INTERNATIONAL CIVIL AVIATION ORGANIZATION

WESTERN AND CENTERAL AFRICAN OFFICE

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Agenda Item 3 : Review of AFISNET earth stations performance by Administrations/Organizations

GUIDANCE MATERIAL CONCERNING RELIABILITY AND AVAILABILITY OF RADIOCOMMUNICATIONS AND NAVIGATION AIDS

(Presented by the Secretariat)

SUMMARY

This paper provides SNMC16 with guidance material concerning reliability and availability of radiocommunications and navigation aids as contained in ICAO Annex 10, Volume 1, Attachment F, for reference and guidance when considering the performance of AFISNET stations under Agenda Item 3.

1. Introduction and fundamental concepts

This document is intended to provide guidance material which States may find helpful in providing the degree of facility reliability and availability consistent with their operational requirement. The material herein 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 Volume 1.

1.1 Definitions

Facility availability. The ratio of actual operating time to specified operating time.
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.
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.
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 is in general 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.
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, low levels of skill among maintenance personnel may be offset by providing equipment of high reliability.

1.2.2 The following formula expresses facility reliability as a percentage:
$R = 100\ e^{-t/m}$ 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, Ps);
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 is 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 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 F-1 shows the probability of facility survival, Ps, 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, it is not assumed 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.

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,

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

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.

2. Practical aspects of reliability and availability

2.1 Measurement of reliability and availability

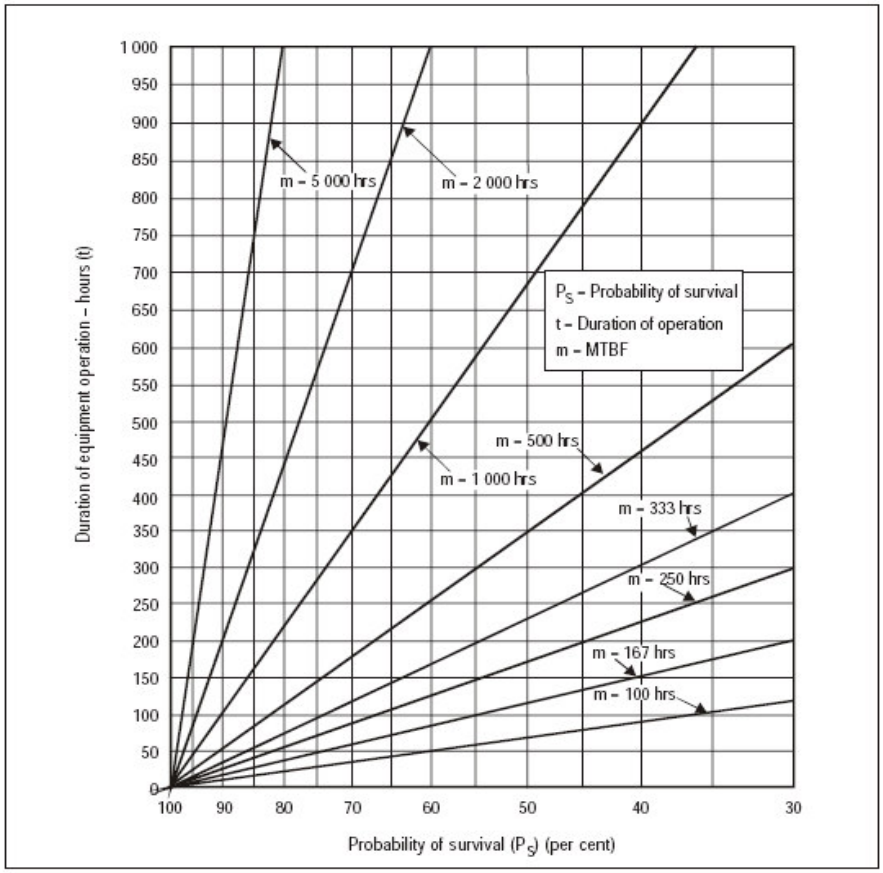
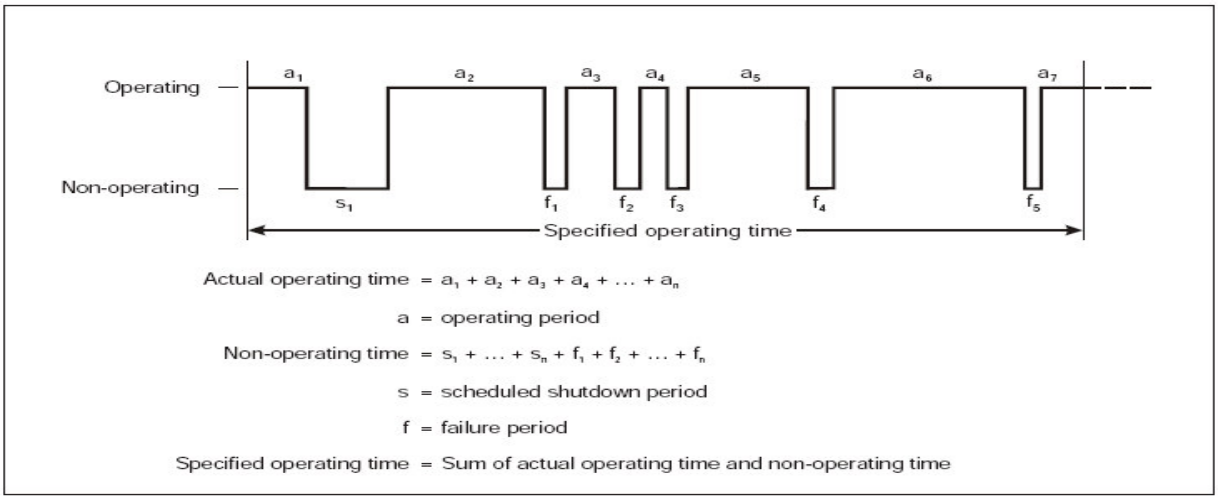


