DOI 10.5162/ETTC2024/A4.1

Telemetry Spectrum Reallocation Risk Update: An Update on Threats to Telemetry Spectrum

Tim Chalfant[1], Sergio Penna[2]
[1] GMRE, Inc., supporting the U.S. Department of Defense Test Resource Management Center, Arlington, VA, USA,
[2] Instituto Superior de Engenharia do Porto, Porto, Portugal
timothy.chalfant.1.ctr@us.af.mil

Abstract:
A review of spectrum issues that can challenge the future use of radio frequency telemetry. The International Consortium for Telemetry Spectrum (ICTS) will present the status of World Radiocommunications Conference items that address telemetry that were considered at the 2023 World Radiocommunication Conference and may be planned for future World Radiocommunications Conferences. International telemetry vendors, suppliers, and users need to be aware of, and potentially engage with their national administrations on these items.

The ICTS (www.telemetryspectrum.org) was formed in 1999 and is chartered under the sponsorship of the International Foundation for Telemetering (IFT). The IFT (www.telemetry.org) is a non-profit organization dedicated to serving the professional and technical interests of the telemetering community. This paper provides an update to potential spectrum allocation issues for each telemetry band perceived by the ICTS as of interest to the international telemetering community.

Key words: Telemetry spectrum, Frequency spectrum encroachment, Airborne Mobile Telemetry.

Introduction: Higher Demand

Several factors within and outside of the telemetering community have revolutionized demand for electromagnetic spectrum, including spectrum allocated for flight test telemetry. These factors include:

- Commercial radio frequency (RF) spectrum utilization is increasing rapidly, particularly for mobile broadband, and this trend is expected to continue.
- Real-time data and video telemetry is critical to the economic viability of the commercial aeronautical industry.
- Frequency bands used for telemetry have been reallocated for other uses.
- Telemetry data rates are increasing, thereby increasing the RF bandwidth needed for each mission.

Telemetry users are caught between a proverbial rock (telemetry demand is increasing) and a hard place (less spectrum is available for telemetry).

As an example, CTIA (the cellular industry trade association) has filed a chart with the U.S. Federal Communications Commission (FCC) presenting a list of target bands for future cellular use (4G/5G) (Figure 1). Several of these bands are currently allocated for telemetry. While carriers still prefer exclusive licenses, the spectrum is congested, and clearing a band of incumbents to auction those frequencies may no longer be practical. If telemetry bands become targeted for repurposing, telemetry operations could become further cramped and congested whether via band clearing or spectrum sharing.

Globally the bands in Figure 1 – which are critical to Aeronautical Mobile Telemetry (AMT) and associated operations (telemetry command and control and time-space-position information, or TSPI) – are covered by three bands: L-Band, S-Band, and C-Band. These bands reside in an RF spectrum “sweet spot.” This region between 300 MHz and 3 500 MHz is well-suited for mobile communications due to its RF propagation characteristics (penetration of atmospherics, buildings, terrain). This region is ideal for AMT, where the transmission of data over long distances using low-power transmitters on maneuvering test articles, is typical. It is also attractive for cellular operators for many of the same reasons.

