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Envoyé : jeudi 3 octobre 2002 07:10
Joindre : header.htm
Objet : R00-WP8B-C-0283!!MSW-E[1]

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

Delayed contribution
Document 8B/283-E
6 September 2002
English only

Received: 6 September 2002

United States of America

RESPONSE TO THE LIAISON STATEMENT FROM WP-8D CONCERNING SHARING BETWEEN AERONAUTICAL MOBILE TELEMETRY AND GSO MSS SYSTEMS

Introduction

Working Party 8D has requested input, for consideration at its September 2002 meeting, from Working Party 8B concerning the PDNR proposed in connection with WRC-2003 Agenda Item 1.31. Agenda item 1.31 deals with sharing between Aeronautical Mobile Telemetry (AMT) and the GSO Mobile Satellite Service (MSS) in the band 1 518 – 1 525 MHz.

This document notes several concerns with the PDNR, and responds to a request for technical information concerning AMT operations. A companion document submitted to WP 8D outlines additional technical concern. In anticipation of a Joint Experts Meeting between 8B and 8D, the contents of that submission will not be duplicated here.

Concerns with the PDNR

WP8D is being asked to review a new PDNR that includes AMT matters that are not within WP8D's sphere of expertise. Just two years ago, Recommendation ITU-R M.1459 was adopted after several years of detailed study by a different Working Party, W P8B, the expert group on AMT matters. The new PDNR appears to conflict with Recommendation ITU-R M.1459. For example, the PDNR relies upon notions such as dependence on post-mission processing of telemetry data, repositioning of flight test zones, imposition of no-fly zones over sovereign territory of the U.S., duplication of ground site facilities, and reduction of data rates to accommodate the overhead associated with additional error correction processes.

These notions implicate the details of AMT operations and have been presented to WP 8D as being technically viable sharing options. WP 8D has been put in the position of re-defining in a separate recommendation the parameters under which another service within the competence of another Working Party may safely be operated. It must be emphasized that Rec. ITU-R

M.1459 is the current authoritative recommendation on AMT protection criteria to facilitate sharing. The development of a separate ITU-R recommendation that nullifies or weakens the protection criteria in Rec. ITU-R M.1459 is inappropriate.

A meeting of a joint experts group with WP 8B is anticipated for September 2002. The views of the AMT experts from WP 8B will be important to the outcome of those meetings. However, the nature of the PDNR, namely as a substitute or separate Recommendation to be considered, remains unchanged. If any changes are to be made to Rec. ITU-R M.1459, they should appropriately be made by Working Party 8B.

Two other preliminary points should also be made. In general, sharing between MSS systems and flight test downlinks is extremely difficult when the satellite is in view of the flight test ground station, because the ground site antennas for receipt of the downlinked signal are high gain directional antennas. This fundamental difference from MSS systems, with their relatively low gain ground station antennas, provides a serious obstacle to sharing under these circumstances. Thus far, no practical sharing techniques have been shown able to overcome this antenna gain differential between AMT and MSS systems.

In addition, it should be noted that, although one administration in Document 8D/335 (1 May 2002) has indicated a willingness to relax its protection level to –140 dBW/m^2/4kHz, this is only in the sub-band 1 518–1 525 MHz. Operations in this sub-band by this administration support a flight vehicle command and control up-link, and should not be confused with a telemetry data downlink. Note that even with this relaxed protection level, several MSS systems detailed in ITU Recommendation ITU-R M.1184 cannot operate under a co-frequency co-coverage scenario. Indeed, the PDNR articulates the need to relax pfd levels to a value of –125 dBW/m^2/4kHz in order to permit successful MSS operation. With respect to the protection level of –140 dBW/m^2/4kHz cited above, it is noteworthy that this administration is not able to extend this relaxed pfd limit to the portion of their flight test spectrum below 1518 MHz. In other words, like the U.S., this administration's telemetry operations of the downlink variety could not co-exist with MSS transmissions on an interference-free basis.

