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THE RELIABILITY AND AVAILABILITY OF ELECTRONIC EQUIPMENT

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FOREWORD

The specification of reliability objectives for electronic equipment in a uniform manner has become increasingly important because of the growing reliance on electronic aids in all phases of flight, and has particular significance during certain critical phases of flight, as when employing ILS to very low minima.

The text of this Circular was originally developed by the COM/OPS Divisional Meeting (1966), and was subsequently amended to accommodate, as far as practicable, the comments of States. The resulting document represents a first attempt within ICAO to provide a common basis for further international activity in the specification of reliability objectives.

A quantity of material having only a limited bearing on the definition and measurement of reliability has been included in the Circular for the benefit of Administrations who have no previous experience in reliability work, and have therefore not yet developed procedures or general operations manuals. Such material need not necessarily influence States already having developed reliability programmes using different procedures and methods.

Notwithstanding the importance and desirability of achieving international agreement on basic reliability definitions and objectives, States' comments on the material presented in this Circular emphasized the complex nature of the problem, and the need to provide sufficient flexibility to enable each Administration to establish reliability procedures best suited to its needs. The statement in Chapter 1 concerning the tentative nature of the material therefore has particular significance, and it should be noted that Standards and Recommended Practices on this subject which may ultimately be introduced into Annex 10 may not necessarily conform to the material contained in this document.

It should also be noted that the substance of paragraphs 1 to 2.1.4 inclusive of this Circular is identical to the material incorporated in Amendment 47 to Annex 10, Volume I, as Attachment "F" to Part I.

TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	i
1. INTRODUCTION AND FUNDAMENTAL CONCEPTS	1
1.1 Definitions	1
1.2 Facility Reliability	1
1.3 Facility Availability	4
2. PRACTICAL ASPECTS OF RELIABILITY AND AVAILABILITY	5
2.1 Measurement of Reliability and Availability	5
2.2 Achievement of Reliability and Availability	6
2.3 Design Consideration.	8
2.4 Maintenance	9
3. SIGNAL RELIABILITY	12
3.1 General	12
3.2 Signal Derogation in Space	12
3.3 Conclusion	13
EXAMPLES OF PROGRAMMES FOR THE COLLECTION AND UTILIZATION OF DATA ON FACILITY RELIABILITY	14
EXAMPLE 1 - Typical Data Relating to the Serviceability, Reliability and Availability of Navigation Aids Ground Facilities Achieved in Australia	14
EXAMPLE 2 - Typical Data Relating to Reliability and Availability of Radio Aids in the United States of America	19

THE RELIABILITY AND AVAILABILITY
OF ELECTRONIC EQUIPMENT

CHAPTER 1.- INTRODUCTION AND FUNDAMENTAL CONCEPTS

Due to the rapid increase in numbers of aircraft and the trend toward all weather operations, aircraft are increasingly dependent upon ground-based navigation and communication facilities. This Circular is intended to provide guidance material which member States may find helpful in providing the degree of facility reliability and availability consistent with their operational requirement.

The material in this Circular is intended for guidance and clarification purposes, and is not to be considered as part of the Standards and Recommended Practices contained in Annex 10. It should be noted that this material is tentative, and is still under review.

1.1 Definitions

1.1.1 Facility Availability - the ratio of actual operating time to specified operating time.

1.1.2 Facility Failure - any unanticipated occurrence which gives rise to an operationally significant period during which a facility does not provide service within the specified tolerances.

1.1.3 Facility Reliability - the probability that the ground installation operates within the specified tolerances.

Note.- This definition refers to the probability that the facility will operate for a specified period of time.

1.1.4 Mean Time Between Failures (MTBF) - the actual operating time of a facility divided by the total number of failures of the facility during that period of time.

Note.- The operating time should in general be chosen so as to include at least five, and preferably more, facility failures in order to give a reasonable measure of confidence in the figure derived.

1.1.5 Signal Reliability - the probability that a signal in space of specified characteristics is available to the aircraft.

Note.- This definition refers to the probability that the signal is present for a specified period of time.

1.2 Facility Reliability

1.2.1 Reliability is achieved by a combination of factors. These factors are variable and may be individually adjusted for an integrated approach that is optimum for and consistent with the needs and conditions of a particular environment. For example, one may compensate to some extent for low reliability by providing increased maintenance staffing and/or equipment redundancy. Similarly, shortage of skilled maintenance personnel may be offset by providing equipment of high reliability.

1.2.2 The following formula expresses facility reliability as a percentage:

$$R = 100e^{-t/m}$$

where R = reliability (probability that the facility will be operative within the specified tolerances for a time t, also referred to as probability of survival, P_s)

e = base of natural logarithms

t = time period of interest

m = mean time between facility failures.

It may be seen that reliability increases as mean time between failures (MTBF) increases. For a high degree of reliability, and for operationally significant values of t, we must have a large MTBF; thus MTBF is another more convenient way of expressing reliability.

1.2.3 Experimental evidence indicates that the above formula is true for the majority of electronic equipments where the failures follow a Poisson distribution. It will not be applicable during the early life of an equipment when there are a relatively large number of premature failures of individual components; neither will it be true when the equipment is nearing the end of its useful life.

1.2.4 At many facility types utilizing conventional (vacuum tube type) equipment, MTBF values of 1 000 hours or more have been consistently achieved. To indicate the significance of a 1 000 hour MTBF, the corresponding 24-hour reliability is approximately 97.5 per cent (i.e. the likelihood of facility failure during a 24-hour period is about 2.5 per cent).

