RECOMMENDATION ITU-R M.1181

# MINIMUM PERFORMANCE OBJECTIVES FOR NARROW-BAND DIGITAL CHANNELS USING GEOSTATIONARY SATELLITES TO SERVE TRANSPORTABLE AND VEHICULAR MOBILE EARTH STATIONS IN THE 1-3 GHz RANGE, NOT FORMING PART OF THE ISDN

(Question ITU-R 112/8)

(1995)


## Summary

This Recommendation concerns the minimum bit-error ratio performance objectives for voice mode and data mode of geostationary-satellite orbit (GSO) mobile-satellite service (MSS) systems.


The ITU Radiocommunication Assembly,

*considering*

a) that performance objectives for digital mobile-satellite channels using narrow-band modulation and geostationary satellites should include an allowance for interference levels among and within systems operating in the 1-3 GHz range, as well as comply with user requirements for performance;

b) that "general purpose" digital mobile-satellite channels may be used by land, maritime and aeronautical mobile earth stations, are designed to alternatively operate in data or voice transmission modes, or in-band signalling modes using the same frequencies during the same communications session;

c) that reception of signals transmitted to and from mobile earth stations at most locations may be substantially degraded by location and orientation dependant signal propagation impairments which determine spatial performance;

d) that "store and forward" messaging digital mobile-satellite channels using geostationary satellites are generally not sensitive to delay, and therefore are able to use near perfect interleaving in mitigating channel bit-error bursts, arising from multipath and light shadowing effects and thus can be operated within the performance objectives specified herein;

e) that digital mobile-satellite channels may be used in global or spot coverage beams as part of a worldwide MSS, in which case stringent satellite power constraints are expected, combined with a minimum elevation angle to the satellite as low as 5°,

*recommends*

**1** that in both directions of transmission through the service and feeder links, the combined radio-link minimum performance objectives for digital channels used by geostationary satellites to serve transportable or vehicular mobile earth stations in the MSS are as follows:

**1.1** for "general purpose" digital mobile-satellite channel (user rates up to 9.6 kbit/s):

**1.1.1** provisionally a channel bit-error ratio (BER) of better than $4 \times 10^{-2}$ in the voice mode for not less than 90% of the available time;

**1.1.2** provisionally a BER of better than $1 \times 10^{-5}$ in the data and signalling mode after error correction for not less than 90% of the available time;

**1.2** for transportable digital mobile-satellite channel (user rates up to 16 kbit/s);

**1.2.1** a channel BER of better than $1 \times 10^{-2}$ in the voice mode for not less than 95% of the available time;

**1.2.2** a BER of better than $1 \times 10^{-5}$ in the data and signalling modes after error correction for not less than 95% of the available time;

**1.3** for "store and forward", messaging digital mobile-satellite channels (up to 600 bit/s user rates):

– a BER of better than $4 \times 10^{-5}$ after error correction for not less than 95% of the available time;

where available time is the total time for which the radio link is allocated and available to the user;

**2** that the individual uplinks and downlinks may be so designed that the overall percentage of time for which the link is available is to a large extent determined by the service link. One method of allocating the overall percentage of time between the service and feeder links is described in Annex 2 as a guidance for the system designer;

**3** that the additional conditions specified in the following Notes are part of the performance objectives specified in § 1 and 2.

NOTE 1 – Annexes 1 and 2 provide the basis of the performance objectives specified above.

NOTE 2 – For "general purpose" digital mobile-satellite channels used by vehicular land mobile earth stations, temporal availability is generally more critical than spatial availability because severe signal propagation impairments generally are eliminated when the mobile earth station antenna is moved a small distance. The specified signal quality and temporal availability levels are associated with mobile earth station operations in areas that are devoid of persistent heavy shadowing.

NOTE 3 – Sporadic, moderate shadowing of the signal to or from a geostationary satellite occurs with land mobile earth stations in most areas outside urban areas. These sporadic degradations can be effectively mitigated.

NOTE 4 – For voice communications, error control techniques may be provided as an integral part of the voice coder/decoder (codec) processing algorithm, but may also be incorporated in the modulator/demodulator (modem) module, or alternatively be partitioned between the modem and codec modules. Therefore, the performance objectives for voice communications should take into account the BER at the codec input.

