# HF Skywave ITU-R P.533-9 Gets a Re-Write

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HF skywave propagation was introduced to this world as a technology beyond line-of-sight communications. Radio systems in the HF band (3-30 MHz) have always been around and performing well. The HF band is utilized in broadcast networks, maritime networks, aviation communications systems and various government and military communications systems for multiple purposes. With the development of Automatic Link Establishment (ALE) technology and modern high speed modems, HF communication has regained interest in these communities of users.
This white paper discusses about the aspects of ITU-R P.533-9 Model with ATDI's software product line which uses ionospheric propagation to achieve results.

**Background**

Propagation in HF has a Groundwave and a Skywave component. The Groundwave component is described by the ITU-R P.368-9 recommendation, and has been a standard part of ATDI planning tools for many years now. The Skywave component, described by the ITU-R P.533-9 recommendation was integrated through a wrapper around a development undertaken by NTIA-ITS, REC533, included in a very well known and distributed HF propagation suite that includes VOACAP. Unfortunately, this suite is no longer supported and its architect retired. With the introduction of 64-bit operating systems and the ever present requirement for a flexible and secure HF Skywave modeling platform open to improvements, the wrapper option is no longer a viable solution. ATDI decided to translate, debug and modernize the original FORTRAN code. This huge undertaking is now complete and version 2.x is now integrated and supported as the ICS-HF module.

**Parameters**

ATDI's module is designed to predict HF Skywave propagation parameters such as Signal to Noise Ratio (SNR), Maximum usable frequency (MUF), Frequency of Optimum Transmission (FOT), Field Strength, Reliability. The characteristics of the ionosphere are key factors in Skywave propagation. They depend on the time of day, month and solar activity. ICS-HF integrates all the required tables and assists the user with defaults and presets.

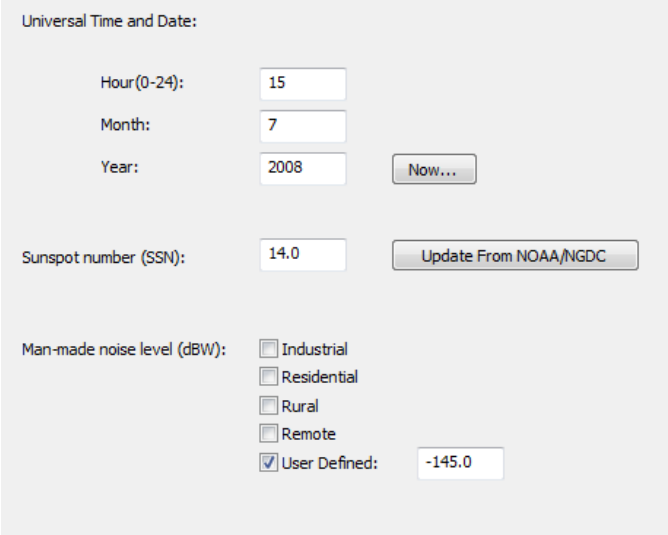


Fig1: Environment parameters

Antennas in HF bring an added complexity to the modeling. They are often designed to a frequency and used through the HF spectrum, making their 3D pattern widely variable. The ground type, dielectric constant and conductivity affect the radiation pattern as well. Therefore, each new frequency run requires the calculation of a new pattern.

