, as considerable atmospheric pressure variations may be encountered.

b) In addition to desiccant breathing cartridges, some manufacturers build into each window airspace another desiccator which consists of small discs of activated alumina strung on wire and encased in a cylindrical fabric stocking. Normally the desiccator does not require renewing.

3.21.3 Electrically Heated Windscreens

Extreme care is necessary in handling and storing windscreens. It is generally recommended that windscreens are stored in the manufacturer's packing, which usually consists of protecting both surfaces with adhesive polythene, wrapping in acid-free paper and cellulose wadding and storing in reinforced cartons.

a) The panels should be stored separately in their cartons on racks, away from any strong light at a controlled temperature of approximately 10° to 21°C in well ventilated conditions.

b) It is important that during handling or storage the thick glass laminate is kept uppermost to prevent delamination and that the polythene film is not removed until the panel is fitted to the aircraft.

3.22 Wire Rope

Wire rope should be stored in dry, reasonably well ventilated and temperature controlled conditions to prevent condensation. Wire ropes should not be stored where they might be exposed to the corrosive influence of acid fumes, steam or other corrosive agents, and should never be placed on a stone or concrete floor.

3.22.1 Wire rope in store should be inspected periodically for signs of corrosion or other damage. Where a wire rope dressing has been used, this should be renewed when necessary.

3.22.2 Wire rope should be wound on a reel, the diameter of which will be specified by the manufacturer according to the size and type of rope (usually 40 to 50 times the diameter of the rope).

3.22.3 If reels are made locally, it is important that oak, chestnut or western red cedar are not used in their manufacture as these timbers may corrode the wire rope. The inside of the reel should be lined with waterproof paper.

3.22.4 When unwinding wire rope, a spindle should be placed through the centre of the reel and fixed so that the reel is free to rotate and the free end of the cable can be pulled out in direct line with the reel. The cable should not be unwound by paying off loose coils, or by pulling the wire away from a stationery reel laid on its side. When cut-off lengths of wire rope are hand coiled, the coils should be of a diameter not less than 50 times the diameter of the wire rope concerned, with a minimum of 152 mm (6 in) diameter. When hand coils are unwound, the coil should be rotated so that the wire rope is paid out in a straight line. If the wire rope forms a loop on itself, this indicates a localisation of turn and should be eliminated by taking the turn out and not by pulling straight.

3.22.5 Before cutting the cable to length, it should be bound either side of the proposed cut to prevent loss of tension from the woven strands.

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Leaflet 1-10 Civil Aviation Regulation of Small Aircraft used for General Aviation

1 Introduction

1.1 The Civil Aviation Authority (CAA) has set out its policies and timescales for implementation of European Regulations within the transitional arrangements allowed by these regulations in Airworthiness Notice (AN) number 7, current issue.

1.2 It is the intention of the Aircraft Maintenance Standards Department of the CAA to use this Leaflet to highlight changes brought about by these regulations, which have continued airworthiness implications for UK operators of Small Aircraft used for General Aviation (GA) purposes.

1.3 The above regulations will increasingly impact UK operators of Small Aircraft used for General Aviation where issued with EASA Airworthiness Certificates by the CAA from 28 September 2004.

2 References

Air Navigation Order and the Regulations (CAP 393)

Airworthiness Notice number 7 – The Implementation of the European Parliament Regulation and Council of the European Union Regulations (CAP 455)

GR No. 24 - Light Aircraft Piston Engine Overhaul Periods (CAP 747)

British Civil Airworthiness Requirements Sections A and B (CAP 553/554)

Regulation (EC) 1592/2002 – Common rules in the field of civil aviation and establishing EASA. (“the basic EASA Regulation”)

Commission Regulation (EC) 1702/2003 – Implementing rules for airworthiness and environmental certification of aircraft and related products (“the Certification Regulation”)

The Annex to the Certification Regulation (Part 21)

Commission Regulation (EC) 2042/2003 – Continuing airworthiness of aircraft and aeronautical products (“the Continuing Airworthiness Regulation”)

Annex I to the Continuing Airworthiness Regulation (Part M)

Light Aircraft Maintenance Schedule (LAMS) (CAP 411 & 412)

Mandatory Requirements for Airworthiness (CAP 747)

Parachuting (CAP 660)

3 Definitions

3.1 Small Aircraft means those aircraft with a maximum take off mass of 5700 kg or less excluding multi-engined helicopters.

