United States of America

Potential Candidate Bands for
Wideband Aeronautical Mobile Telemetry (AMT)
WRC-07 Agenda Item 1.5

Purpose: This contribution is intended to identify potential candidate bands for wideband aeronautical telemetry, consistent with WRC-07 Agenda Items 1.5, and to develop a consensus within the ITU-R on the technical and operational parameters of incumbent radio services within any such bands. This information will be used to develop technical sharing studies on compatibility between wideband aeronautical mobile telemetry and incumbent radio services in bands identified as potential candidates for regulatory action under Agenda Item 1.5 at WRC-07.

Background: The 2003 World Radiocommunication Conference (WRC-03) adopted Agenda Item 1.5 for the 2007 WRC to address requirements for wideband aeronautical mobile telemetry (AMT) operations. Consideration of spectrum requirements and possible additional spectrum allocations for wideband aeronautical telemetry is guided by Resolution 230 (WRC-03). Resolution 230 calls for sharing studies to be performed to ensure compatible operations between wideband telemetry systems and incumbent users in any bands identified for possible regulatory changes under Agenda Item 1.5.

Further, ITU-R Question 231/8, which is the basis for performing the requested sharing studies, requires that studies determine "…the appropriate frequency bands and in which bands is harmonized worldwide usage possible…" and to determine "…the technical and operational characteristics, or practical arrangements that could be made, to facilitate sharing between wideband aeronautical mobile telemetry and incumbent radio services" in bands identified under this agenda item. Question 231/8 calls for the results of these studies to be included in one or more ITU-R Recommendations.

As work progresses under Agenda Item 1.5 in Working Party 8B, detailed sharing studies will be performed between AMT and incumbent services in any bands that WP 8B agrees are potential candidates for sharing, and these studies will be captured in an ITU-R Report or Recommendation. At this early stage however, there is a need to get agreement on potential candidate bands for aeronautical telemetry usage and on the technical and operational characteristics, or means of gathering this information, of incumbent radio services in any identified candidate bands.

Candidate Band Identification Summary: The initial effort of identifying which bands may be potential candidates for satisfying short-to-near term spectrum requirements focused on bands between 3 and 16 GHz where there was an existing Mobile Service (MS) allocation without a prohibition against aeronautical mobile use, since telemetry is not a radiocommunication service in its own right, but rather one use of the Mobile Service. Bands between 16 and 30 GHz were examined for sharing potential in

anticipation of technology advances that may make these bands useable for telemetry applications in the future. Additionally, other bands which might offer good prospects for introducing a new MS allocation that can be used for telemetry were also considered. Also considered were any incumbent systems of other radio services in the subject bands, the intensity of use of the band by incumbents, and the possibility that coordinated use between aeronautical mobile telemetry and incumbent users might be feasible.

In general, incumbent services with limited geographical deployment, or deployment at fixed locations, may offer the best sharing opportunities. Of course, ultimate selection of a preferred band or bands must also be consistent with band usage by other users.

There are several factors which will facilitate sharing between AMT and incumbent services. These include, for example, the use of low transmit power from an aircraft under test, the limited number of test areas and the general remoteness of these areas, the use of low power airborne transmitters, and the less sensitive nature of the new telemetry operations (e.g., as compared to safety-related operations carried out in the existing telemetry bands). These factors should facilitate the compatible introduction of telemetry operations in the bands identified in this paper.

It is expected that, where incumbent stations are already in operation, some coordination will be necessary to facilitate the introduction of telemetry into bands occupied by operational stations of the incumbent services and that in general the new entrant would have the greater, though not exclusive, burden to mitigate interference caused to, or received from, these stations during such coordination.

As a general matter the ITU Radio Regulations contain rules governing the use of the bands discussed in this paper by incumbent services. For instance, there are permitted levels of power flux-density in Article 21 in the 4500-4800 MHz band for emissions from FSS space stations (reference Table 21.4). These were adopted to protect FS operations in this band. Any telemetry operations introduced into the band by an Administration will have to accept this level of space station emission, or higher values if permitted within an Administration (ref. 21.17), as a condition of implementing telemetry operation in this band if the Administration has authorized FSS services in its territory and if sharing studies prove that the band is otherwise sharable with incumbent operations.

