XVII A.P.
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XVIIth PLENARY ASSEMBLY
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INTERNATIONAL TELECOMMUNICATION UNION

# REPORTS OF THE CCIR, 1990

(ALSO DECISIONS)

## ANNEX 3 TO VOLUME VIII

## MOBILE SATELLITE SERVICES (AERONAUTICAL, LAND, MARITIME, MOBILE AND RADIODETERMINATION) AERONAUTICAL MOBILE SERVICE

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

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## ANNEX 3 TO VOLUME VIII

ANNEX 3 TO VOLUME VIII

# MOBILE, RADIODETERMINATION, AMATEUR AND RELATED SATELLITE SERVICES

(Study Group 8)

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REPORT 770-3

# TECHNICAL AND OPERATING CONSIDERATIONS FOR A LAND MOBILE-SATELLITE SERVICE OPERATING IN BAND 9

(Question 82/2)

(1978-1982-1986-1990)

## 1. Introduction

The purpose of this Report is to explore the operational utility of satellites in the land mobile service, to present information on the probable technical characteristics of certain types of land mobile-satellite systems, and to employ these characteristics in a preliminary assessment of sharing between such a land mobile-satellite service and other services in the vicinity of 1 GHz.

Radio Regulations Nos. 29, 68A and 69A provide the definitions concerning the land mobile-satellite service.

## 2. Background

In the United States, and in some other countries, frequencies in the vicinity of 900 MHz have been allocated domestically for use by the land mobile service. In the USA in particular, the intent is to develop a nationwide land mobile service which is both a mobile extension of the public telephone services and a substantial augmentation of the Public Safety, Industrial, and Land Transportation Radio Services.

The application of space systems could increase the capacity, capability and versatility of these land mobile systems and services, particularly for covering large geographical areas with a single system, for assuring communications during emergencies and natural disasters, and for extending service to remote and isolated areas.

Because they are intended to be complementary, the technical characteristics of land mobile and land mobile-satellite systems should be compatible. That is, the technical characteristics should allow inter-operability between the systems where appropriate, and they should facilitate frequency sharing under mutually agreed circumstances.

## 3. Potential applications

Three possible roles for the land mobile-satellite service are experimental, operational, and emergency use. The first of these is a prelude to the others, in that it would permit experimentation in close collaboration with the land mobile service. The purposes of such experiments would be twofold: first, to identify operational services for which satellites may provide a logical and cost-effective alternative, supplement or augmentation for the land mobile service, and second, to establish criteria for possible sharing between the land mobile-satellite service and the land mobile service in rendering these services.

Operationally, the land mobile-satellite service may prove to be the most effective means for dependable coverage into rural and isolated areas. Satellites could either provide geographical extensions of conventional land mobile services (as in the case of aeronautical and maritime satellite services beyond line-of-sight of land masses); or satellites could provide new services not now possible with existing facilities because of line-of-sight limitations of the land mobile service at VHF and UHF. For example, mobile users operating over wide areas would benefit by having direct access to both mobile satellite and terrestrial systems. In this regard, further studies are necessary to determine the applicability and potential benefits of allocating adjacent frequency bands for the land mobile and land mobile-satellite services.

Another application is a satellite data communication system for vehicles. Preliminary market surveys in Europe have indicated considerable interest in reliable communication for long distance road transports. From these market contacts, it appears that a dispatch system* based on two-way telex and data transmission would satisfy the essential needs. Excluding voice transmission enables a considerable reduction to be made in the system $C/N_0$. The basic system elements conceived are:

- dispatch centres working through the public telex and data networks;
- a land earth station;
- a satellite transponder; and
- mobile earth stations.

Practical experiments in the concept envisaged in this system would be of great value in finalizing the details. Such a communication system could find wider use, for example finding roaming subscribers in land mobile radio systems.

Annex IV describes and provides the results of voice communication and position location experiments conducted in the United States using the ATS-6 experimental geostationary satellite.

