INTERNATIONAL CIVIL AVIATION ORGANIZATION CNMC/01– WP/03

Western and Central Africa Office

First Meeting of the Central Atlantic FIRs Satellite (CAFSAT) Network Management Committee (CNMC/1)
(Recife, Brazil 2 May 2011)

Agenda Item 2: Review of CAFSAT earth stations performances and operational statistics of availability for supported links

(Presented by the secretariat)

SUMMARY
The purpose of this paper is to review the performances of CAFSAT earth stations as well as the operational performance in term of Aeronautical fixed service availability rate.
Action by the meeting is at paragraph 3.
References : Decision: SAT/15/01 of SAT 15 meeting. *Note: References can be downloaded from* ***www.icao.int/wacaf*****.**
Related ICAO Strategic Objective A.

1. Introduction

The direct links between FIRs within SAT area were based in the past on leased PSTN circuits. Those circuits were not cost effective and their performance (Quality of Service, Availability, Reliability, Continuity) were not always appropriate. The implementation of Satellite telecommunication technologies for the provision of Aeronautical Fixed Service aiming at matching the operational requirements was recommended by ICAO AFI/7 RAN Meeting (Recommendation 9/2) that strongly supports the use of VSAT technology to improve the ATS/DS circuits and AFTN links between adjacent FIRs. The continuous monitoring of the end to end quality of service as well as the facilities components plays a key role in the system assessment in order to accordingly take the necessary corrective actions to keep the system required performance.

2. Discussion

2.1 Performance of CAFSAT Earth stations

The CAFSAT network involves various technical components which contribute to the Quality of the Aeronautical Fixed Service provision. Due to the wide variety of architectures, protocols, type of access used by VSAT industries worldwide, ICAO has not standardized the physical layer of communication.

However as earth based station, the guidance material concerning the reliability and availability of radiocommunication and radionavigation aids can be applied for the monitoring of VSAT network nodes.
The metrics for VSAT monitoring can therefore be expressed in term of availability and reliability whose definitions are contained in **Attachment F of Annex X Vol. 1** as attached to this working paper in **Appendix A**.

Moreover, ICAO has developed Guidelines on Performance of Very Small Aperture Terminal (VSAT) networks aiming at supporting States/Organization for the implementation and the operation of VSAT Networks as attached in **Appendix B.**

2.2 Statistics of availability of Aeronautical Fixed Service supported by CAFSAT

The evaluation of the operation of VSAT Networks is generally performed through the end to end supported service availability, reliability, continuity, and efficiency. Guidelines have been developed for the assessment of some Aeronautical Fixed Service quality with metrics parameters;

The guidelines on Performance of Very Small Aperture Terminal (VSAT) networks indicates some parameters that can help for the assessment of CAFSAT Network (Availability, Bit Error Rate, One way latency Time, Call Blocking Probability, Call Set up Time...).

In practice some Network management committee have developed templates to be fed for the assessment of both facilities and Aeronautical Fixed Service as presented respectively in **Appendixes C** and **D**.

3. Action by the meeting:

The meeting is invited to:

a) Take note of the above information

b) Examine and use the templates presented in **Appendixes C** and **D** to collect CAFSAT nodes and services parameters and monthly forward them to CNMC current team leader with copy to CNMC Secretariat.

ANNEX X VOL 1, ATTACHMENT F: GUIDANCE MATERIAL CONCERNING RELIABILITY AND AVAILABILITY OF RADIOCOMMUNICATIONS AND NAVIGATION AIDS

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, Attachment F.***

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/mm* where:

R = reliability (probability that the facility will be operative within the specified tolerances for a time t, also referredto 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 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,

