Radio Frequency Detection, Spectrum Analysis, and Direction Finding Equipment

Market Survey Report

April 2019

Homeland Security
Science and Technology

NUSTL®
NATIONAL URBAN SECURITY TECHNOLOGY LABORATORY

Approved for Public Release

SAVER-T-MSR-19

The *Radio Frequency Detection, Spectrum Analysis, and Direction Finding Market Survey Report* is funded under Interagency Agreement No. HSHQPM 15 X 00134 from the U.S. Department of Homeland Security, Science and Technology Directorate.

The cover photo and images included herein were provided by the National Urban Security Technology Laboratory, unless otherwise noted.

FOREWORD

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions. The National Urban Security Technology Laboratory (NUSTL) located within the DHS Science and Technology Directorate (S&T) manages the SAVER Program, conducts objective assessments and validations on commercially available equipment and systems, and develops knowledge products that provide relevant equipment information to the emergency responder community. The SAVER Program mission includes:

- Conducting impartial, practitioner relevant, operationally oriented assessments and validations of emergency response equipment.
- Providing information, in the form of knowledge products, that enables decision makers and responders to better select, procure, use, and maintain emergency response equipment.

SAVER Program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: "What equipment is available?" and "How does it perform?" These knowledge products are shared nationally with the responder community, providing a life-and cost-saving asset to DHS, as well as to federal, state, and local responders.

NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER knowledge products, coordinating with other organizations, and ensuring flexibility and responsiveness to first responder requirements.

NUSTL provides expertise and analysis on a wide range of key subject areas, including chemical, biological, radiological, nuclear, and explosive weapons detection; emergency response and recovery; and related equipment, instrumentation, and technologies. NUSTL developed this report to provide emergency responders with information obtained from an operationally oriented assessment of radio frequency (RF) detection, spectrum analysis, and direction finding equipment, which fall under AEL reference numbers 06CP-07-RFSA, titled RF Detection and Spectrum Analysis Equipment, and 06CP-07-RFDF, titled RF Direction Finding Equipment.

For more information on NUSTL's SAVER Program or to view additional reports on RF detection, spectrum analysis, and direction finding equipment, visit the DHS S&T SAVER home page at www.dhs.gov/science-and-technology/saver.

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders

POINT OF CONTACT

National Urban Security Technology Laboratory (NUSTL)
U.S. Department of Homeland Security
Science and Technology Directorate
201 Varick Street
New York, NY 10014

E-mail: NUSTL@hq.dhs.gov
Website: www.dhs.gov/science-and-technology/saver

Author:
Hasan Shahid, SAVER Program

EXECUTIVE SUMMARY

In recent years, radio frequency (RF) jammers have become increasingly more accessible to the public. While most RF jamming is benign and simply intended to provide extra privacy, first responder operations have also been specifically targeted by jamming and interference attacks. RF detection, spectrum analysis, and direction finding equipment can be used to detect, identify, and locate RF interference sources that may be disrupting first responder communications systems.

Many RF technologies are available for operational field usage, as opposed to laboratory usage. This allows for quick deployment, letting responders locate and mitigate radio interference. Some of these products can be installed as a permanent fixed sensor or can be portable and deployed temporarily as a fixed sensor. Other products are handheld and mobile, allowing responders to thoroughly search an area, which may be affected by RF interference.

Some of these products have features such as built-in map and spectrum plot displays to provide data visualization or internal storage drives that allow data to be recorded for future analysis. These technologies can detect RF interference sources at frequencies as low as 9 kHz and as high as 18 GHz.

The purpose of this market survey report is to provide emergency responders with information on RF detection, spectrum analysis, and direction finding equipment that are commercially available in order to guide purchasing and acquisition decision-making.

In June 2018, NUSTL through its System Assessment and Validation for Emergency Responders (SAVER) Program, conducted a market survey of RF detection, spectrum analysis, and direction finding equipment. The survey produced 14 products ranging in price from $15,000 to $270,000. The results of the market survey are highlighted in this report. Performance of these products has not been independently verified by NUSTL.