NOTE 5 – Performance objectives and performance criteria for voice communications are likely to evolve with codec techniques becoming more efficient and with lower transmission rates. Therefore, voice performance objectives in future Recommendations may be stated in terms of actual voice quality (e.g. mean opinion score). Further study is needed on how to define the voice grade, and on selecting an evaluation method for low rate voice codecs.

NOTE 6 – For data communications, error control techniques are generally provided as an integral part of the modem. Additional end-to-end error control measures may be implemented to enhance performance for specific user applications. However, for the purpose of this Recommendation, the effects of these user application techniques are not included in the performance objectives.

NOTE 7 – Spatial performance is defined as the cumulative probability of link availability arising from the joint distribution of location and orientation dependent random losses in the link. Percentage of available time reflects the fraction of time the channel is not faded due to multipath and rain attenuation.

NOTE 8 – The Recommendation for performance objectives of the aeronautical mobile-satellite (R) service channels is described in Recommendation ITU-R M.1037.

NOTE 9 – In the case of backup using a previous generation satellite the BER performance objectives given in § 1 might be achieved for a lower percentage of the time.

NOTE 10 – The effects of aggregate interference from other systems and services should be taken into account in ensuring that the overall performance objectives of the digital MSS channel are met.

NOTE 11 – Further study is required for the necessity of short-term performance criteria to define the associated BER thresholds and percentages of time.

NOTE 12 – For terminals at low elevation angles operating through the "general purpose" satellite channel, the BER performance objectives given in § 1 might be achieved for a lower percentage of the time.

NOTE 13 – The specifications for performance objectives for store and forward messaging digital mobile-satellite channels is a subject for further study.

ANNEX 1

# Basis for the specified performance objectives

## 1 Introduction

The performance objectives for digital mobile radio-link satellite channels are based on the users requirements corresponding to each service. The requirements vary with the service operational requirements and functions, users perception of service quality and service characteristics (e.g. voice, circuit-mode data). Three channel types (supporting three different services) are covered in this Annex in order to support *recommends* 1:

– general purpose digital mobile channels (up to 9.6 kbit/s), supporting low rate voice and real-time data, with performance objectives at a level equivalent to "terrestrial cellular quality";

– transportable digital mobile channels (up to 16 kbit/s), supporting medium rate voice and real-time data, with performance objectives approaching terrestrial "toll quality";

– "store and forward" digital mobile channel (up to 600 bit/s), supporting messaging data services where errors are not tolerated but the message delay may be compromised.

The following sections review the user requirements corresponding to each channel type, and summarize the associated hypothesized performance objectives proposed for the channels.

## 2 General purpose digital mobile channel (up to 9.6 kbit/s)

### 2.1 User requirements

Progress in speech coding technology has resulted in the reduction of voice codec rate required for a given voice quality. The development of error correction techniques has also contributed to the "robustness" of the voice codec when operating with channel impairments. The voice codec should provide a voice quality acceptable to the user under typical user conditions such as different BER conditions (random and burst errors), fading conditions, acoustic background noise and audio level. The voice quality should be compatible with different languages and gender. This is especially important for the provision of a worldwide general purpose communication service.

Users have come to expect that all wireless telephony services should have speech quality at least similar to that provided by terrestrial cellular systems. Generally, a system needs to sustain voice communication with a mean opinion score (MOS) of around 3 or higher on a 1-5 scale (equivalent to a MOS of around 2 on a 0-4 scale) in order to meet this expectation.

For data communications services, the BER performance of the data channel should be compatible with the performance achieved in the corresponding terrestrial networks. A data channel with a BER performance not worse than $1 \times 10^{-5}$ meets this criterion. External end-to-end error control measures can be implemented generally by the user for applications requiring lower BER levels.

Users understand that wireless modes of transmission entail intermittent outages due to multipath fading and shadowing. However, users will not tolerate redialling to re-establish communications. Thus, it is important for communications links to maintain synchronization for a significant period of time even under degraded propagation conditions.

## 2.2 Hypothetical performance objectives

### 2.2.1 Voice

An improved multiband excitation (IMBE) codec operating at a 6.4 kbit/s data rate (including error control) was assumed for evaluation of performance in the voice mode. Subjective tests have shown a minimum required channel BER of $4 \times 10^{-2}$ in order to maintain the required voice quality as described in § 1.1.