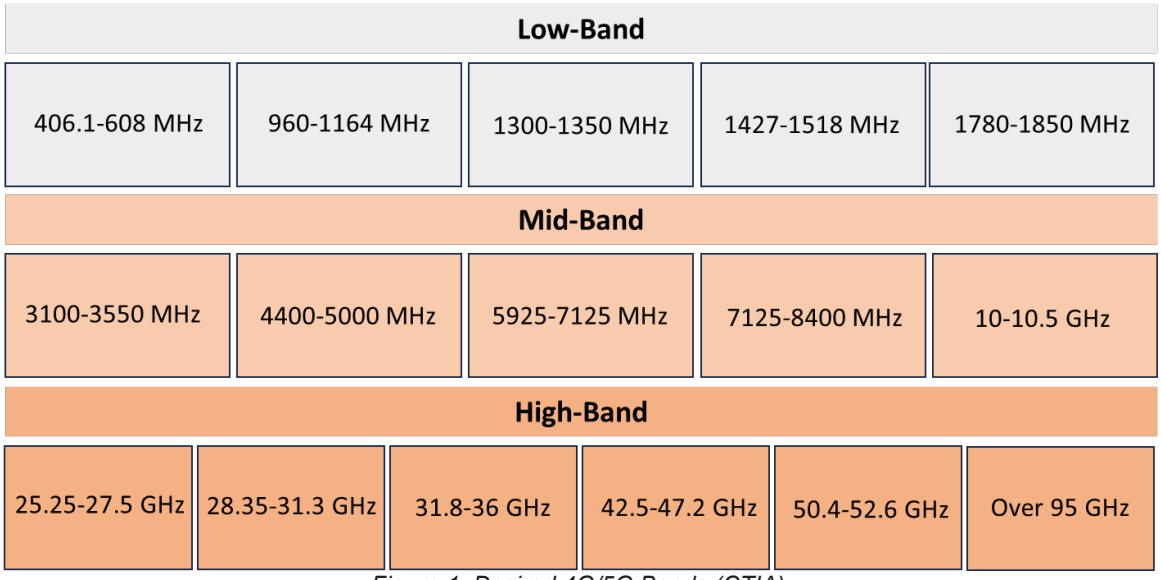

Figure 1. Desired 4G/5G Bands (CTIA)

WRC-23 Results

The International Telecommunication Union (ITU), chartered by the United Nations, manages the ITU's Radio Regulations at periodic World Radiocommunications Conferences (WRCs).

The ITU manages this regulation within three regions (Fig 2). The recent World Radiocommunications Conference was just completed in December in Dubai (WRC-23). Several of the AMT-related radio regulations (RR) were amended or modified at this Conference. Many changes were administrative only, some were substantive or critical. A synopsis of WRC-23 AMT-related radio regulation discussions and updates follows.

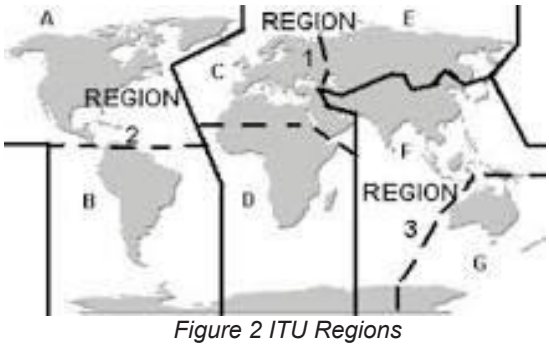

Figure 2 ITU Regions

L-Band

IMT. The appetite for spectrum to support International Mobile Telecommunications (IMT) efforts (IMT-2000, IMT-Advanced and IMT-2020, cell phones, wireless, broadband) is driven by the vision of global mobile access – providing telecommunication services on a worldwide scale regardless of location, network, or terminal used. Much of the ITU focus is on frequency bands below 3 GHz.

There has been a tremendous growth in mobile communications driving an increasing demand for spectrum – already encroaching in some regions on several heavily used AMT bands (1 435-1 535 MHz, 1 710-1 885 MHz, 2 300-2 400 MHz. 4 400-4 800 MHz, 5 091-5 250 MHz…). As a result, one administration added themselves to the use of 1 452-1 492 MHz for IMT, a critical AMT band in the United States and other areas. The following regulation was discussed at WRC-23:

*- RR 5.346 In Algeria, Angola, Saudi Arabia, Bahrain, Benin, Botswana, Burkina Fao, Burundi, Cameroon, Central African Republic, Congo (Rep. of the), Côte d'Ivoire, Djibouti, Egypt, United Arab Emirates, Eswatini, Gabon, Gambia, Ghana, Guinea, Iraq, Jordan, Kenya, Kuwait, Lesotho, Lebanon, Liberia, Madagascar, Malawi, Mali, Morocco, Mauritius, Mauritania, Mozambique, Namibia, Niger, Nigeria, Oman, Uganda, Palestine**, Qatar, Dem. Rep. of the Congo, Rwanda, Senegal, Seychelles, Somalia, Sudan, South Sudan, South Africa, Tanzania, Chad, Togo, Tunisia, Zambia, and Zimbabwe, the frequency band 1 452-1 492 MHz is identified for use by administrations listed above wishing to implement International Mobile Telecommunications (IMT) in accordance with Resolution 223. (Rev.WRC-19/23).*

This regulation was revised at WRC-23 to modify the affected countries (Somalia was added). Asterisks were added to Palestine to note the

use by Palestine of the allocation to the mobile service.

S-Band

Upper S-Band. The WRC approved revision of RR 5.394 to increase the affected telemetry band from 2 360-2 390 MHz to 2 360-2 395 MHz.

- RR 5.394 In the United States, the use of the frequency band 2 360-2 395 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile services. In Canada, the use of the frequency band 2 360-2 400 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile services. (WRC-23)

S-S Links. WRC-23, noting that there is growing interest for utilizing space-to-space satellite links for a variety of applications, adopted the following agenda item 1.11 for WRC-27:

… to consider the technical and operational issues, and regulatory provisions, for space-to-space links among non-geostationary and geostationary satellites in the frequency bands 1 518-1 544 MHz, 1 545-1 559 MHz, 1 610-1 645.5 MHz, 1 646.5-1 660 MHz, 1 670-1 675 MHz and 2 483.5-2 500 MHz allocated to the mobile-satellite service, in accordance with Resolution 249. (Rev.WRC-23)

The accompanying Resolution 249 provides:

- RESOLUTION 249 (Rev.WRC-23) Study of technical and operational issues and regulatory provisions for space-to-space transmissions in the frequency bands 1 518-1 544 MHz, 1 545-1 559 MHz,1 610-1 645.5 MHz, 1 646.5-1 660 MHz, 1 670-1 675 MHz and 2 483.5-2 500 MHz.

This resolution notes that in Region 2 the frequency band 1 435-1 525 MHz is used by the aeronautical mobile service for telemetry in the United States. It seeks studies of the technical and operational characteristics of different types of non-geosynchronous-orbit (non-GSO) space stations that operate space-to-space links with non-GSO systems or GSO networks for space-to-Earth direction in the frequency bands 1 518-1 525 MHz, among others.

This new agenda item for a WRC-27 decision could affect AMT operators in the United States and other administrations. This would also include the space-to-Earth direction in the frequency band 1 518-1 544 MHz.

Supplemental Space Coverage. The Conference also discussed possible allocations to enable supplemental coverage from space (SCS) via direct connection with IMT terminals. WRC-23 noted the growth in demand for mobile-satellite systems (MSS) is making it difficult to sustain MSS services on a long-term basis in the existing bands. Believing that new allocations to the MSS would be consistent with the International Telecommunication Union's objective of promoting access to telecommunication services, particularly in remote and rural areas, it adopted the following WRC-27 agenda item 1.13:

…to consider studies on possible new allocations to the mobile-satellite service for direct connectivity between space stations and International Mobile Telecommunications (IMT) user equipment to complement terrestrial IMT network coverage, in accordance with Resolution COM6/9. (WRC-23)

The agenda item and accompanying Resolution COM6/9 (WRC-23) provide that the studies will deal with the frequency range between 694/698 MHz and 2.7 GHz, which includes several AMT bands.