Emergency response agencies that consider purchasing RF detection, spectrum analysis, and direction finding equipment should carefully research the overall capabilities and limitations and technical specifications of each system in relation to their agency's operational needs.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Radio frequency (RF) detection and spectrum analysis equipment includes devices that can detect, identify, and analyze RF signals transmitted by various sources. RF direction finding equipment includes devices that measure and triangulate the direction from which an RF signal was transmitted. These devices can be used to identify and locate transmissions from suspicious or threatening sources, including RF interference that may be blocking first responder communications or damaging electronic devices. NUSTL, through its System Assessment and Validation for Emergency Responders (SAVER) Program, conducted a market survey to provide emergency responders with information on RF detection, spectrum analysis, and direction finding equipment.

This market survey report is based on information gathered during June 2018 from vendor websites, internet research, industry publications and a government-issued Request for Information (RFI) that was posted on the Federal Business Opportunities website. For inclusion in this report, products had to meet the following criteria:

- Product must be commercially available
- Product must be designed for usage in the field rather than in a laboratory environment
- Product must be designed to detect RF signals intended to interfere with first responder communications systems.

Due diligence was performed to develop a report that is representative of products in the marketplace.

2.0 RF DETECTION, SPECTRUM ANALYSIS, AND DIRECTION FINDING EQUIPMENT OVERVIEW

In recent years RF jammers have become increasingly more accessible to the public. While most RF jamming is simply intended to provide extra privacy, first responder operations have also been specifically targeted by jamming and interference attacks.

Radio interference works by targeting receivers. An RF jammer will transmit a signal on the same frequency as the desired signal. The jamming signal may be received at the same power level or a greater power level, thus preventing receivers from being able to distinguish the desired signal from the jamming signal.

While radio communications may be the most obvious target of RF jammers, these interference sources can also disrupt the operation of other devices that communicate wirelessly. An example of this is the usage of a Global Positioning System (GPS) jammer by a truck driver to avoid paying highway tolls and avoid being tracked by his or her employer. Alternatively, an example of an RF jammer specifically targeting first responder operations is an interference source preventing a control center from receiving video uploaded by traffic cameras.

2.1 Current Technologies

The technologies listed in this report range from fixed site sensors with omnidirectional antennas for spectrum monitoring to mobile handheld sensors with directional antennas for direction finding. Most of the products in this report can operate as a standalone sensor. However, some products, especially fixed site sensors, can be networked for greater monitoring coverage. While some of the technologies include a built-in display, many use an external laptop or tablet, which provides a spectrum analyzer or a map display locating any detected RF jamming and interference sources.

2.2 Applications

As mentioned above, RF jamming and interference can disrupt first responder communications during emergency response operations. RF detection devices can be used to identify any RF interference that might impact communications. Spectrum analysis devices can be used to determine the frequency and received strength of RF interference. Spectrum analysis devices can also be used to identify frequencies that are free of interference should a responder use channel switching as a RF jamming mitigation tactic. RF direction finders can assist in locating RF jamming devices. If the interference source is located, responders can apply direct mitigation tactics to overcome the impacts of RF jamming.

3.0 PRODUCT INFORMATION

This section provides information on 14 RF detection, spectrum analysis, and direction finding devices that range in price from $15,000 to $270,000. Table 3-1 provides general product characteristics and/or specifications. Product information presented in this section was obtained directly from manufacturers, vendors, and their websites. The information has not been independently verified by the SAVER Program.

Product information in Table 3-1 includes price and product features such as:

Manufacturer: The company that develops the product.

Product: The name of the product.

Price: The cost of the base configuration of the product. This cost does not include maintenance, training, custom configurations, or upgrades,

Basic Capabilities and Features: RF detection, spectrum analysis, and direction finding capabilities, and the presence of a built-in display. A checkmark indicates that the base configurations of the product has the capability or feature.

Detection Bandwidth: The frequencies that the base configuration of the product is capable of operating, not including extensions.

Scanning Bandwidth: The instantaneous bandwidth, not including extensions, of the receiver included in the base configuration of the product.

Receiver Sensitivity: The minimum signal-to-noise ratio that the base configuration of the product is able to detect.

