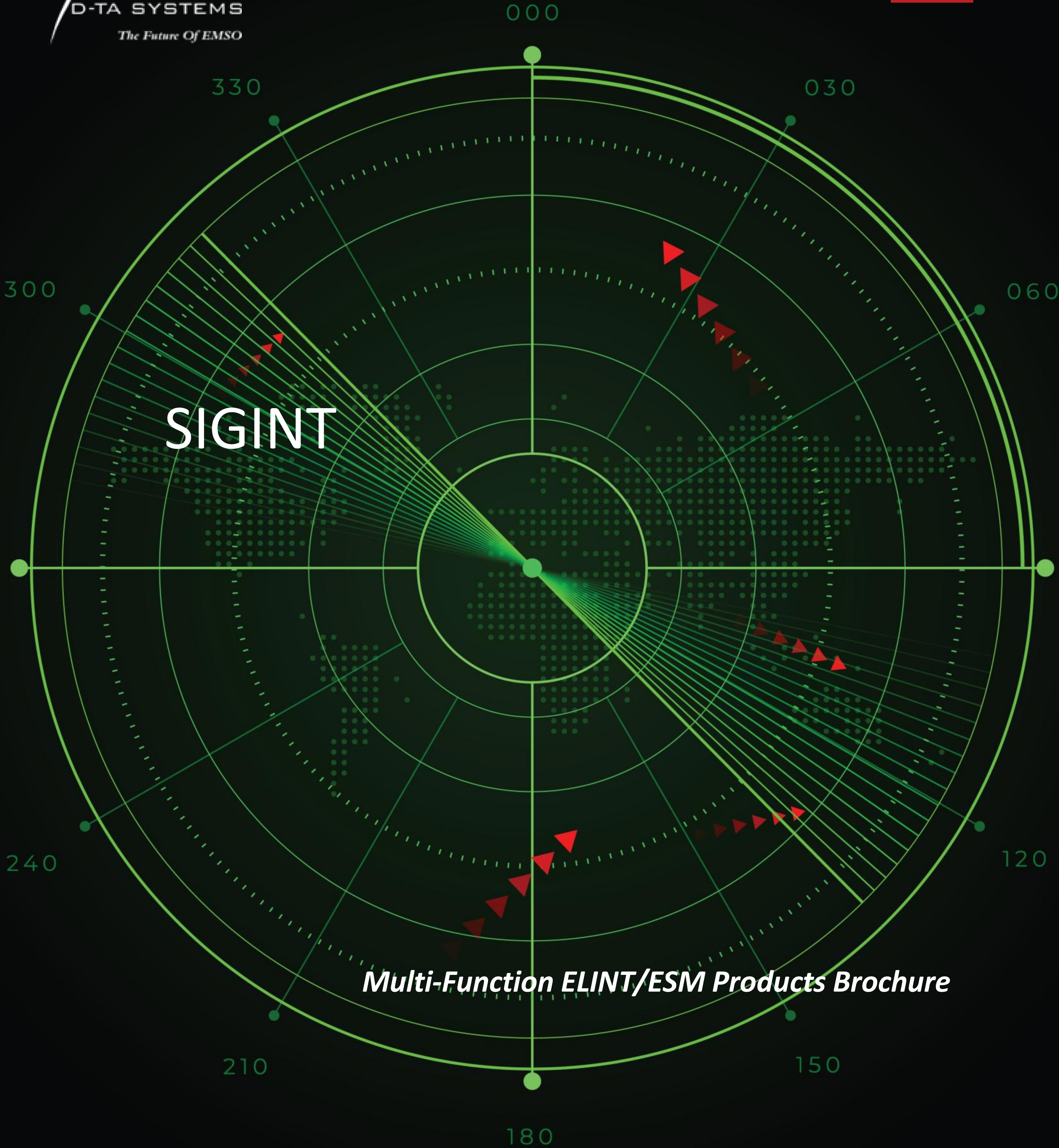
D-TA SYSTEMS

The Future Of EMSO

2026

SIGINT



Multi-Function ELINT/ESM Products Brochure

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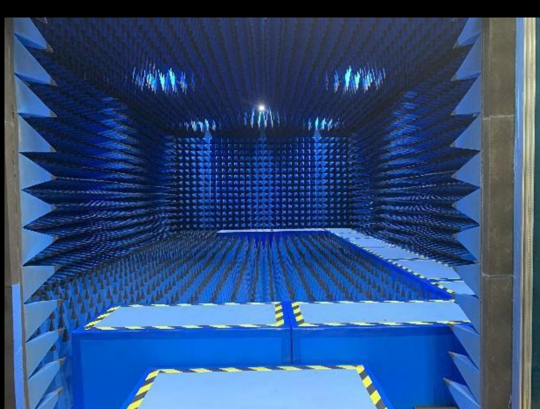


About D-TA Systems

D-TA SYSTEMS
The Future Of EMSO

Founded in 2007, D-TA designs, develops and manufactures spectrum processing solutions for demanding applications. D-TA's standard products cover virtually all aspect of Electromagnetic Spectrum Operations (EMSO): from spectrum sensing to spectrum creation. D-TA is the only SMB capable of offering complete turn-key solutions for all EMSO missions.

D-TA products are results of 'out of the box' thinking, technical innovation, and no-compromise development that fulfills the company's mandate to cut deployment risk, time, and cost by orders of magnitude. All D-TA products use antenna level digitization, high-speed optical networks as data backbone and software centric processing.

All D-TA products, including ESM/ELINT Radar, EW Emulation and Extreme-SWaP optimized products for disposable EMSO missions, are based on just two sub-systems (LRUs) connected by high-speed optical cables: a smart sensor-interface unit; and a (commercially available) processing server. The approach simplifies system design, installation, maintenance, and future upgradability.

Over the years D-TA has assembled a highly qualified technical team that has unparalleled expertise in RF, IF and Network system design and real-time multi-core software processing and EMSO application development. D-TA's management staff has significant domain expertise and successful track record of managing and growing innovative businesses. D-TA has extensively equipped R&D and manufacturing facilities, including its own anechoic chamber. D-TA has over 50 active customers in FVEY, NATO and QUAD countries. Many of them are repeat customers.

MFEL Multi-Function ELINT System

MFEL-1000 ELINT Collection System with Situation View, Emitter ID, Full BW I/Q Data Recording & Post Analysis

The compact and value-focused MFEL-1000 system is designed to provide 360-degree spectrum surveillance to detect, analyze, classify, and identify radar emitters. On-demand, it can record emitter track information, PDWs and burst and wideband I/Q data for the purpose of detailed intentional and unintentional intra-pulse analysis and specific emitter identification (SEI). It includes a highly sophisticated signal detection scheme for reliable operation in low and negative signal-to-noise ratios (SNR) and in dense electromagnetic environments. It is particularly suitable for detecting Low Probability of Intercept (LPI) signals. MFEL-1000 supports manned and unattended operations as a standalone ELINT system or as an add-on to ESM systems to provide 360-degree situational awareness.

MFEL-1000 system is available in rackmount or portable package. It includes a highly sophisticated wideband super-heterodyne receiver, tunable from 0.5-18 or 40 GHz (option). The IBW is 500 MHz or 1 GHz (option) and sensitivity at full IBW, without accounting for the antenna gain, is approximately -80 dBm. A GPS system for generating timing signals is also offered. The receiver provides full bandwidth I/Q data to a multi-core RAID server for processing and data recording.

MFEL-1000 is offered with either an Omni-directional antenna (standard) or a dual-ridged horn-antenna (option). The latter provides up to 20 dBi antenna gain, however, the beamwidth is narrow for high frequencies and should be used when the signal direction is known, or when the antenna is mounted on a rotating platform. A fixed adjustable mast is offered with the antenna.

Figure 1: MFEL-1000 System (3U)

MFEL-1000 Highlights:

- Situational Awareness from 0.5 to 18 GHz (optionally up to 40 GHz);
- Instantaneous BW from 10 MHz to 500 MHz (optionally up to 1 GHz); 4
- LPI Signal Interception in Dense EM Environments;
- Comprehensive Parameter Extraction & PDW Creation;
- Automatic measurement and recognition of intentional modulation on pulse (IMOP) and unintentional modulation on pulse (UMOP);
- De-interleaving PDWs into Tracks of Distinct Signals;
- Library matching and specific emitter identification;
- Post Processing and Analysis of Recorded Data Files by means of the Signal Visualization and Analysis Software (SVAS) application;
- GPS Based Clock & Reference Signals and Time Stamping of Data Packets;
- Full BW Long-Duration Recording of Signals of Interest (SOIs);
- 24 TB (Optionally 96 TB) Storage Capacity;
- Simple To Install and Operate (Minimal Operator Training);
- Networking ready and easy integration into Command and Control (C2) systems;
- Dual Receiver Option for Uninterrupted Spectrum Scanning (Contact Factory); and,
- Value-focused.

System Operation:

MFEL-1000 (SOI) system is designed with the goal to maximize the probability of intercepting a Signal of Interest and minimize the time that the Operator needs to recognize the signal against the background clutter of other intercepts.