Information Regarding AMT sites in the United States

Working Party 8D has requested information concerning the layout of typical AMT sites, including any "keep-out" zones, and the plans for current and future operational airspace. Note that there is no such thing as a "typical" layout. Each ground site has unique geometry, and special operational considerations that are functions of this geometry and of the specific measurement requirements of the aircraft under test.

While certain flight test operations are conducted close to flight test ground stations for purposes of characterizing take-offs, landings, and approaches, most testing is performed at extended distances of up to 200 miles from the telemetry receiver. Testing of aircraft in the US is conducted at remote inland sites (Nevada, the California deserts, Washington State, and Montana, to name a few), as well as offshore, over the Atlantic and Pacific Oceans as well as the Gulf of Mexico. Operations are also conducted at bases as far North as Elmendorf Air Force Base in Anchorage, Alaska. A variety of exercises have been conducted in Hawaii and Puerto Rico. The spectrum in question, 1 518–1 525 MHz, is routinely used for flight tests conducted at sea from aircraft carriers. Finally, even though flight tests are typically conducted over sparsely populated areas, flights originate from flight test centers such as Panama City, Florida; Wichita, Kansas; Seattle, Washington; and St. Louis, Missouri.

Flight tests are already conducted subject to numerous "keep-out" zones. This is true, for example, at Atlantic Coast ranges that are not far from metropolitan areas such as Washington, D.C. or Baltimore, Maryland. Flight testing at these ranges is conducted toward the east, over the Ocean. For ranges in the Southwestern United States, flight tests are conducted away from populated areas like Los Angeles. Operational airspace for test ranges is further constrained by the need to avoid commercial air corridors. Thus, relocation of airspace to keep antennas from pointing at the Geostationary arc is not possible.

The PDNR presumes that airspace at flight test ranges is underutilized, and that the flight test community has an abundance of spectrum. However, a typical flight test aircraft has several data buses, each handling several megabits per second of data. A goal of flight test operators is to transmit data at rates of >10 megabits per second from individual aircraft. Since channel capacity is logarithmic in power, but linear in bandwidth, substituting power for bandwidth is not practical, even if this didn't cause interference to operations conducted at adjacent test ranges using the same frequencies.

The PDNR depends critically upon the presumption that ground site antenna diversity is a practical method of dealing with interference to flight test ground stations from MSS satellites. Basically, when one ground site antenna is in bore-sight conjunction with an MSS satellite, a second telemetry receive antenna, at a different location, is brought into service.

However, even with the use of antenna diversity, the methodology described in the PDNR mandates the imposition of keep-out zones. The PDNR uses as an example Andrews Air Force Base in the United States, and notes that as an interference mitigation technique, an MSS-mandated keep-out zone will exist East of the base.

The Patuxent River Naval Air Station, with its telemetry ground station at Wallops Island, Virginia, is at approximately the same latitude as Andrews Air Force Base, but is located on the Atlantic Coast approximately 100 miles away. Essentially all flight test operations managed at Wallops and Patuxent River NAS operate in the proposed keep-out zone. Imposition of the keep-out zone as specified in the PDNR is not possible.

The PDNR suggests that the appropriate response to imposition of such a keep-out zone would be to shift flight test operations in the opposite direction. In the case of Wallops Island, for example, this would move flight test operations into commercial airspace over heavily populated areas, including Washington, D.C., Norfolk, Virginia, and Richmond, Virginia. Furthermore, terrain blockage of telemetry signals would reduce the available airspace well below the minimum required for flight tests of high-speed aircraft.

In the case of flight test ranges elsewhere in the United States, there are multiple ranges that operate simultaneously. These include Edwards Air Force Base, Vandenberg Air Force Base, NASA's Dryden facility, the China Lake and Pt. Mugu Naval Air Stations, and several non-governmental facilities and ranges. This is a partial list of ranges that are just in the State of California, and doesn't include ranges in the neighboring states of Arizona and Nevada. There are also government and commercial ranges in Washington State, Kansas, Missouri, Florida, Alaska, Hawaii, Puerto Rico, and New Jersey, to name a few.