C-Band

Protection from IMT. WRC-23 Agenda Item 1.1 The upper portion of the 4 GHz band, namely 4 800-4 990 MHz, is identified for IMT in numerous countries (including China, South Africa, Russia, Nigeria, Gambia, Uruguay, and Iran). WRC-23 agenda item 1.1 called for studies to consider measures to protect stations of the aeronautical and maritime mobile services located in international airspace and waters from IMT operations in the 4 800-4 940 MHz band. France, the United States, Canada and other administrations sought to protect Aeronautical Mobile Service systems (AMS; note AMT is included in AMS) and Maritime Mobile Service (MMS) systems. Russia, supported by China, Iran, and others, sought changes that would weaken existing protection for AMS/MMS in international airspace and waters.

5.441B In Angola, Argentina, Armenia, Azerbaijan, Benin, Botswana, Brazil, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Chile, China, Colombia, Congo (Rep. of the), Côte d'Ivoire, Djibouti, Eswatini, Russian Federation, Gabon, Ghana, Guinea, Iran (Islamic Republic of), Iraq, Kazakhstan, Lao P.D.R., Lesotho, Liberia, Madagascar, Malawi, Mali, Mongolia, Namibia, Niger, Uganda, Uzbekistan, the Dem. Rep. of the Congo, Kyrgyzstan, the Dem. People's Rep. of Korea, South Sudan, South Africa, Chad, Togo, Viet Nam, Zambia and Zimbabwe, the frequency band 4 800-4 990 MHz, or portions thereof, is identified for use by administrations wishing to implement International Mobile

Telecommunications (IMT). This identification does not preclude the use of this frequency band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. The use of IMT stations is subject to agreement obtained under No. 9.21 with concerned administrations, and IMT stations shall not claim protection from stations of other applications of the mobile service. In addition, before an administration brings into use an IMT station in the mobile service, it shall ensure that the power flux-density (pfd) produced by this station does not exceed −155 dB (W/(m2 · 1 MHz)) produced up to 19 km above sea level at 20 km from the coast, defined as the low-water mark, as officially recognized by the coastal State. Resolution 223 (Rev.WRC-23) applies. (WRC-23)

WRC-23 made no change (i.e., no relaxation) to the power flux density protection level for aeronautical mobile systems (which includes AMT as noted above) in the relevant ITU Radio Regulations. At the Conference, Mexico stated its intention to deploy IMT in 4 800-4 990 MHz, which could lead to potential AMT interference. Telemetry operators in this region should pay close attention to bi-lateral negotiations for protection of these operations. The Conference did not remove the part of Resolution 223 exempting administrations (including Russia and China) from that protection.

Wireless Access Systems. WRC-23 also addressed the need for additional wireless access systems (WAS), including radio local area networks (RLANs) and the need to protect existing primary services in these bands (5 150-5 350 MHz and 5 470-5 725 MHz). There is concern that this expansion could interfere with AMT operations in 5 150- 5 250 MHz in Region 1 (and other administrations).

- RESOLUTION 229 (REV.WRC-23) Use of the frequency bands 5 150-5 250 MHz, 5 250-5 350 MHz and 5 470-5 725 MHz by the mobile service for the implementation of wireless access systems including radio local area networks

This resolution was revised at WRC-23 to enable additional WAS and RLANS in this band. This resolution notes that this band is also allocated to AMT (see RR 5.446C) and notes the need to protect the existing primary services in the bands. It also specifies emission limits for WAS and RLANS implementations. As 5 150- 5 250 MHz is widely used in Region 1 including Europe and several other administrations for AMT, this is a watch item for telemetry users in this band.

IMT Implementation. WRC-23 approved WRC-27 Agenda item 1.7 to consider the use of the frequency bands 4 400-4 800 MHz, for IMT.