The baseband I/Q time samples are sent via high-speed optical links to the RAID server. A highly sophisticated detection algorithm separates the signal space into statistical and deterministic parts to facilitate signal detection.

The pulses detected during the Search Task are converted to PDWs and automatically de-interleaved into Tracks representing distinct signals. The active Tracks are presented to the Operator in the Situation view and the Track table view. The Situation page provides the Operator with a managed view of the current EW environment. The Situation view page is a combination of an active Track table with a waterfall Time vs. Frequency plot. This view is a key screen for the Operator during normal operation. All critical information is presented here.

The Operator can annotate Tracks to add a name tag, to add comments or to mark a Track for ELINT Collection.

Tracks have automatic analysis of signal parameters and agility types. Each time the de-interleaver sends new PDWs to the Track, the signal characterization analysis will be performed; until the analysis results converge on a static description of the signal behavior. The automated signal characterization will compile an intercept report for the Track which will contain statistical inter-pulse data such as means and min-max limits as well as ELINT agility parameters such as, PW, PRI, and RF agility types, and intrapulse data enabling specific emitter identification.

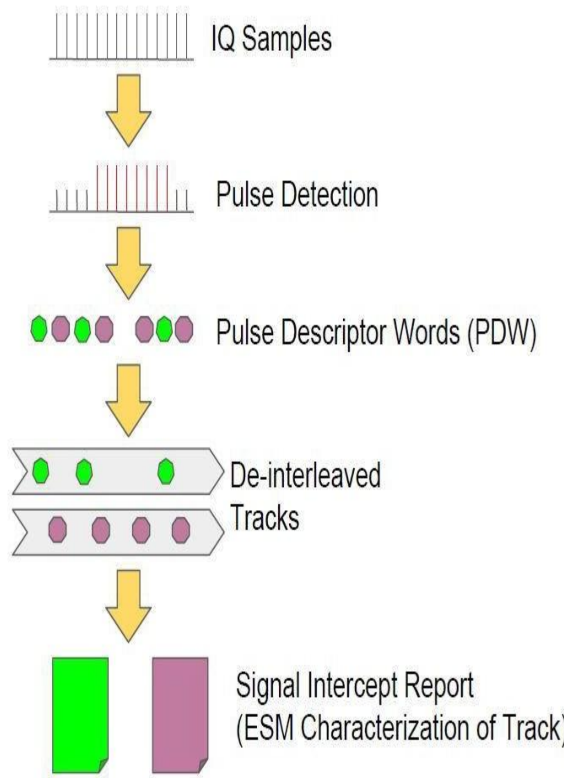


Figure 2: Signal Processing Concept

MFEL Human Machine Interface & Displays:

MFEL-1000 system is designed to operate with minimal operator training. Once the system is set up with appropriate frequency scan parameters, the system starts providing situational awareness with detected signal details without human intervention.

The MFEL system uses a search strategy that provides complete flexibility in RF search coverage. The Operator is free to enable/disable bands and to set the relative revisit weighting for each band. In addition, the Operator has control over the Dwell time that will be used for all hops in the search. This simple to understand strategy allows the Operator a very high degree of control over the search pattern.

Once the system is activated with the appropriate search script, the situation view page is displayed. The situation view page is the “home” page for the system while it is actively searching for signals of interest. This page provides a high-level EW situational view by displaying the signals that are currently active in the environment. EW situational view shows waterfall display and track details which shows SOIs with PW, Centre Frequency, PRI, Signal Power, Time of Arrivals for the operator to select a particular signal track to record.

MFEL
Multi-Function ELINT System

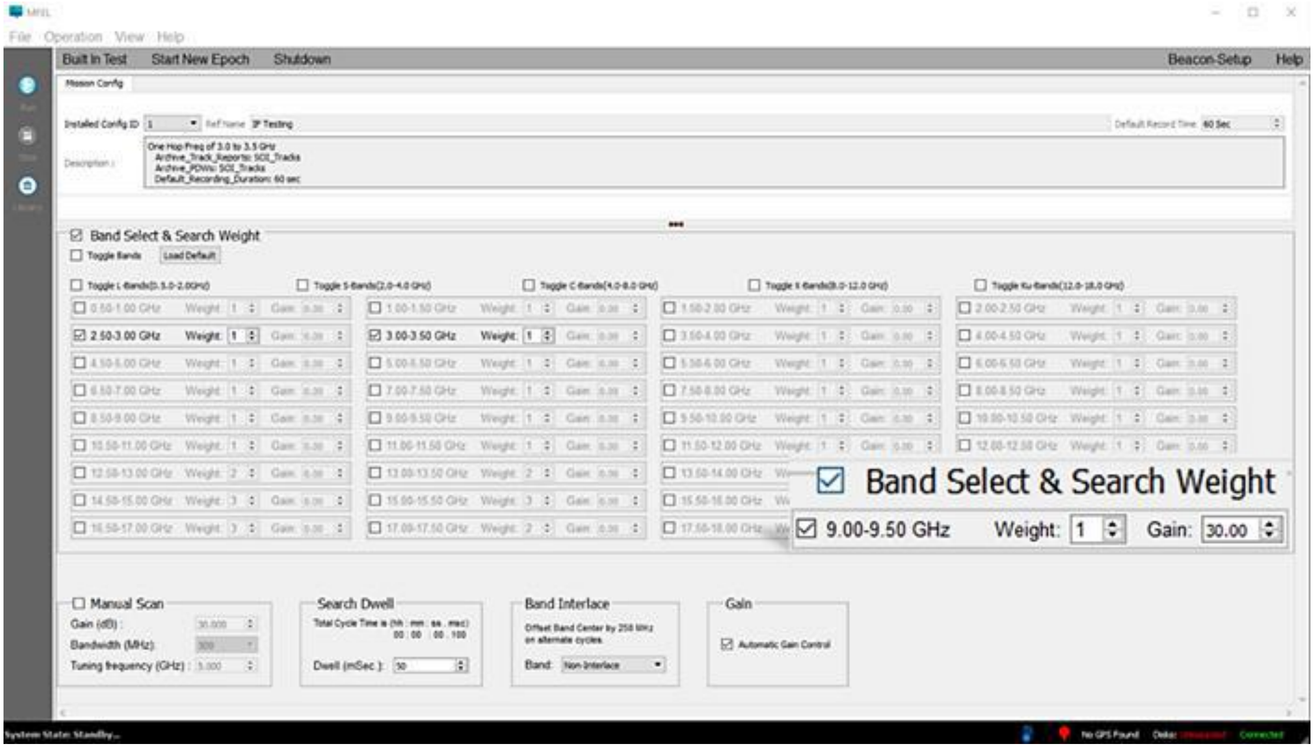


Figure 3: MFEL UI Mission Selection

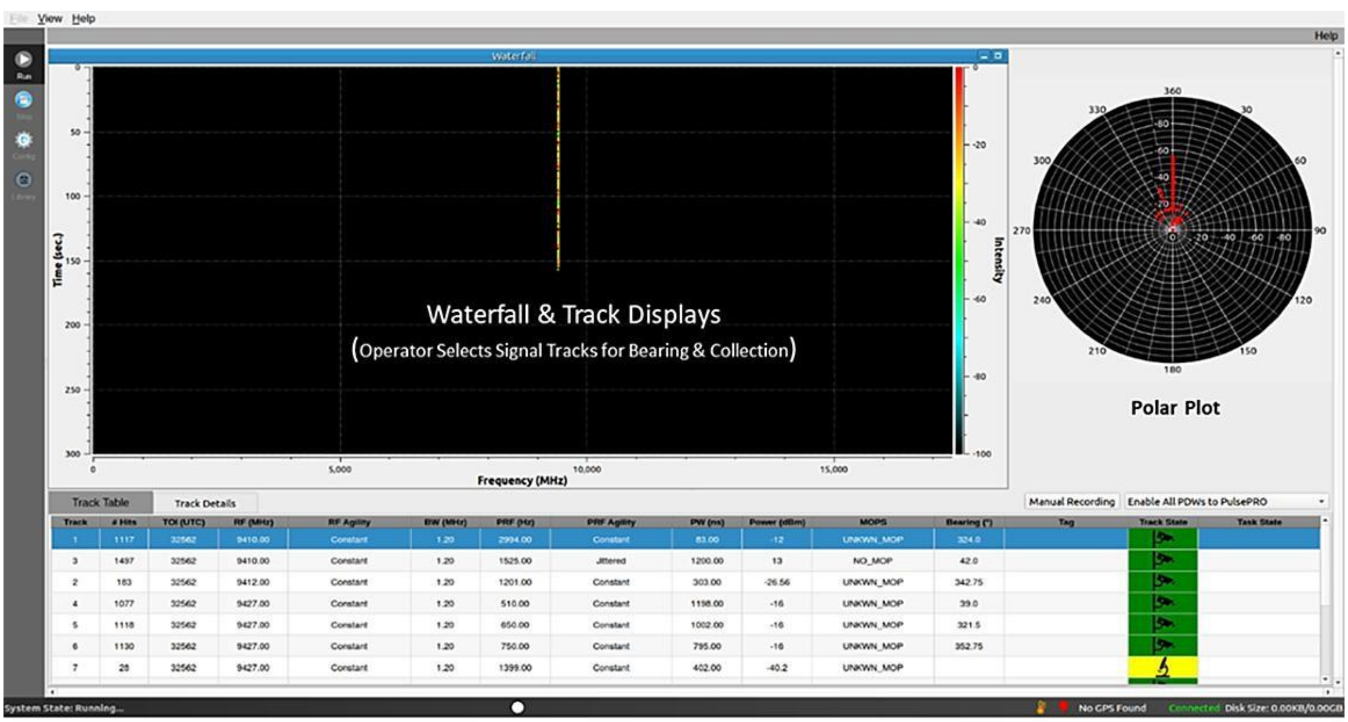


Figure 4: MFEL UI Waterfall Display

Analysis of Recorded Data Files (SVAS Software):