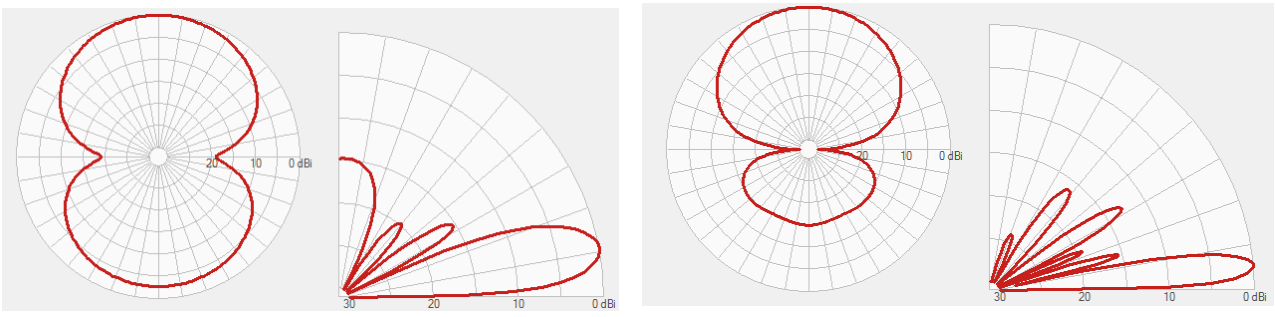


Fig 2: Same dual-band center fed half-wave dipole array, patterns at 10MHz and 5MHz

**Circuit Calculation**

The establishment of a point to point communication, or circuit, requires the determination of the Maximum Usable Frequency (MUF). When the operating frequency is greater than the MUF for a given circuit and environment, the signal does not get reflected by the ionosphere and the link cannot be established. The optimum frequency of communication (FOT) is usually a little below the MUF, and is calculated from ITU-R P.1240-1. ICS-HF produces a clean circuit chart that allows the users to identify the best hours and frequencies of operation.

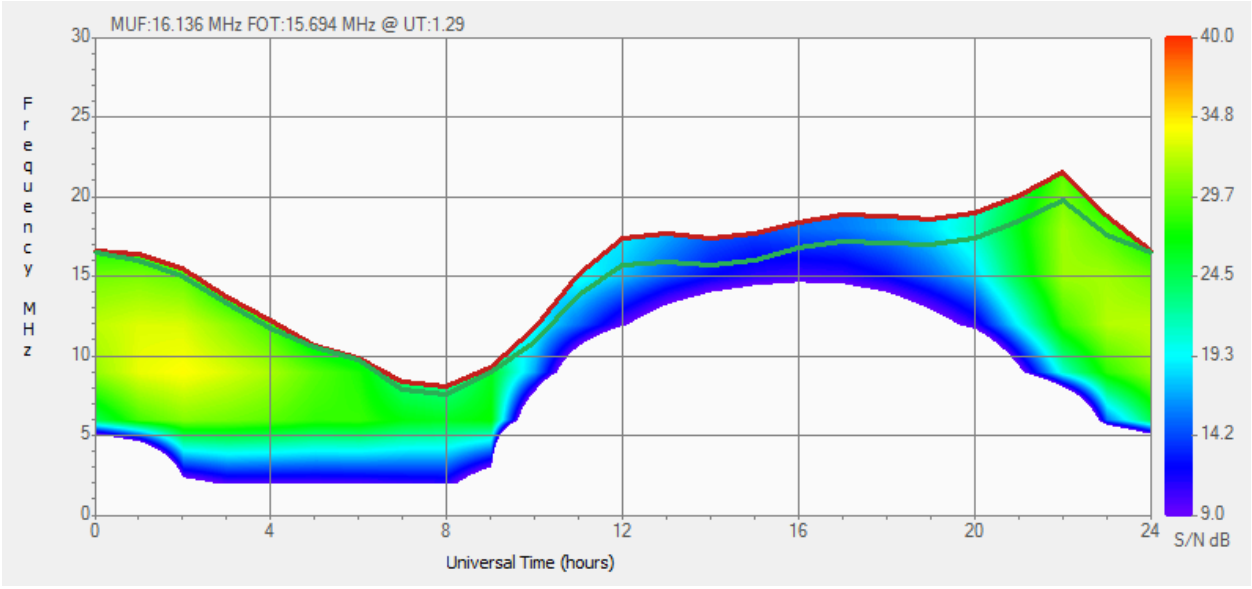


Fig 3: Circuit chart with MUF (Red), FOT (Green) and Signal to Noise ratio under MUF

**Coverage Calculation**

At fixed frequencies, the circuit calculation is batched for every degree of the world to generate a complete coverage area. A unique capability for forward or reverse coverage is already included. Signal to Noise ratios and MUF are stored for the whole world.