## 4. Frequency allocations

At the WARC-79 frequency allocations were made, later modified by the WARC MOB-87, for the mobile-satellite service (which can be utilized by the land mobile-satellite service), in the 900 MHz band, in Regions 2 and 3 (see Radio Regulations Nos. 700, 701 and 705B). At the WARC MOB-87 world-wide allocations were made for the land mobile-satellite service in the 1.5/1.6 GHz frequency band (see Article 8 of the Radio Regulations).

## 5. Technical characteristics

The transmission quality objectives for a system in the land mobile-satellite service would be similar to the transmission quality objectives of a land mobile system. For example, for a mobile telephone service, the transmission quality objective would be that there is a 0.90 probability of obtaining a voice circuit which 75% of the subscribers rate as circuit merit 4; and a 0.90 probability of obtaining a voice circuit which 90% of the subscribers rate as circuit merit 3.

A concept definition study [Anderson and Milton, 1979; Anderson, *et al.*, 1981] for a land mobile-satellite system to provide mobile radiotelephone service to about 200,000 subscribers located primarily in rural areas of the contiguous 48 states in the United States has been completed. The satellite consisted of 69 beam multi-beam antenna system featuring a beamwidth of 0.5° between the 3 dB points. There were 111 channels per beam and with a frequency re-use factor of 3, this yielded a total of 333 channels. The total occupied bandwidth was 10 MHz in both the satellite-to-mobile and mobile-to-satellite directions of transmission. For operation in the 800 MHz band, the space station antenna would be about 42 m in diameter and the prime power would be about 12 kW. Operation in the 1550-1650 MHz bands would decrease the antenna diameter to 21 m, but increase the prime power to 48 kW.

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* For the purpose of this text, "dispatch system" has the meaning: a radio system used to control the operation of a fleet of mobiles, such as aircrafts, taxis, police, etc.

With present technology the complexity of a system with a high degree of reuse may rise at a faster rate than the benefits which can be derived from the extra channels. Therefore, the first generation of land mobile-satellite systems which are currently being planned for implementation might be more cost-effective utilizing a lesser degree of frequency reuse and smaller antennas. On the other hand, future reuse systems may prove to bring benefits for the efficient use of the radio spectrum and the geostationary satellite orbit.

Annexes I and II to this Report present the principal technical characteristics of the land mobile and land mobile-satellite services which are pertinent to the feasibility of sharing between these services. The material is drawn largely from these sources:

- Annex I of Report 631 contains summary information on the characteristics of a land mobile service used in Japan.
- Report 358 summarizes information from numerous sources on protection ratios applicable to sharing in the land and maritime mobile services at VHF and UHF. Much of this information is "service-independent" and can be applied, with proper attention to the particular geographical considerations, to analyze sharing between land mobile and land mobile-satellite systems.
- In the United States, experiments are being planned for a nation-wide public radiotelephone system designed on a cellular basis [Addeo, 1976; Fisher, 1976].
- The technical characteristics for a land mobile-satellite service are being developed by the US National Aeronautics and Space Administration, based on an authoritative sampling of the public service community [NASA/GSFC, 1976, 1977].

Annex V presents results of subjective voice quality listening tests, performed in Canada, on ACSSB, narrow-band FM without threshold extention and LPC/DMSK modems in order to establish their relative performance in the land mobile-satellite service.

## 6. Sharing considerations

The technical characteristics given in Annex I and II are employed in Annex III to examine a number of specific aspects of sharing between the land mobile and land mobile-satellite services. In particular, the annexes contain data on minimum values of signals to be protected, protection ratios, power flux-density limitations, and coordination distances. It is emphasized, however, that the coalescence of these parameters into detailed sharing criteria is not possible until the potential for use of satellites becomes more clearly defined, and until further experimentation with proposed land mobile systems provides more data on minimum desired signals and other factors which will influence sharing.

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## ANNEX I

### CHARACTERISTICS OF THE LAND MOBILE SERVICE NEEDED TO EXAMINE SHARING POSSIBILITIES

### 1. General

Technical characteristics from three sources are examined. Maximum allowed interference levels to protect the three systems are found to be nearly identical.