3.2 EASA means the European Aviation Safety Agency.

3.3 Non EASA aircraft means:

Aircraft coming within Annex II of the Basic EASA Regulation and Aircraft engaged in military, customs or police services. Aircraft classified by the CAA as Annex II are listed in publication CAP 747. (Section 1 Part 2 refers).

3.4 EASA Airworthiness Certificate means a certificate issued or deemed to be issued under the Certification Regulation recognising that an aircraft complies with the applicable airworthiness requirements. These certificates are classified as Certificates of Airworthiness (Form 25), Restricted Certificates of Airworthiness (Form 24), or Permits to Fly (Form 20).

3.5 EASA Certificate of Airworthiness means a Certificate recognising that an aircraft conforms to a type-certificate, issued or deemed to be issued in accordance with Part-21.

3.6 EASA Restricted Certificate of Airworthiness means a Certificate recognising that an aircraft conforms to a restricted type-certificate which has been issued in accordance with Part-21 or which has been shown to comply with specific certification specifications ensuring adequate safety.

3.7 EASA Permit to Fly, issued to an EASA aircraft, which has not been shown to meet, or currently does not satisfy the applicable airworthiness requirements for the issue of a Certificate of Airworthiness or Restricted Certificate of Airworthiness but which is capable of safe flight under defined conditions.

3.8 Commercial Air Transport (CAT) means the carriage of Passengers / Cargo / Mail for remuneration.

3.9 General Aviation (GA) as defined in this Leaflet means Small Aircraft not used for Commercial Air Transport or Public Transport.

3.10 Public Transport for the purposes of this Leaflet is defined as where valuable consideration is given by a person for the purposes of hiring an aircraft, conferring on a particular person the right to fly the aircraft. e.g. from a flying club or from an owner/operator.

NOTE 1: Under such circumstances the flight is deemed to be public transport for continuing airworthiness purposes. The flight will be private for all other purposes (provided no other payments are made in relation to the flight).
Aerial Work for the purposes of this Leaflet is defined as where valuable consideration is given in respect of the flight. e.g. flying instruction.

NOTE 2: If the only payment made is for the payment of the pilot (flying instructor), the flight is deemed to be private for airworthiness purposes. This enables private owners to pay a flying instructor for lessons in their own aircraft.

4 General

4.1 Commission Regulation (EC) 1702/2003, including its associated Annex (Part-21), together with Commission Regulation (EC) 2042/2003 Annex 1 (Part-M), has direct implications on continuing airworthiness for operators of UK registered aircraft.

4.2 These EC regulations are common to all EU member states and compliance is obligatory. However, there are transitional provisions regarding entry into force of Part-M, depending on aircraft use. CAA use of these provisions is set out in Airworthiness Notice number 7.

4.3 Part-21 sets out airworthiness certification rules for aircraft, related products, parts, and appliances together with those for design and production organisations. Subpart H of Part-21 deals with EASA Airworthiness Certificates.

4.4 Part-M sets out continuing airworthiness (CAW) and validation rules for those aircraft issued with an EASA Certificate of Airworthiness or a Restricted Certificate of Airworthiness. It also includes rules for those who maintain aircraft not used for CAT operations.

4.5 National legislation as prescribed in the Air Navigation Order and implemented by reference to BCAR's Sub-Sections A/B-3 continues to apply for aircraft classified by the CAA as non-EASA aircraft, which will retain a national Airworthiness Certificate.

5 Part-21 Subpart H - Airworthiness Certificates

5.1 As a result of transitional provisions in the Continuing Airworthiness Regulation much of Part-M does not yet apply to aircraft issued with an EASA Airworthiness Certificate which are not involved in CAT. This means that until notified otherwise, renewal of EASA Airworthiness Certificates issued by the UKCAA for such aircraft will be through the existing national standards prescribed in BCAR's Sections A/B.

5.2 Owners and operators are reminded that EASA Certificates of Airworthiness and Restricted Certificates of Airworthiness are not categorised based on operational usage. It should be further noted that the operational use of aircraft is not yet regulated by Commission Regulations. This means that until notified otherwise, the carriage of particular equipment for all UK registered aircraft specific to the circumstances of the flight is mandated through the Air Navigation Order 2005 (as amended) Article 19 and 20 and Schedules 4 and 5.

5.3 To enable Approved Maintenance Organisations and Licensed Engineers to determine the required maintenance to be performed on an aircraft, it is the responsibility of the Owner/Operator to declare the purpose for which the aircraft is currently operated.

