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| **U.S. Radiocommunications Sector****Fact Sheet** |
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| **Purpose/Objective:** This is a Fact Sheet for the development of technical characteristics for modernization of high-frequency spectrum use in the aeronautical mobile (OR) service and sharing and compatibility studies in support of Agenda Item 1.9. The studies will include a comparison between measured 3, 6, 12, 24, 48 kHz channel bandwidth emissions and emission masks that are currently supported within Appendix 26. Interference and compatibility analysis will focus on the impact that wide channel bandwidths could have on incumbent services within the band. |
| **Abstract****:** This Report will present the results of WBHF interference and compatibility studies within the 2.8 to 18.05 MHZ Frequency Band. It will be segmented into sub-bands associated with the following services: AM(R)S, AM(OR)S, Fixed/Mobile, Fixed Broadcasting, AMS Broadcasting, Amateur Fixed, Land Mobile Broadcasting, Mobile, Maritime Mobile and Standard Frequency and Time and will include technical characteristics for modernization of high-frequency spectrum use in the aeronautical mobile (OR) service. |

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| SUPPORTING MATERIAL for WRC-27 AGENDA ITEM 1.9  |
| **Working Document towards a Preliminary Draft Report M.[Modernization of HF AM(OR)S]** |

**Introduction**

Agenda Item 1.9 calls for the review of and the consideration of appropriate regulatory actions and updates to Appendix 26 of the Radio Regulations based on ITU-R studies to accommodate digital technologies for commercial aviation safety-of-life applications in existing 2.8 to 18.05 MHz HF frequency bands allocated to the aeronautical mobile (R) service while ensuring the coexistence of modernized HF systems alongside incumbent systems.

The United States propose that the ITU-R Working Party (WP) 5B consider the Supporting Material “Elements and technical characteristics for modernization of high-frequency spectrum use in the aeronautical mobile (OR) service”

**Attachment:** 1

**ATTACHMENT**

**SUPPORTING MATERIAL FOR WRC-27 AGENDA ITEM 1.9**

**Working Document towards a Preliminary Draft Report M.[Modernization of HF AM(OR)S]**

**Scope**

This Report will provide technical characteristics for modernization of high-frequency spectrum use in the aeronautical mobile (OR) service and will include the results of Wide Band High Frequency (WBHF) bandwidth utilization and interference and compatibility studies within the 2.8 to 18.05 MHZ Frequency Band. It will be segmented into sub-bands associated with the following services: AM(R)S, AM(OR)S, Fixed/Mobile, Fixed Broadcasting, AMS Broadcasting, Amateur Fixed, Land Mobile Broadcasting, Mobile, Maritime Mobile and Standard Frequency and Time. The studies will include a comparison between measured 3, 6, 12, 24, 48 kHz channel bandwidth emissions and emission masks that are currently supported within Appendix 26 Interference and compatibility analysis will focus on the impact that wide channel bandwidths could have on incumbent services within the band as a function of the emission spectrum.

**Keywords**

Skywave: The propagation of radio waves reflected or refracted back toward Earth from the ionosphere

Groundwave: Radio waves propagating parallel to and adjacent to the surface of the Earth, following the curvature of the Earth

Abbreviations/Glossary

ADS-C: Automatic Dependent Surveillance - Contract

AOC: Air Operator Certificate

CPDLC: Control Pilot Data Link Communications

e.i.r.p.: Effective Isotropic Radiated Power

FSK: Frequency Shift Keying

HF: High Frequency

HFDL: High Frequency Data Link

NVIS: Near vertical incidence skywave

OFDM: Orthogonal Frequency Division Multiplexing

PSK: Phase Shift Keying

QAM: Quadrature Amplitude Modulation

RF: Radio Frequency

VHF: Very High Frequency

WBHF: Wide Band High Frequency

**Related ITU Recommendations and Reports**

Recommendation ITU-R BS.80-– Transmitting antennas in HF broadcasting

Recommendation ITU-R BS.705 – HF transmitting and receiving antennas characteristics and diagrams

Recommendation ITU-R F.240 – Signal-to-interference protection ratios for various classes of emission in the fixed service below about 30 MHz

Recommendation ITU-R F.1610 – Planning, design and implementation of HF fixed service radio systems