Similarly, the Radio Regulations allow certain transmit levels from stations of the FS and MS and from FSS Earth stations. It is expected that any Administration that wishes to introduce new telemetry operations into bands already occupied by operational terrestrial stations or satellite Earth stations would of necessity also implement appropriate domestic regulatory mechanisms between these services to ensure their compatible operation.

The telemetry operations for any new spectrum identified at WRC-07, particularly in bands below 16 GHz, will be introduced in bands already occupied. For this reason, and as noted above, the new telemetry spectrum will not be used for operations involving test range safety considerations. It is expected that AMT operations implemented in new spectrum will be more interference-tolerant than current telemetry operations in existing telemetry bands.

Of the bands considered, the potential for success in meeting the short to near term spectrum requirements seems greatest in the 4400-4940 MHz and 5925-6700 MHz bands. In addition, the French have proposed the band 5091-5150 MHz for AMT. It must be noted however that besides the incumbent services, the ongoing studies under the auspices of Agenda Item 1.6 must also be taken into account when considering the 5091-5150 MHz band. For longer term requirements, that will take advances in technology to utilize, the bands 22.5-23.6 GHz, 24.75-25.5 GHz, and 27-27.5 GHz appear to offer the best potential for success. Each of these candidate bands is discussed in the following sections.

Allocations and Regulatory Considerations:

4400-4990 MHz: This band is allocated to the MS on a Primary basis and has no prohibition against aeronautical Mobile use except for the bands 4825-4835 and 4950-4990 MHz. Other incumbent services in the band are the Fixed-Satellite Service (FSS) in the 4500-4800 MHz band (satellite use governed by Appendix 30B) on a Primary basis in the space-to-Earth direction, the Fixed Service (FS) on a Primary basis, and the radio astronomy service on a secondary basis in the 4800-4990 MHz band. The bands 4940-4990 and 4825-4835 MHz have a prohibition against aeronautical use and the 4940-4990 MHz band has recently been reallocated in the US from exclusive federal use to public safety communications purposes. Moreover, the 4950-4990 MHz band is allocated to Radio Astronomy service on a Primary basis in Canada, Argentina, and Australia (ref. 5.443). Also, by Footnote 5.339, the 4950-4990 MHz band is allocated on a Secondary basis to the space research (passive) and earth observation satellite services. For these reasons, the 4940-4990 MHz band was not considered an appropriate candidate for further study for wideband telemetry applications and further study is limited to the 4400-4940 MHz band.

5090-5150 MHz: This band is a protected aviation safety service band, allocated on a Primary basis to the Aeronautical Radionavigation Service (ARNS). Additionally, there is a Primary allocation to the Aeronautical Mobile-Satellite (R) Service (AMS(R)S) in the 5000-5150 MHz band (ref. 5.367). There is not an MS allocation in this band and a new MS allocation would be needed to facilitate use for wideband aeronautical telemetry applications. There is a Primary FSS uplink allocation in the 5091-5150 MHz band for Mobile-Satellite Service (MSS) feederlinks that will revert to Secondary status – to the ARNS -- as of 1 January 2018 (ref. 5.444A). This band is also being considered as part of the studies for WRC-07 Agenda Item 1.6 to accommodate new Aeronautical Mobile (Route) Service safety communications. As a result, since the satellite field of view is essentially continental in scope, any sharing studies between AMT and FSS would also likely need to take account of future AM(R)S use.

5925-6700 MHz: This band is allocated to the FSS (Earth-to-space), MS, and FS on a primary basis. There is also a provision, via RR 5.458, for microwave sensor measurements taken over ocean areas in the 6425-7075 MHz bands but this would not appear prohibitive to sharing with potential AMT operations. Coordination of AMT with incumbent operations would be necessary.