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

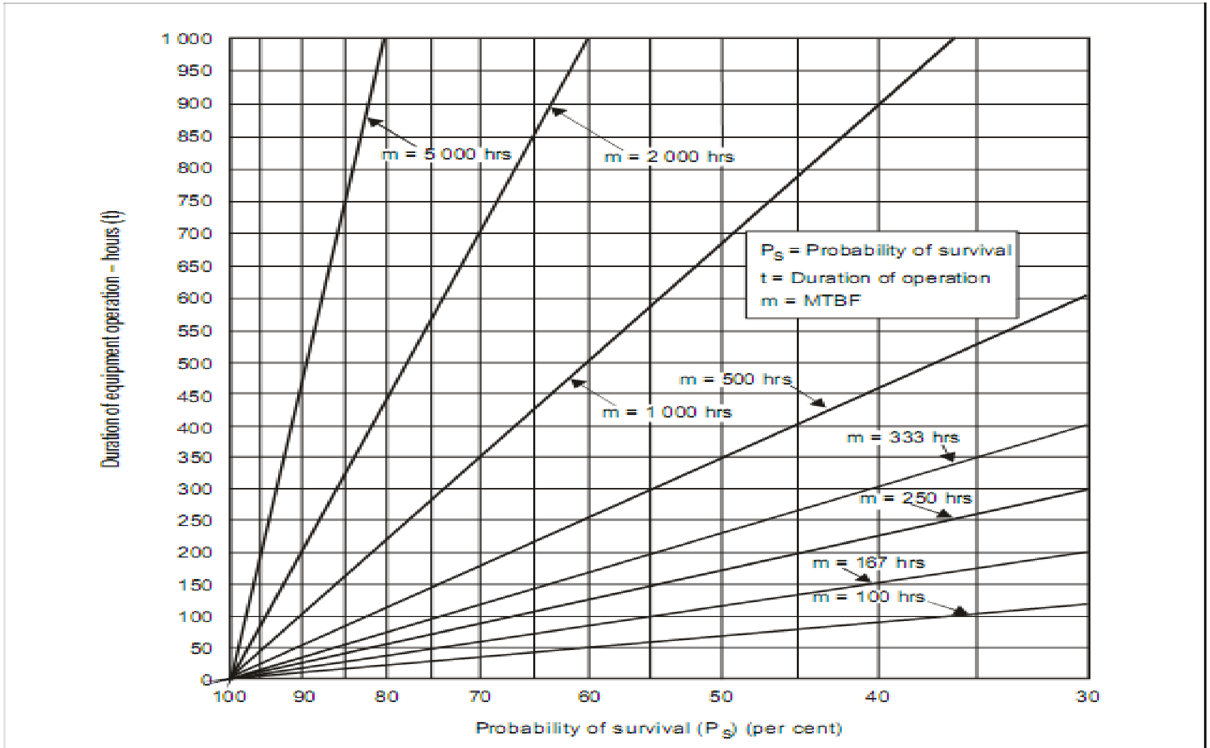


Figure F-1. Plot of $P_s = 100\ e^{-t/m}$

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.

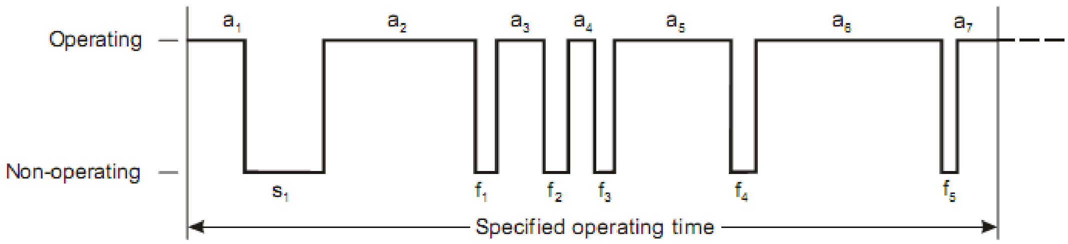
2. Practical aspects of reliability and availability

2.1 Measurement of reliability and availability

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: a1 + a2 + a3 + a4 + a5 + a6 + a7 = 5 540 hours

s1 = 20 hours

f1 = 2½ hours

f2 = 6¼ hours

f3 = 3¾ hours

f4 = 5 hours

f5 = 2½ hours

Specified operating time = 5 580 hours

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

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

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

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

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

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

Guidelines on Performance of Very Small Aperture Terminal (VSAT) Networks

1. Introduction

1.1 Digital communication networks based on very small aperture terminal (VSAT) are being increasingly used in the provision of aeronautical ground-ground communications in areas where terrestrial communication systems are unavailable, unreliable or uneconomical. VSAT networks are generally flexible, scalable, versatile, easy to implement/operate and cost-effective in certain areas, terrains or conditions.