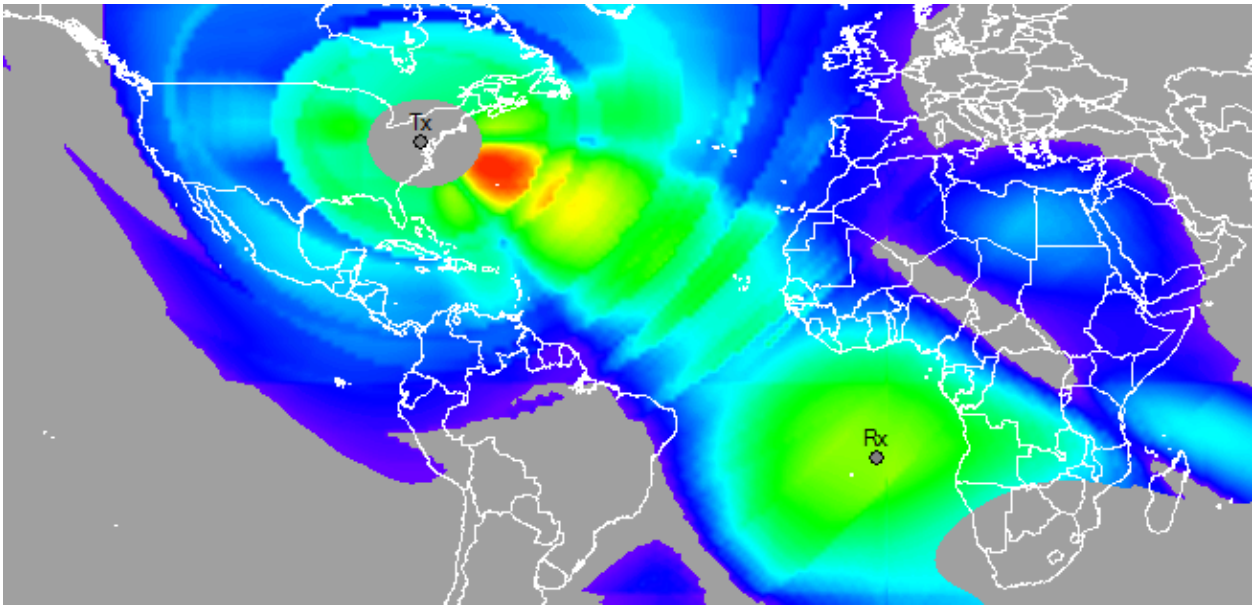


Fig 4: S/N coverage over world map

**Maritime Systems**

Recent developments into ICS-HF module have customized the tool to not only generating downlink analysis but also uplink calculations to offer full reciprocity to users modeling mobile systems. This is specifically applied to Maritime networks that require modeling their networks from the perspective of the ship transmitter communicating to the shore station. Reverse coverage, or “Ship to shore” communications modeling is a hallmark in ATDI’s RF modeling capabilities and has been again implemented in the new ICS-HF module.

## Validation

A very large number of test points were used to validate that the ICS-HF implementation matches the original REC533 application and code. First, questionable results were identified from the respective coverage areas and run through individual circuits. A summary of the analysis is documented in the following technical document: “Validation of ATDI’s Software Product Line with ITU-R P.533-9 (HF Skywave Propagation) Model”. Second, test points were selected according to break points in the REC533-9 model: distances <2000km, 4000km, 7000km and 9000km, night and day, sunspot number above and under 150. Finally, the 10 families of antennas described in ITU-REC-BS.705-1 were individually tested: constant gain isotrope, multiband aperiodic reflector, dual band centre-fed half-wave dipole array, dual band end-fed half-wave dipole array, tropical array, horizontal log-periodic array, horizontal rhombic, quadrant, crossed dipole, vertical monopole.

## Conclusion

This modern implementation of the HF Skywave propagation engine opens the whole range of modeling capabilities that are already available to VHF-UHF users through ATDI RF platforms: composites, best servers, interference, what-ifs scenarios, advanced network management and printing. ICS-HF is a great, unique capability that confirms ATDI’s dedication to support the widest range of radio systems and technologies.

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