D-TA Signal Visualization and Analysis Software (SVAS) is a Windows compatible standalone executable which allows for the visualization, baseband data retrieval and advanced signal processing for the recorded baseband or I/Q data on the MFEL-1000 server. The software architecture is fully flexible and open to user requirements in terms of providing support for advanced digital signal processing. The base version of the software encompasses visualization of baseband I/Q data and its subsequent analysis including signal detection, intrapulse modulation on pulse analysis, Pulse Descriptor Words (PDW) creation and pulse deinterleaving and classification of multiple sources. More detailed information on SVAS is provided after the MFEL-5000 UAS discussions.

MFEL-1000 System Specifications:

Parameter	Value	Comment
Frequency Range	0.5 to 18 GHz (40 GHz optional)	*Up to 40 GHz optional
Instantaneous BW	500 MHz or 1 GHz (Optional)	Operating BW DDC selectable from 10 MHz to 500 MHz or 1 GHz
Receiver Architecture	Super-Heterodyne Receivers	14-Bit Data Converters
System Sensitivity	-80 dBm	At Full 500 MHz BW
Typical System Dynamic Range	60 dB	
Operating BW	500, 250, 100, 50, 25 and 10 MHz	Any BW can be selected for Receiver Frequency Scanning
Pulse Amplitude Accuracy	+/- 1 dB	
PW Range	20 ns to 10 ms	The upper value can be reduced by the operator since it is also the CW chopping threshold
PW Accuracy	10 ns RMS	
PRI Range	1 us to 100 ms	
PRI Accuracy	10 ns RMS	
Scan Measurement Range	5 ms to 30 s	Automatic recognition of the following types: Circular, Conical, Bi-directional Sector, track-while-scan, Raster, Helical,
Pulse Density	>1 Mpps (Within IBW)	
No. of Emitters Tracked	> 500	
Intentional Modulation on Pulse Recognition	Linear Chirp, Non-linear Chirp, FSK, Barker Codes, Nested Barker Codes, BPSK, QPSK, Frank and Costas Codes, Polyphase (P1, P2, P3, P4) Codes	Automatically recognized
Emitter Types (Frequency)	CW, Frequency Agile, Random, or periodic Hopper, Dwell-Switched, Modulated	
Emitter Types (PRI)	Fixed, Jitter, Slide, Stagger, Dwell-Switched, Sliding, Modulated	
Emitter PW Types	Agile, Fixed, Dwell-Switched	
Recording Capacity	24TB Standard	Higher recording capacity offered

MFEL-5000 Family of ELINT/ESM Systems:

D-TA's MFEL-5000 standard ELINT/ESM system is offered for ground, surface naval and airborne applications. The heart of the system is high-performance multi-channel ELINT/ESM receivers that can have as many as 8 RF input channels (phase-coherent or independently tuned) with a frequency tuning range from 0.5 to 18/40 GHz and an instantaneous bandwidth (IBW) of 500 MHz or 1GHz. All processing and wideband I/Q data recording are done in a commercially available RAID server. In some deployment scenarios, the receivers are placed up mast and RF cable losses are virtually eliminated. The RAID server can be placed away from the antenna site in a sheltered and secured location. Only high-speed fiber optic cables connect the receivers to the server.

The different variants of the MFEL-5000 systems are:

1. **MFEL-5000 GSN** is a dual receiver system for ground and surface naval deployment with an Omni and a Spinning DF antenna. The frequency tuning range is 0.5 – 18 GHz (optionally 40 GHz) and IBW is 500 MHz (optionally 1 GHz).

Figure 5: MFEL-5000 GSN

2. **MFEL-5000 UAS** is a compact and lightweight multi-receiver (4, 6, 8 or more) system for deployment in any platform. A compact low SWaP solution with 4 spiral antennas in a circular configuration can be deployed in Group 1 UAS or man-portable applications. The MFEL-5000 UAS system comes in different variations. The difference is primarily in antenna configurations: 4, 6 or 8 elements circular or 4-element linear. The latter can offer high DF accuracy with 120-degree field-of-view (FOV). Multiple linear arrays can be used to increase the FOV.

Figure 6: MFEL-5000 UAS (4-Channel Array)

MFEL-5000 GSN

High-Fidelity ELINT Collection with Situation View & Signal Bearing:

MFEL-5000 GSN system includes an OMNI antenna for situation view and a spinning DF antenna for finding signal bearing and recording of signals of interest (SOIs). D-TA's open-architecture MFEL-5000 GSN dual channel ELINT solution leverages multi-core software-based processing for rapid adaptation for evolving threats. The system combines the antennas with dual high-performance superheterodyne receivers and a powerful RAID server with large processing power and storage capability.

Antenna Control Unit (ACU)

DTA-9590R (Ultra-Wideband Receiver)

CLK-15A (GPS & Clock Distribution Unit)

DTA-9590R (Ultra-Wideband Receiver)

DTA-5000W (RAID Server)

1GbE Ethernet Switch

Figure 7(a): MFEL-5000 GSN (Processing Subsystem)

Omni Antenna

Spinning DF Antenna

RF Distribution Module

Mast

Figure 7(b): MFEL-5000 GSN (with Omni and Spinning DF Antennas, RF Distribution Module is mounted up mast to allow for long RF cables)

MFEL-5000 GSN System Overview:

MFEL-5000 GSN system includes the following sub systems:

- An Omni and a Spinning DF antenna for situation view and bearing estimation of signals of interest upon operator command or automatically;
- An Antenna Control Unit (ACU) that controls the operation of the Spinning Antenna (Start, Stop, Spin rate, etc). The antenna pointing angle (APA) is provided as 14-bit data word to the receiver;
- An RF distribution unit (DTA-959T, placed up mast) with input protection, blanking control, gain, frequency band selection filtering and provision for BIT (Built-In-Test);
- Dual high-performance ELINT/ESM receivers, one for the Omni and the other for the DF antennas. The receivers are tunable across the entire 0.5 to 18 GHz band with a 500 MHz IBW (or 1 GHz). The operating bandwidth is DDC selectable from 10 to 500 MHz. The receivers output baseband I/Q data over a 100 Gbit optical networks to the RAID server. The receiver data packet headers include relevant programmed parameters and timing information. The DF receiver data packet header also includes APA information;
- A GPS clock and timing signal distribution unit (CLK-15A) that provides receiver synchronization, as well as the UTC time and Network Time Server function. The CLK15A incorporates a GPS receiver to maintain the UTC time reference; and,
- A RAID Server (DTA-5000, 1U) that has multiple processing cores, multiple 100 GbE optical ports for data and 1 GbE copper ports for control. The DTA-5000 also includes twenty-four (24) 2.5” bays for data storage. RAID-0 configuration is used to support sustained data recording at very high throughput rate. With 24 TB storage the data recording time is 2 hours 40 minutes continuous at full 500 MHz BW. With 96 TB, the recording time quadruples.

Processing Concept:

As discussed, MFEL-5000 GSN is a dual antenna and dual receiver architecture for providing high quality signal intercepts and data collection. The system uses an Omni, and a Spinning DF antenna. Aside from the antennas, MFEL-5000 GSN essentially has an RF Distribution Module, two (2) DTA-9590R receivers and DTA-5000 RAID Server.

The MFEL-5000 system uses a weighted random 'hop' search strategy and provides the operator full flexibility to enable/disable frequency bands and set relative revisit weighting and dwell time for each band (see figure 3). The Omni receiver channel performs search, detection, and signal track establishment. Automatically or when commanded, the DF channel finds signal bearing and/or recording I/Q data. The scan task continues during DF for maximum probability of intercept. D-TA's powerful signal detection and parameter extraction algorithm can operate in a low SNR environment. The PDWs are created for the Omni channel and are used to estimate tracks of distinct signals. The tracks are held in a track table and remain active if new pulses for the signal are intercepted. MFEL-5000 has multiple data streams available to external clients in various formats. They include live raw I/Q data & PDW data streams.

In simple terms the basic MFEL system operation is as follows:

The Omni and Spinning DF antennas are configured to work collaboratively for automatic long-range intercept and DF achieve an ESM support role. Alternatively, in the ELINT role, the Omni channel is used to find signals of interest (SOI) based on operator defined scan script. The operator then decides based on signal track information which signals to get bearing on. The Spinner channels is then activated to get bearing information for the specific signal frequency and bandwidth. When the system is commanded to record a particular SOI, the spinner is set on that bearing for data collection for the defined duration.