Table 3-1 Product Comparison Matrix

Manufacturer	Product	Price	RF Detection	Spectrum Analysis	Direction Finding	Built-In Display	Detection Bandwidth*	Scanning Bandwidth*	Receiver Sensitivity
Alion	Versatile RF Automated Monitoring System	$76,270.53	✓	✓	✓		20 MHz to 6 GHz	10 Hz to 650 kHz	22 dB, centered at 2 GHz
Applied Signals Intelligence	ASI 2020DF Fixed Site	$125,000	✓	✓	✓		2 MHz to 600 MHz	1 MHz	-134 dB to -123 dB
Applied Signals Intelligence	ASI 2020DF Backpack	$100,000	✓	✓	✓		2 MHz to 600 MHz	1 MHz	-134 dB to -123 dB
Chemring Technology Solutions	Resolve 3 HF/VHF/UHF Direction Finding System	$150,000	✓	✓	✓		1 MHz to 3 GHz (detection); 2 MHz to 3 GHz (direction finding)	40 MHz	<20 dB to <6 dB, dependent on frequency
CRFS	RF Eye Node	See Table 3-2	✓	✓			See Table 3-2	See Table 3-2	See Table 3-2
CRFS	RF Eye Guard	$130,000	✓	✓			Dependent on RF Eye Node integrated into the system	Dependent on RF Eye Node integrated into the system	Dependent on RF Eye Node integrated into the system
CRFS	RF Eye Array	See Table 3-3	✓	✓	✓		See Table 3-3	See Table 3-3	See Table 3-3
DGS	SigBASE 6000	$50,629	✓	✓	✓		50 MHz to 6 GHz	20 MHz to 80 MHz	Dependent on transmission frequencies and antenna configuration
DGS	SigBASE 4000	$15,999; $7,999 for software	✓	✓		✓	70 MHz to 6 GHz	20 to 40 MHz	-114 dBm with 1 kHz bandwidth, centered at 2.4 GHz

Manufacturer	Product	Price	RF Detection	Spectrum Analysis	Direction Finding	Built-In Display	Detection Bandwidth*	Scanning Bandwidth*	Receiver Sensitivity
LS Telcom	LS Observer	$27,600 (FMU); $34,500 (PPU); $33,400 (PMU)	✓	✓	✓		9 kHz to 18 GHz (FMU and PPU); 9 kHz to 12.4 GHz (PMU)	9 kHz to 6 GHz (WB1 scanning mode); 100 kHz to 18 GHz (WB2 scanning mode); 100 kHz to 12.4 GHz (NB scanning mode)	Dependent on frequency; see Table 3-4
PCTEL	SeeWave Interference Locating System	$25,445	✓	✓	✓	✓	690 MHz to 6 GHz	5 kHz to 20 MHz	-120 dBm to -30 dBm, centered at 30 kHz
Rohde and Schwarz	PR100 Portable Receiver	$24,000	✓	✓	✓	✓	9 kHz to 7.5 GHz	Contact Rohde and Schwarz for specifications**	Contact Rohde and Schwarz for specifications**
Rohde and Schwarz	DDF007 Portable Direction Finder	$150,000	✓	✓	✓	✓	9 kHz to 7.5 GHz (detection); 20 MHz-6 GHz (direction finding)	Contact sales rep	Contact sales rep
Rohde and Schwarz	NESTOR Mobile Network Survey Software and RF Scanner**	Contact Rohde and Schwarz for pricing*		✓			350 MHz to 4.4 GHz	140 Hz to 1.438 MHz	-126 dBm with a 22.46 kHz bandwidth, centered at 900 MHz

***This information was not given because it is considered proprietary or competition specific by the vendor.**
****Specifications given for the R&S NESTOR reflect the typical configuration with the R&S TSMA Scanner.**

Acronyms:
FMU: Fixed Monitoring Unit
PPU: Protected Portable Unit
PMU: Portable Monitoring Unit
WB1: Wideband 1
WB2: Wideband 2
NB: Narrowband

Units:
Hz: Hertz
kHz: Kilohertz
MHz: Megahertz
GHz: Gigahertz
dB: Decibel
dBm: Decibel relative to 1 milliwatt

3.1 Alion Versatile RF Automated Monitoring System

The Alion Versatile RF Monitoring System (V-RAMS) is capable of RF detection, spectrum analysis, and direction finding. Key spectrum analysis features of the V-RAMS include stored trace, parametric and in-phase and quadrature (I/Q) data; terrain mapping of potential interference sources; editable spectrum masks; and a licensed database of emitters for identification of detected signals.