…to consider studies on sharing and compatibility and develop technical conditions for the use of International Mobile Telecommunications (IMT) in the frequency bands 4 400-4 800 MHz, 7 125-8 400 MHz (or parts thereof), and 14.8-15.35 GHz taking into account existing primary services operating in these, and adjacent, frequency bands, in accordance with Resolution COM 6/26 (WRC-23)

It also adopted a resolution on IMT that could affect the 4 400- 4 940 MHz band used for AMT. The resolution discusses the necessary studies for the use of International Mobile Telecommunications (IMT) in several bands, including 4 400-4 800 MHz (Region 1 and 3 only), to implement IMT. The resolution references relevant protective information relating to previous sharing studies including ITU-R M.2116 (but not M.1459).

- RESOLUTION COM 6/26 (WRC-23) Sharing and compatibility studies and development of technical conditions for the use of International Mobile Telecommunications (IMT) in the frequency bands 4 400-4 800 MHz, 7 125-8 400 MHz (or parts thereof), and 14.8-15.35 GHz for the terrestrial component of IMT

Use of 4 400-4 800 MHz for telemetry in Region 1 and 3 (and other administration) can be at risk. The Region 2 allocation for AMT in this band appears unaffected.

RNSS Spectrum. WRC-23 adopted a preliminary agenda item for WRC-31 as follows:

…to consider possible allocations to the radionavigation-satellite service (space-to-Earth) in the frequency bands [5 030-5 150 MHz and 5 150-5 250 MHz] or parts thereof, in accordance with Resolution COM6/19 (WRC-23)

The accompanying resolution, presented by the European Conference of Post and Telecoms (CEPT) per a proposal initiated by the European Space Agency (ESA), was adopted for studies of the proposed new allocation:

- RESOLUTION COM 6/19 (WRC-23) Studies on possible new allocations to the radionavigation-satellite service (space-to-Earth) in the frequency bands [5 030-5 150 MHz and 5 150-5 250 MHz] or parts thereof

Parts of these bands are currently used by AMT (5 091-5 150 MHz globally and 5150-5250 in Region 1 (and others). This resolution, in support of the ESA's R&D activities on the European Global Navigation Satellite System (EGNSS) and Positioning, Navigation and Timing in Low Earth Orbit (LEO-PNT), asks for new frequency bands and allocations suitable for very wide band PNT signals. Clearly, these new services could be exploited by all other RNSS users, including aeronautical transportation systems. It is felt that these potential new signals cannot be supported in the existing allocations.

ITU-R Studies on sharing and compatibility between RNSS and the incumbent services may be considered at WRC-27 with the result depending on confirmation of the preliminary agenda item for WRC-31.

Domestic Issues

While ITU regulations are determined at the WRC, each administration (country) has national regulations in place apart from the ITU regulations. This section addresses a few spectrum regulatory issues of particular note for each band used for AMT in specific administrations as reported to the ICTS.

L-Band

Cellular Interference (U.S.). While the band is currently not perceived as threatened, it is on several target lists due to its proximity to other low-band spectrum. While 1 300-1 350 MHz is being considered for repurposing, the National Telecommunications and Information Administration (NTIA) noted that this would also apply to equipment certification requests for all stages in 1 240-1 390 MHz; in other words, repurposing will impact usage in the entire band, not just 1 300-1 350 MHz.

There is a concern that TSPI data links (Advanced Range Data System (ARDS), Common Range Integrated Instrumentation System (CRIIS), 1 350-1 390 MHz) may be affected by adjacent channel interference from cellular operation below 1 350 MHz. This is a watch item for test and training ranges that rely on GPS-based TSPI instrumentation as the susceptibility of the TSPI data link operations to Long Term Evolution (LTE) interference is unknown as this time. Efforts to access this susceptibility, and necessary protection criteria, are needed to analyze this threat.

IMT (Region 2). The International Telecommunication Union (ITU) Radio Regulations give AMT priority over IMT in 1 435-1 535 MHz in Region 2 (North and South America). RR 5.343. It remains high on the list of encroachment concerns for ICTS as it resides in the low band "sweet spot" for RF propagation characteristics for international mobile communications. ITU Recommendations M. 1459 is particularly relevant for AMT protection criteria.