Mission Planning:

Receiver Hopping:

- The MFEL receiver is optimally designed for high-fidelity recording of radar signals. The trade-off to obtain a high-fidelity signal was an instantaneous bandwidth limited to 500 MHz. Reducing the bandwidth any further to improve measurement resolution would seriously hamper the ability to capture high value targets with wide bandwidth RF agility.
- MFEL must dwell and HOP to scan the entire 0.5 to 18 GHz range: and,
- The HOP Schedule provides the Mission Planners, and the Operator, supervisory control over the hopping algorithm, to optimize the trade-off between spectrum coverage and receiver availability at any frequency.

Simple Operator Display:

The Track display shows waterfall display and track details with polar plot for DF reference. After the hop schedule is set up, the track table shows SOIs with PW, centre Frequency, PRI, Signal Power, and Time of Arrivals for the Operator to select a particular signal track to DF or record.

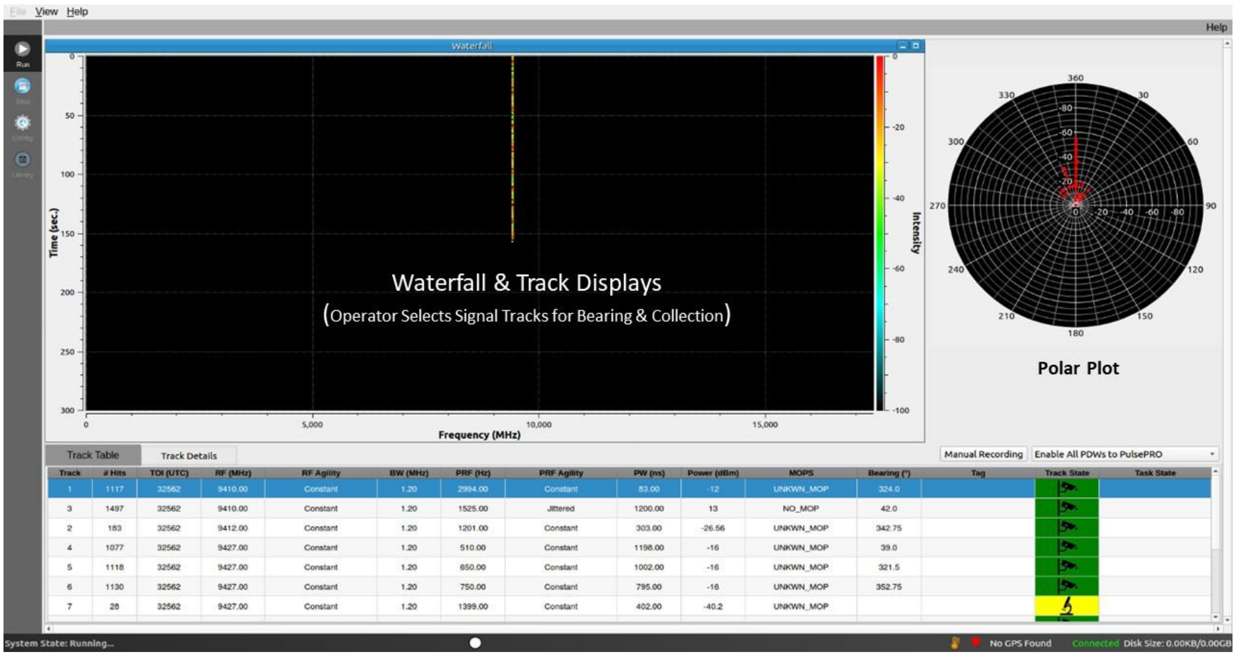


Figure 8: MFEL User Interface Display

The MFEL system provides a signal level view of the EW environment which greatly reduces the complexity and chaos that the Operator is faced with when viewing raw live pulse data. The MFEL Track Table contains the known active signals (Tracks) that were recently detected in the environment.

Each row of the Track Table is a separate signal in the environment, and the columns summarize the key ELINT signal parameters. The PDW Table of individual pulses contains generic parameter features, such as Pulse Width, Center Frequency, PRI, Time of Arrival (TOA) and MOP flag. Once a Track row is selected, the complete signal parameter description is displayed in the text window below the table. Many of the detailed signal attributes are only applicable to a particular class of signal agility so the full Track description is a formatted text description tailored to each agility class (see figure 10).

The Track Table is a focal point for many of the functions that the Operator does. Once a Track is selected in the Track Table the Operator will be able to:

- Tag the Track with a name for quick reference (e.g., Consort) [14]
- Add Comments to the Track (e.g., collection conditions, etc.)
- Open graphical views of the PDWs for the selected Track
- Open graphical views of MOP features of a pulse in the Track
- Schedule the Track for DF
- Schedule the Track for ELINT Collection (following DF estimation)

Each Track maintains a collection of recent PDWs for the associated signal. Opening a PulseView window from a selected Track gives the Operator a de-interleaved signal to view, which greatly enhances the Operator's ability to be productive quickly. PulseView offers a large selection of display options:

- 2D scatter plots of pulse parameters
- Any PDW attribute vs TOA (Time)
- PRI (Delta-TOA) vs TOA
- RF vs PW
- Histograms (RF, PW, PRI, etc.)
- Falling Raster plots (Time vs Time)
- Transition Matrix plots (state transitions)
- Scan Envelope plots

Figure 9: 2D Scatter Plot Display

The 2D scatter plot consists of up to 4 plot panes within a single window which can independently select the PDW parameter for the X and Y axis. A default view is to display 4 PDW parameters (e.g., Power, Frequency, PW & PRI) against a common X axis of TOA (Time of Arrival). The histograms of the selected Y-axis parameters can be shown as well.

The Operator can Pan or Zoom the displayed data. Any data points selected in one display pane will select the underlying PDW and cause all display panes to highlight any points associated with the selected PDWs. This linking of the display panes greatly enhances the operator's ability to explore the signal data.

Emitter Identification and Threat Libraries:

MFEL-5000 GSN System supports automatic Emitter Identification of intercepted signals against a customer supplied Threat Library of known radar operating modes. An API message is used to load the threat library into the system. MFEL system's Emitter Identification can operate with a wide range of available knowledge of the known radars; from incomplete or simple Emitter Parameter Limited libraries (combinations of RF, PRI, PW, and Antenna Scan behaviors), up to very detailed agility data (similar, in structure, and compatible with the Electronic Warfare Integrated Reprogramming Database EWIR-DB). The process involves matching candidate

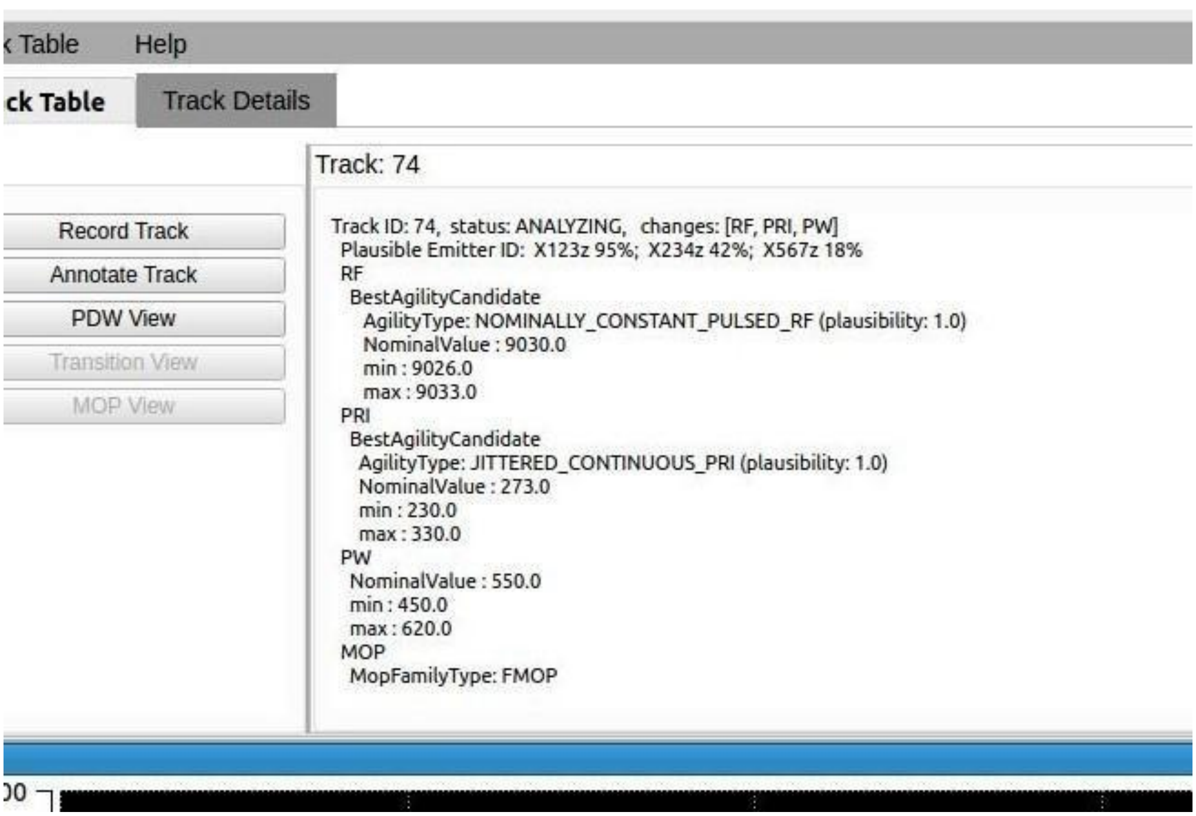


Figure 10: Track Details

emitter descriptions from the Threat Library against each observed Track (signal) to attempt to identify the emitter. Each match returns a ranked list of plausible Emitter IDs, each with a Plausibility measure for the degree of fit (typically known as the confidence level). All measured parameters are used in the emitter matching process to reduce ambiguities and achieve specific emitter identification (SEI). The system provides a list of the best emitter candidates ranked with decreasing order of plausibility (i.e., confidence levels) values.