### 2.2.2 Data

For data transmission, a baseband BER of $1 \times 10^{-5}$ (after channel error correction coding) enables virtually all messages to be interpreted correctly without special error control measures. Where additional error detection and retransmission schemes are used, a channel BER of $1 \times 10^{-5}$ would result in few retransmissions and would yield high throughput efficiency.

### 2.2.3 Signalling

For in-band signalling transmissions, an average baseband BER of $1 \times 10^{-3}$ ensures a low probability of error in a signalling message and signalling protocols can effectively mitigate the errors that do occur. The design of the voice and data modes must ensure that the signalling performance requirements are met at link conditions corresponding to the channel minimum performance objectives.

# 3 Transportable digital mobile satellite channel (up to 16 kbit/s)

## 3.1 User requirements

User requirements for this service are similar to the requirements for the "general purpose" digital mobile channel, but in addition users expect a higher degree of channel reliability (less outages due to transmission link impairments). Furthermore, generally the transportable digital mobile channel equipment is capable of supporting higher channel rates with higher overall link availability, and therefore is more suitable for extension of terrestrial telephone network user options.

The use of a higher rate voice codec provides better voice quality and can be more resilient to channel impairments. Additionally, the 16 kbit/s adaptive predictive coding (APC) voice codec evaluated has the advantage of being transparent to analogue facsimile and signalling transmission as well as voiceband data of up to 2.4 kbit/s.

In the case of data communications, the BER performance of the data channel should be compatible to the performance achieved in terrestrial networks. A data channel with a BER performance of $1 \times 10^{-5}$ meets this criterion, with a data transmission rate of up to 9.6 kbit/s.

For in-band signalling transmissions, requirements similar to those of the "general purpose" digital mobile channel are sufficient, and may be achieved in the voice channel by adding relatively low redundancy to the channel bits.

## 3.2 Hypothetical performance objectives

### 3.2.1 Voice

A BER of $1 \times 10^{-2}$ is needed in order to achieve the higher quality level required of the higher rate voice codec.

### 3.2.2 Data

BER of $1 \times 10^{-5}$.

## 4 "Store and forward", messaging digital mobile-satellite channels (up to 600 bit/s)

### 4.1 User requirements

The messaging channel is designed as an error-free medium for message transfer, using an automatic request for repetition (ARQ) protocol as a higher level error control scheme. The required BER is selected in order to minimize the total energy per message length, during a message transfer transaction. A higher BER would result in further ARQ activity, thus increasing the total energy required for message transfer. A better BER would require a higher satellite e.i.r.p.

### 4.2 Hypothetical performance objective

BER of $4 \times 10^{-5}$.

ANNEX 2

# A method for allocating the overall percentage of time for which the link is available between the service link and feeder link

Generally individual uplinks and downlinks are so designed that the overall percentage of time for which the link is available is to a large extent determined by the service link. This means that the service link is subject to a much tighter power constraint.

The percentage of time for which the end-to-end link is available may be achieved by allocating percentages of available time to the corresponding uplink and downlink using Table 1:

TABLE 1

| Direction of transmission | Radio path | Percentage of time for which the link is available |
|---|---|---|
| Forward | Feeder uplink | $(1 - (1 - A)\ 0.1)\ 100$ |
| | Service downlink | $A/A_{f,u}$ |
| Return | Feeder downlink | $(1 - (1 - A)\ 0.1)\ 100$ |
| | Service uplink | $A/A_{f,d}$ |

$A$: overall radio-link time availability

$A_{f,u}$: forward feeder uplink time availability

$A_{f,d}$: return feeder downlink time availability.

For example, an end-to-end link availability requirement of 90% could be achieved with a service link availability requirement of 90.9%, and a feeder link availability requirement of 99%.

In the described allocation method the feeder link is ascribed 10% of overall link unavailability. Ascribing a larger unavailability to the feeder link will result in a significant increase in the service link availability requirement. Conversely, reducing the unavailability ascribed to the feeder link will result in little or no change to the service link requirement, i.e. the overall link availability is dominated by the service link.