Figure F-1. Plot of $P_s = 100\ e^{-t/m}$

2.1.1 *Reliability.* The value that is obtained for MTBF in practice must of necessity be an estimate since the measurement will have to be made over a finite period of time. Measurement of MTBF over finite periods of time will enable Administrations to determine variations in the reliability of their facilities.

2.1.2 *Availability.* This is also important in that it provides an indication of the degree to which a facility (or group of facilities) is available to the users. Availability is directly related to the efficiency achieved in restoring facilities to normal service.

2.1.3 The basic quantities and manner of their measurement are indicated in Figure F-2. This figure is not intended to represent a typical situation which would normally involve a larger number of inoperative periods during the specified operating time. It should also be recognized that to obtain the most meaningful values for reliability and availability the specified operating time over which measurements are made should be as long as practicable.



Actual operating time = $a_1 + a_2 + a_3 + a_4 + \ldots + a_n$

a = operating period

Non-operating time = $s_1 + \ldots + s_n + f_1 + f_2 + \ldots + f_n$

s = scheduled shutdown period

f = failure period

Specified operating time = Sum of actual operating time and non-operating time

Figure F-2. Evaluation of facility availability and reliability

2.1.4 Using the quantities illustrated in Figure F-2, which includes one scheduled shutdown period and five failure periods, one may calculate mean time between failures (MTBF) and availability (A) as follows:

Let:

$a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7$	=	5 540	hours
s_1	=	20	hours
f_1	=	2½	hours
f_2	=	6¼	hours
f_3	=	3¾	hours
f_4	=	5	hours
f_5	=	2½	hours
Specified operating time	=	5 580	hours

$$\text{MTBF} = \frac{\text{Actual operating time}}{\text{Number of failures}}$$

$$= \frac{\sum_{i=1}^{7} a_i}{5}$$

$$= \frac{5\,540}{5} = 1\,108 \text{ hours}$$

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

$$= \frac{\sum_{i=1}^{7} a_i \times 100}{\sum_{i=1}^{7} a_i + s_1 + \sum_{i=1}^{5} f_i}$$

$$= \frac{5\,540}{5\,580} \times 100 = 99.3 \text{ per cent}$$