Ligado (U.S.). The upper part of the L-band is home to several global positioning systems (GPS). Along with AMT operations below 1 525 MHz, one of these signals is potentially threatened. L1 (encrypted precision code, coarse acquisition code), at 1 575.42 MHz, could receive interference from a terrestrial data link proposed by Ligado Networks (Reston, VA) in the United States. Despite major pushback from the Department of Defense (DoD) and other federal agencies over GPS interference concerns, the FCC initially granted the Ligado application for a terrestrial Internet of Things (IoT) network. Several agencies and commercial interests filed Petitions for Reconsideration due to concerns about interference to GPS. If this IoT network is implemented, it could have significant impact on GPS-dependent systems (like TSPI). The U.S. Congress has enacted legislation intended to protect DoD spectrum uses against the possibility of Ligado interference.

Ligado has filed a lawsuit alleging "theft" of its L-band spectrum by the U.S. Government, but the Department of Justice has moved to dismiss the Ligado lawsuit. Several groups and companies have indicated their support for the Government's motion.

AWS-3 Auction (U.S.). In 2014, the FCC in the United States started the process of auctioning 65 MHz of spectrum to meet the goals of the National Broadband Plan. This was the last of three auctions required for funding FirstNet, the public safety broadband network, and other services. Previous auction results had raised nearly $1.6 billion of the $7 billion needed. The AWS-3 (Advanced Wireless Services) auction generated $44.9 billion in revenue. As a result, several government users were compensated to vacate the band. AMT operations, previously in the band 1 755-1 780 MHz, were compressed into the remaining spectrum between 1 780 and 1 850 MHz. The ICTS is concerned that commercial interests may not be satisfied with the 65 MHz.

Lower S-Band

Commercial Space Launch (U.S.). In the United States, the FCC is considering potential

allocation of several additional bands for commercial space launch – including 2 360-2 395 MHz. Last year the FCC adopted rules for a new allocation in the 2 025-2 110 MHz band for space operations on a secondary basis, expanded the spectrum available for commercial space operations on a secondary basis in the 2 200-2 290 MHz band from four channels to the entire band, and adopted licensing and technical rules for space launch operations. The Office of Engineering and Technology is to issue a public notice opening a new docket for comments on expanded federal earth station use of non-federal satellite bands. The Aeronautical and Flight Test Radio Coordinating Council, Inc. (AFTRCC) has proposed that it to coordinate non-Federal space launch requests with the DoD area frequency coordinators.

C-Band

Allocation Restrictions (Germany). In a recent decision the German administration decided that new allocations in the future will only be granted in the range 5 091-5 150 MHz, not in the range 5 150-5 250 MHz. No new or temporary allocation on a new test site will get granted in the 5 150-5 250MHZ. Current allocations in the range 5 150-5 250 MHz will remain.

Non-Federal AMT Use (U.S.). In the United States, AFTRCC has submitted a proposal to the FCC for a non-federal AMT allocation in the band 4 400-4 940 MHz with DoD support. AFTRCC would coordinate use of any such allocation, if approved, with DoD area frequency coordinators. This is not considered a “threat” since AFTRCC member companies work hand-in-glove with DoD personnel in the development of new and modified aircraft and missiles for the Department.

RADAR-Alt Interference (U.S.). In the band below 4 400-4 940 MHz, there has been major controversy regarding 5G compatibility in the band 3 700-3 980 MHz, with radar altimeters (R-Alt) operating in the band 4 200-4 400 MHz. A Federal Aviation Administration (FAA) Special Airworthiness Information Bulletin calls on R-Alt vendors and others to provide data on specific R-Alts, and to assess the need for further mitigation. Meanwhile, AT&T and Verizon have agreed to delay deployment of certain 5G operations in 3 700-3 980 MHz.

