RECOMMENDATION ITU-R SA.1162-1

TELECOMMUNICATION REQUIREMENTS AND PERFORMANCE CRITERIA FOR SERVICE LINKS IN DATA COLLECTION AND PLATFORM LOCATION SYSTEMS IN THE EARTH EXPLORATION- AND METEOROLOGICAL-SATELLITE SERVICES

(Question ITU-R 142/7)

(1995-1997)

The ITU Radiocommunication Assembly,

considering

a) that satellite systems for data collection and platform location of the Earth exploration- and meteorological-satellite (METSAT) services have unique telecommunication requirements;

b) that the hypothetical reference system specified in Recommendation ITU-R SA.1020 defines service and feeder links for data collection, and data collection platform interrogation by satellite;

c) that performance objectives for these transmissions must be consistent with the attendant functional requirements and with the performance limitations associated with the systems and frequency bands in which the requirements will be fulfilled;

d) that performance objectives for representative systems operating in the Earth exploration-satellite (including METSAT) services are intended to provide guidelines for the development of actual systems;

e) that performance objectives may be determined using the methodology described in Recommendation ITU-R SA.1021;

f) that performance objectives are a prerequisite for the determination of interference criteria;

g) that Resolution No. 710 of the World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum (Malaga-Torremolinos, 1992) (WARC-92) resolves that the next competent world radiocommunication conference study the 401-403 MHz band with the intent of raising the METSAT and Earth exploration-satellite (EES) services to primary status equivalent to the meteorological aids service,

recommends

1 that the requirements and characteristics described in Annex 1 should be taken into account in connection with frequency assignments and other regulatory matters concerning satellite systems for data collection and platform location of the EES and METSAT services, and their interaction with services other than the EES service;

2 that the service links associated with data collection systems (DCS) have the performance objectives specified in Table 1.

TABLE 1

Performance objectives for DCS links in the METSAT service

Frequency band (MHz)	Satellite orbit	Modulation	Applicable elevation angle (degrees)	Maximum BER	Required time availability (%)	Function and type of earth station Antenna
401-403 (Earth-to-space)	Non-geostationary	Manchester encoded split-phase PSK	≥ 5	1×10^{-5}	99.6	Data collection Low-gain antenna
	Geostationary	Biphase – L	≥ 3	1×10^{-4}	99.6	Data collection Low-gain antenna
460-470 (space-to-Earth)	Non-geostationary	Biphase – L	≥ 5	1×10^{-5}	99.6	Data collection platform interrogation, Low-gain antenna
	Geostationary	Biphase – L	≥ 3	1×10^{-5}	99.6	Data collection platform interrogation, Low-gain antenna

NOTE 1 – Performance objectives for specific systems may differ from the objectives presented in this Recommendation; however, the objectives defined herein are used as a basis for deriving permissible levels of interference that are the minimum interference thresholds to be accepted by specific systems.

NOTE 2 – Additional performance objectives could be associated with an availability of 99.99% of the time that relate to the need to synchronize the receiver to the data transmission frames and to avoid bit slips within a frame. However, for the purpose of deriving interference criteria, these objectives can be assumed to be met if the objectives associated with the above specified lower availability levels are met.

NOTE 3 – The service links addressed herein are between satellite and data collection platforms. The performance objectives for feeder links associated with the data collection and data collection platform interrogation functions are not specified in this Recommendation.

NOTE 4 – Data collection platform interrogation from non-geostationary satellites will be available in the near future.

ANNEX 1

Telecommunication requirements and characteristics of the EES and METSAT systems for data collection and platform location

1 Principal and applications

This Recommendation applies to EES and METSAT systems for data collection and platform location. The purpose of satellite DCSs is to provide a telecommunication network for users needing information from a variety of sources, which may be located anywhere in the world, including oceans, deserts or not easily accessible regions.

The concept of a satellite DCS is the following:

– automatic, autonomous platforms installed on land or mounted on a support (boat, aircraft, balloon, anchored or drifting buoy, land vehicle) for the transmission of meteorological (pressure, temperature, humidity, etc.) or geophysical (tsunami warnings, seismic, oceanographic and geodetic data, etc.) parameters. These platforms should, as far as possible, be light and compact, use little power and be inexpensive;

– the information compiled and transmitted by the platforms is received on board a satellite and forwarded through one or more data acquisition earth stations to a system management centre;

– once centralized, the information is carried to users by conventional means of telecommunication;

– if necessary, provision may also be made to distribute information from the management centre to the platforms through the same system.

Such a system differs from conventional telecommunications in that it cannot be conceived without the use of satellites and is intended for a special category of customers whose needs cannot be met by other means. In general, it favours one direction of transmission and essentially serves to centralize information. It may, however, be backed up by a facility for the distribution of information to the collection platforms. Finally, a requirement that is very important for many users, is that the data collection function may easily be coupled with a location system which determines the coordinates of the transmitting platforms.

A DCS has many fields of application: meteorology, Earth resources, hydrography, seismic observation, vulcanology, geodesy and geodynamics, anchored or drifting oceanographic buoys, oil prospecting, wild animal tracking,...