22.5-23.6 GHz: This band is allocated internationally on a primary basis to the FS, MS, and, in the 22.55-23.55 GHz band, to the Inter-Satellite Service (ISS) in all three ITU regions. Footnote 5.149 indicates that there are Radio Astronomy Service (RAS) observation conducted in the 23.07-23.12 GHz sub-band; however, there may be an ability to share with RAS sites based on geographical separation. In general, sharing in the aircraft-to-ground direction with the ISS should be less of a problem than sharing in the ground-to-aircraft direction.

24.75-25.5 GHz: The 24.75-25.25 GHz band is allocated internationally on a primary basis only to the FS in Region 1, only to the FSS in Region 2, and to the FSS (uplink), FS, and the Inter-Satellite Service (ISS) in Region 3. In the US, the band 24.75-25.05 is also allocated to the Radionavigation service on a primary basis. The 25.25-25.5 GHz band is allocated internationally on a primary basis to the FS, ISS, and MS in all three ITU regions. Additionally, there is a secondary allocation to the standard frequency and time signal service for satellites in all three regions.

27.0-27.5 GHz: This band is allocated internationally on a primary basis to the FS, ISS, and MS in all three ITU regions. Additionally, there is a primary FSS (uplink) allocation in Regions 2 and 3.

Sharing Considerations: Each of the bands identified above is discussed in this section relative to possible AMT sharing with other co-band services. Once agreement is reached in WP 8B, detailed sharing studies should begin. Coordination with the responsible working parties for the incumbent services should commence as soon as possible. Agreement should be sought with these other working parties and existing users on any relevant technical or operational parameters and sharing criteria that need be considered in conducting more detailed sharing studies with the incumbent services. These studies will be conducted following the April 2005 WP 8B meeting.

The bands discussed above will be studied for possible sharing with aircraft-to-ground telemetry operations. One Administration has proposed also using the band 5091-5150 MHz for higher power ground station-to-aircraft telecommand operations. Such use may strain compatibility with incumbent users (e.g., the FSS).

Technical/Operational Parameters of Aeronautical Mobile Telemetry Systems:

The technical and operational parameters of existing telemetry systems are as specified in ITU-R Recommendation ITU-R M.1459. As a general matter, the characteristics of aeronautical mobile telemetry (AMT) systems that have been considered in the ITU thus far have been relative to protecting these systems from interference by new Broadcasting-Satellite Service (BSS) and MSS satellite systems and not as prospective new entrants into a band. While not safety services as defined in the ITU, these telemetry operations nevertheless have important range-safety considerations which require stringent interference protection. It is expected that new spectrum for telemetry would be used for less sensitive communications that would require less stringent interference protection than communications which is carried out in existing telemetry bands. In this regard, the protection afforded to telemetry operations, once established in any new telemetry bands,

from other incumbent services operating in these bands would be consistent with the protection that these services provide to each other (e.g., between the incumbent services), provided that limitations imposed by aeronautical telemetry stations to the future deployment of stations in the incumbent services are comparable to those encountered today in view of the spectrum sharing among incumbent services. An advanced architecture that is more robust than current telemetry operations should enable new telemetry bands to be more easily shared with incumbent services. It is intended that more robust telemetry operations (e.g., not entailing range safety considerations) would be conducted in any new bands identified at WRC-07 and that less interference-tolerant communications (those currently conducted in current telemetry bands) will be conducted in the existing telemetry spectrum.

Typical AMT systems have very low effective isotropic radiated power (EIRP) from the aircraft…typically 10 Watts fed into a 3 dBi omni-directional antenna. Reception of these signals requires a high-gain tracking antenna on the ground at the test ranges. In fact, without a high gain receiving antenna oriented precisely at the aircraft, the chances of a ground-based antenna from another radio service even detecting the AMT signal, much less receiving interference from same, is minimal. Thus, airborne AMT systems, by their weak-signal nature, do not generally present much of an interference threat to other incumbent services. Additionally, since areas authorized for telemetry operations are usually located in fairly isolated areas for safety and other reasons, and given the limited range at which frequencies above 4500 MHz can propagate between terrestrial stations, it is anticipated that interference that could impact telemetry operations would typically be limited to telemetry receivers and terrestrial transmitters that are within radio line of sight to one another. Due to ground attenuation, for example, the number of stations of other radio services that might be subject to interference, or which could impact telemetry operations, should be quite limited. Retaining the geographic restrictions on the limited number of well-defined areas where telemetry operations are authorized within an Administration will be important to minimizing potential interference to other authorized spectrum users.