Future Spectrum Legislation (U.S.). Several proposed bills currently being considered by the U.S. Congress, would require NTIA to study the 4 400-4 490 MHz band for possible future reallocation and auction. This band remains of great interest to cellular and broadband users.

Global AMT Band (All Regions). While 5 091-5 150 MHz is the globally harmonized band allocated for aeronautical telemetry world-wide, its utilization is a domestic issue. Global telemetry users are encouraged to make use of this AMT band. AMT use may need to co-exist with airport ground communications depending on the administration.

Upper C-Band (5 925-6 700 MHz) Unlicensed Wi-Fi (U.S.): In the United States, the FCC concluded 5 925-7 125 MHz could be utilized for unlicensed Wi-Fi and very low-power devices for high data rate applications, such as wearables, augmented-reality, and virtual-reality. The band is also used for point-to-point microwave links; terrestrial microwave operators (mainly public safety and utilities) have unsuccessfully opposed the FCC’s Wi-Fi plans. While the FCC has tabled any AMT assignments/allocations in the band, DoD has studied new spectrum aggregation technologies.

New National Spectrum Strategy (U.S.). The draft Implementation Plan for the National Spectrum Strategy was released in November along with a Presidential Memorandum; a draft Implementation Plan has been developed by NTIA. While data is not telemetered to the ground using the five bands targeted, several “Outcomes” address topics with significant potential to affect telemetry users as the NSS seeks additional spectrum for the study pipeline. Several outcomes talk of the need to develop/field new spectrum management tools, metrics, and utility specifications. U.S. telemetry users will need to be prepared to articulate spectrum utilization and sharing potential.

Articulation of spectrum utilization in telemetry and Flight Test can be difficult. Flight Test use of telemetry is one link in the test and evaluation chain of events that are required to complete a test program. Telemetry is a “late-in-the-cost-chain” asset where a failure (mission cancellation) could cause significant down-chain impact (cost/schedule) in a test program (targets, test environments, test assets, ranges). Capturing and articulating these costs can be very difficult.

Conclusions

Significant encroachment challenges to telemetry spectrum exist both domestically (in the United States) and internationally (ITU/WRC). The encroachment of incompatible services in- band and adjacent to bands used for AMT, can degrade telemetry data and result in test failure, loss of test articles, and even pose hazards to life. Adequate RF spectrum for telemetry operations is critical for flight test and other scientific applications.

The information in this paper is presented so that telemetry practitioners are aware of

developments that could affect the business of telemetry.

Acknowledgment

The International Consortium for Telemetry Spectrum, chartered by the International Foundation for Telemetering, is dedicated to serving the professional and technical interests of those in the telemetering community.

This work was supported by the CISTER Research Unit (UIDP/UIDB/04234/ 2020), financed by National Funds through FCT/MCTES (Portuguese Foundation for Science and Technology), and by project Aero.Next Portugal (ref. C645727867-00000066), funded by the EU/Next Generation, within call nº 02/C05-i01/2022 of the Recovery and Resilience Plan (RRP).

References

[1] CTIA, https://www.ctia.org/the-wireless-industry/wireless-industry

[2] “The Great Radio Spectrum Famine,” Mitchell Lazarus, *Institute of Electrical and Electronics Engineers Spectrum Magazine* (30 Sept. 2010). http://spectrum.ieee.org/telecom/wireless/the-great-radio-spectrum-famine

[3] International Consortium for Telemetry Spectrum (ICTS), www.telemetryspectrum.org

[4] International Foundation for Telemetering (IFT), www.telemetry.org/who-we-are/

[5] Aeronautical and Flight Test Radio Coordinating Council, Inc. (AFTRCC), https://aftrcc.org/

[6] International Telecommunications Union, Radiocommunications Sector, https://www.itu.int/en/ITU-R/Pages/default.aspx

[7] World Radiocommunication Conference 2023 (WRC-23) Provisional Final Acts, ITU Publications, International Telecommunication Union, Radiocommunication Sector