1.2 On the other hand, a wide variety of often incompatible architectures, configurations, access techniques, management, operation schemes and protocols are used in different VSAT networks. Moreover, almost all VSAT networks available in the market employ some proprietary products. As a result, in general, non-identical VSAT networks are not interoperable.

1.3 There are no international standards governing VSAT networks. A number of International Telecommunication Union (ITU) recommendations relating to radio frequency or other aspects of communication systems are applicable to VSATs and are often complied with by VSAT vendors. Such compliance should not, however, be interpreted as a indication of compatibility with other products.

1.4. ICAO has not standardized the physical layer of communications, therefore there are no provisions for VSATs, nor for terrestrial-based systems-like cable, microwave relay system or optical fibre.

1.5 Noting the above, States or organizations that plan to implement VSAT networks for the provisions of aeronautical ground-ground communications, are advised to:

a) ascertain that VSAT is in fact the preferred and most cost-effective means of communication sin the geographical area(s) or interest;

b) take into consideration Conclusion 5/16 of ALLPIRG/5; and

c) use the performance requirements states in the ensuing paragraph as a guide to planning, system design and evaluation activities.

2. Performance requirements

2.1 Many factors influence the architecture, configuration and system design of a VSAT network. The end user is however mainly interested in the quality or performance of the communication service that is being provided and not so much in the technical details. As such, the user should state the desired basic performance requirements at the very early stage of planning to enable VSAT system design to proceed accordingly. Such performance requirements, once agreed upon by all parties concerned, would be used as a basis for further evaluation and continuing monitoring of the network.

2.2 In general, there is a direct relationship between performance and cost. This is particularly important for VSAT networks as there are also many parameters involved in achieving a given performance level. For example, insisting on higher availability implies duplicate terminals using

Center

Date/

Parameters	Values	Remarks
Fixed Parameters		
Intelsat link Name	IS 901 @°E	
Transponder Number	36/36	
Satellite Earth Station Coordinates	AZ = ddd, mm O/E EL = dd, mm N/S	
Antenna Type and Size	….m	
Antenna Gain	Tx : …dBi Rx : …dBi	
SSPA type	X W	
Up Converter Frequency	MHz	
Down Converter Frequency	MHz	
Global Dynamic parameters		
EIRP		
G/T		
C/N0		
BER		
MTBF		
MTTR		
Parameter for Carrier Performance		
Carrier failure rate		
C/N0		
BER		

Appendix D

D1: Performance of Aeronautical Fixed Service supported by CAFSAT

Performance of AFTN

Centre : Atlántico
Date /

Country	Terminal I	Terminal II	Support	COM Protocol	Speed	Transit Time	Routing	Monthly Availability 2011												½ Annual Average Availability	
								01		02		03		04		05		06		1	
Brazil	**Atlántico**	**Dakar**	**CAFSAT**					**TX**	**RX**	**TX**	**RX**	**TX**	**RX**	**TX**	**RX**	**TX**	**RX**	**TX**	**RX**	**TX**	**RX**

D2: Qualitative performance of ATS/DS

Centre :
Date /

Country	Terminal I	Terminal II	Support	Connexion Time	Nb of Attemps	One Way Latence Time	Call set up time	Voice Quality (1 to 5)	Monthly Availability 2011						½ Annual Average Availability
Brazil	**Atlántico**	**Dakar**	**CAFSAT**						01	02	03	04	05	06	

D3: Qualitative performance of Future CNS Services

Country	Terminal 1	Terminal II	Support	Provided Service	COM Protocol	Speed	Transit Time	Routing	Availability 2005-2010						Remarks
									05	06	07	08	09	10	
Brazil	**Atlántico**	**Dakar**	**CAFSAT**	AIDC											
Spain	**Las Palmas**	**Sal**	**CAFSAT**	AMHS											