5.4 Where an aircraft being subject to a maintenance inspection can only satisfy the requirements for Private purposes, the Approved Maintenance Organisation or Licensed Engineer, when certifying a scheduled maintenance inspection, should specify, '**'Maintained for Private purposes only''** in the aircraft log book.

5.5 Aircraft operated for Private purposes may continue to apply the pilot maintenance provisions of LAMS and Regulation 12 of the Air Navigation (General) Regulations 2006. Furthermore, for aircraft below 2730 kg Maximum Take-off Weight, which are operated for Private purposes, the installed piston engine may continue in service indefinitely subject to compliance with CAP 747 GR No. 24. However, whenever the aircraft is to be used for Public Transport, Aerial Work or CAT purposes, further conditions apply as follows:

5.5.1 Any pilot maintenance, which has been performed, as provided for by ANO General Regulation (2006) number 12, will need to be assessed and re-certified as necessary prior to the aircraft being operated for the purposes of CAT, Public Transport or Aerial Work.

NOTE: Pilot maintenance is prohibited for aircraft operated in the parachuting role.

5.5.2 Any permitted pilot scheduled maintenance, which has been performed as provided for by LAMS Section 5, will need to be assessed and re-certificated as necessary prior to the aircraft being operated for the purposes of CAT, Public Transport or Aerial Work.

5.5.3 Any piston engine overhaul lives, as published in CAP 747 GR No. 24, must be those applicable to aircraft usage. As such, where an aircraft usage changes to CAT, Public Transport or Aerial Work extensions in excess of 20% above the normal overhaul period are not permitted, and to qualify extensions of up to 20% maintenance inspections in accordance with CAP 747 GR No. 24 are required.

5.5.4 An assessment of applicable Air Navigation Order and Official Record Series 4 requirements must be carried out and compliance verified.

Certification of maintenance associated with the above is to be completed by an appropriately licensed engineer or an organisation specifically approved for the purpose.

Owners and Operators who purchase or lease an aircraft intended to be operated for the purposes of CAT, Public Transport or Aerial Work use must review the aircraft maintenance records to ensure that the current maintenance status is compatible with its intended use.

6 Part-M – Continuing Airworthiness Requirements

From September 2008, Part-M becomes fully effective and mandatory for all UK registered aircraft to which Commission Regulation (EC) 1592/2002 applies. The CAA will amend this Leaflet to provide further advice on Part-M transition prior to full implementation.

Leaflet 1-11 Maintenance Schedules and Programmes - A Guide to Compilation and Development

1 Introduction

In the early days of aviation, owners and engineers concerned with in-flight failures and component reliability developed Maintenance Schedules to help prevent costly occurrences. As aviation grew and scheduled air transport arrived, safety, reliability and economics became important in order to attract passengers. It became apparent that to achieve a controlled balance between safety and economics Regulatory

Authorities needed to ensure minimum standards were maintained and a level playing field existed for fair competition between operators.

What to maintain, when to maintain and how to maintain, is the key to the content of Maintenance Schedules and a system was developed for Operators, Manufacturers and Regulators to share experience and knowledge on these very issues for new aircraft being developed.

Today Commercial Air Transport operators are required to operate to a Maintenance Programme. This is a 'real time system' which consists of a Schedule and a whole group of review and management procedures to ensure that it remains realistic and effective.

In the UK, the Air Navigation Order (ANO) 2005 (as amended) Article 10 requires all aircraft with a Certificate of Airworthiness to be maintained to a Schedule 'Approved' by the Civil Aviation Authority (CAA). For commercial air transport, operating to EASA requirements, then Regulation 2042/2003 Annex 1 (Part M.A.302) requires that aircraft are maintained in accordance with an 'Approved' Maintenance Programme. For aircraft operating on a Permit to Fly, BCAR (A3-7) states that 'maintenance arrangements must be agreed with the CAA' - which tacitly means a schedule is required. BCAR A8-20 for ex-military aircraft also states that a Maintenance Schedule is required.

This document is intended to give guidance for the compilation of a Maintenance Schedule or Programme that will satisfy the CAA for approval. Further help and guidance can be provided by the manufacturer of the product in question.

2 Schedules and Programmes

2.1 What are Maintenance Schedules and Maintenance Programmes?

2.1.1 Maintenance Schedules

A Maintenance Schedule contains details of what is to be maintained on an aircraft and how often. The details are those as published by the Original Equipment Manufacturer (OEM) who may also be the Type Certificate Holder (TCH) of that product. As the aircraft will consist of an airframe, engine, propeller and other equipment, there will be several sources of basic information. Not only will there be details of 'What and When' but also 'How' the parts are to be maintained; more detail on the types of task that are usually described can be found in paragraph 3.4 of this Leaflet.

