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# Intern Project Poster - "Spread Spectrum Digital Communications Modeling in Electronic Warfare Modeling and Simulation Software"

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# Spread Spectrum Digital Communications Modeling in Electronic Warfare Modeling and Simulation Software

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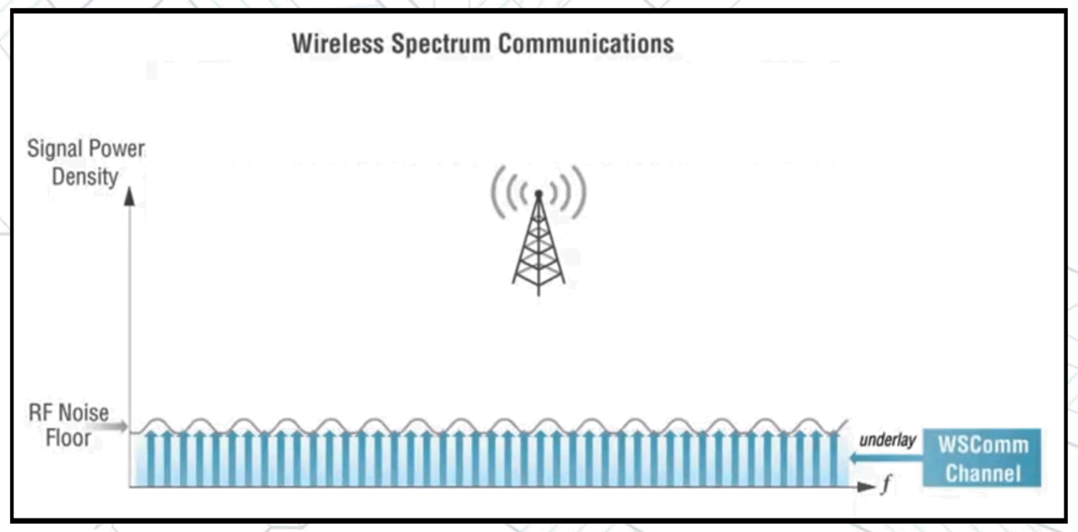
***Background and Objective:*** *INL National and Homeland Security produces Electronic Warfare Modeling and Simulation software (EWMSS). Among its many capabilities, EWMSS provides RF transmission coverage and communications network analyses utilizing several propagation models. These analyses can model a variety of analog and digital signal types, however spread spectrum (SS) techniques such as DSSS and FHSS are not currently supported. The objective of this research is to use existing EWMSS functionality to model SS techniques, specifically filter bank multicarrier spread spectrum (FBMCSS). FBMCSS is utilized by the underlay control channel (UCC) of Wireless Spectrum Communications (WSComm), a product of INL with potential military, emergency response, and disaster relief applications [1].*



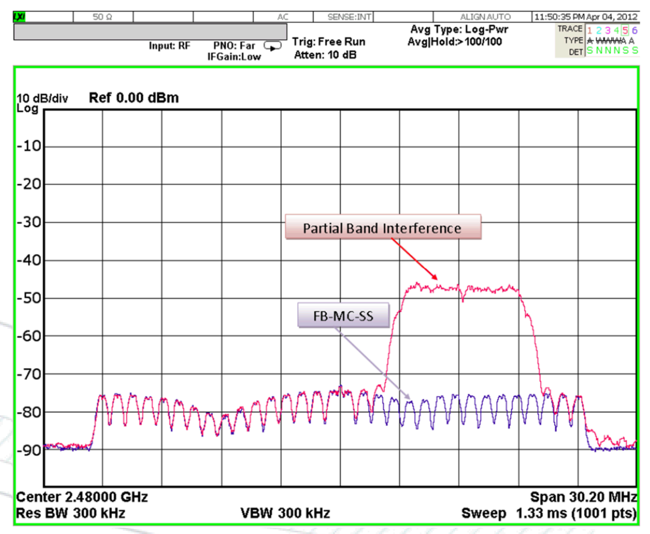




***Figure 1. WSComm UCC diagram [1] (left). FBMCSS received signal spectrum (purple); with interference (red) [2].***

***Problem:*** Communication link quality can be assessed with a link budget, a collection of terms that characterize a link. For a given scenario, EWMSS assigns values to link budget terms that account for hardware specifications, modulation scheme, frequency, environment, etc. Negative terms (losses) weaken a link, positive terms (gains) strengthen it. The link margin is the net of all losses and gains in a link budget, and is used as a quality metric. A key feature of FBMCSS is its "processing gain," a link budget term which is not accounted for in EWMSS.

