

REPORT 918-1*

AVAILABILITY OF COMMUNICATIONS CIRCUITS IN THE MARITIME MOBILE-SATELLITE SERVICE

(Question 85/8)

(1982-1990)

1. Introduction

The availability of communications circuits in the maritime mobile-satellite service 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 maritime mobile-satellite service and the fixed-satellite service are identified. However, it is considered that the concept of availability for the maritime mobile-satellite service should, as far as possible, be compatible with similar concepts adopted for the fixed-satellite service (Report 706) and for radio-relay systems (Report 445).

The approach adopted in this Report is to consider only those factors which can be accommodated by adequate system planning, equipment design and maintenance procedures. Examples of the INMARSAT system availability for general and distress communications are based on historic data obtained from actual operations.

2 General definitions and philosophy

2.1 Definition of circuit availability

The availability of communications circuits in the maritime mobile-satellite service will depend on the availability objectives set for each component part of the circuit. In this Report, 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 communications circuit is thus determined.

In the maritime mobile-satellite service, 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:

$$A = \frac{(\text{scheduled operating time}) - (\text{down-time})}{(\text{scheduled operating time})} \times 100 (\%)$$

where scheduled operating time is the time during which the circuit of interest is expected to perform its intended function, and down-time is the cumulative time of circuit interruptions within the scheduled operating time.

* The Director, CCIR, is also requested to bring this Report to the attention of the International Maritime Organization (IMO) and the International Maritime Satellite Organization (INMARSAT).

When the concept of availability is applied to individual component parts of a circuit, and in particular to equipment at coast earth stations (CES) and ship earth stations (SES), 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:

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

When considering the availability of telephone circuits, use can be made of the hypothetical reference circuit (Recommendation 546).

The time for which a communications circuit is said to be unavailable should include delays in setting up the call arising from failures in the satellite signalling system.* Failures in the shore-to-ship signalling channel, the ship-to-shore random access channel or the shore-to-shore signalling channel, due to adverse propagation conditions on the radio paths may result in a failed call.

It should be noted that in order to ensure continuous and reliable operation of the INMARSAT system, the following special measures have been implemented:

- (a) to protect the system from possible interfering, e.g. signals resulting from malfunction of ship earth stations, coast earth station, satellite or other sources outside the system, contingency frequency plans and reserve frequencies both for signalling and communications circuits are provided in each ocean region;
- (b) two common request channels are used;
- (c) an operational and at least one spare satellite is provided in each ocean region. In the event of failure or degradation of service, traffic can be transferred to a spare satellite;
- (d) the INMARSAT Operations Control Centre continuously monitors system performance and initiates appropriate actions as necessary to preserve system integrity; and
- (e) equipment redundancy is provided at CESs to minimize risk of outage. In some cases, this extends to providing for access from spare antennas and RF equipment.

Calls lost due to congestion in the terrestrial network or the satellite network are not included in availability considerations as they relate to grade-of-service requirements rather than to availability.

* 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 communications circuits.

2.2 Definitions 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 this 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 maritime mobile-satellite service is consistent with that proposed for the fixed-satellite service (Report 706):

A telephone circuit in the maritime mobile-satellite service 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 Bit Error Rate (BER) worse than 10^{-2} (for 99% time) occurs.

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

2.2.2 Telegraphy

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

A telex circuit in the maritime mobile-satellite service 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 10 characters.

In practice, a fade of 5 to 6 dB above AFC level in the radio path is considered by coast earth station operators to represent an interruption. Persistent occurrences of such an interruption will cause the CES 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:

(i) Space Segment Outage

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

(ii) Network Coordination Station Outage

Any interruption of the vital network coordination functions, such as loss of call processing capability, of more than ten consecutive seconds, affecting the collocated coast earth station or coast earth stations.

(iii) Network Outage

Any interruption of services of more than ten consecutive seconds affecting all coast earth stations in an ocean region caused by adverse propagation phenomena or interfering signals on any of the AFC channels, request channels, Coast Earth Station TDM frequencies or on the common TDM frequency.

(iv) Coast Earth Station Outage

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

2.3 *Scheduled operating time*

Availability criteria proposed for the fixed-satellite service 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 mobile-satellite service 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 (shore-to-ship and ship-to-shore) and the telegraphy/signalling channels transmitted by ships will only be activated for the duration of the call.

Equipment availability at coast earth stations and ship earth stations is not affected significantly by the inherently demand-assigned nature of the maritime service (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 maritime mobile-satellite service 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;
- *Coast 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;
- *Ship 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 coast earth stations (e.g. frequency control, power control and channel assignment);
- *Shore/satellite and ship/satellite 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.