Frequency reuse of the allocated flight test spectrum is accomplished via extensive inter-range coordination, as the available airspace in all directions is used simultaneously. The shifting of airspace to avoid interference from MSS, as stipulated in the PDNR, would have the effect, for example, of moving operations from test ranges in Nevada, such as Nellis Air Force Base, into the airspace of the test ranges in California. However, operational and safety considerations preclude this.

There are other deficiencies as well with the antenna site diversity notion. Flight test operations utilize high gain tracking antennas. Even if the keep-out zones didn't prevent this approach from being unusable, the PDNR does not recognize the difficult problems of acquisition and reacquisition associated with the use of these antennas when telemetry signals are lost due to interference.

For example, the signal to noise ratio needed for signal acquisition by a receiver is several dB higher than that required to maintain carrier lock and bit synchronization. If this signal acquisition margin is included in the analyses in the PDNR, which it is not, the keep-out zones in which aircraft cannot fly due to MSS interference will become much larger. However, there are no technical studies in WP 8B or WP8D that address this problem.

Related to the problems of track and acquisition is the issue of channel fidelity. High

bandwidth telemetry signals, particularly at low elevation angles, are susceptible to problems such as frequency selective fade, multipath, and terrain blockage effects. These effects combine with other phenomena, such as atmospheric and rainfall attenuation, and polarization, to define the properties of the communications channel. In Rec. ITU-R M.1459, experimental data describing the channel properties are presented using a Rayleigh fading model. With regard to the use of site diversity, there are no studies that show how fades in one channel (i.e., the signal path to one of the ground site antennas) correlate with the simultaneous properties of the second channel. Until this is addressed, no conclusions with predictive validity can be derived with regard to the viability of antenna ground site diversity.

The PDNR also suggests the use of post-processing of flight test data. Post-processing is already used extensively in order to cope with the lack of available spectrum. Data selected for real-time telemetry transmission to the ground are a small subset of the total test data accumulated and stored aboard typical test aircraft. Safety-of-life and protection of the aircraft are the considerations that typically determine what data are selected for real-time telemetry transmission during flight.

The PDNR also suggests that error correction can improve link margin, and thus reduce the susceptibility of AMT operations to interference from MSS systems. However, to achieve the 5.6 dB improvement in link performance associated with rate ½ forward error correction, 33% percent of the binary data in the telemetry downlink will need to be devoted to error correcting bits. This reduction in data throughput presumes an excess telemetry channel capacity that, due to existing spectrum shortages, does not exist. Also, the improvement of 5.6 dB is optimistic for the wide-bandwidth channels used by AMT systems, due to phenomena such as frequency selective fading.

In conclusion, Recommendation ITU-R M.1459 is based on the real-world experience of AMT operators obtained over many years under an enormous variety of conditions. Experimental data is used as the basis for defining the parameters and theoretical analyses that comprise the Recommendation. Likewise, the protection levels presented by a second Administration (cf. Document 8D/335) evolved from experimental data and real-world experience. However, the PDNR on sharing between MSS and AMT is purely theoretical, and there is no factual basis under which to assess the validity of ground site antenna diversity as a means of interference mitigation. Without such a factual basis, it is not possible to draw the conclusion that the PDNR presents a successful sharing analysis. Furthermore, the methodology assumes that large segments of the U.S. territory could be rendered unusable for telemetry operations, a premise that is not usually acceptable in an ITU-R Recommendation. If sharing between AMT and MSS is not possible on a co-frequency, co-coverage basis, without infringing on the sovereign right to operate a service in the territory of another Administration, which is clearly the case with AMT operations in the U.S., then this result should be reported to the CPM. Further study of such a methodology would then await the results of a WRC. Consequently, it is premature to consider elevating the status of the PDNR to a DNR, or indeed, maintaining the PDNR at its current status.

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