RECOMMENDATION ITU-R M.828-2*

Definition of availability for radiocommunication circuits in the mobile-satellite service

(Question ITU-R 85/8)

(1992-1994-2006)

Scope

This Recommendation defines the temporal availability for radiocommunication circuits in the mobile-satellite service (MSS) to provide a guide to designers and planners, as well as to provide a basis for interference criteria.

The ITU Radiocommunication Assembly,

considering

a) that the availability of radiocommunication circuits in the mobile-satellite service (MSS) needs to be defined as a guide to designers and planners and in order to provide a basis for interference criteria;

b) that the approach used to define availability in the fixed-satellite service is not applicable to radiocommunication circuits in the mobile-satellite services because, *inter alia*, the MSS circuits are generally established on a demand assignment basis;

c) that the service link availability depends *inter alia* on the mobile earth station (MES) location, at the time a radiocommunications circuit is sought and for the duration of the communication;

d) that sometimes different system components are utilized for system access and for communications;

e) that the equipment availability (including the space station) is dependent on reliability, performance and maintainability;

f) that the availability of radiocommunication circuits is determined by the combined effects of equipment and propagation availability,

recommends

1 that the overall availability of radiocommunications circuits should be defined in terms of access availability and communications availability by using as a basis the availability of the components (see Note 1) comprising the access channel and the radiocommunication circuits as follows:

– space station;

– feeder-link radio path and service-link radio path under line-of-sight conditions (see Note 2) and,

– earth stations (land earth stations (LES), mobile earth stations (MES) and other related earth stations should be included);

---

* This Recommendation should be brought to the attention of the Telecommunication Standardization Sector (Study Groups 12 and 13).

2 that the availability of radiocommunication circuits in the mobile-satellite services should be defined by the following formula:

$$\text{Availability} = (100 - \text{Unavailability})(\%)$$

where unavailability represents the cumulative percentages of time of circuit interruption caused by all the components. In the mobile-satellite systems, unavailability is approximately represented by the following formula (see Note 3):

$$\begin{aligned}\text{Unavailability} = {} & \text{Unavailability (space station)} + \\ & \text{Unavailability (radio path)} + \\ & \text{Unavailability (earth station) (see Note 4)}\end{aligned}$$

where unavailability of each component is calculated by the formula:

$$\text{Unavailability (component)}(\%) = (100 - \text{Availability (component)})(\%).$$

Availability (component) represents the availability of each component and is calculated by the following formula:

$$A \text{ component} = \frac{(\text{scheduled operating time}) - (\text{duration of circuit interruption})}{(\text{scheduled operating time})} \times 100\%$$

where the scheduled operating time of the components is defined as the period of time during which the user requires a circuit to be in a condition to perform a required function at a specified level of performance; and the duration of circuit interruption is defined as the period of time during which a communication circuit experiences one of the following conditions for more than 10 consecutive seconds. (A period of circuit interruption begins when one of the following conditions persists for a period of 10 consecutive seconds. Circuit unavailability begins at the beginning of this corrupted 10 s interval. The period of circuit interruption time terminates when the same condition ceases for a period of 10 consecutive seconds. Circuit availability resumes at the beginning of this non-interrupted 10 s interval):

– the radiocommunication circuit cannot be established;

– the wanted signal entering one end of the channel is not received at the other end;

– for an analogue-type circuit, the unweighted subjectively equivalent noise power in the hypothetical telephone reference circuit (HTRC) (Recommendation ITU-R M.547) exceeds a defined limit;

– for a digital-type circuit, an information bit error ratio (BER) in the appropriate hypothetical reference digital path (HRDP) (Recommendation ITU-R M.827) worse than a defined limit occurs;

3 that when determining the appropriate system components to be included in the definition of availability, the guidance in Annex 1 to this Recommendation should be referred to;

4 that the following Notes should be regarded as part of this Recommendation.

NOTE 1 – Component refers to either a single component or an ensemble of components in a redundancy configuration.

