LITTLE LEO SATELLITE SYSTEMS

POTENTIAL FOR INTERFERENCE TO EARTH STATION RECEIVERS IN THE BAND 137 - 138 MHz

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1. Abstract

This report is an analysis of the potential for interference from television broadcasting transmitters operating in the band 137 - 144 MHz to earth station receivers of low earth orbiting (LEO) satellite systems in the band 137 - 138 MHz[1]. The report outlines the typical characteristics of these earth station receivers and the television transmitters. The potential for interference is assessed by modelling the television signal as noise in an earth station receiver channel, comparing the received noise level at an earth station with an estimate of the received signal level required from a low earth orbiting satellite, and from that determining resultant separation distances using appropriate propagation models.

2. Little LEO Satellite Systems

In 1992, the ITU World Radio Administrative Conference (WARC) made new allocations reflecting USA and Russian proposals in a number of bands below 1 GHz for the MSS (non-geostationary orbit types), shared with existing allocations to other services. Australia supported these allocations and adopted them through their inclusion in the Australia Radiofrequency Spectrum Plan [1].

The allocations were introduced to support a number of proposals for new LEO satellite systems providing *low cost* global data services such as:

- emergency alerting;
- data acquisition;
- paging;
- tracking and positioning; and
- message transfer.

These systems are often referred to as little LEO satellite systems (in contrast to the above 1 GHz LEO satellite systems which are known as big LEO satellite systems).

The allocations reflecting the USA proposals are of most interest to Australia, due to the expressed desire of companies wishing to provide low cost data services in Australia utilising little LEO satellite systems based on those allocations. The allocations provide

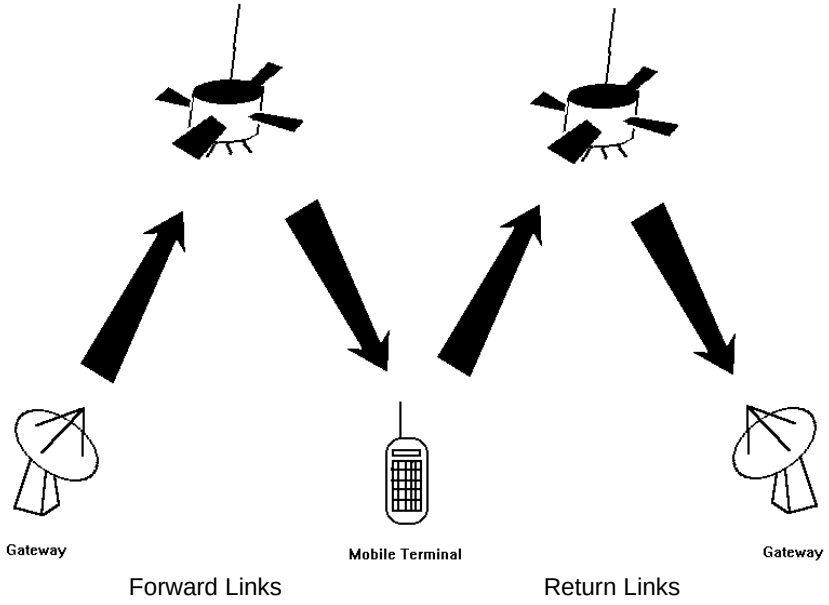
[1] Low earth orbiting (LEO) satellites are satellites with orbiting altitudes in the range of 200 - 2000 km, typically they circle the Earth every few hours.

for use of the bands 137 - 138 MHz and 400.15 - 401 MHz for downlinks, and the band 148 - 150.05 MHz for uplinks. The details of these allocations are at Attachment A.

2.1 Typical Little LEO Satellite Systems and Characteristics

The configuration of a typical little LEO satellite system is shown in Figure 1. This figure shows LEO satellites and two types of earth stations - gateway stations (used by the system operator) and mobile terminals (used by subscribers to the system). As indicated in Figure 1, the communications paths between the various components are divided into forward and return links (sometimes termed outbound and inbound links). Forward links describe the transmission of information from a gateway station to a mobile terminal and return links the transmission of information from a mobile terminal to a gateway station. As little LEO satellites typically circle the earth every few hours a gateway station or mobile terminal will only be visible to a satellite for a relatively small period of time. Consequently, store and forward techniques may need to be used to complete the communications path.