Recommendation ITU-R F.1611 – Prediction methods for adaptive HF system planning and operation

Recommendation ITU-R F.1761 – Characteristics of HF fixed radiocommunication systems

Recommendation ITU-R F.1762 – Characteristics of enhanced applications for high frequency (HF) radiocommunication systems

Recommendation ITU-R F.1778 – Channel access requirements for HF adaptive systems in the fixed and land mobile services

Recommendation ITU-R F.1821 – Characteristics of advanced digital high frequency (HF) radiocommunication systems

Recommendation ITU-R SM.326 - Determination and measurement of the power of amplitude-modulated radio transmitters

Recommendation ITU-R SM.339 - Bandwidths, signal-to-noise ratios and fading allowances in complete systems

Report ITU-R BS.458 – Characteristics of systems in LF, MF and HF broadcasting

Report ITU-R F.2061 – HF fixed radiocommunications systems

Report ITU-R F-2062 – Enhanced high frequency digital radiocommunication systems capable of providing enhanced applications

Report ITU-R F.2087 – Requirements for high frequency (HF) radiocommunication systems in the fixed service

Report ITU-R F.2484 – Cooperative frequency competition model and the corresponding algorithms

**Annex 1**

**Elements and technical characteristics for modernization of high-frequency spectrum use in the aeronautical mobile (OR) service**

**1 Introduction**

HF Radio communications has been the primary long-range communication system for safe, efficient air travel over long range routes beyond the range of ground-based VHF radios, next generation WBHF technologies can accommodate digital technologies for commercial aviation safety-of-life applications in existing HF bands allocated to the aeronautical mobile (R) service and ensure coexistence of current HF systems alongside modernized HF systems. A next generation WBHF radio system can address the limitations of today’s HF radio communications systems. To support such a system, Appendix 26 of the ITU Radio Regulations (RR) will need to be modified to accommodate technical and regulatory elements to permit an overlay of WBHF channels on the current Appendix 26 allotment plan.

This report addresses the elements and technical characteristics for modernization of high-frequency spectrum use in the aeronautical mobile (OR) service that will be needed to meet the objectives of WRC-23 Agenda Item 1.9 (AI 1.9).[[1]](#footnote-1) without altering the current allocations.

**2 Relevant allocation information from Appendix 26and adjacent frequency bands, as appropriate**

[TBD]

**3 General description of high frequency usage of aeronautical mobile (OR) service[[2]](#footnote-2)**

The aeronautical mobile service is a mobile service between aeronautical stations and aircraft stations, or between aircraft stations, in which survival craft stations may participate; emergency position-indicating radio-beacon stations may also participate in this service on designated distress and emergency frequencies.

The objective of this service is to provide communications between a pilot and a controller within a given sector. The controller must be able to communicate with all aircraft inside the sector using only one radio channels (each sector has a unique frequency assigned). The number and dimension of the sectors condition the location of the communication centres and the frequency assigned to each sector establishes a double direction pilot-controller; controller-pilot channel which is the fundamental instrument in the functions of information, surveillance, and control of aircraft in flight.

The categories of messages handled by the aeronautical mobile service and the order of priority in the establishment of communications and the transmission of messages shall be as follows:

* Distress calls, distress messages, and distress traffic (emergency messages).
* Urgency messages.
* Communications relating to direction finding (to modify the course).
* Flight safety messages (movement and control).
* Meteorological messages (meteorological information).
* Flight regularity messages.
* There are two types of aircraft-controller communications:
	+ Controller-pilot voice communications.
	+ Controller-pilot data-link communications (CPDLC).

From a HF perspective, voice communications are provided using radio channels in the HF and VHF frequency bands. The channels in HF are only used for long-distance communications, when it is impossible to establish communication using VHF. HF radio communications utilize practically the whole HF spectrum (3MHz to 30MHz), depending on times of the day, seasonal variations, solar activity, etc.

Considering the operational usage, WBHF will be operated in similar locations and in the same manner as the existing HFDL system. HF is typically used in areas that lack VHF coverage, such as Oceanic and Remote areas.