(a) $M(\text{dB}) = \text{EIRP (dBW)} + \frac{G_r}{T^\circ}(\text{dB/K}) - \left(\frac{E_b}{N_0}\right)_{reqd}(\text{dB}) - R(\text{dB–bits/s}) - \kappa(\text{dBW/K–Hz}) - L_s(\text{dB}) - L_o(\text{dB})$

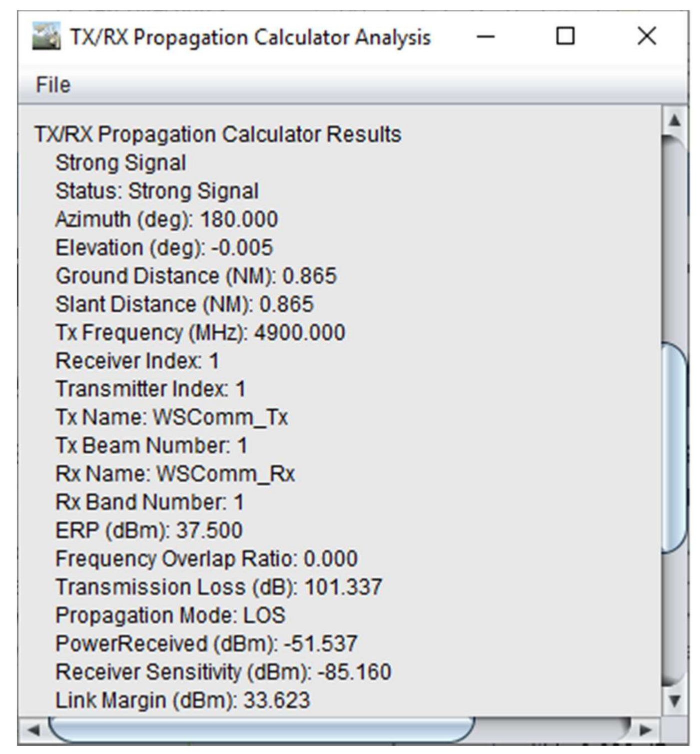
(b) EWMSS Link Margin = transmitter power + frequency overlap ratio - polarization loss - propagation loss + transmitter antenna gain + receiver antenna gain - fog precipitation loss - additional loss - additional loss distance - thermal noise - receiver noise figure - minimum SNR

***Figure 2. Link budget terms. (a) The link margin equation [3]. (b) EWMSS terms (dB), note that processing gain is absent.***

***Methods:*** This research will use a WSComm link budget and equipment specifications, provided by the WSComm group, as the basis for evaluating EWMSS SS modeling. The given link budget models communication between a WSComm UCC Enhanced Model 210-C transmitter and receiver, assuming free space path loss. A transmitter, receiver, and antenna will be constructed in EWMSS and communications will be analyzed using the TX/RX Propagation Calculator with free space propagation. Because the EWMSS link budget does not account for FBMCSS processing gain, it will be included as a user-defined "negative" additional loss in the EWMSS analysis parameters.

References:
[1] IdahoNationalLab. *Wireless Spectrum Communications, WSComm*. (Nov. 11, 2013). Accessed: July 26, 2019. [Online Video]. Available: https://www.youtube.com/watch?v=q8ErkgDgn9s
[2] D.L. Wasden, "Filter Bank Multicarrier Spread Spectrum Communications," Ph.D. dissertation, Dept. Elect. Comput. Eng., Univ. Utah, Salt Lake City, UT, 2014. [Online]. Available: http://cdmbuntu.lib.utah.edu/utils/getfile/collection/etd3/id/3127/filename/3131.pdf
[3] B. Sklar, "Communications Link Analysis," in *Digital Communications: Fundamentals and Applications,* 2nd ed. Upper Saddle River, NJ, USA: Prentice-Hall, 2001, p.288.

***Results:*** The results of the EWMSS analysis and the sample WSComm UCC link budget are shown below. The calculated link margins agree to within 0.023 dB, or a 0.531% difference.