Incumbent Services in the 4400-4940 MHz Band: One of the incumbent services in this band is the FSS downlink in the 4500-4800 MHz band, for which a significant amount of information is available via the parameters listed in Appendix 30B and a significant number of ITU-R Recommendations for commercial satellite receivers in this band. It should also be noted that the 4500-4800 MHz band covered by Appendix 30B is, at present, relatively lightly used internationally by the FSS. No safety-of-life services operate in this band.

Typical parameters of the FSS stations as listed in Appendix 30B that will be initially useful include the satellite and Earth station EIRP density and typical receive antenna side-lobe patterns. This information, along with performance characteristics and interference criteria in existing ITU-R recommendations, will provide a solid basis for performing the necessary interference calculations to demonstrate compatibility between AMT and FSS operations between 4500-4800 MHz.

In general, there appear to be several interference mitigation mechanisms available that should allow sharing between telemetry operations and FSS downlinks. Mechanisms

such as keep-out or no-fly zones for telemetry operations that avoid main beam coupling to FSS Earth station antennas, geographical separation of flight test areas, and more robust telemetry networks can be explored such that new telemetry operations are able to co-exist with incumbent FSS operations. These and other possible sharing mechanisms can be explored in the context of the detailed sharing studies that will follow in Working Party 8B, and other affected study groups (e.g., WP 4A).

Other primary services in this band are the MS and FS. This spectrum is designated in the U.S. and some European countries for fixed and mobile communications and is not authorized for the FSS. Typical uses include, but are not limited to, point-to-point microwave, drone vehicle control and telemetry. Of particular interest for sharing consideration is the relatively high transmit power and highly directional line-of-sight microwave and troposcatter stations. Because of these high power systems, sharing of the 4400-4940 MHz band by ubiquitously deployed mobile radio systems seems impractical; on the other hand, sharing between telemetry operations and these systems, if done in a coordinated fashion, would seem feasible. It is thought that the most of this consultation would be on a bilateral basis rather than through formal ITU mechanisms.

Existing ITU-R recommendations, augmented by information obtained via liaison statements between WP 8B and other relevant working parties, will be used to conduct sharing studies with these other Primary services. There has not been a significant body of work performed in the ITU-R regarding technical or operational characteristics associated with the FS or the MS in the 4400-4940 MHz band. It is anticipated that much of the information needed for sharing studies in this band will come from existing uses in countries that have implemented FS or MS systems in this band or from MS and FS characteristics in nearby bands that can be extrapolated to provide a basis for performing sharing studies.

Incumbent Services in the 5091-5150 MHz Band: With the exception of the FSS feederlink Earth stations in the 5091-5150 MHz band, the dominant incumbent service in this band is the microwave landing system (MLS). This band is currently allocated to two safety services, the Aeronautical Radionavigation Service (ARNS) and the Aeronautical Mobile Satellite (Route) Service (AMS(R)S), though there are currently no known AMS(R)S applications for the band.

The MLS allows precise aircraft landings and it represents an improvement over the well-known ILS (Instrument Landing System). The current development of MLS is limited to approximately 150 channels between 5 030 and 5 091 MHz. The band from 5 091 – 5 150 MHz is reserved in the aeronautical world as an extension band for the MLS. The use of this extension band has not been determined. Sharing with MLS may be possible based on power and geometric considerations, on the limited deployment areas of both systems, and due to expected geographical separation.

The band 5091-5150 MHz is also being considered for the implementation of another safety-of-life service, the AM(R)S, under WRC-07 Agenda Item 1.6. Studies would need to be completed to determine compatibility between AMT and this new AM(R)S, however it is expected that geographical separation would enhance such sharing.