**4 Technical characteristics [[3]](#footnote-3)**

**4.1 Technical and operational characteristics of WBHF services and systems operating in Appendix 26 bands**

The WBHF system will utilize the existing 2.8 to 18.05 MHz AM(OR)S HF aeronautical frequency bands, so no additional spectrum will need to be allocated, and new modulation waveforms will fall under the same J2D emission designator as legacy HFDL. Since the WBHF signal will also comply with the legacy HFDL spectral mask regarding adjacent channel power (see figures below), it will coexist with legacy HF voice and HFDL, as well as existing adjacent band services in the HF spectrum. Tables 1,2 and 3 provide typical technical characteristics of a WBHF system.

Table 1 – Typical WBHF Technical Characteristics

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Ground Station | Aircraft Station | Units |
| Channel Bandwidths | 3,6,9,12,15,18,21,24,27,30,33,36,39,42,45,48 | 3,6,9,12,15,18,21,24,27,30,33,36,39,42,45,48 | kHz |
| Emission Type | SSB | SSB |  |
| Duplex Type | Half-Duplex, Full Duplex, and Broadcast | Half-Duplex, and Broadcast |  |
| Waveform Type | Walsh, BPSK, QPSK, 8PSK, 16QAM,32 QAM, 64QAM, 256 QAM  | Walsh, BPSK, QPSK, 8PSK, 16QAM,32 QAM, 64QAM, 256 QAM |  |
| Power Spectral Density | 6 kW/3 kHz | 400 W/3 KHz |  |
| HF Propagation | Skywave | Skywave |  |

Table 2 -Characteristics of advanced digital HF radiocommunication systems (ISB and Contiguous channels Systems)

|  |  |
| --- | --- |
| Parameter | Propagation mode |
| Ground wave | Sky wave |
| NVIS | Oblique incidence |
| Frequency band (MHz) range | 2-10 | 2-10 | 3-30 |
| Approximate service area | Up to 80 km | Between 80 and 200 km | Greater than 200 km |
| Antenna polarization | Vertical | Horizontal | Vertical/horizontal |
| Transmitting antenna gain (dBi) | 1-3 | 1-6 | 6-15 |
| Maximum e.i.r.p. (dBW) | 1-29 | 10-32 | 16-55 |
| *S*/*N* (dB)1 | SSB 17DRM 18 | SSB 25DRM 26 | SSB 26DRM 26 |
| Necessary bandwidths and types of emission  | SSB/ISB: 3, 6, 9, 12 kHz, 18, 24, and 48 kHz3K00J2D, 6K00J2D, 9K00J2D 12K0J2D, 18K0J2D, 24K0J2D and 48K0J2D |
| DRM: 3, 4.5, 5, 9, 10 and 20 kHz3K00J2D, 4K50J2D, 5K00J2D, 9K0J2D, 10K0J2D, 20K0J2D |
| *Note:  More detailed information on required S/Ns can be found in Recommendation ITU-R F.339.**Note:  For emission type the last letter (D) refers to data transmissions. If emission is not data (D), substitute (E) for voice, (C) for facsimile, (W) combination or (X) for cases not otherwise covered.*Table 3 -Characteristics of advanced digital HF radiocommunication systems (non-contiguous multichannel systems)

|  |  |
| --- | --- |
| Parameter | Propagation mode |
| Ground wave | Sky wave |
| NVIS | Oblique incidence |
| Frequency band (MHz) | 2-12 (TBC) | 2-12 (TBC) | 3-30 (TBC) |
| Approximate service area | Up to 80 km (ground)Up to 200 NM (sea) | Up to 300 km | Greater than 300 km |
| Antenna polarization | Vertical | Vertical/horizontal | Vertical/horizontal |
| Transmitting antenna gain (dBi) | 1-3 | 1-6 | 1-15 |
| *S*/*N* per channel (dB)1 | 17 | 25 | 25 |
| Necessary bandwidth and  | SSB: 3 kHz  |
| Type of modulation per channel | 3K00J2D |
| Sensitivity for 10 dB SINAD in 3 kHz (dBm) | -111 |
| Receiver IF filter bandwidth (kHz) | > 200 kHz |
| *Note: 1 second interleave, 16 channels.**Note: For emission type the last letter (D) refers to data transmissions. If emission is not data (D), substitute (E) for voice, (C) for facsimile, (W) combination or (X) for cases not otherwise covered.* |

 |

* 1. **Technical and operational characteristics of services and systems operating in Appendix 26 bands and in adjacent frequency bands, as appropriate**