The V-RAMS can function in spectrum survey mode, manual or semi-automated mode, or real-time interference forensics and enforcement mode. The V-RAMS is a portable deployable system that operates as a fixed sensor system. The product can act as a standalone sensor or be networked with other V-RAMS units. The fixed yet portable setup enables real-time electromagnetic emissions monitoring, allowing users to track spectrum usage, recognize anomalous signals, and identify potential interference sources. V-RAMS alerts users to threshold violations as they occur, through audio, visual, or e-mail alerts.

Figure 3-1 Alion V-RAMS

Courtesy of Alion Science Signal

V-RAMS also incorporates a graphical user interface (GUI) software that can be run on Windows operating systems. The GUI can play back spectrum files and display parametric data of detected signals with a terrain map showing nearby transmitters. Azimuth charts can also be displayed if a directional antenna system is used.

The V-RAMS is capable of detecting RF signals within the bandwidth of 20 MHz to 6 GHz. An optional range extension to 75 GHz is also available. The scanning bandwidth of the V-RAMS ranges from 10 Hz to 650 kHz. The noise floor of the V-RAMS is 22 dB at 2 GHz. An external low noise amplifier (LNA) can increase the sensitivity of the receiver. The vendor specifies the entire system weighs less than 30 pounds. The price of the V-RAMS, as quoted by Alion, is $76,270.53.

3.2 Applied Signals Intelligence ASI 2020 DF Fixed Site

The Applied Signals Intelligence ASI 2020DF Fixed Site is capable of RF detection, spectrum analysis, and direction finding. The technology is a fixed site sensor that can intercept and locate analog and digital RF emitters in the high frequency (HF), very high frequency (VHF), and ultra-high frequency (UHF) frequency bands. The product can act as a standalone sensor or be networked for interoperability and data sharing with multiple systems.

The ASI 2020DF Fixed Site includes a user-interface software application that can be used with Windows-based operating systems. The interface provides spectrum plots and map displays as well as receiver control, search and scan, record, and other basic receiver functions. The software application can record audio files, geolocation data, and digital mobile radio metadata, which can be stored on internal or external hard drives.

The ASI 2020DF has a detection bandwidth of 2 MHz to 600 MHz. The scanning bandwidth of the product is 1 MHz with an available extension up to 50 MHz for permanent fixed site installations.

Figure 3-2 ASI 2020 DF Fixed Site

Courtesy of Applied Signals Intelligence

The receiver sensitivity, while dependent on frequency, ranges from -134 dB to -123 dB. The maximum detection range, as given by the vendor, is 10 to 15 miles; however, this is dependent on factors including the transmission frequency and power of the RF interference source and attenuation due to environmental conditions. Software-defined radio hardware used with the system is 12 x 5 x 2.75 inches and weighs 4.75 pounds. The antenna is 45 x 8.5 x 8.5 inches and weighs 12 pounds. The ASI 2020DF Fixed Site costs approximately $125,000.

3.3 Applied Signals Intelligence ASI 2020DF Backpack

The Applied Signals Intelligence ASI 2020DF Backpack is a mobile version of the fixed site sensor. The ASI 2020DF Backpack is designed for on-the-move operation and can be concealed for covert operations. The backpack version of the product also includes a ruggedized tablet on which the user interface software application is loaded.

Figure 3-3 ASI 2020 DF Backpack

Courtesy of Applied Signals Intelligence

The ASI 2020DF Backpack has a detection bandwidth of 2 MHz to 600 MHz. The scanning bandwidth of the product is 1 MHz. The receiver sensitivity, while dependent on frequency, ranges from -134 dB to -123 dB. The maximum detection range is 10 to 15 miles; however, this is dependent on factors including the transmission frequency and power and environmental conditions. Software-defined radio hardware used with the system is 12 x 5 x 2.75 inches and weighs 4.75 pounds. The antenna is 16.2 x 9.1 x 4.3 inches and weighs 2.4 pounds. The ASI 2020 DF Backpack costs approximately $100,000.