Emitter Tracks with associated Radar Systems IDs fulfill multiple roles:

- ES Situational Awareness;
- Collect an Electronic Order of Battle (EOB); and,
- Identify Signals of Interest to record for detailed post analysis.

Optionally, an Emitter Library Editor is provided as a stand-alone web UI application that enables a threat library to be generated. The application provides the ability to add new platforms, emitters, and modes to a database file. Multiple files can be saved and used by the MFEL user interface (UI) as needed by the specific mission. Each library file supports >10,000 emitter modes. The emitter library application provides other important views to the user such as the association between emitters, platforms, and associated platforms.

Data Recording:

As discussed, the operator at any time selects a particular track for collection. The track information along with baseband I/Q data of the signal of interest (SOI) is collected for the defined duration. During this operation, the DF channel is tuned to the SOI center frequency and bandwidth, and the spinning antenna is pointed to the signal direction.

MFEL-5000 GSN System Specifications:

Parameter	Value	Comment
Frequency Range	0.5 to 18 GHz	*Up to 40 GHz optional
Instantaneous BW	500 MHz	Operating BW DDC selectable from 10 to 500 MHz
Antenna Types	1 x Omni, 1 x Spinning DF, and 1 x GPS antennas	GPS Antenna provides Timing signals and Global Time & Positioning data
RF Distribution & BIT Unit	Dual Channel with 40 dB Programmable Gain & 4 Selectable Filter Bands	The RF Distribution & BIT Unit also includes a Synthesizer for Built-in-Test (BIT), Blanking & Protection Circuitry
Receiver Architecture	Super-Heterodyne Dual Receivers	14-Bit Data Converters
System Sensitivity	-80 dBm	At Full 500 MHz BW
Typical Dynamic Range	60 dB	
Operating BW	500, 250, 100, 50 & 10 MHz	BW selected for RF Scanning
Pulse Amplitude Accuracy	+/- 1 dB	`
PW Range	20 ns to 10 ms	
PW Range Resolution	10 ns	
PRI Range	1 us to 100 ms	
PRI Range Resolution	10 ns	
Scan Measurement Range	5 ms to 30 s	
DF Azimuth Coverage	360°	
DF Coverage Elevation	45°	
Antenna Rotor Speed	Up to 200 rpm	
Pulse Density	>1 MPS (Within IBW)	
No. of Emitters Tracked	>500	
Intra-pulse Analysis	For Recorded Data	Using D-TA's SVAS software
Emitter Types (Frequency/PRF)	Chirp, CW, Frequency Agile, Phase, Coded, PRF Jittered, PRF Staggered, Pulse Coded, Pulse Doppler, Stable Pulse	
Emitter Types (PRI)	Fixed, Jitter, Slide, Stagger, Switch	
Emitter PW Types	Agile, Fixed	
Recording Capacity	24TB Standard	>100 TB available for >106 hrs. of recording at full BW of 500 MHz.

MFEL-5000 UAS

Lightweight R-ESM System for UAV and Soldier-Portable Deployments:

MFEL-5000 UAS R-ESM system is designed for virtually any platform for rapid deployment. It uses the latest RF and FPGA technologies to provide advanced ESM solution that only has 2 LRUs. A 4-element antenna array (ANT-4RC) and a Receiver Processor Unit (RPU, DTA-9590R-4RU). All ESM processing is done in the RPU. The total system weight is only 21 lbs. and power consumption is less than 150 Watts.

MFEL-5000 UAS R-ESM System:

For UAV deployment, the MFEL-5000 UAS system is connected to the UAS datalink, GNSS receiver and external 10 MHz reference and 1 PPS signals. The signal track output from the RPU is streamed to the Ground Control Station (GCS) via the customer supplied datalink. The system is remotely controlled and managed from the Ground Control Station.

ANT-4RL Linear Array
(14.25” L x 4.75” H, 3” D)

ANT-4RC Circular Array
(4” H x 6” D, Wgt. 3 lbs.)

DTA-9590R-4RU 4-Ch. Phase-Coherent Receiver Processing Unit (RPU) with integrated ESM processing. RPU directly outputs Signal Track and Bearing data. (12.62” W x 11.37” H, 6.7” D)

Figure 11: MFEL-5000 UAS system is primarily comprised of two major sub systems (LRUs): Antenna array (circular or linear) and a Receiver processing unit. The linear array provides higher DF accuracy over a limited FOV (120 deg).

For Man-portable deployment the MFEL system is mounted on a mast. The GPS antenna, integrated with the antenna array, provides reference signals and positional information. The signal track output is sent to the user device (a rugged Laptop) via a 1 GbE LAN. The user device controls the operation of the MFEL system.

As shown in Figure 13, two lightweight LRUs form the heart of the MFEL system. The base system covers 2-18 GHz frequency range which can be expanded to cover up to 40 GHz. The standard IBW is 500 MHz.

Circular Antenna Array for Instantaneous 360° Azimuth Coverage:

A circular antenna array built with 4 spiral antennas is used for instantaneous 360-deg field of view (FOV). The antenna array has 6" diameter, approximately 4" tall and weighs only 3 lbs. DTA Systems took advantage of the recent advancements in lightweight strong materials to build antenna array enclosures using 3D printing.

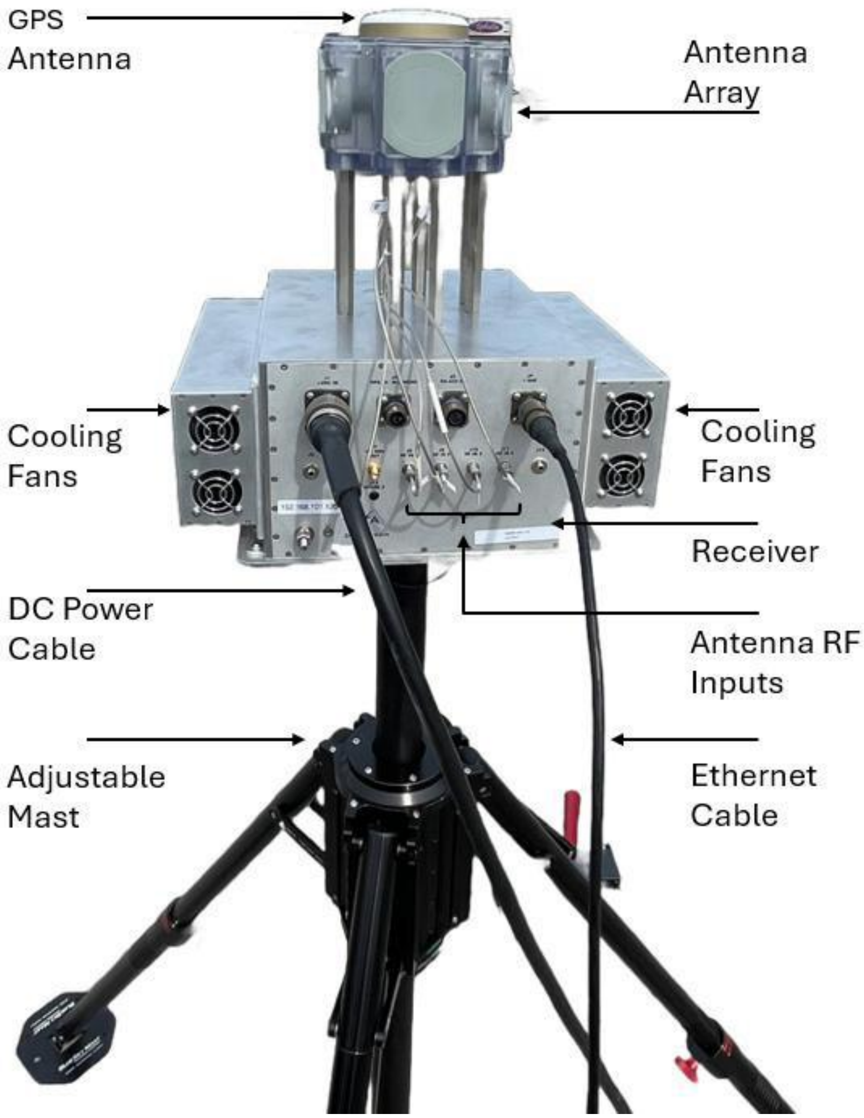


Figure 12: Soldier-Portable version of the MFEL-5000 UAS

The 3D printing technology accelerates development time by allowing for direct manufacturing from a 3D model rather than investing in the establishment of product-specific manufacturing processes.