[TBD]

**4.3 Protection Criteria Considerations**

Appendix 26 rules are based on 3 kHz channels where channels are assigned, and a spectral mask defined by the carrier frequency and/or the assigned frequency such that the spectrum emission limits are specified for the assigned and first, second and third adjacent 3 kHz bandwidth channels. To accommodate WBHF, Appendix 26 will need to allow for a spectral mask definition to accommodate multiple contiguous channels configured as a single wideband channel, defined around the center frequency and bandwidth of the wideband channel Wideband HF will meet the same spectrum emission limits with respect to adjacent channels as the existing 3 kHz allotments, which will ease compatibility analysis.

The proposed protection criteria would not change and would be equivalent to 15 dB Desired-to-Undesired (D/U) ratio per 3 kHz channel for Data on Data, Data on Voice, and Voice on Data. Considering wideband channels, the protection ratio would be 15 dB D/U per 3 kHz

The proposed power spectral density (W/kHz) would not exceed the existing HFDL and HF Voice frequencies authorized in Appendix 26[[4]](#footnote-4). This would be 6 kW/3kHz for the Aeronautical Station and 400 W/3 kHz for the Aircraft station. When a larger bandwidth is used, the total peak envelope power may increase, but the power spectral density would not exceed the current levels seen in each 3 kHz bandwidth.

**4.4 Propagation Models for sharing and compatibility studies for AM(OR)S and Services in adjacent bands**

[TBD]

**5 Sharing and Compatibility Studies**

[TBD]

**5.1 Incumbent Services**

*Editor’s Note: List incumbent services and protection criteria*

**5.2 Methodology**

[TBD]

*Editor’s Note: Detail analysis methodology with examples*

**5.3 Emission Spectrum Mask**

[TBD]

*Editor’s Note: Include emission spectrum masks for contiguous and non-contiguous channel aggregation*

**5.4 Emission Spectrum**

*Editor’s Note: The intention here is to include a tabular version of the emission spectrum for each of the channel bandwidths*

**5.4.1.1 3 kHz Channel Bandwidth**

[TBD]

**5.4.1.2 6 kHz Channel Bandwidth**

[TBD]

**5.4.1.3 12 kHz Channel Bandwidth**

[TBD]

**5.4.1.4 24 kHz Channel Bandwidth**

[TBD]

**5.4.1.5 48 kHz Channel Bandwidth**

[TBD}

**5.5 Comparative Emission Analysis**

[TBD]

*Editor’s Note: The intention here is to add a table that compares the tabular version of the emission spectrum for each of the channel bandwidths to the emission masks.*

**5.6 Interference and Compatibility Assessment**

[TBD]

*Editor’s Note: The intention here is to include a discussion that focuses on the mechanisms can implemented to avoid and or mitigate interference to incumbent services operating within or adjacent to both contiguous and non-contiguous WBHF channels and provide supporting analysis and/or measurement data.*

**6 Regulatory Analysis to Modernize Appendix 26**

[TBD]

*Editor’s note: The intention here is to identify proposed modifications that would facilitate modernization of Appendix 26.*

**7 Summary on the technical and regulatory Studies**

*Editor’s Note: The intention here is to summarize the results from section 6.5 and 6.6 along with the results of any other studies that may have been conducted***.**

[TBD]

1. The objective of AI 1.9 is to review Appendix 26 of the Radio Regulations and consider appropriate regulatory actions and updates based on ITU-R studies in accordance with Resolution 429 (WRC-19.) [↑](#footnote-ref-1)
2. As defined by ICAO Standards documents in Annex 10 Vol II: [↑](#footnote-ref-2)
3. FREQUENCY SPECTRUM MANAGEMENT PANEL (FSMP), Tenth Working Group Meeting, Montréal, Canada, 17-26 August 2020, TECHNICAL CONSIDERATIONS FOR THE WIDEBAND HF OVERLAY CONCEPT FOR AGENDA ITEM 1.9 WRC-23 [↑](#footnote-ref-3)
4. [↑](#footnote-ref-4)