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| **Radiocommunication Study Groups** |  |
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WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT
NEW REPORT ITU-R M.[HF-SPECTRAL OCCUPANCY]

Spectral occupancy of fixed and mobile allocations
within the band 5 250-5 450 kHz

*[Editor’s Note: This document is carried forward for information and future consideration. The workplan for agenda item 1.4 as adopted during the May 2012 meeting of Working Party 5A calls for the preparation of two relevant reports, one for characteristics of amateur stations, and one documenting compatibility studies with existing services.]*

Scope

This Report describes ITU-R studies undertaken to determine the spectral occupancy of fixed and mobile allocations within the band 5 250-5 450 kHz.

Vocabulary

Busy hour: the hour of the day when a frequency allocation is most congested.

Congestion: the likelihood that a randomly selected channel sampled within a given spectrum allocation will exceed a specified power threshold.

Occupancy: the percentage of time that the measured signal power exceeds a specified threshold.

Abbreviations

HF – high frequency

References

[1] TCI International, Inc, TCI Model 613-N Broadband Dipole Antenna, Data Sheet.

[2] D.I. Warner, S. Bantseev, and N. Serinken. “Spectral occupancy of fixed and mobile allocations within the high frequency band,” *Ionospheric radio systems and techniques Conference York UK*, May 15-17, 2012.

[3] Industry Canada – Spectrum Management and Telecommunications. (2009, December) Industry Canada.

[Online] www.ic.gc.ca/eic/site/smtgst.nsf/eng/sf09686.html

[4] (2012, Feb) Solar Influences Data Analysis Centre.

[Online]. <http://sidc.oma.be/sunspot-data/>

[5] N.F. Wong, G.F. Gott, and L.W. Barclay, “HF Spectral occupancy and frequency planning,” *IEE Proceedings – Communications, radar and signal processing*, vol. 132 Part F, no. 7,
pp. 548-557, December 1985.

[6] Roy H. Stehle and George H. Hagn, “HF Channel occupancy and band congestion: The other-user interference problem,” *Radio Science*, vol. 26, no. 4, pp. 959-970,
July-August 1991.

ITU-R Recommendations

# 1 Introduction

The high frequency (HF) band is the highest frequency band that supports propagation of radio signals via a reflected path incident on the ionosphere. This is called ionospheric or sky-wave propagation. Because of this unique characteristic, an important feature of the HF spectrum is its ability to support long range communications via sky-wave propagation. However, one disadvantage of long range propagation is the likelihood that noise and interference from distant sources may affect a desired communication. Therefore, the usability of HF sky-wave communication channels depends on both signal propagation and the absence of excess noise and interference. While propagation conditions have been studied extensively over several decades, there are relatively few published studies that have looked at noise and interference in the HF band.

This Report examines congestion and occupancy statistics in frequency allocations for fixed and mobile services in the vicinity of the frequency range 5 250-5 450 kHz to determine how channel availability varies with frequency, hour of the day, and channel bandwidth. Allocations for maritime and aeronautical mobile users were not included as wideband HF has not been approved by the ITU for use in these allocations.

# 2 Data collection procedures

Measurements were taken in Ottawa, Canada (Lat 45.36N Long 75.88W) using a TCI-613N broadband dipole antenna [1]. The antenna was connected, via a band-pass filter, to a Rohde and Schwarz FSP spectrum analyzer. The TCI 613N is a passive, horizontally polarized, nearly omni-directional antenna, with nulls at the horizontal elevation angle. At 3.4 MHz the maximum gain is at vertical, with the elevation angle decreasing to 30° as the frequency increases to 13.6 MHz. A band-pass filter with cut-off frequencies at 2.5 and 33 MHz and a surge protector were used to protect the input of the spectrum analyzer.

The system was able to scan the entire spectrum between 3 and 30.03 MHz in approximately 2 seconds. During the month of August 2011, measurements were taken for approximately 20 minutes each hour resulting in approximately 600 samples. November 2011 data were collected for periods of approximate 10 minutes for approximately 300 samples each hour. In August, between 22 and 28 days of data were collected depending on the hour, and between 25 and 27 days of data were collected in November. A measurement database is held at the Communications Research Centre Canada, in Ottawa.

# 3 Observations

The channel occupancy was computed for each 1 kHz channel for each hour based on a 10 dB threshold above the estimated noise level[[1]](#footnote-1) [2]. Congestion rates based on fixed and mobile allocation in the Canadian Table of Frequency Allocations [3] were computed for each hour and then averaged across four hour time blocks. Hourly figures for both months are presented in Table 1 for each of the fixed and mobile user allocations. Hourly and seasonal trends variations are apparent in the congestion statistics, which correlate to the diurnal cycles and variation in the hours of daylight. In Ottawa, during the month of August, sunrise ranges from 9:47 to 10:23 UTC and sunset from 0:31 to 23:43 UTC. Sunrise in November ranges from 11:42 to 12:21 UTC, and sunset ranges from 21:50 to 21:22 UTC. Observed sunspot numbers for August and November were 42.4 and 66.1 respectively [4]. [Editor’s Note: Color coding should be replaced with some other manner of differentiation.]