### 2. Characteristics of Japanese land mobile system to operate at about 800 MHz

In Annex 1 of Report 631, a preliminary evaluation of the feasibility of sharing between the broadcasting-satellite service and the terrestrial mobile service in the 800 MHz band is provided. The permissible limits of power flux density produced on the surface of the Earth are based on worst-case co-channel interference, no account being taken of the advantage of channel interleaving.

The limits of interfering power flux-density produced on the surface of the Earth by a satellite to protect a high grade service are given as:

$-133$ dB(W/m$^2$) in a 16 kHz band at the receiving antenna of a mobile station,

$-146$ dB(W/m$^2$) in a 16 kHz band at the receiving antenna of a base station which correspond to field strengths of 12.8 and $-0.2$ dB(μV/m), respectively.

The following base station characteristics were assumed:

| | |
|---|---|
| Channel spacing | 25 kHz |
| Receiver bandwidth | 16 kHz |
| Receiver noise factor | 10 dB |
| Improvement factor | 12 dB |
| Antenna gain | 15 dB |
| Protection ratio | 18 dB |
| Polarization discrimination | 3 dB. |

## 3. Field strength and protection ratios in the mobile service

Report 358, gives the minimum field strength to be protected as:

$$E_{min} = -41 + d + 20 \log f \qquad \text{dB}(\mu\text{V/m}) \tag{1}$$

where:

$d$ = multipath degradation (dB)
= 10 dB for mobile receiver in motion
= 21 dB for base station receiver (mobile transmitter in motion)
= 0 dB for base station receiver (stationary hand-held portable transmitter)

$f$ = frequency in MHz.

At 860 MHz the minimum field strength and corresponding power flux densities to be protected are:

| | |
|---|---|
| 27.7 dB(μV/m) or −118.1 dB(W/m²) | for mobile receiver in motion |
| 38.7 dB(μV/m) or −107.1 dB(W/m²) | for base station receiver (mobile transmitter in motion) |
| 17.7 dB(μV/m) or −128.1 dB(W/m²) | for base station receiver (stationary hand-held portable transmitter). |

According to Table 1 in Report 358, the RF protection ratio is a function of the modulation parameters and difference in frequency between the desired and interfering carriers. However, the RF protection ratio is bounded by 8 and 17 dB. Taking into account a 3 dB polarization isolation and a conservative value of 17 dB for the RF protection ratio (assumes co-channel interference), the permissible interfering field strength and corresponding power flux-density is:

| | |
|---|---|
| 13.7 dB(μV/m) or −132.1 dB(W/m²) | for mobile receiver in motion |
| 24.7 dB(μV/m) or −121.1 dB(W/m²) | for base station receiver (mobile transmitter in motion) |
| 3.7 dB(μV/m) or −142.1 dB(W/m²) | for base station receiver (stationary hand-held portable transmitter). |

## 4. Characteristics of a cellular public radiotelephone system planned for use in the United States of America

| | | |
|---|---|---|
| Channel spacing | | 30 kHz |
| Receiver bandwidth | | 30 kHz |
| Modulation | (FM voice) | 12 kHz deviation |
| | (FM 10 kbit data) | 8 kHz deviation |
| Transmitting antenna gain | (base station) | 10 dBi (or 7.9 dBd) |
| | (mobile station) | 3 dBi (or 0.9 dBd) |
| e.i.r.p. | (base station) | 20 dBW (erp = 17.9 dB) |
| | (mobile station) | 13.8 dBW (erp = 11.7 dB) |
| Receiving antenna gain | (base station) (60° sector) | 17 dBi (14.9 dB) |
| | (mobile station) | 4.1 dBi (2.0 dB) |
| Typical base station height | | 150 m |
| Receiver sensitivity (12 dB, SINAD) | (base station) | −146 dBW (0.71 μV (e.m.f.)) |
| | (mobile station) | −143 dBW (1.0 μV (e.m.f.)) |

The minimum desired power flux-density may be determined from:

$$\rho = \frac{4\pi P}{\lambda^2 G_r} \qquad \text{W/m}^2$$

where:

$P$: minimum desired signal power (watts)

$\lambda$: wavelength (metres)

$G_r$: receive antenna gain relative to isotropic

Based on the 12 dB SINAD receiver sensitivity, the minimum desired power flux density and corresponding field strength at 860 MHz is:

$-142.9$ dB(W/m$^2$) or 2.9 dB(μV/m) for the base station,

$-127.0$ dB(W/m$^2$) or 18.8 dB(μV/m) for the mobile station.