3.4 Chemring Technology Solutions Resolve 3 HF/VHF/UHF Direction Finding System

The Resolve 3 Direction Finding System was developed by Chemring Technology Solutions and is distributed in North America by Rapid Response Defense Systems. The system is designed as a man-portable direction finding system. The Resolve 3 provides operators wideband direction finding capabilities and real time position fixing in the HF, VHF, and UHF bands.

The Resolve 3 is modular and scalable, which enables mission specific tasking. System configurations allow for operation in a static position, on the march (on foot), and on the move (vehicle). While designed as a mobile solution, the Resolve 3 can also be used as a fixed site sensor. The product can be deployed as a standalone device and can be networked with other sensors through a wide variety of communications networks.

The Resolve 3 can be operated with either the TacFix software loaded onto a tablet running an Android operating system or the PreFix software loaded onto a laptop running a Windows operating system. The TacFix software allows for easy spectral surveying and monitoring and provides Esri maps for plotting direction-finding results. The TacFix also provides an audio alert when a potential RF interference source is detected. The PreFix software provides spectral displays, spectrograms, and Esri mapping. Any data accessed on the PreFix software can be saved to the laptop's internal hard drive for future analysis.

The Resolve 3 has a detection bandwidth of 1 MHz to 3 GHz for intercepting and receiving signals and 2 MHz to 3 GHz for direction finding with a scanning bandwidth of 40 MHz and a scan rate of 1.5 GHz/sec. The receiver sensitivity of the system is less than 20 dB from 1 MHz to 30 MHz, less than 20 dB from 30 MHz to 1690 MHz, and less than 6 dB at 1690 MHz, increasing linearly to less than 16 dB at 3000 MHz. The system weight, as given by the vendor, depends on the configuration, ranging from less than 18 pounds for a man portable system to a maximum of 60 pounds for a fully configured fixed system. The Resolve 3 costs $150,000 per unit and is subject to additional costs for accessories and training.

3.5 CRFS RF Eye Node 20-6, 50-8, 100-8, 100-18

The CRFS RF Eye Node is an intelligent wideband receiver capable of RF detection and spectrum analysis. The receiver can be deployed as a fixed sensor or a mobile sensor. It can also be integrated into the RF Eye Guard system. Multiple models of the RF Eye Node are available with total bandwidths up to 18 GHz and instantaneous bandwidths up to 100 MHz. Specifications of each model are listed in Table 3-2. The RF Eye Node is equipped with an internal solid state drive (SSD) to save data for future analysis. Various outdoor kits are available for the RF Eye Node. The RF Eye Node can be integrated into the RF Eye Guard and the RF Eye Array, both of which are described below. The size of the RF Eye Node 20-6 is 6.7 x 2.4 x 4.9 inches with a weight of 3.1 pounds. The size of the 50-8, 100-8 and 100-18 models are all 7.9 x 2.0 x 7.6 inches with a weight of 5.3 pounds.

Figure 3-4 CRFS RF Eye 100-18 Node

Courtesy of CRFS

Table 3-2 Comparison of RF Eye Node Models

RF Eye Node Model	20-6	50-8	100-8	100-18
Detection Bandwidth	10 MHZ to 6000 MHz	0.009 MHz to 8000 MHz	0.009 MHz to 8000 MHz	0.009 MHz to 18000 MHz
Instantaneous Bandwidth	20 MHz	50 MHz	100 MHz	100 MHz
Minimum Frequency Resolution	18 Hz	1 Hz	1 Hz	1 Hz
Noise Floor*	8 dB to 11 dB	6 dB to 10 dB	6 dB to 10 dB	8.5 dB to 13 dB
Receiver Sensitivity	-126 dBm	-128 dBm	-128 dBm	-125 dBm
Base Cost	$21,000	$26,500	$36,500	$60,000
System Cost**	$96,000	$147,000	$177,000	$247,500

***Noise floor specifications in this table represent a 10 kHz bandwidth centered at 1 GHz.**
****System cost includes 3 RF Eye Nodes and accompanying software.**

3.6 CRFS RF EYE GUARD

The CRFS RF Eye Guard continuous TSCM (Technical Surveillance Countermeasures) monitoring system is used for detection and spectrum analysis of RF listening devices (or bugs). The RF Eye Guard is designed for use in buildings and is typically installed in ceiling tiles.