For aircraft below 2730 kg MTOM the CAA and EASA permit the use of a generic 'Light Aircraft Maintenance Schedule' (LAMS). Light aircraft Owners have a choice, in that they can follow the Manufacturer's recommended schedule, as found in the aircraft maintenance manual, or they can use LAMS. Most opt to use LAMS, as historically they had to get an alternative schedule approved, which was perceived as too onerous. However, the LAMS system requires that the Manufacturer's recommendations are considered as well, so users of LAMS have to employ both sets of data.

Owners and operators should be aware that properly maintained records not only assist in maintaining the safety of an aircraft but also help retain the resale value of an aircraft.

To assist owners/operators the Authority encourages the use of CAP 543 (Time Limited Task, Additional Inspections and Component Change Record) to be kept in conjunction with LAMS to control the overhaul life of engines, propellers and any other piece of equipment that may be installed.

2.1.2 Maintenance Programmes

In its simplest form a Maintenance Programme is an approved schedule with a host of procedures that are designed to continually review its applicability and effectiveness for the aircraft it is approved for. The two principal procedures required are Management interest and a Reliability Programme.

Part M, Appendix 1 to AMC M.A.302 gives a comprehensive list of what should be in a Maintenance Programme and a programme will not be approved unless compliance with that list can be demonstrated. To assist operators with showing compliance, the CAA have produced a form AD981C (free on the CAA web site) that should be submitted with any new Schedule. (Form AD981D has been customised for owners who wish to use LAMS as the basis of their maintenance programme.)

NOTE: For brevity throughout this document the term 'Schedule' will be used to mean either a schedule or programme.

2.2 How to Compile a Schedule or Programme

As previously stated, the first place for information is the OEM/TCH documentation that is relevant to the aircraft being operated. As data will be obtained from several manuals, there will be a collection of tasks to be accomplished at varying intervals. These intervals can be based either on flying hours, flight cycles or calendar time and sometimes there are combinations of these. It is quite often inconvenient to take each task as it comes and accomplish it; it is usually expedient to parcel the tasks into packages of work that can be carried out when it is convenient to do so, but at a frequency not exceeding the approval intervals.

The general rule that can be applied for compiling work packages is that tasks can quite often be done earlier than when recommended. They can only be done later with agreement of the CAA and only in exceptional circumstances. So for tasks that have more than one frequency in terms of flying hours and calendar time, then the event that occurs first is normally the governing one.

For Large Transport Aircraft the tasks can be found in Maintenance Planning Documents provided by the TCH, these are described further in part 3 of this Leaflet.

Smaller aircraft usually have the TCH recommended maintenance in the Maintenance Manual (Chapter 5).

The frequency of maintenance tasks is affected by the way the aircraft is to be operated. When the TCH recommendations are first compiled they will have in mind a 'typical' flight profile for the aircraft type; any deviation from this may need an adjustment on the basic recommendations. For example, an aircraft may be designed and its typical operation could be considered to be 'One flying hour to each flight cycle'. Someone may have a version that will fly six hours for every cycle and another may be doing six cycles every hour. It can be seen that in these cases a schedule based solely on flying hours may mean the first aircraft is maintained too often and the other not enough, so, with the help of the TCH, usually a schedule can be developed for any particular type of operation.

The area of operation is another important consideration, for example operating over salt water may require special tasks, such as engine compressor washes and other maintenance, to be done on a more frequent basis. Similarly, operation in sandy areas or off rough strips may affect the tasks required.

The age of an aircraft may affect the number and frequency of tasks, particularly if it has ageing structural inspections and significant repairs.

Significant parts of the aircraft such as make and type of engines, propellers and/or APU should be detailed as quite often operators have a choice of equipment and adding the same type with a different engine to a common schedule will mean careful identification of tasks applicable to each aircraft.

Finally, the modification state of equipment on board has to be considered as it may be unique to the aircraft on any particular schedule.

2.3 How to Develop a Schedule

Once established an owner or operator may wish to change the frequency of some tasks away from where the OEM has set them. This can be done with the aid of an amendment to the Schedule, which is submitted to the CAA for their agreement and subsequent approval.

Doing tasks less frequently requires suitable justification in order that it may be approved. Proof that safety will not be compromised must be provided. Maintenance Programmes supported by a reliability programme will have an advantage here as they will readily be able to show how often a task has been performed without deterioration of the item/system.