NOTE 2 – Line-of-sight conditions should include ionospheric, tropospheric events and multipath fading. Persistent, heavy shadowing should, in general, be excluded from the requirement but it should be considered in designing the system. In the case of the land mobile-satellite service (LMSS), light shadowing due to trees and foliage etc. should be included in the calculation of the availability.

NOTE 3 – The availabilities for the space station, earth stations and radio path are assumed to be statistically independent.

NOTE 4 – MES, LES and other related earth stations should be included.

NOTE 5 – This Recommendation does not apply to the aeronautical mobile-satellite (R) service (AMS(R)S). AMS(R)S circuit availability is an area for further study.

Annex 1

Availability of radiocommunication circuits in the MSS

1 Introduction

The availability of radiocommunication circuits in the MSS needs to be defined in order to provide guidance to system planners and equipment manufacturers, and thus to provide an adequate standard of service to the user. In deriving a suggested philosophy for availability criteria, differences between the MSS and the FSS are identified. However, it is considered that the concept of availability for the MSS should, as far as possible, be compatible with similar concepts adopted for the fixed-satellite service and for radio-relay systems.

The approach adopted in this Recommendation is to consider only those factors which can be accommodated by adequate system planning, equipment design and maintenance procedures.

2 General definitions and philosophy

2.1 Definition of circuit availability

The availability of radiocommunication circuits in the MSS will depend on the availability objectives set for each component part of the circuit. In this Recommendation, consideration is given to availability objectives for the space sector, earth-station equipment and auxiliary functions, and for the radio paths between satellite and earth stations. The overall availability of the radiocommunication circuit is thus determined.

In the MSS, circuit availability, A, can be derived from the duration and rate of occurrence of interruptions to the component parts of the circuit, and can be defined as follows:

$$A = \frac{(\textit{scheduled operating time}) - (\textit{duration of circuit interruption})}{(\textit{scheduled operating time})} \times 100 \quad (\%)$$

where the scheduled operating time of the components is defined as the period of time during which the user requires a circuit to be in a condition to perform a required function at a specified level of performance; and the duration of circuit interruption is defined as the period of time during which a communication circuit experiences one of the following conditions for more than 10 consecutive seconds. (A period of circuit interruption begins when one of the following conditions persists for a period of 10 consecutive seconds. Circuit unavailability begins at the beginning of this corrupted

10 s interval. The period of circuit interruption time terminates when the same condition ceases for a period of 10 consecutive seconds. Circuit availability resumes at the beginning of this non-interrupted 10 s interval):

– the radiocommunication circuit cannot be established;
– the wanted signal entering one end of the channel is not received at the other end;
– for an analogue-type circuit, the unweighted subjectively equivalent noise power in the hypothetical telephone reference circuit (HTRC) (Recommendation ITU-R M.547) exceeds a defined limit;
– for a digital-type circuit, an information BER in the appropriate HRDP (Recommendation ITU-R M.827) worse than a defined limit occurs.

When the concept of availability is applied to individual component parts of a circuit, and in particular to equipment at LES and MES, the definition of availability for these component parts (A') may be written in terms of mean-time-between-failure (MTBF) and mean-time-to-repair (MTTR), as follows:

$$A' = \frac{MTBF}{MTBF + MTTR} \times 100 \quad (\%) \tag{1}$$

When considering the availability of telephone circuits, use can be made of the HRDP (see for example Recommendation ITU-R M.827).

The time for which a radiocommunication circuit is said to be unavailable should include delays in setting up the call arising from failures in the satellite signalling system.[1] Failures in the LES-to-MES signalling channel, the MES-to-LES random access channel or, where appropriate, the LES-to-LES signalling channel, due to adverse propagation conditions on the radio paths may result in a failed call.

2.2 Definition of interruption

The following sections give definitions of interruption for telephony and telegraphy. In view of the differing nature of these services, different availability criteria may be required for them, and his should be the subject of further study. Interruptions to data channels are also considered below.