Figure 3-5 CRFS RF Eye Guard

Courtesy of CRFS

The system is integrated with the RF Eye Node and can be a permanent security fixture or a temporary installation. A software based user interface displays spectrum plots and detailed floor plans locating any detected transmitters. The RF Eye Guard can locate interference sources within buildings by using time delay of arrival (TDOA) or Power on Arrival techniques. An internal SyncLinc timing system allows all nodes in a building to synchronize time within 10 to 20 nanoseconds without the need for GPS or other timing sources. The system is capable of generating permanent records of RF emission detections and be configured to generate alarms and notification in case an RF interference source is detected. Technical specifications including detection bandwidth, instantaneous bandwidth, minimum frequency resolution, noise floor, and receiver sensitivity are all dependent on the RF Eye Node model used with the system. The cost of the RF Eye Guard, as quoted by the vendor, is $130,000. This cost includes three RF Eye Nodes and accompanying software.

3.7 CRFS RF EYE ARRAY 50, 100, 125, 150, 300

The CRFS RF Eye Array is an integrated RF detection, spectrum monitoring, and direction finding system designed for vehicle mounted, transportable, or ground-fixed installations. The RF Eye Array can serve as a standalone sensor or be integrated with other RF Eye Arrays or RF Eye Nodes. A software based user interface provides spectrum plot and map displays. Like the RF Eye Node, multiple models of the RF Eye Array are available with different maximum bandwidths and instantaneous bandwidths. Detection bandwidth, instantaneous bandwidth, minimum frequency resolution, noise floor, and receiver sensitivity are all dependent on the RF Eye Node model used with the system.

Figure 3-6 CRFS RF Eye Array

Courtesy of CRFS

Specifications for each model are listed in Table 3-3. The size of the RF Eye Array 50 is 17.9 x 7.9 inches with a weight of 11 pounds. The 100, 125, and 150 models are all 25.6 x 16.5 inches with a weight of 61.7 pounds. The RF Eye Array 300 is 43 x 31 inches with a weight of 176 pounds.

Table 3-3 Comparison of RF Eye Array Models

RF Eye Array Model	50	100	125	150	300
Integrated RF Eye Node Model	One 20-6	One 50-8	One 100-8	One 100-18	Two 100-8 or two 100-18
Detection Bandwidth	10 MHz to 6000 MHz	0.009 MHz to 8000 MHz	0.009 MHz to 8000 MHz	0.009 MHZ to 18000 MHz	0.009 MHz to 8000 MHz (100-8 config.); 0.009 MHz to 8000 MHz (100-18 config.)
Direction Finding Bandwidth	500 MHz to 6000 MHz	500 MHz to 8000 MHz	500 MHz to 8000 MHz	500 MHz to 18000 MHz	20 MHz to 8000 MHz (100-8 config.); 20 MHZ to 18000 MHz (100-18 config.)
Instantaneous Bandwidth	20 MHz	50 MHz	100 MHz	100 MHz	100 MHz
Minimum Frequency Resolution	18 Hz	1 Hz	1 Hz	1 Hz	1 Hz
Noise Floor*	8 dB to 11 dB	7 dB to 12 dB	7 dB to 12 dB	8.5 dB to 13 dB	6 dB to 8.5 dB or 10 dB to 13 dB
Receiver Sensitivity	-126 dBm	-127 dBm	-127 dBm	-125 dBm	-125 dBm
Base Cost	$62,000	$79,000	$89,000	$124,000	$232,000
System Cost**	$103,000	$120,000	$130,000	$165,000	$263,500

***Noise floor specifications in this table represent a 10 kHz bandwidth centered at 1 GHz.**
****System cost includes RF Eye Array, mounting accessories and accompanying software. The RF Eye Array 300 system cost does not include mounting accessories.**

3.8 DGS SigBASE 6000

The DGS SigBASE series can automate the capturing, classifying, direction finding, and alerting of anomalous RF signals including jammers, unmanned aerial vehicles (UAVs) and unauthorized land mobile radio (LMR) devices. The SigBASE is a fixed sensor that can operate as a standalone sensor or a node in a multi-unit network. A single SigBASE 6000 can support multiple mission-specific antenna configurations and up to four software defined radios.