2 Satellite system design

Two types of orbit may be used: the geostationary-satellite orbit (GSO) or low orbits (LEO).

2.1 LEO Satellite systems

The LEO satellites are generally placed in circular orbit at altitudes of between 600 and 1 800 km, with a period of revolution of approximately 2 h. The whole of the Earth, including the poles, can be scanned with a single satellite, but the number of passes is relatively low (about 3 or 4 per day over the Equator). It may be increased by using several satellites e.g. a dozen passes per day over the equator may be obtained with three satellites. Passes are far more frequent near the poles.

The platforms of the LEO satellite systems are generally simple due to the better radio link budget compared with the GSO satellites. The location function is easier to provide using the Doppler-Fizeau effect.

However they have a limited instantaneous coverage area; typically the geocentric half-angle of the field of view is of the order of 30°, and the duration of the mutual visibility between the satellite and a given beacon is limited to a range generally from 10 to 15 min. Furthermore, it is necessary to store information on board the satellite to provide the worldwide coverage.

A typical example of a LEO satellite system is the one of the NOAA (National Oceanographic and Atmospheric Administration) in the United States of America with two meteorological satellites in sun-synchronous orbits. The planes of the two circular orbits are orthogonal, the inclination about 98°, the altitudes are 830 and 870 km, and the orbital period about 102 min.

2.2 GSO Satellite systems

The geometric coverage area of a geostationary satellite is a spherical cap with a geocentric half-angle of approximately 81°.

The GSO satellite provides a permanent visibility over a vast area, quasi of the scale of an hemisphere. The information is transmitted continuously and reaches the user very rapidly. However, at least four satellites are required for world coverage, excluding the polar regions. The platforms must be equipped with directional antennas and/or higher powered transmitters than for the LEO case. Finally the location function is difficult to provide.

A GSO-satellite system is essential where instantaneous transmission is required either continuously or at set times.

3 Platform location

Mobile platforms (balloons, drifting buoys, wild animals, etc.) are used for a great many applications and their movements, which are unpredictable, need to be tracked in order to carry out the mission (wind determination, study of marine currents, study of migratory movements, etc.). In such cases, the location and collection functions are performed simultaneously.

Either the distance or the radial velocity (Doppler effect), or both, may be measured. A number of measurements are taken and processed in order to locate the transmitting platform with an accuracy ranging from a few metres to a few kilometres.

The Doppler method of location is not applicable to GSO satellites. Location from GSO satellites may be theoretically achieved by interferometry from a single satellite or by ranging within the overlap area of two satellites.

4 Platform modes of operation

4.1 Interrogated platforms

4.1.1 Interrogated platforms in GSO satellites systems

Each platform contains both a transmitter and a receiver. The system management centre transmits to the satellite a work programme containing the addresses of the platforms to be interrogated and the time at which this operation must be carried out. The platforms cannot transmit unless they are interrogated. However, they can be designed to request interrogation, e.g. geophysical warning systems. This mode of operation is very reliable and there is no risk of mutual interference. However, the platform must be equipped with a receiver which increases its cost.

4.1.2 Interrogated platforms in LEO satellites systems

A service link is currently being implemented in LEO satellite systems to allow a communication from management centres to data collection platforms (DCPs). The purpose of this service link is multiple. It can be simply to turn on or off the main power consumption components of a DCP, or more sophisticated actions like a reconfiguration of the DCP sensors. It could also improve the throughput of data collection by acknowledging the correct reception of messages and thus avoiding a useless repetition. This new link is currently being implemented on the satellite ADEOS-II, to be launched in 1999, and is foreseen on the METOP and NPOES series of satellites.

4.2 Platforms operating in a random access mode

In GSO DCSs, random access platforms are used for transmitting warnings. The platform normally reports only when a fixed threshold of the phenomenon being measured is met or exceeded. An example is a platform which in monitoring seismic activity only reports if the seismic activity is greater than normal. In practice, separate channels in the allocated band are reserved for random-access platforms in order to reduce the probability of interference with the other types of platform.

In LEO data collection systems, each platform repeats its message separately from the others and at given intervals. Interference may therefore occur between platforms which are in line-of-sight of the satellite at the same time. Consequently, the satellite can work with only a limited number of platforms in line-of-sight at the same time.

4.3 Self-timed platforms

Self-timed platforms are used principally with GSO DCSs. Each platform transmits its messages automatically within preset times. The reporting intervals are determined at preset times by a clock internal to the platform. Each platform is identified by its address and the frequency (assigned channel) on which it transmits its report. In practice, satellite operators manage the assignment of the time slots and the broadcast channels of the platforms.

5 Typical platform transmitter characteristics

5.1 Platforms of LEO systems

The typical characteristics of LEO data collection and location platforms indicated hereafter are those of the ARGOS and MOS DCSs.

Each platform transmits sporadically. Each emission consists of two successive parts: during the first part a pure carrier is transmitted; during the second part the signal is modulated by the message to be transmitted.