Again for those with a reliability programme, Part-M gives provision for some 'self development' of the Approved Maintenance Programme (AMP) within parameters and to procedures agreed with the CAA.

More information on schedule/programme development is contained in part 4 of this Leaflet.

2.4 Application for and Approval of Schedules and Programmes

For light aircraft, copies of LAMS are available on the CAA website (CAP 411 and 412 refer), no application is required to use this programme.

Application forms (AD981M) for any other type of programme can be found on the SRG website.

3 New Schedules - Initial Task Compilation

3.1 Maintenance Review Boards (MRB)

A Maintenance Review Board is formed during the Type Certification process of an aircraft the MTOM of which is greater than 5700 kg. It consists of members of interested National Authorities chaired by the Authority of the state of design/ manufacture.

Reporting to the Board is an Industry Steering Committee (ISC) which is a group containing representatives from various working groups who are looking at various aspects of the aircraft's design from a maintenance perspective. The ISC and the working groups will contain members from Authorities, the OEMs and the Operators

Each working group will consist of specialists in that particular discipline (e.g. structures, powerplant, avionics etc.) from interested Authorities, the Design organisation and Operators, usually those who are already customers and have a vested interest in the meeting outcome. For a particularly advanced design, if the lead Authority believes that the customers do not have sufficient knowledge to contribute then they may invite specialists from operators that do.

Before commencing work the Board will put together a 'Policy and Procedures Handbook', which will describe how the whole review process will work. The final outcome from the ISC will be Maintenance Programme Proposals that is approved by the chairman of the MRB.

If an aircraft type which has been subject to the MRB process is modified by an STC, the systems, powerplant and structure must be reviewed and consideration given to forming an MRB to determine the maintenance requirements.

3.2 Maintenance Steering Group (MSG) Analyses

This is basically a process driven by a set of logic diagrams, that are followed by the MRB working groups in order to determine types of and frequency of tasks, depending on component and system failure modes and visibility of those failures to the users.

For more information on MSG analysis contact the Air Transport Association of America on www.airlines.org/home/default.aspx as the owner of this analysis process.

3.3 Maintenance Planning Document (MPD)

All the working groups will detail the tasks they have identified during the MSG 3 analysis procedure in an MRB document, which for EASA aircraft is approved by EASA. These tasks, along with other tasks (such as Airworthiness Limitations Items (ALIs)) considered applicable by the OEM/TCH are all published in the MPD and hence this is the stock document an operator of a new type needs in order to start compiling his schedule.

3.4 Types of Task

3.4.1 Mandatory

3.4.1.1 Certification Maintenance Requirements (CMR)

CMRs arise from the aircraft Certification process. CS 25.1309, for example, requires an aircraft System Safety Assessment (SSA) to ensure that failures are categorised on their consequential severity and within defined bounds of probability.

A CMR is a task required to reveal hidden or dormant failures and to ensure that a system meets the SSA target (e.g. <1 failure in 109 flights). The failures individually, or in combination with another failure or a sequence of failures, must not compromise the safety of the aircraft, or its occupants.

Major aircraft manufacturers predominantly refer to two types of CMR task:

a) One Star CMR. (CMR*)

Such tasks and intervals are mandatory and cannot be changed or deleted without the approval of the state of certification Authority.

b) Two Star CMR. (CMR**)

Changes to task intervals must be supported by an approved procedure and monitoring programme. Tasks may not be changed or deleted without the agreement of the state of registration Authority.

NOTE: It is important to read carefully the introduction to the TC Holder's data that is being used for the production of a maintenance Schedule/ Programme. Some manufacturers will use a different terminology, for example some TCHs have the opposite definition for one/two star tasks to other TCHs.

CMRs should be clearly identified as such in a Schedule submitted to the Authority for approval.

Any subsequent applications for approval to vary these tasks must be supported by the TCH. Again, care should be taken in understanding the Manufacturer's certification philosophy as some do allow short-term variations of these tasks.

3.4.1.2 **Airworthiness Limitation Items (ALI)**

ALI are structural items that the Certification process has defined as critical from a fatigue point of view during the Damage Tolerance assessment. Again, the inspection frequency of such items is Mandatory and they should be treated in the same way as a CMR*.

These lives are published in a supplement of the MRB report and may not be found in an MPD.