The SigBASE uses machine learning to compare environmental RF data against a baseline of learned and/or programmed data (such as channel masks or whitelisted radios) at the point of intercept, without requiring backhaul of I/Q data for post processing. This capability provides quicker access to knowledge and real-time RF situational awareness. The "trigger manager" feature allows users to set triggers and alerts for specific signals of interest. The product can also be operated in "stealth mode" without requiring network backhaul. Raw I/Q data and fast Fourier transform (FFT) data can be recorded for future analysis. Data is typically stored on an internal SSD or can be saved to centralized storage devices.

The detection bandwidth of the SigBASE 6000 ranges from 50 MHz to 6 GHz. The scanning bandwidth of the receiver ranges from 20 MHz to 80 MHz. Detection range and receiver sensitivity is dependent on the transmission frequency and antenna configuration of the receiver. Ranges of up to 50 kilometers are claimed by the vendor. The size of the product, as given by the vendor, is 17 x 15 x 6.85 inches with a weight of 19.4 pounds. The SigBASE costs approximately $51,000 with annual maintenance fees of $6,300.

3.9 DGS SigBASE 4000

The DGS SigBASE is a mobile version of the SigBASE series. The system is comprised of a ruggedized laptop that provides wideband RF detection and spectrum analysis from 70 MHz to 6 GHz, primarily for the purposes of interference hunting. Because of its form factor and single radio, it does not provide direction finding. Like its fixed counterpart, the SigBASE 4000 offers the same machine learning feature for identification of interference sources, and is also capable of recording data for future analysis. Unlike the SigBASE 6000, the mobile version includes a built-in display.

The detection bandwidth of the SigBASE 4000 ranges from 70 MHz to 6 GHz. The scanning bandwidth ranges from 20 MHz to 40 MHz. The receiver sensitivity is -114 dB with a 1 kHz bandwidth and a 2.4 GHz center frequency. The size of the product, as given by the vendor is 13.7 x 8.78 x 1.34 inches with a weight of 6.61 pounds. The SigBASE 4000 hardware costs approximately $16,000. The accompanying software costs approximately $8,000. Annual maintenance fees for the SigBASE 4000 are $1,600.

3.10 LS Telcom LS Observer

The LS Observer is a fully integrated spectrum monitoring system capable of RF detection, spectrum analysis, and direction finding. The system can be used for applications such as radio surveillance of critical infrastructures, network coverage measurements, and identification and location of illegal RF interference sources.

The system consists of various remote monitoring units (RMUs), a central control unit, and software for detailed measurement data analysis. Depending on the configuration of the system, deployment of the LS Observer can range from a handheld unit to a fixed unit to airborne deployments. All configurations are capable of acting as a standalone product yet can also network with other sensors.

The fixed monitoring unit (FMU) is relatively small and allows for "single pole" mounting. The FMU is designed for hard weather conditions. The portable monitoring unit (PMU) is a small lightweight option that is equipped with a touchscreen tablet for control and measurement displays. The protected portable unit (PPU) is designed for outdoor operations under extreme weather conditions.

Figure 3-7 LS Observer FMU

Courtesy of LS Telcom

A software application allows users to access spectrum analysis displays and map displays while operating the device. The software application can be loaded onto a separate laptop for fixed units or onto a table for portable units. Raw spectrum data can be recorded and stored in local storage devices in the monitoring units. Data is stored for 30 days when uncompressed and two years when compressed.