Mono-pulse DF technique is used for bearing estimation. The DF accuracy is typically between 5-10 degrees for 4 element circular antenna array.

Figure 13: Typical UAV deployment of MFEL-5000 UAS

Receiver Processing Unit:

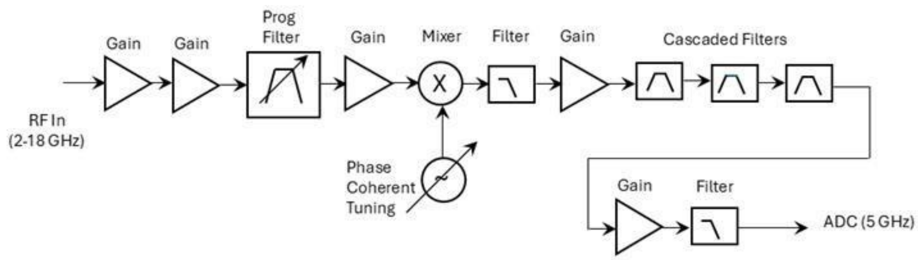
The RPU is the heart of the processing that converts antenna signals to signal tracks. As discussed, the frequency tuning range is from 2-18 GHz (optionally from 0.5 – 40 GHz) and the IBW is 500 MHz.

The receiver system includes 3 major subsystems:

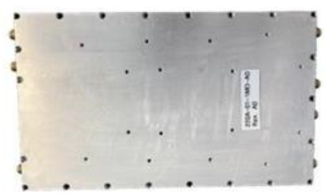
a) 4-phase coherent RF downconverters;
b) Xilinx's RFSoC FPGA based digitizer and real-time digital signal processor; and
c) a single board computer for system management, signal track estimation and communication.

a) Wideband Downconverter:

Two dual-channel compact downconverters are used to construct a 4-channel phase coherent RF down converter. The downconverter has a typical gain of 50dB, a noise figure of 10-13 dB (over the frequency range), a third order intercept (IP3) of typically 25dBm and a single tone spurious of typically 60dBc. The downconverter is calibrated for gain flatness over the temperature range and is digitally controllable for tuning frequency, gain and tunable filters.



RF Down Converter block diagram (1 of 4 Channels). A single mixing stage is used by taking advantage high ADC sampling rate



Dual Channel RF Down Converter module (2 used for 4 channels)

Figure 14: A simplified block diagram of the RF down converter (single channel) and picture of the down converter module (x2) used in the software radio.

The RF down converter design takes advantage of the high ADC sample rate (5 GSPS) to use a single mixing stage to achieve superheterodyne performance. The sensitivity of the receiver system is better than -72 dBm (note the spiral antenna offers no gain) and the instantaneous BW is 500 MHz.

For the MFEL-5000-UAS system 4 matched RF down converts (phase and gain matched) are used with a common synthesizer circuitry for phase coherent tuning. The frequency tuning range is from 2 to 18 GHz.

b) FPGA Based High-Speed Digitizer & Processor:

Digitization is done by AMD’s Zynq Ultrascale+ RFSoC technology that integrates 14-bit 5GSPS ADCs with the FPGA logic and multi-core processors into a single chip to enable low latency, efficient parallel processing capabilities, small size and low power consumption, and large instantaneous bandwidth. Furthermore, this tight integration facilitates the RF side by having fewer analog components and by performing the second stage of the down-conversion by high ADC sample rate, resulting in faster development time and upgrades of EW systems.

The FPGAs of the digitizer boards perform the second down-conversion stage and its associated digital filtering, and signal detection where the high-speed I & Q samples are compressed into Pulse Descriptor Words (PDWs) for Pulsed and CW signals.

Pulse detection is performed in time domain after a proprietary signal-to-noise ratio booster transform to extract time of arrival, pulse width, power, and SNR while FFT-based frequency domain processing is used for frequency, bandwidth and phase estimation, and modulation-on-pulse recognition. This hybrid approach allowed the ES system to achieve the best possible time and frequency parameters accuracy.

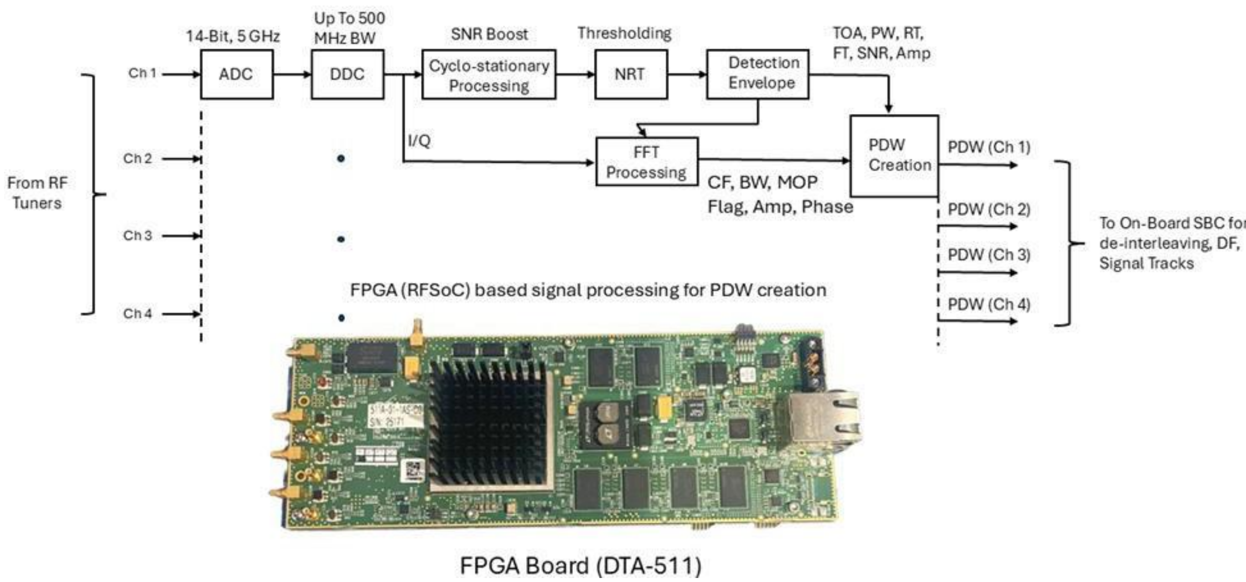
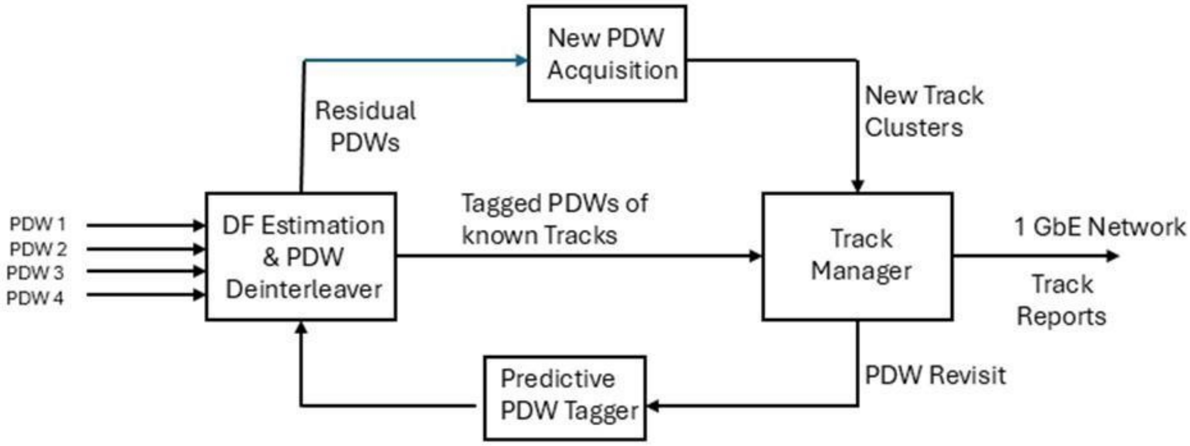


Figure 15: RFSoC FPGA signal processing architecture (top) and the FPGA board (bottom).

c) Single-Board Computer:



Signal track estimation using a low-power small form factor SBC

Arm Processor SBC

Figure 16: Processing configuration (top) of the single-board computer board.

The PDWs from the FPGA board provide amplitude information which is used estimate signal bearing (DF) using a predefined calibration table (frequency vs amplitude for different AoAs). The PDWs are deinterleaved to associate clusters of PDWs to different radar types. It is a complex process as this association is not perfect due to poor SNR, receiver artifacts, propagation effects, etc. and a statistical approach is used create signal track reports for transferring to the user. The single board computer houses software applications responsible for managing the receivers, providing status reports and processing PDWs to generate concise emitter tracks. These tracks are then streamed through the customer datalink.