3.4.1.3 **Critical Design Configuration Control Limitation (CDCCL)**

CDCCLs will be listed in a uniquely referenced section within the ALIs. They are design features that have been identified as being critical to the integrity of the Fuel System and must be maintained in order to ensure that unsafe conditions do not develop throughout the service life of the aircraft and must be retained during modification, repair or maintenance.

3.4.1.4 **Other Items**

There are significant parts of aircraft that also have Mandatory lives that are not determined from the Certification process but arise due to their significance and use. Such items might include the rotating assembly within an engine, transmission parts of helicopters and landing gear parts. Details of these items do not have to be in a Schedule/Programme but information on how they are controlled should be.

3.4.2 **Zonal Inspections**

The inspection level for the Zonal tasks in each programme must be clearly defined, since interpretation of the MSG rule may differ between aircraft types and their respective Zonal programmes. The MRB report should provide clearly defined criteria and in most cases this is repeated in the MPD.

General visual or surveillance tasks from the MSG analysis may be appropriate for the Zonal Inspection programme.

The principal of Zonal inspections is to group tasks within an area together, in order to minimise the number of times an area is disturbed. Systems, installations and structure within a zone will all be inspected for security and general condition.

3.4.3 **Lubrication**

During the working group phase of the certification process the MSG analysis has lubrication as the first consideration when looking at reducing a risk of failure of a component or system. It is a relatively quick and cost effective method of preventative maintenance.

Lubrication servicing requirements may either be in the ATA chapters of the schedule with the daily and weekly check or in a specific lubrication section defining the intervals determined by the MRB.

Rescheduling of the lubrication frequency may be necessary if a check cycle is changed or the operating pattern is changed, so that degradation does not result.

Deterioration may take some time to be evident so the effectiveness of a lubrication programme must be monitored.

3.4.4 **Inspection Levels**

There are no defined standards of Inspection level; different manufacturers will have applied their own standards and these need to be understood and published for the schedule/programme user's benefit. Examples of types of Inspection are:

General Visual Inspection - A visual examination of an interior or exterior area, installation or assembly to detect obvious damage, failure or irregularity. Typically this level of inspection is made within touching distance unless otherwise specified. A mirror may be necessary in order to see all exposed surfaces and only available lighting, such as daylight or hangar lighting, may be necessary. Stands, ladders or platforms may be required to obtain adequate access.

Detailed Inspection - An intensive examination of a specific item, installation or assembly to detect damage, failure or irregularity. Available lighting may be supplemented with a direct source at an appropriate intensity. Inspection aids such as mirrors and/or magnifiers may be required. Cleaning of areas may be necessary to carry out inspection.

Special Detailed Inspection - An intensive examination of a specific item, installation, or assembly that may require specialised inspection techniques such as Non-destructive testing or boroscope inspection. In this case intensive cleaning may be required prior to inspection.

Functional Check - A quantative check to determine if one or more functions of an item performs within specified limits.

3.5 **Task Frequency**

Tasks identified as necessary during the certification programme will have a time interval allocated that is based on the most appropriate parameter to maintain the condition of the item to which the task refers. The three types of frequency are: Flying hours, Flight cycles and Calendar time; sometimes there will be two limits with the operator normally having to comply with whichever comes first in their particular operation.

In cases of structural inspections, the threshold inspection and repeat frequency can vary depending on the type of operation being used. Structural inspections are always based on flight cycle limits as their reliability is directly related to cyclic fatigue.

When reviewing the effectiveness of a Maintenance Programme, or carrying out an annual review of a schedule, it is the frequency of all the tasks that is being considered. Reliability monitoring is the continual monitoring of task frequency; it is permissible to amend these frequencies away from those recommended by the manufacturer by making application to the CAA. As the operation of an aircraft is usually unique to an Operator a conscientious owner/operator will develop their schedule to maximise reliability and minimise costs.

3.6 **Engine Tasks**

Turbine powered engines, by implication, are more complex than Piston ones and the way their lives and reliability are managed is significantly different, so they will be treated separately below.

3.6.1 **Turbine Engines**

Turbine engine reliability is based on an approved Condition Monitored Maintenance Programme for both on-wing and off-wing tasks. BCAR A6-2 was developed by the CAA to provide guidance as to what should be contained in an 'Engine Maintenance Programme' (EMP). An EMP document becomes part of the aircraft Maintenance Programme.

By implication Auxiliary Power Units, being Turbine powered, are treated in a similar manner.