- Unmodulated part:
  - duration of the order of 160 ms.
- Modulated part:
  - includes 48 service bits followed by the data from the sensors. Depending on the number of sensors the total duration of the modulated part ranges between 200 and 760 ms.
- Period of repetition:
  - platforms to be located: chosen between 60 and 100 s;
  - platforms to be used only for data collection: chosen above 200 s.
- Encoding:
  - two-phase Manchester code at a bit rate of 400 bit/s.
- Carrier:
  - present ARGOS platforms = 401.65 MHz $\pm$ 3 kHz;
  - present MOS platforms = 401.50 MHz;
  - in the near future (from 1995 onwards) = 401.65 MHz $\pm$ 30 kHz;
  - modulation: PCM/PSK with a modulation index of 1.1 $\pm$ 0.1 rad.
- Emitted power:
  - less or near 3 W.
- Frequency stability (to obtain a location accuracy of better than 1 km):
  - medium-term drift (15 min) not to exceed 0.5×10^{-9}/min;
  - short-term stability (100 ms): 10^{-9}.

The location accuracy depends to some extent on the stability of the platform oscillator; this specification may vary according to the objective sought.

Some of the LEO satellite system platforms are currently studied to incorporate a receiver in the band 460-470 MHz. They will receive, from a satellite flying over, a continuous data stream at low bit rate (typically few hundreds bit/s) containing flags and messages. The received power flux-density will be low therefore the receivers have to be very sensitive, but not expensive and so not too sophisticated. The antenna will be of a simple low cost/low gain type.

5.2 Platforms of GSO systems

In the meteorological GSO systems, the DCP transmissions are called “reports” and the details of these reports vary between domestic and international services. The following information pertains to transmissions for the international system.

The DCP international format reports consist of the following contiguous elements:

- unmodulated carrier for 5 s;
- a 250 bits alternate “0” and “1” preamble;
- a 15 bits maximal linear sequence code synchronization word;
- the DCP address which is a 31 bits BCH coded word;
- the environmental data which are a maximum of 649 words, each word being 8 bits long;
- the 31 bits end-of-transmission sequence;

- bit rate of 100 bit/s;
- encoding: NRZ split-phase Manchester.
- Carrier:
  - the International DCP includes 33 channels, of 3 kHz each, filling the band 402.001-402.100 MHz;
  - through coordination, satellite operators share other domestic DCP frequencies in the band 401-403 MHz;
  - modulation: the carrier is phase modulated, the modulation index being 60°.
- Transmitted power:
  - approximately 10 W for a platform with high-gain antenna; about 40 W for a semi-isotropic (full horizon to zenith) antenna. The antenna polarisation is right-hand circular.
- Frequency stability:
  - 1.5×10^{-6}/year; phase jitter on the unmodulated carrier shall not exceed 3° rms.

6 Typical satellite receiver characteristics

6.1 LEO satellite receiver characteristics

6.1.1 ARGOS DCS satellite receiver characteristics

- Range of the power received from the DCP:
  - from –161 to –138 dBW, for an antenna gain varying from –6 dBi at the nadir to +2 dBi at the satellite horizon (the system margin allows reception of an important proportion of signals down to –167 dBW).
- Typical noise power density level:
  - –201 dB(W/Hz), (equivalent receiving noise temperature = 600 K).
- Bit error rate (for interference free messages):
  - $< 1 \times 10^{-5}$.
- Receiving bandwidth:
  - 24 kHz, centred at 401.65 MHz, and 80 kHz from 1995 onwards.
- Number of processing channels:
  - 4, and 8 from 1995 onwards.

6.1.2 MOS DCS satellite receiver characteristics

- Range of the power flux-density received from a DCP:
  - from –145 to –120 dB(W/m^2).
- Typical noise power density level:
  - –201 dB(W/Hz).
- Bit error rate (for interference free messages):
  - $< 1 \times 10^{-5}$.
- Receiving bandwidth:
  - 80 kHz centred at 401.5 MHz.

6.2 GSO satellite receiver characteristics

- Range of the power flux-density received from a DCP:
  - from –150 to –140 dB(W/m^2).

– Receiver sensitivity:
  – $G/T = -28.5$ dB(K^{-1}) with a margin of 3 dB (for an antenna gain of –0.8 dBi).
– Bit error rate:
  – $< 1 \times 10^{-4}$.
– Data relay receiving bandwidth:
  – 0.2 MHz or more depending on the type of satellite.

6.3 LEO satellite transmitter characteristics

The transmitter, currently under study, will have the main following characteristics:

– Frequency: in the band 460-470 MHz,
– Transmitter power: low power, less than 10 W (still under study),
– Transmitter occupied bandwidth: in the order of a few kilohertz (still under study),
– Antenna gain: variable from nadir to the horizon seen by the satellite to compensate for the space attenuation (still under study).

7 Conclusions

The satellite systems for data collection and platform location of the EES and METSAT services provide data for users needing information from a variety of sources, which may be located anywhere in the world, including oceans, deserts or not easily accessible regions. The GSO systems provide data with a delay of typically 5 min but do not cover the polar regions while the LEO systems offer a worldwide coverage as well as the platform location, if needed, with a delay of up to 1 to 3 h. These DCS and location system using very sensitive satellite and DCP receivers have unique telecommunication requirements.