MFEL Human Machine Interface & Displays:

The MFEL-5000 system can be operated from the user device (Laptop computer) for man-portable deployment or from the GCS for UAS deployment. The MFEL-5000 system is designed to operate with minimal operator training. Once the system is set up with appropriate frequency scan parameters, the system starts providing situational awareness with detected signal details without human intervention.

The MFEL system uses a search strategy that provides complete flexibility in RF search coverage. The Operator is free to enable/disable bands and to set the relative revisit weighting for each band. In addition, the Operator has control over the Dwell time that will be used for all hops in the search. This simple to understand strategy allows the Operator a very high degree of control over the search pattern.

Once the system is activated with the appropriate search script, the situation view page is displayed. The situation view page is the “home” page for the system while it is actively searching for signals of interest. This page provides a high-level EW situational view by displaying the signals that are currently active in the environment. EW situational view shows waterfall display and track details which shows SOIs with PW, Centre Frequency, PRI, Signal Power, DF, Time of Arrivals for the operator to select a particular signal track to record.

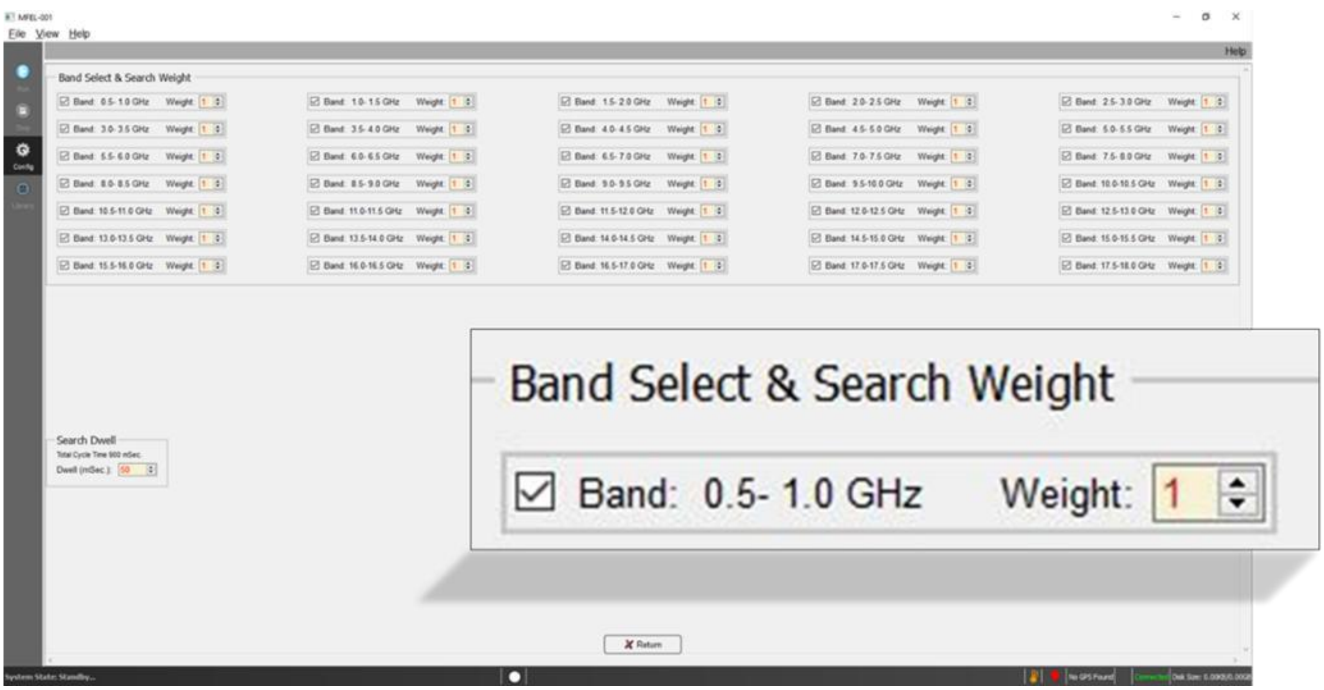


Figure 17: The operator only fills the scan table and dwell time in each selected frequency band to obtain situational view.

Situational View:

Track display shows waterfall display and track details with polar plot for DF reference. After the hop schedule is set up, the track table shows SOIs with PW, centre Frequency, PRI, Signal Power, Time of Arrivals and DF.

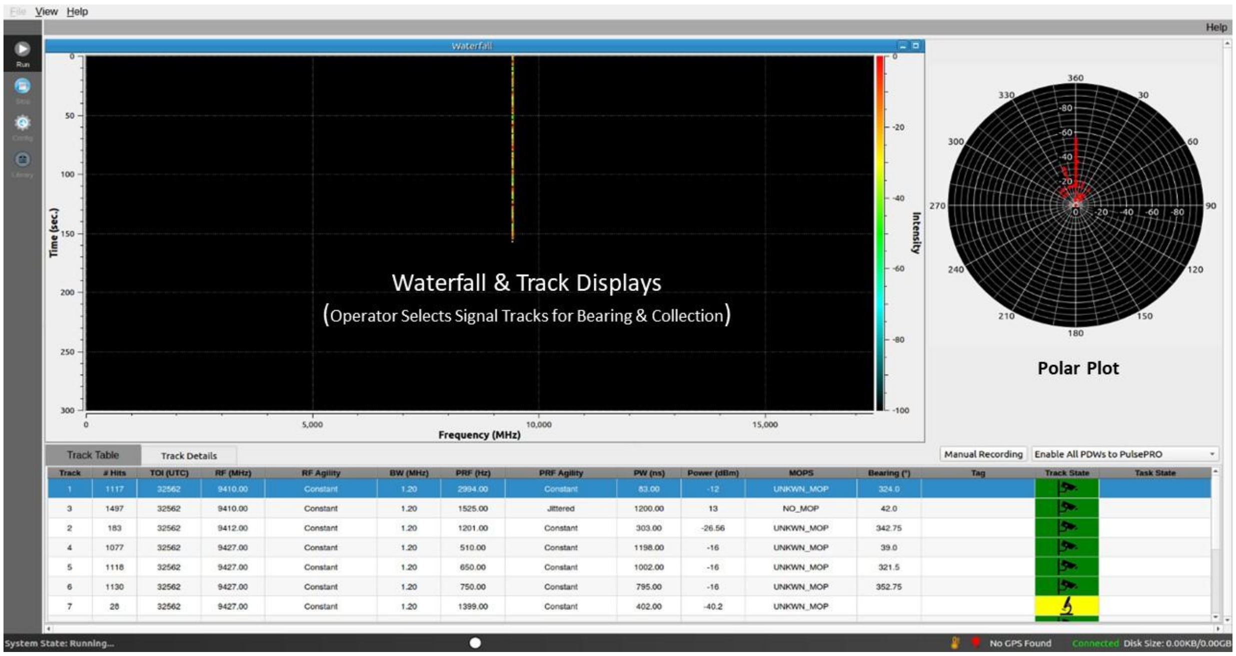


Figure 18: Waterfall and Track display

The MFEL system provides a signal level view of the EW environment which greatly reduces the complexity and chaos that the Operator is faced with when viewing raw live pulse data. The MFEL Track Table contains the known active signals (Tracks) that were recently detected in the environment.

Each row of the Track Table is a separate signal in the environment, and the columns summarize the key ELINT signal parameters. The PDW Table of individual pulses contains generic parameter features, such as Pulse Width, Center Frequency, PRI, Time of Arrival (TOA) and MOP flag. Once a Track row is selected, the complete signal parameter description is displayed in the text window below the table.

MFEL-5000 UAS Broad Specifications:

Parameter	Value	Comment
Frequency Range	2.0 to 18.0 GHz	(Opt. to 40 GHz)
Instantaneous Bandwidth (IBW)	500 MHz (1 GHz Opt.)	Operating BW DDC Selectable from 10 to 500 MHz (Opt. 1 GHz)
Receiver Architecture **System Sensitivity**	Super-Heterodyne Receiver -72 dBm	14 - Bit Data Converter At full 500 MHz BW
Typical System Dynamic Range	60 dB	
Operating BW	500, 250, 100, 50, 25, & 10 MHz	Any BW can be Selected by DDC Programming
Pulse Amplitude Accuracy	+/- 1 dB	
PW Range	30 ns to 10 ms	
PW Accuracy	0.01 usec RMS	
PRI Range	1 usec to 100 ms	
PRI Accuracy	0.01 usec RMS	
Pulse Density	1 MPPS (within the IBW)	
Number of Emitters Tracked	Greater than 500	
Intentional Modulation-on-Pulse Recognition	LFMOP, NLFMOP, FSK, Barker Codes, QPSK, Frank and Costa Codes, Polyphase Codes	Only MOP flag (FMOP, PMOP and NOMOP) is provided in track table. SVAS software allows MOP recognition capability
DF Accuracy	5-10 Degrees (monopulse DF)	Opt. linear array with 1 to 2° DF accuracy (interferometric technique)
Emitter Types (Frequency)	CW, Agile, Random or Periodic	
Emitter Types (PRI & PW)	Agile, Fixed	

Software Highlights

Recorded Signal Visualization and Analysis Software (SVAS):

SVAS is a Windows compatible standalone executable which allows for the baseband data retrieval, visualization, and advanced signal processing for the recorded baseband I/Q data on the D-TA server. The software is powered by state-of-the-art D-TA proprietary algorithms running under the hood to provide the user with detailed analysis of the recorded digital data for ELINT/ESM applications. The software architecture is fully flexible and open to user requirements in terms of providing support for advanced digital signal processing. The base version of the software encompasses visualization of baseband I/Q data and its subsequent analysis including signal detection, Pulse Descriptor Words (PDW) creation and pulse deinterleaving and classification of multiple sources. I/Q data can be ingested by the software with any unclassified format. Standard format includes, dta, .csv, .txt, VITA49, etc.