Figure 1: Typical Little LEO Satellite System



Different little LEO satellite systems use different downlink bands for forward and return links. By way of example, the Starsys system uses the 400.15 - 401 MHz downlink band for forward links to its mobile terminals and the 137 - 138 MHz downlink band for return links to its gateway stations, whereas the Orbcomm system uses the 137 - 138 MHz downlink band for both forward links to mobile terminals and return links to gateway stations.

Another difference between little LEO satellite systems is the type of modulation used. Spread spectrum and narrowband schemes are presently being used; sometimes both are used within a single system.

2.2 How Many Systems

The ITU has identified 9 proposed little LEO satellite systems planning to use the WARC 92 allocations, although it also notes that the currently allocated spectrum cannot support all of the proposed systems [2]. The Orbcomm and Starsys little LEO satellite systems appear to be the most advanced of these systems, particularly in terms of providing services in Australia. Indeed, a number of companies have already expressed interest in providing services using these systems in this country. As a consequence, this report, while making some general comments on the technical characteristics of little LEO satellite systems in the band 137 - 138 MHz, is primarily concerned with the analysis of interference potential to Orbcomm and Starsys systems in this band.

2.3 Earth Station Receivers in the Band 137 - 138 MHz

From the available information, there could be four types of little LEO satellite earth station receivers operating in the band 137 - 138 MHz. They are:

- gateway stations for systems with spread spectrum modulation schemes;
- gateway stations for systems with narrowband modulation schemes;
- mobile terminals for systems with spread spectrum modulation schemes; and
- mobile terminals for systems with narrowband modulation schemes.

As neither the Orbcomm or Starsys systems use mobile terminals with spread spectrum modulation schemes in the band 137 - 138 MHz, this type of receiver is not considered further in this analysis. The general characteristics of the remaining types of receivers are discussed below.

2.3.1 Gateway Stations

Gateway stations typically use steerable directional antennas with antenna gains between 15 - 20 dBi. Narrowband and spread spectrum modulation schemes are used with channel bandwidths varying from 50 kHz to 1000 kHz. Both Orbcomm and Starsys gateway stations operate in the 137 - 138 MHz band, and together can be considered representative of the type of gateways stations operating in this band. The parameters for both the Starsys and Orbcomm gateway stations are shown at Attachment A.

2.3.2 Mobile Terminals

Mobile terminals typically use omni-directional antennas with a 0 dBi antenna gain. Typically, narrowband modulation schemes are used with bandwidths varying from 15 - 30 kHz. Orbcomm mobile terminals operate in the 137 - 138 MHz band and can be considered representative of the type of mobile terminals used in this band. Parameters for Orbcomm mobile terminals are shown at Attachment A.

3. Television Broadcasting Transmitters

The band 137 - 144 MHz has been used in Australia for television broadcasting purposes since circa 1950 and is known as TV channel 5A. Currently there are 19 channel 5A television transmitters in operation [3].

All but one of the 19 channel 5A transmitters are located in country areas away from capital cities. The exception is a 50 kW ERP[2] transmitter located near Newcastle that is approximately 110 km north of Sydney. The radiated power of channel 5A transmitters varies from 15 W to 100 kW ERP, and typically antennas with directional patterns are used.

The Australian Broadcasting Authority specifies a field strength of 50 dBuV/m as the level from a channel 5A transmitter at which a minimum level of service is achieved in an area of low ambient noise level (ie, typically rural areas) [4]. The area enclosed by a 50 dBuV/m contour is known as the coverage area. The distance to the outermost edge of this area from a channel 5A transmitter is estimated as varying between 16 km for a channel 5A ERP of 15 W, to 120 km for an ERP of 100 kW. A map showing the location of channel 5A transmitters, maps of coverage areas and a table summarising their technical parameters is at Attachment B.

The broadcasting service allocation in the band 137 - 144 MHz is unique to Australia. No new assignments will be made for channel 5A stations and eventually these broadcasting requirements will be accommodated in other spectrum within ITU regional allocations for the broadcasting service; this objective is embodied in footnotes 207 and AUS26 of the Australian Radiofrequency Spectrum Plan [1].

4. Interference Assessment

The potential for interference from channel 5A television transmitters to little LEO satellite systems' gateway and mobile stations is analysed below.

4.1 Gateway Stations

Gateway stations can be expected to be planned in detail and the locations and emission characteristics of the 19 channel 5A television transmitters taken into account in that planning, in order to ensure that interference does not occur. Consequently they are not considered further in this report.