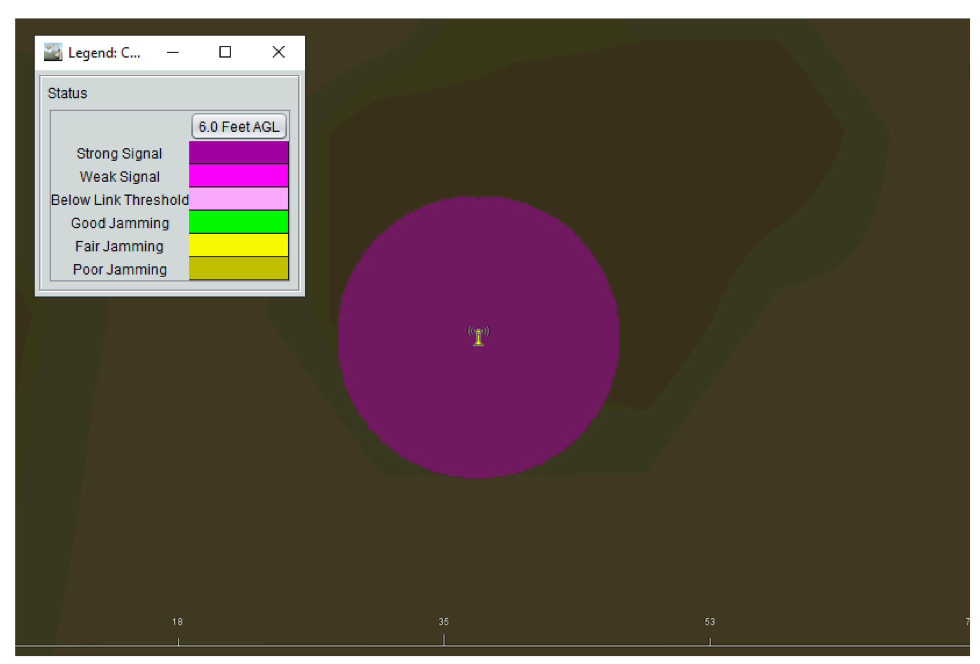



**Summary Analysis**

| | Model 210 UCC Enhanced '19 |
|---|---|
| Frequency (MHz) | 4900.0 MHz |
| Range (m) -max | 1609.31 m |
| Range (m) -min | 15.25 m |
| PAPR | 4.6 dBm |
| Transmit Power Max | 42.8 dBm |
| Transmit Power Target | 33.0 dBm |
| Analysis Power | 33.0 dBm |
| Path Loss | 110.38 dB |
| Implementation Loss (Sim) | 0.50 dB |
| Minimum Detectable Signal | -103.2 dBm |
| Noise Figure | 2.73 dB |
| Cable Loss (Tx & Rx) | 0.75 dB |
| Antenna Tx (dBi) | 4.50 dBi |
| Antenna Rx (dBi) | 4.50 dBi |
| | |
| Signal Power (dBm) | -69.1 dBm |
| Waveform MDS (dBm) | -102.7 dBm |
| Link Margin (dB) | 33.60 dB |

***Figure 3. Link margin calculations. EWMSS (left), WSComm***

***Discussion:*** The agreement of both link margins illustrates that EWMSS can produce an accurate FBMCSS model if processing gain is taken into account. Free space path loss, however, is an ideal model. These analyses do not use terrain or more sophisticated propagation models, but EWMSS has those capabilities. Thus EWMSS has the potential to generate realistic, location-specific WSComm UCC models and could be valuable for WSComm end users. Also not considered are the effects of additional signals such as jamming; the accuracy of EWMSS FBMCSS modeling in such environments was not studied in this project.



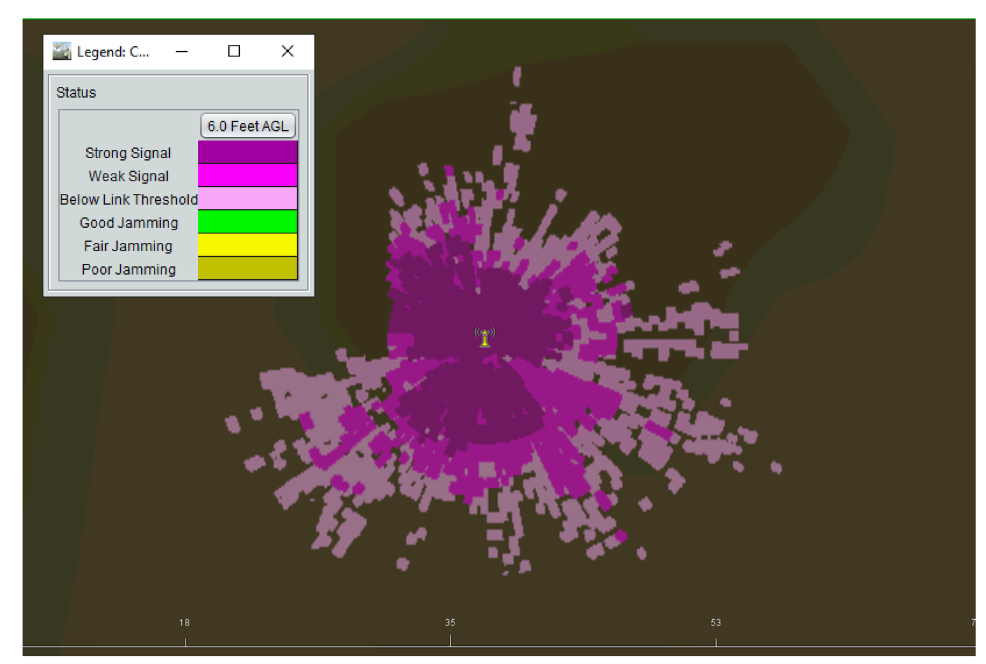




***Figure 4. EWMSS' modeling capabilities: Collection Coverage Analysis results for WSComm UCC Enhanced Model 210-C. Free space propagation, terrain not used in analysis (left). TIREM propagation, terrain used in analysis.***