Taking into account a 3 dB polarization isolation and an assumed 8 dB RF protection ratio, the permissible interfering power flux density and corresponding field strength is:

$-147.9$ dB(W/m$^2$) or $-2.1$ dB(μV/m) for the base station,

$-132.0$ dB(W/m$^2$) or 13.8 dB(μV/m) for the mobile station.

## 5. **Summary**

Values of permissible interfering power flux density and corresponding field strength are summarized in Table I.

TABLE I – *Summary of permissible interfering power flux-density and corresponding field-strengths*

| Interfered with station | Report 631-1 | | Report 358-3 | | Cellular | |
|---|---|---|---|---|---|---|
| | dB (W/m$^2$) | dB (μV/m) | dB (W/m$^2$) | dB (μV/m) | dB (W/m$^2$) | dB (μV/m) |
| Base station | −146.0 | −0.20 | −142.1 | +3.7 | −147.9 | −2.1 |
| Mobile station | −133.0 | +12.8 | −132.1 | +13.7 | −132.0 | +13.8 |

# ANNEX II

## CHARACTERISTICS OF THE PROPOSED LAND MOBILE-SATELLITE SERVICE NEEDED TO EXAMINE SHARING POSSIBILITIES

### 1. General

Services offered by the proposed land mobile-satellite service will include voice and data. In order to reduce experimental and development costs, for an initial system, transmitting and receiving equipments are assumed similar to those planned for the land mobile cellular system described in § 4 of Annex I, with the addition of:

– a low-noise receiving pre-amplifier (4 dB, NF) to provide −152 dBW receiver sensitivity (12 dB, SINAD),*

– a transmitting power amplifier (100 W maximum).

Three earth station types are contemplated:

– mobile, roof-mounted, approximately 0.3 m square to allow mobile operation without antenna tracking for satellite elevations above 25°,

– transportable,** approximately 1 m diameter, pointed toward satellite with ± 8° accuracy,

– base station, approximately 2 m diameter, pointed toward satellite with ± 4° accuracy.

### 2. Earth station characteristics

| | | |
|---|---|---|
| Antenna gain | (mobile) | 3.5 dBi |
| | (transportable) | 16.5 dBi |
| | (base) | 22.5 dBi |
| E.i.r.p. | (mobile) | 17.8 dBW |
| | (transportable) | 17.8 dBW |
| | (base) | 17.8 dBW |
| Antenna discrimination in the horizontal plane (25° minimum elevation angle) | | |
| | (mobile) | 0.6 dB |
| | (transportable) | 12.4 dB |
| | (base) | 22.5 dB |
| Receiver sensitivity (12 dB SINAD) | | −152 dBW |
| Protection ratio | | 8-17 dB |

The minimum required power flux densities at the edge of the service area are determined by:

$$\rho = \frac{C}{N_T} \frac{4\pi \, kTB}{\lambda^2 G_r} \qquad \text{W/m}^2$$

where:

$\frac{C}{N_T}$ : nominal operating received carrier-to-thermal noise ratio (10 dB assumed),

$k$ : Boltzmann's constant (J/K),

$T$ : operating noise temperature (438 K corresponding to 4 dB noise figure),

$B$ : noise bandwidth (28 kHz),

$\lambda$ : wavelength (0.35 metres ≈ 860 MHz),

$G_r$ : receiver antenna gain.

Because of the propagation uncertainties associated with the use of low gain mobile antennas, a margin of 8 dB has been assumed.

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* SINAD is an abbreviation for the ratio between signal-plus-noise-plus-distortion to noise-plus-distortion.

** In this Annex, a transportable station is an earth station in the land mobile-satellite service which may be moved from location to location for temporary use at each location.