Table 1

Congestion in fixed and mobile allocations computed for 1 kHz channel bandwidth
within the frequency range 5 250-5 450 MHz



There is a trend toward moderately higher congestion rates in November as compared to August. The congested periods are longer in duration, which is consistent with the shorter daylight hours when D layer absorption limits propagation in these bands.

The “busy hour” was also computed and is included in Table 1. [The busy hour statistic appears to be highly correlated to diurnal variations in propagation conditions, the length of the path, seasonal variations, and latitude of stations.] The fact that frequencies are most congested in the early evening hours may be related to time of use patterns, and/or changing propagation conditions allowing long range propagation of signals from Europe.[[2]](#footnote-2)

An objective of this study is to determine the availability of contiguous channels that can support wideband waveforms up to 24 kHz bandwidth. Table 2 displays percentages which represent the number of unoccupied channels in fixed and mobile allocations in 1 MHz frequency spans, divided by the total number of channels that each allocation could support assuming no guard band between channels. An “unoccupied channel” is arbitrarily defined as a 1 kHz channel where the occupancy rate is less than 5%, nine days out of ten. Available 3 kHz, 12 kHz, and 24 kHz channels are determined by contiguous spans of 1 kHz channels that meet the “unoccupied channel” criteria described above.

Table 2

Percentage of channels that are unoccupied (occupancy < 5%, 9 days out of 10) in fixed and mobile allocations for 3, 12 and 24 kHz channel bandwidths within the frequency range 5 000‑6 000 kHz



The results in Table 2 show that there are few if any contiguous channels available even with 3 kHz bandwidth during the first time block and that the lack of available channels at night is more severe in the August data. There are also marginal regions in time and frequency where there are some smaller bandwidth channels available, but few or no wider-band channels. This suggests that during the more congested times in the early evening and night, there may be times when a trade-off will need to be made between using a narrower bandwidth channel with better propagation conditions and less interference, or tolerating the effects of poorer propagation and/or more interference in order to use a wider bandwidth waveform. However, during time blocks and frequency ranges where congestion is lower, the amount of bandwidth available in contiguous channels has little dependence on the modulation bandwidth used. [Ed. Note—Clarification of the previous sentence would be welcome.] When congestion is moderate, the availability of unoccupied bandwidth increases if smaller channel increments are used.

# 4 Conclusions

This study shows that during the timeframes observed, there is adequate frequency support at most times of the day for HF modulation techniques using wider bandwidths up to 24 kHz. However, during the late afternoon and evening hours when congestion is most severe, there are few contiguous unoccupied channels available in the frequency range that is most usable for ionospheric propagation. Selection of the optimal modulation bandwidth will vary depending on the time of day and number of channels required.

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1. Propagation predictions were performed to determine to coverage area for a monitoring station in Ottawa, Canada. The occupancy calculations used a threshold of 10 dB above noise level to count a 1 kHz frequency block as occupied. [↑](#footnote-ref-1)
2. Results for congestion measurements from the University of Manchester Institute of Science and Technology (UMIST) study have been published and may be used for comparison [5]. However, it is difficult to make a direct comparison because the UMIST study used a vertical monopole antenna, which has the opposite polarization and different antenna pattern. The UMIST study also used absolute power level thresholds instead of signal/noise ratio. Nevertheless, a rough comparison can be made by using the noise channel estimates estimated antenna conversion factor to approximately determine an absolute power threshold. For instance, when the highest noise levels were observed around 5 MHz at midnight, the 10 dB SNR threshold would be roughly equivalent to using a –122 dBm threshold in the UMIST study, whereas 10 dB threshold above the
–132 dBm receiver noise floor is equivalent to setting the threshold for the UMIST study in the range from –132 to –117 dBm as the frequency increases from 5 to 30 MHz. Based on these crude approximations, it appears that both noise levels and occupancy rates are considerably lower at the site in Ottawa than what was measured in the UK in July 1981[5]. This is expected based on the characteristics of the antenna used and given the observations in [6]. Further processing of the data could be conducted by converting measurements to field strength and compute occupancy based on absolute threshold, which would provide a better comparison, although this would not account the effects of the different antenna pattern and polarization. [Ed. Note: Are references sufficiently available to permit citation?] [↑](#footnote-ref-2)