2.2.1 Telephony

The following definition for interruption to telephony circuits in the MSS is consistent with that proposed for FSS:

A telephone circuit in the MSS should be considered to be interrupted if a channel experiences one of the following conditions for more than 10 consecutive seconds:

– the wanted signal entering one end of the channel is not received at the other end,
– for analogue transmission, the unweighted subjectively equivalent noise power in the telephone channel exceeds 10^6 pW0p.
– for digital transmissions a channel BER worse than 10^{-2} occurs.

Further information on the availability of telephony circuits can be found in ITU-T Recommendation G.821.

---

[1] Note signalling channels should be designed to have a very high reliability such that signalling outage effects are insignificant compared to other possible causes of interruptions to radiocommunication circuits.

2.2.2 Telegraphy

The following definition for interruption to telegraphy circuits has also been suggested:

A telex circuit in the MSS should be considered to be interrupted if *N* character errors are detected in a time interval less than 1.5 *N* s, where *N* is between 10 and 20.

This definition is considered to provide for sufficient measurement time and accuracy, and to take account of character error rates of the order of one error in ten characters,

In practice, a fade of 5 to 6 dB in the radio path is considered by coast earth station operators to represent an interruption. Persistent occurrences of such an interruption will cause the LES operator to shift the traffic to a reserve carrier.

2.2.3 Data

The definition of interruption will depend on the bit rate adopted for the service, the required error rate and the distribution of the errors. The availability of data channels requires further study.

2.2.4 System element outages

The following are definitions of system element outages that may result in interruption of a service:

– Space segment outage

Any interruption of more than 10 consecutive seconds directly attributable to the operational satellite.

– Network control station outage

Any interruption of the vital network control functions, such as loss of call processing capability, of more than 10 consecutive seconds, affecting the LES.

– Network outage

Any interruption of services of more than 10 consecutive seconds affecting all LESs in an ocean region caused by adverse propagation phenomena or interfering signals on any of the automatic frequency compensation (AFC) channels, request channels, LES TDM frequencies or on the common TDM frequency.

– Coast earth station outage

Any complete loss of all telephone channels, or all telex channels, or of both, of more than 10 consecutive seconds, or a corresponding loss of call processing capability of more than 1 min that is directly attributable to the coast earth station.

2.3 Scheduled operating time

Availability criteria proposed for the FSS apply to the availability of full-time circuits (telephony and television), where the scheduled operating time is the same as the calendar time. In the maritime MSS the shore-to-ship telegraphy/signalling channels will be operated on a full-time basis in that the carriers will be permanently activated, but telephony channels and the telegraphy/signalling channels transmitted by MESs will only be activated for the duration of the call.

Equipment availability at LES and MES is not affected significantly by the inherently demand-assigned nature of the MSS (compared to the availability of essentially the same equipment operating with permanently activated carriers). Hence the scheduled operating time is equated to calendar time for all equipment.

2.4 Factors affecting availability

The overall availability of circuits in the MSS will depend on the availability criteria adopted for the following:

– *Space sector*, including satellite equipment, the effects of satellite manoeuvres and the provision of spare satellites;

– *Land earth station equipment*, including the effects of natural phenomena on equipment performance (e.g. sun interference and natural disasters), and the effects of human error;

– *Mobile earth station equipment*, including the effects of natural phenomena on equipment performance (e.g. sun interference and environmental conditions), and the effects of human error:

– *Auxiliary functions*, such as might be performed by control land earth stations (e.g. frequency control, power control and channel assignment);

– *Forward and return RF links*, in particular the effects of attenuation and excess noise due to precipitation, the effects of multipath fading and the effects of interference such as might arise from terrestrial and space services.

Despite this, in determining realistic availability objectives, it would not be practicable to take account of all the above eventualities.

2.5 Influence of natural or extreme phenomena

For the purpose of this Recommendation interruptions are classified as follows:

– *Predicted interruptions:* either interruptions to correct non-catastrophic failures which may be planned to occur at some time and which can be tolerated for relatively short periods (e.g. equipment faults, propagation fading), or scheduled interruptions which are known to occur at specific times (e.g. certain types of preventive maintenance on equipment, sun interference at coast earth stations);

– *Unpredicted interruptions:* those interruptions whose occurrence or duration cannot be predicted and which could cause prolonged outages e.g. natural disasters such as earthquakes, high winds or exceptionally severe sea conditions, and natural blockage effect such as shielding by mountains).