Engine health management is complicated and requires some expert control. On-wing Health monitoring may include regular oil analysis (SOAP), magnetic plug inspections and boroscope inspection. Modules may have separate lives, generally hot sections being shorter than cold, and Rotating Parts have finite cyclic lives. Removed engines need agreed workscopes and good strip reports all to remain in compliance with the EMP.

3.6.2 **Piston Engines**

Piston engines work on a 'manufacturer's recommended' overhaul life. The Authority views this 'recommended' life as the life. Some aircraft not used for commercial air transport may have the life of their engine extended beyond that recommended by the manufacturer by closely following the requirements of CAP 747 - Mandatory Requirements for Airworthiness, Generic Requirement (GR) No. 24.

4 Development of Schedules and Programmes

4.1 **Reliability Programmes**

Part M (M.A.302 (d)) requires that any maintenance Programme based on MSG logic or containing Condition Monitoring tasks should contain a Reliability Programme. There is some guidance in Appendix I to AMC M.A.302 on what constitutes a Reliability Programme. Typically, on a monthly basis an operator will look at Tech log entries, component failures (in particular - cause of failure), delays, Ground or Air safety reports (MORs) and findings from task cards and look for trends or areas of hurt that can be addressed by taking some kind of preventative maintenance action.

Operators whose aircraft are not designated as 'Large' by EASA definition are exempt from this requirement. It has also been found that for fleets of six or fewer aircraft insufficient data is produced to maintain an accurate programme and hence alternative procedures need to be established, whereby events rather than trends are monitored.

4.2 **Annual Review**

This is a requirement for operators of small aircraft and/or small fleets of aircraft. At least once in a year an owner or operator should sit down with their maintainer and discuss the performance of the aircraft over the preceding period of time. As already stated a good programme will make an aircraft more reliable, cheaper to run and more available so it is really a 'no brainer' to get together and make it right.

4.3 **Utilisation**

The utilisation of an aircraft is inextricably linked to the effectiveness of a Maintenance Programme. When optimised for a certain utilisation, tasks will lose their effectiveness if the relationship between Flying hours and Cycles varies by a significant amount. The MRB will set task intervals to meet, what they have considered to be a 'typical' flight profile for their product. For example the Boeing 747 might reasonably have been considered to have a profile of about 7 flight hours to one cycle. An operator then chose to use the aircraft on thirty minute sectors. By using the original MRB derived data the operator would suffer failures due to the flight hour tasks not being done soon enough to protect the cyclic dependent parts and systems.

Operators are required to state their expected annual utilisation in the front of the programme. Part of the annual review of effectiveness is to determine that this figure remains within plus or minus 25% of that figure. Significant deviations should be discussed with the TCH to see how tasks may need to be changed.

Quite often manufacturers will produce a 'low utilisation' programme for operators doing very low hours, for example an executive jet operation. This can be a cost effective solution for such an operator.

Finally, Supplemental Structural Inspection Programmes (SSIP) can have different inspection frequencies dependent on the type of operation. Details of these will be found in the introduction of the SSIP document itself.

4.4 Task Escalation

Following a period in operation it may be noticed that a particular inspection is carried out routinely and no faults are ever detected. Providing data supporting this can be presented to the CAA, it is possible for the task frequency to be reduced, such that the task is carried out less frequently. This gives an immediate cost saving with no loss of safety or reliability.

This is carried out on a grander scale by the manufacturers, as less frequent tasks mean lower maintenance costs for their product, which they perceive makes it more saleable. They achieve this by holding Industry Steering Committee meetings, where a group of operators and regulators meet with the manufacturer to review the results of scheduled inspections pooled by as many operators as they can get interested. This is basically a way of validating their original predictions for task requirements, which would have been understandably quite conservative.

In order to escalate the tasks, they will revisit the failure rates that type design required that they achieve, and apply operational experience to determine that they can be still be met with less frequent inspections.

5 Applicability

An aircraft must be maintained to an Approved Maintenance Schedule. It can only be maintained to **one** Approved Maintenance Schedule at any time. More than one aircraft, however, can be maintained to the same Schedule, providing they all bear similarities that are covered entirely by that Schedule. The introductory part of the Schedule will therefore contain details of the aircraft to which it applies.

To move an aircraft from one programme to another will involve making an amendment requiring the CAA approval to remove it from one Schedule and add it to another, and requires the operator to propose to the CAA a 'B' amendment for each of the affected Schedules. In this case the operator will need to consider the differences between the two Schedules and the need for a 'Bridging Check' to cater for such differences.