4.2 Mobile Terminals

Typically, little LEO satellite systems are such that mobile terminals could be used anywhere in Australia. Thus the potential for interference to mobile terminals from channel 5A television transmitters needs to be analysed further.

The interference potential of channel 5A transmitters is analysed by modelling the television 5A signal as noise in the mobile terminal channel and comparing the received noise level with the typical received signal level from a LEO satellite. Such an analysis is contained in Attachment C. The procedure used in the analysis is outlined below.

1. Derive a piecewise linear representation of channel 5A emissions in the band 137 - 138 MHz from a plot of the emissions associated with the vision carrier of a television signal generated from typical program material.

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[2] ERP, effective radiated power, radiated power referenced to a dipole antenna.

2. Compare the piecewise representation with Orbcomm's satellite frequency plan for the band 137 - 138 MHz and identify a sub-band in which the interference potential to mobile terminals can be considered representative of the interference potential to the Orbcomm system as a whole.
3. Using the Hata land mobile propagation model (see Rec ITU-R P.529-1) or broadcasting propagation curves (see Rec ITU-R P.370-7) as appropriate, estimate (for the identified sub-band) distances from channel 5A transmitters at which the received noise level at a mobile terminal from these transmitters *is the same as* the typical received signal level from a LEO satellite.
4. Compare the estimated distances with the coverage area of channel 5A transmitters and draw conclusions.

Using the above procedure leads to the conclusion that Orbcomm mobile terminals are not likely to operate satisfactorily until they are separated from channel 5A transmitters by distances varying from at least 31 km for a channel 5A ERP of 15 W, up to 177 km for an ERP of 100 kW. By way of comparison with channel 5A coverage areas, these distances are 15 to 57 km beyond the outermost 50 dBuV/m contour (see section 3).

It should be noted that the above analysis underestimates the separation distances within which the operation of little LEO terminals is not expected to be possible, because it assumes that terminal operation will not be possible when the received power at a mobile terminal from a channel 5A transmitter is approximately the same as that from a little LEO satellite (ie, -145 dBW). Proprietary data on a proposed satellite to mobile terminal link budget suggests that this is an optimistic premise. The above approach was taken, however, because insufficient information is currently available about the actual performance of a LEO terminal in the presence of PAL-B video sideband energy, that is, the analysis was based on a carrier to noise analysis (with a C/No of 0 dB presumed to be the critical threshold), because the reduction in BER performance of a narrowband little LEO terminal receiver in the presence of line spectra emissions that comprise the channel 5A signal is not yet characterised.

If it is assumed that a further 5 - 20 dB attenuation will need to be achieved (this estimate is deliberately broad, given the lack of relevant information as noted above), then estimates of separation distances vary between 43 to 213 km for an Eb/No of 5 dB, or 100 to 335 km for an Eb/No of 20 dB. For the longer distances in particular, terrain shielding from hills (not part of the Rec ITU-R P.370-7 curves) is likely to assist. To quantify the likely separation distances more accurately, laboratory testing would be required to characterise little LEO terminal BER degradation in the presence of a channel 5A transmission. Field trials are also expected to contribute valuable understanding. To date no equipment has been able to be supplied by little LEO system developers for these purposes.

5. Summary

The interference analysis in this report indicates that narrowband little LEO ground terminals designed for operation in the band 137 - 138 MHz are not likely to operate

satisfactorily until they are outside the coverage areas of the existing 19 channel 5A television transmitters, by distances ranging from 15 to 57 km. Intentionally, the analysis has been done in a way which underestimates likely separation distances, until further work can be undertaken to characterise little LEO terminal BER degradation in the presence of a channel 5A transmissions. This can be done after terminal equipment becomes available.

6. References

1. Australian Radiofrequency Spectrum Plan Including General Information - January 1997, Spectrum Management Agency, January 1997.
2. Preliminary Draft New Recommendation ITU-R M.[8D/XP], Attachment 4 of the Report of the Sixth Meeting of ITU-R Working Party 8D, Geneva, 29 October - 8 November 1996.
3. Radio and Television Broadcasting Stations 1996, Australian Broadcasting Authority, Canberra, January 1996.
4. Technical Planning Parameters and Methods for Terrestrial Broadcasting, Station Planning Branch, Department of Transport and Communications, Canberra, June 1992.