For the LES and MES, it is considered that interruptions due to unforeseen circumstances should he excluded from availability considerations, and account should be taken only of foreseen interruptions. In addition, for MES equipment, the following foreseen interruptions should be ignored:

2.5.1 Interruptions due to sun interference

With fixed earth stations, outages due to excessive noise on the down-path when the sun passes through the antenna beam can be predicted: durations of outages will depend on individual station locations, but degradations will be encountered for about 30 min for 3-4 days twice a year. Adverse effects on the service can, therefore, be minimized by arranging to pass traffic via alternative routes. With MESs the same situation does not apply. Taking as an example a ship earth station, the occurrence of sun interference will depend on the ship's route, which will vary from ship to ship, and this phenomenon could therefore be encountered several times in the course of a year by particular ships. The duration of the interference would be longer than for LESs because of the relatively broad beamwidth of the MES antenna, although the degradation in receiver noise temperature would be less severe.

2.5.2 Interruptions due to severe weather conditions

In the case of ship earth stations, equipment is designed to withstand severe environmental conditions such as temperature variations, humidity, precipitation, wind and vessel motions.

Additional protection to the above-deck equipment is provided by a radome, but at some time most ships will encounter weather conditions which will render the equipment inoperable, e.g. inability to maintain antenna-pointing due to high sea state conditions. It is therefore considered that such interruptions should not be included in the assessment of ship terminal availability, although equipment manufacturers and system planners should not be discouraged from investigating means of maintaining ship terminal operation under extreme conditions.

2.5.3 Interruptions due to antenna blockage effects

The radio propagation path between the MES and satellite may, on occasions, be blocked. This may, for example, be due to vegetation or buildings near the MES.

Persistent, heavy shadowing should, in general, be excluded from the requirement but it should be considered in designing the system. In the case of the land mobile-satellite service (LMSS), light shadowing due to trees and foliage, etc. should be included in the calculation of the availability.

In the case of ship earth stations, blockage may be caused by parts of the ship's superstructure. Although ship owners and manufacturers should be encouraged to install ship earth stations in locations which minimize the probability of antenna blockage, such locations may not be available in all cases. It is therefore proposed that these outages be excluded from availability criteria.

2.6 Measurement of circuit availability

Taking account of the exceptions outlined in § 2.5, the following expression should be used for the measurement of radiocommunications circuit availability in the MSS:

$$A = \frac{T_s - (T_{sat} + T_1 + T_2 + T_{LES} + T_{MES} + T_{aux})}{T_s} \times 100 \ (\%) \qquad (2)$$

where:

T_s: scheduled operating time

T_{sat}: cumulative time of circuit interruptions caused by failures of the satellite;

T_1: cumulative time of circuit interruptions attributable to factors on the forward link radio path (i.e. $T_1 = T_{LES\text{-}sat} + T_{sat\text{-}MES}$

where:

$T_{LES\text{-}sat}$ refers to the LES-to-satellite link, and

$T_{sat\text{-}MES}$ refers to the satellite-to-MES link)

T_2: cumulative time of circuit interruptions attributable to factors on the return link radio path (i.e. $T_2 = T_{MES\text{-}sat} + T_{sat\text{-}LES}$

where:

$T_{MES\text{-}sat}$ refers to the MES-to-satellite link, and

$T_{sat\text{-}LES}$ refers to the satellite-to-LES link)

T_{LES}: cumulative time of circuit interruptions caused by failures of LES station equipment and communications capability

T_{MES}: cumulative time of circuit interruptions caused by failures of MES terminal equipment and communications capability

T_{aux}: cumulative time of circuit interruptions caused by failures of auxiliary functions at separate control earth stations.

In the event of two or more items occurring a simultaneously, only the duration of the longest interruption should be taken into account.