5.1 Registrations

Aircraft maintained to any Schedule are listed by registration in that document and on a CAA database. If the registration of an aircraft is changed but it remains on the same programme, or new aircraft is added, an amendment will be required to be submitted for CAA approval highlighting the fact.

5.2 Mixed Age/Modification Fleets

For a programme with a number of aircraft of the same type on it, the varying ages and modification standards should be catered for, by highlighting affectivity of tasks that apply. For example, should two aircraft out of the fleet have an STC applied that does not feature on the others, then any task relevant to the STC should be included but clearly denoted in the programme which two aircraft it applies to.

It follows that any aircraft being added to a programme is to be assessed by the operator for its modification standard and equipment fit to ensure the programme adequately addresses the needs of the individual aircraft build/change standard. Should any further tasks need to be added, then an amendment should be submitted addressing these needs.

5.3 Adding Aircraft to the Schedule

When adding an aircraft to a Schedule an amendment must be submitted to the CAA. As stated above the commonality of the aircraft and the Schedule must be established, in terms of Modification standard, Equipment fit, Structural life inspections etc.

5.4 Bridging Checks

A Bridging Check is a set of tasks required to transfer an aircraft from one Schedule to another. As previously discussed, every Operation is unique and hence an aircraft may have been maintained to the same tasks at a different frequency or to different maintenance standards in its previous operation. The Bridging Check is carried out to bring the tasks into line with the new frequencies and standards to ensure standards are met and no task is overrun.

6 Other Considerations

6.1 Task Cards/Work Packaging

Task management will differ from Schedule to Schedule. In LAMS tasks are grouped by inspection frequency, that is all the 50 hour repeat tasks appear consecutively, followed by the 100 or 150 hour tasks. For a large transport aircraft Schedule, the tasks will probably be grouped in ATA order. This means that consecutive tasks in the Schedule have different inspection frequencies.

In order to save costs operators will want to have the minimum number of maintenance checks done on their aircraft, so they will select items with the same or close frequency and 'package' them into workpacks to be done together.

LAMS comes in a format whereby the tasks are laid out in a way that can be used as a set of worksheets. For the compiler of a workpack, the tasks are usually broken down onto separate 'cards' which can be certified individually as the tasks are accomplished.

Traditionally a large transport aircraft Schedule would contain defined periods of A and B line checks and C and D base checks. Nowadays these tasks are not designated by letter but frequency only, these are termed 'Equalised' Programmes, now the old base tasks can be accomplished along with some of the lesser line tasks in order to make more efficient use down time (overnight stops) and manpower.

The downside of equalised programmes is the complex packaging of the tasks and the added responsibility on the continuing airworthiness management organisation to ensure repeat inspections are controlled properly.

6.2 Repairs

Since 1980, large transport aircraft (and latterly some LAMS weight aircraft) have been designed with 'Damage Tolerant' Structures. This means that the designers have calculated with the expected lifetime loads experienced by the aircraft, when significant structural parts will begin to fail from fatigue. In this way they can determine suitable inspection frequencies and techniques to detect fatigue cracks long before the part will fail.

During the aircraft life it will suffer from accidental damage, requiring some repair work to the structure. In most cases the repair will return the damaged part to its 'as was' standard, and routine inspections of that piece of structure will continue as before. In some cases, Damage Tolerance analysis of the repair will require an interim inspection of it before the regular inspection period falls due. This new inspection requirement is now part of the Maintenance Schedule which should be amended to include these inspections.

6.3 **Regulatory Requirements**

The requirements regarding scheduled maintenance are set out in Part-M.A.302 and its associated AMC and JAR OPS, as appropriate to the aircraft, the ANO and CAP 747 Generic Requirements.

6.4 **Special Operations (AWO, RVSM etc.)**

Issues such as All Weather Operations, Reduced Vertical Separation Minima etc. are operational issues, not used by everyone. They do, however, have specific maintenance requirements in order to maintain their accuracy. As such, any of these maintenance requirements must be included in the Maintenance Schedule.

6.5 **Variations**

All maintenance must be carried out at, or before, its specified frequency. In some unforeseen circumstances, the task frequency can be extended by an amount approved by the CAA and detailed in the Schedule by the operator of the aircraft. Typically the frequency can be extended by 10%.

Should the unforeseen circumstances mean that the aircraft cannot meet its maintenance slot even with such a variation, then the operator can approach the CAA with a request for a further extension. His reason will have to be good and the timescale supported by the TCH. If accepted, the extension will be approved as a one off change.

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