1.2.5 Figure 1 shows the probability of facility survival (P_s) after a time period (t), for various values of MTBF.

Note. - It is significant that the probability of surviving a period of time equal to the MTBF is only 0.37 (37 per cent); thus, one should not succumb to the temptation to assume that the MTBF is a failure-free period.

1.2.6 It may be seen that adjustment of MTBF will produce the desired degree of reliability. Factors which affect MTBF and hence facility reliability are:

- (a) inherent equipment reliability;
- (b) degree and type of redundancy;
- (c) reliability of the serving utilities such as power and telephone or control lines;

- (d) degree and quality of maintenance;
- (e) environmental factors such as temperature and humidity.

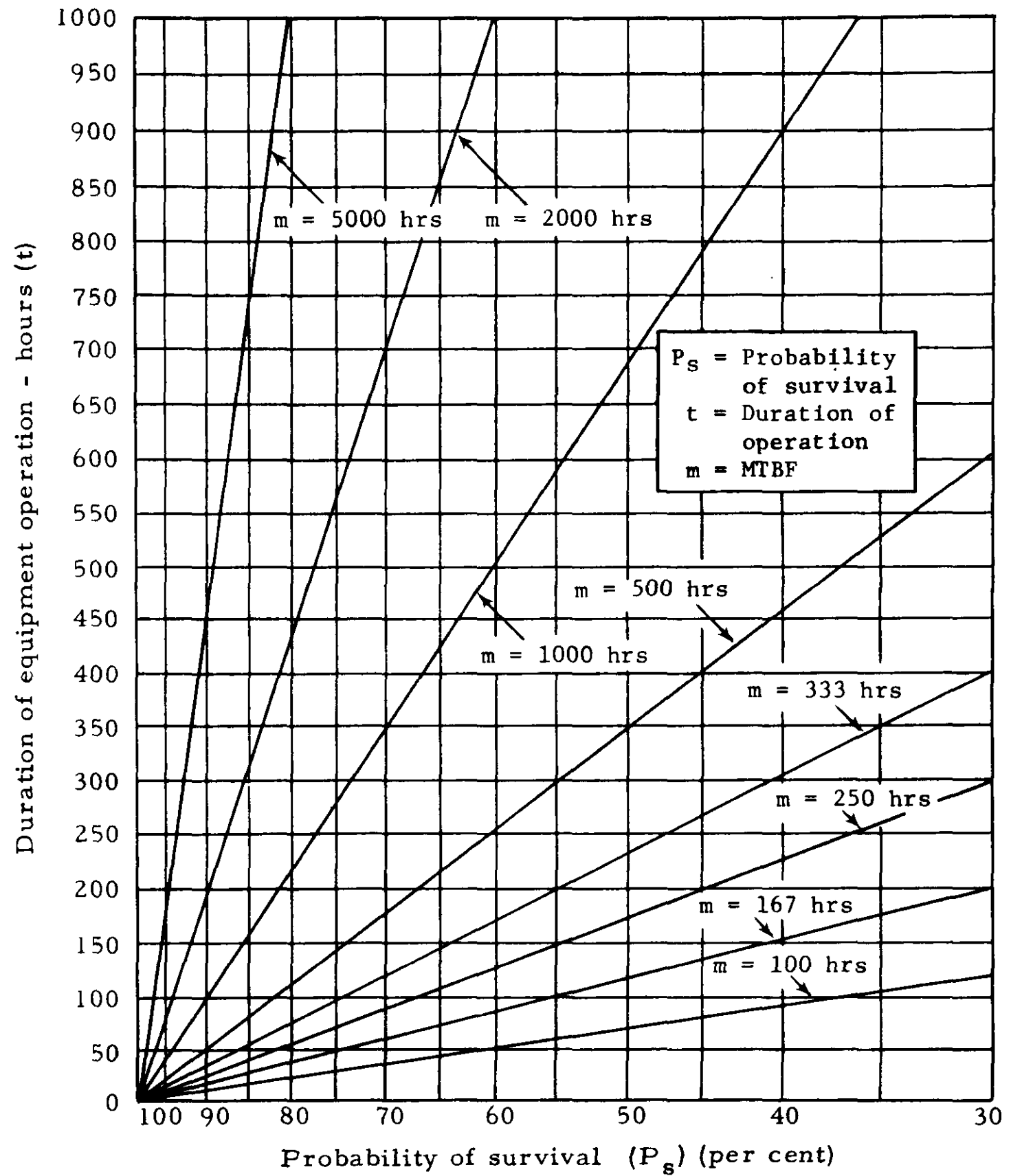


FIGURE 1. PLOT OF $P_s = 100e^{-t/m}$

1.3 Facility Availability

1.3.1 Availability, as a percentage, may be expressed in terms of the ratio of actual operating time divided by specified operating time taken over a long period. Symbolically

$$A = \frac{\text{Actual operating time (100)}}{\text{Specified operating time}}$$

For example, if a facility was operating normally for a total of 700 hours during a 720 hour-month, the availability for that month would be 97.2 per cent.

1.3.2 Factors important in providing a high degree of facility availability are:

- (a) facility reliability;
 - (b) quick response of maintenance personnel to failures;
 - (c) adequate training of maintenance personnel;
 - (d) equipment designs providing good component accessibility and maintainability;
 - (e) efficient logistic support;
 - (f) provision of adequate test equipment;
 - (g) standby equipment and/or utilities.
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