

*D. Lee Fugal, President, Space & Signals Technologies, LLC  
2251 Casa Alta, San Diego, CA 91977  
619/741-3283, Toll-Free 877/845-6459, FAX 619/741-3324  
L.Fugal@ieee.org, lfugal@aol.com, dlf@spaceandsignals.com*

Expert in various Digital Signal Processing (DSP) methods. Extensive preparation of upcoming book providing a highly conceptual, intuitive, in-depth understanding of Wavelets as applied to DSP methods. Instructor for Professional Development Courses in DSP (with wavelets emphasis) for Association of Old Crows (national Electronic Warfare community) and Applied Technology Institute (ATI) on both coasts. Also teach similar short courses and seminars locally. Courses deal with Wavelets, Fourier Transforms, and Time/Frequency analyses. Taught full-semester Upper Division and Graduate Courses in Signal Processing and Satellite Communications Technology for the Electrical and Computer Engineering departments at the University of Utah and at Weber State University.

Also successfully operated a small consulting/contracting firm "Space & Signals Technologies, LLC" full time since 1991. Most projects performed 100% by me, but have been able to use my corporate and academic networks to quickly bring in additional expertise from time to time as needed (and as appropriate).

Worked under both consulting and subcontracting agreements with companies such as ARGOSystems, Boeing, Digital Scientific, Orbtek Electro-Optics (names used with permission) and various other major corporations, startups and universities. Earlier full-time employment as Senior Scientist/Systems Engineer with McDonnell Douglas Astronautics, TRW/ESL, and ASTECH/Nichols Research (1968-1991).

Specific long-term project areas have included Geolocation, Harmonics and Intermodulation Distortions, Advanced Pulse Detection Methods, Space and Airborne Communications, GPS Denoising using Wavelets, Image Processing, and External Data Extraction. In all cases, developed algorithms, built software prototypes (usually in MATLAB) and provided full, clear, illustrated documentation. **(See project technical details on next page)**

M.S., Applied Physics, University of Utah, 1986. (Thesis: "Automated False Alarm Threshold Generation in Transmultiplexed Cross Ambiguity Function Systems"). B.S. Physics, University of Utah, 1967. Extensive personal study and additional coursework as needed to learn and stay current with the latest technologies

Senior Member IEEE and recipient of the IEEE Third Millennium Medal. Founder and Past Chairman of Utah IEEE Consultants Network. Past Coordinator for Tri-State IEEE Student Activities. Member, Association of Old Crows, American MENSA. Clearances at the TS/EBI/SBI/SI/TK level

## **PROJECT TECHNICAL DETAILS**

### **GEOLOCATION:**

Cooperative and non-cooperative emitter location (for GPS and non-GPS, stationary or moving targets). Single and Two-Ball time-sequential Geolocation of slow and fast-moving emitters. CW and Pulsed signals. Spread Spectrum and/or frequency-hopping RF emitters. TDOA only, FDOA only, and TDOA/FDOA (Time/Frequency) Cross Ambiguity Function (CAF) analyses. Precision interpolation and data smoothing. Correction for smearing caused by system kinematics. Various Minimization/Optimization techniques. Simulation/Modeling of Space-Based, Airborne, and Ground Station operations. Error budgets and Error Ellipses. Proof of Concept verification using MATLAB and other high-level mathematical software tools. Developed software prototype for client's Geolocation Workstations.

### **HARMONICS AND INTERMODULATION DISTORTIONS:**

Modeling then Identification of anomalous signals in unexpected frequency bands from Space-Based systems. Volterra Series (polynomial) MATLAB simulations to perform Saturation and Clipping analyses for TWTA/Klystron and GaAsFET systems. Amplitude/Phase Modulation (AM/PM) conversion. Ionospheric and Tropospheric Propagation and Distortion. Range and Range Rates. Anti-aliasing of signals with formidable harmonics using Basebanding and Subband Isolation. Multirate Signal Processing. Proof of Concept. Produced sophisticated, user-friendly MATLAB software tool for client to be used in future analyses.

### **ADVANCED PULSE DETECTION METHODS:**

Simulation of Doppler and Stretching effects on TDOA and FDOA for both Pulsed and CW signals. ARMA techniques. Modification of the FFT algorithm itself for Fast Multiresolution. Split-Radix and Prime Factor Transforms. Polyphase Filtering. Spectral Leakage. Wavelets. Sequential Shifting (to provide scale/time benefits of wavelets but with less smearing). Using MATLAB prototype, recommendations then made for changes in the existing C code of the client's software.

### **SPACE AND AIRBORNE COMMUNICATIONS:**

Uplink/Downlink Analyses and Simulation for Space-Based platforms, Ground Stations, and Remote Transceivers. Bit Error Rates and Forward Error Correction (BER/FEC) studies. AM, FM, PAM, PCM, FSK/CPFSK and BPSK/QPSK Phase Modulation. Multiple access methods (TDMA, CDMA, FDMA, etc.). Very Small/Ultra Small Aperture Terminal (VSAT/USAT) antennas. Orbital Mechanics and Perturbations. Link Budgets addressing Rain Fade, Faraday Rotation and Ionospheric Effects. Regenerative Repeaters and "Bent Pipe" Transponder Systems. Saturation Curves and Backoffs for Linearity. TT&R, EIRP and G/T. LNA/LNB and Noise Factor/Figure.

### **GPS DE-NOISING USING WAVELETS**

FFT, STFT, and Wavelet (DWT and CWT) methods for noise excision of Chirp Jammers. Median Filtering. Haar and Daubechies Orthogonal Wavelets. Wavelet Packets. Windowing. By exploiting the Wavelet Transform's capability to provide both time and frequency information simultaneously, developed a "Custom Time Thresholding" method to dramatically increase the SNR. Upsampling/Downsampling, Sampling Rate Conversion, and then GPS Cross-correlation for processing gain. Able to remove jamming and restore accurate distance and differential distance using GPS systems.

### **IMAGE PROCESSING:**

Edge Detection using ARMA, Median Filtering, Orthogonal and Biorthogonal wavelets, and other advanced filtering and image processing techniques. Polynomial Curve Fits and Splines for optimal smoothing. Histograms, Thresholding, and various Statistical Metrics. Image Enhancement. De-Noising. 3-D Scientific Visualization.

### **EXTERNALS DATA EXTRACTION:**

Exploitation of RF telemetry signal to obtain Multipath, Doppler, Echo, Signal Strength, Polarization (Vertical, Horizontal, Circular), Range and Range Rate. Deconvolution methods. Performed radar and optics trajectory analyses and reflected signature evaluations. Utilized Kalman Filtering and statistical methods to enhance optimal estimation.