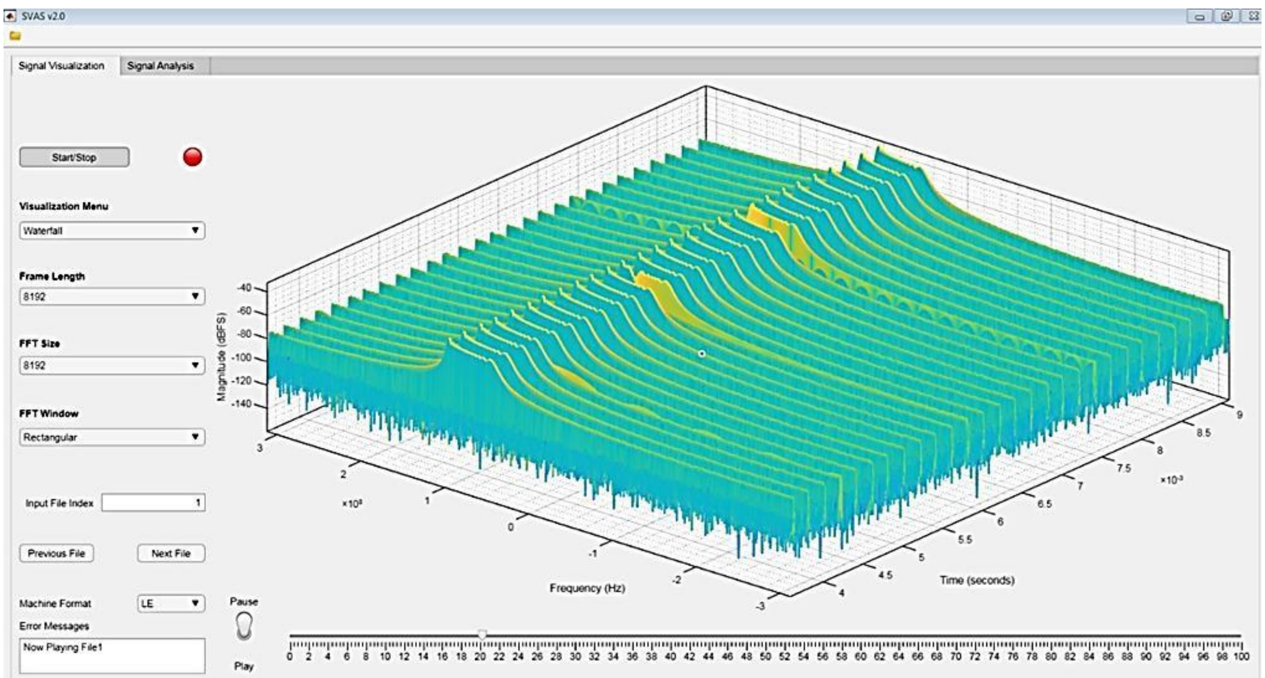


Figure 19: SVAS Signal Display

Signal Visualization Functionality:

1. Allows the users to visualize the recorded signals within Frequency-Temporal space;
2. User defined Time and Frequency resolution on the data;
3. Interactive GUI with slider controls, file navigation options, to examine any portions of the recordings on-the-fly; and,
4. Measurement tools on the GUI to facilitate measurement of time-frequency parameters of the signal. Data/File upload option which is data format agnostic.

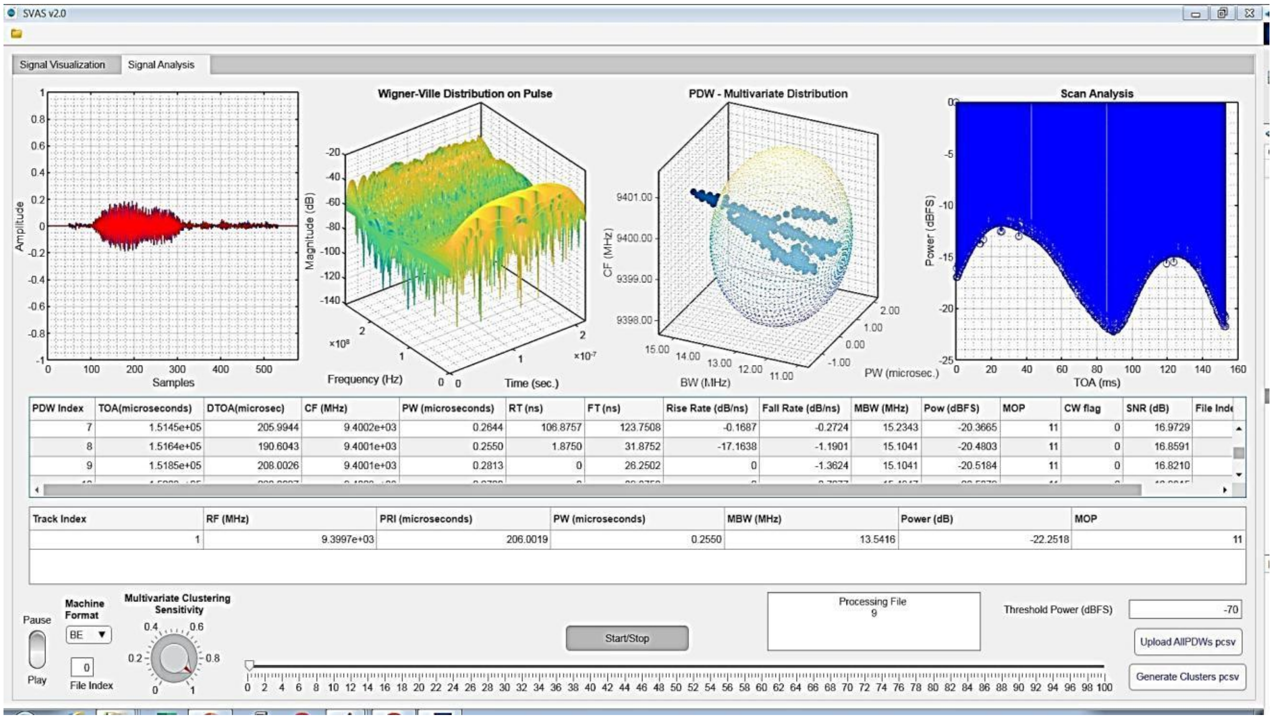


Figure 20: SVAS Signal Visualization

Signal Analysis Functionality:

1. Signal detection and measurements;
2. Intentional and Unintentional Modulation on Pulse (IMOP and UMOP) Identification;
3. Pulse Descriptor Words (PDW) generation;
4. Autonomous and Unsupervised clustering of PDWs using multivariate statistics;
5. Emitter Track Creation and autonomous fusion based on multivariate proximity; and,
6. Scan Analysis display and measurement tools for estimating scan periods and scan types.

DEW-DOS Open-Source Threat Library:

D-TA offers an open-source (unclassified) threat library with over 10,000 emitters. Not every researcher, scientist, engineer, or technician have access to classified electronic warfare data to enable their work. Nor may they need the precision of classified data; instead, relying on representative and typical emitters to perform their activities in a rapid fashion without all of the requirements that come along with accessing and protecting classified data. Our unclassified database of over 10,000 emitter modes includes emitters spanning the globe and has examples of nearly every type of platform and emitter. The database is completely editable and changeable to reflect the parameters and characteristics of signals unique to your requirement. Contact us for more information.

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D-TA Systems

D-TA offers cutting-edge solutions for Electro-Magnetic Spectrum Operations (EMSO) to those who protect us.

From Antenna and RF Design to High-Speed Networks and Multi-core Real-Time Software Technologies, D-TA controls the technology stack to bring you end-to-end solutions for:

- SIGINT for spectral surveillance for threat detection
- EW Threat Emulation for device testing and operator training
- Over-The-Horizon Radar for long-range surveillance
- Wideband multi-channel RF & IF record/playback
- Extreme-SWaP and mission agnostic EMSO solutions

Excellence In Spectrum Operations

WE PROTECT

As threats become more agile, deceptive and diverse, our mandate becomes more focused on delivering open-architecture EW sensor solutions that drastically cut deployment risk, time and cost.




For more information, please visit our website at:
www.d-ta.com

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