Finally, with respect to sharing with FSS systems in this band, account must be taken of the extensive field of view of each satellite. This may require joint sharing studies that account for transmissions from MLS, AMT and AM(R)S.

Incumbent services in the 5925-6700 MHz Band: The 5925-6425 MHz band is used extensively by commercial C-band FSS uplinks worldwide. However, given the FSS uplink receiver is located on a GSO satellite and the low effective radiated signal power of AMT, the potential for interference to FSS satellite receivers from low power telemetry operations should be minimal. Similarly, there does not appear to be significant interference potential to AMT operations from Earth station transmissions. This is due to the expected geographical separation between the two ground stations (AMT and FSS) and the corresponding high levels of attenuation, and the use of high gain directive antennas at both locations so as to eliminate the possibility of any mainbeam-to-mainbeam interaction.

The 5925-6700 MHz band is also used by the terrestrial FS, and this use is extensive in some Administrations (e.g., within the US). While interference to the FS receivers from low power telemetry operations does not appear likely, there is potential for interference from the terrestrial FS transmitters into telemetry receivers unless the operations are coordinated with each other. Information on the operational and technical parameters of incumbent FS operations in this band is readily available in the ITU in the form of numerous ITU-R recommendations.

The ability of telemetry networks to operate in an environment in which incumbent stations already exist (e.g., existing satellite uplinks and terrestrial FS stations) will facilitate compatible introduction of telemetry operations. As noted above, there are several factors that appear to favorably influence the ability of telemetry networks to share with these incumbents users. Among these are geographical separation, more robust telemetry operations, limited terrestrial propagation range, and the use of low power air-to-ground telemetry transmissions that limit the interference level at the satellite receiver. These mechanisms, and their effectiveness, will be the subject of the detailed studies that will be conducted prior to the band being considered suitable for the introduction of new telemetry operations.

This band is also used by the MS in some Administrations. Technical and operational parameters for the MS in this band may be more difficult to obtain from the existing body of ITU-R recommendations but additional information necessary for sharing studies could be obtained and/or confirmed via liaison statements between concerned working parties. No safety-of-life services operate in this band.

Additionally, the 6650-6675.2 MHz band is used for Radio Astronomy observations and any telemetry use of this segment of the 5925-6700 MHz band will need to be compatible with such observations.

Incumbent services in the 22.5-22.55, 22.55-23.55, 23.55-23.6, 24.75-25.5, and 27.0-27.5 GHz Bands: In general the sharing considerations for the FSS uplinks and FS links will mirror those of the lower frequency bands with the added benefit of increased spatial isolation between the stations of the telemetry and incumbent services due to narrower

antenna patterns. Sharing with the Inter-satellite Links (ISL) in the 22.55-23.55 and 27-27.5 GHz bands, since this is only a space-to-space service while telemetry is an airborne-to-ground operation, is not viewed as a sharing scenario that will inhibit either the incumbent or proposed telemetry operations; however, sharing studies will need to confirm that these links and telemetry operations are compatible. Additionally, since the band 22.81-22.86 and 23.07 and 23.12 GHz bands are used for Radio Astronomy operations, sharing studies will need to confirm that telemetry operations are compatible with the RA observations conducted in these bands. No safety-of-life services operate in these bands.

Summary: Each of the candidate bands identified in this document would appear to warrant further study in WP 8B to determine the ability to share the bands between AMT and the incumbent services in these bands. Given the relatively low power of airborne AMT transmissions and the limited number of flight test telemetry operational areas worldwide, it may be possible to share these bands or to coordinate use through a variety of sharing mechanisms that can be explored further in WP 8B. Follow-on efforts should focus on compatibility studies in the ITU-R study groups – taking into account any safety service considerations, and including coordination where needed with studies on other WRC-07 Agenda Items -- and passage of any CPM text and ITU-R recommendations through SG 8. At least one PDNR/DNR is anticipated that would capture the sharing studies between telemetry and incumbent services in identified candidate bands.