Figure 3-9 LS Observer PMU

Courtesy of LS Telcom

Figure 3-8 LS Observer PPU

Courtesy of LS Telcom

The FMU and PPU have a detection bandwidth of 9 kHz to 18 GHz. The PMU has a detection bandwidth of 9 kHz to 12.4 GHz. Three scanning modes are available for the LS Observer: two wideband modes (WB1 and WB2) and a narrowband mode (NB). The scanning bandwidth for WB1 mode is 9 kHz to 6 GHz with a scan rate of 24GHz/second (s). The scanning bandwidth for WB2 mode is 100 kHz to 18 GHz with a scan rate of 24 GHz/s. The scanning bandwidth for NB mode is 100 kHz to 12.4 GHz with a scan rate of 240 kHz/s. Receiver sensitivity is dependent on frequency. Table 3-4 lists the receiver sensitivity for various bandwidths. The size of the FMU, as given by the vendor, is 370 x 522 x 210 millimeters with a weight of 24.5 kilograms. The PPU is 560 x 420 x 250 millimeters and weighs 15 kilograms. The PMU is 350 x 250 x 60 millimeters and weighs 5.3 kilograms. The LS Observer FMU is priced at $27,600, the PPU at $34,500, and the PMU at $33,400.

Table 3-4 LS Observer Receiver Sensitivity

WB1 Scanning Mode (9 khZ to 6 GHz)		WB2 Scanning Mode (100 kHz to 18 GHz)		NB Scanning Mode (100 kHz to 12.4 GHz)	
Bandwidth	Sensitivity	Bandwidth	Sensitivity	Bandwidth	Sensitivity
0.009 MHz to 0.5 MHz	-140 dBm/Hz	0.1 MHz to 700 MHz	-156 dBm/Hz	0.1 MHz to 10 MHz	-147 dBm/Hz
0.5 MHz to 10 MHz	-154 dBm/Hz	700 MHz to 2700 MHz	-161 dBm/Hz	10 MHz to 100 MHz	-151 dBm/Hz
10 MHz to 6000 MHz	-158 dBm/Hz + 1.1 dB/GHz	2700 MHz to 4500 MHz	-158 dBm/Hz	100 MHz to 3000 MHz	-152 dBm/Hz
		4500 MHz to 8200 MHz	-155 dBm/Hz	3000 MHz to 5500 MHz	-145 dBm/Hz
		8200 MHz to 15200 MHz	-156 dBm/Hz	5500 MHz to 7000 MHz	-149 dBm/Hz
		15200 MHz to 20000 MHz	-149 dBm/Hz	7000 MHz to 8000 MHz	-147 dBm/Hz
				8000 MHz to 11000 MHz	-134 dBm/Hz
				11000 MHz to 12400 MHz	-129 dBm/Hz

3.11 PCTEL SeeWave Interference Locating System

The PCTEL SeeWave system is a tool for a single user designed for detecting and locating RF interference sources. The SeeWave system incorporates the PCTEL SeeGull scanning receiver. A host platform links the scanner to both a direction-finding antenna and a touchscreen tablet. The platform can be held in one hand while the user operates SeeWave's software application. The SeeWave system uses advanced spectrum analysis and proprietary algorithms to identify harmful interference and locate its source.

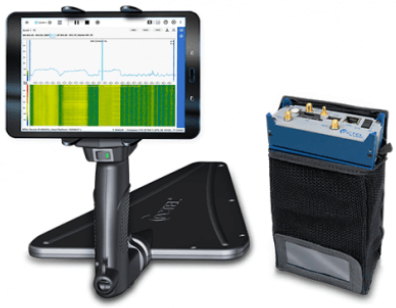

Figure 3-10 SeeWave Interference Locating System

Courtesy of PCTEL

The SeeWave software application loaded onto the tablet includes a digital compass and can display spectrum charts, waterfall spectrograms, and various map displays. Data can be recorded to an SD card from either the SeeGull receiver or the software application.

The SeeWave system has a detection bandwidth of 690 MHz to 6 GHz with an optional extension to 10 MHz to 6 GHz. The scanning bandwidth of the system ranges from 5 kHz to 20 MHz and can be adjusted in increments of 2.5 kHz. The receiver sensitivity is -120 to -30 dBm at 30 kHz. The size of the system, as given by the vendor, is 7.3 x 8.5 x 10.5 inches with an 8-inch mounted tablet. The system has a weight of 1.2 pounds. The system costs $25,445 and the detection bandwidth extension costs $4,095.

3.12 Rohde and Schwarz PR100 Portable Receiver

The Rohde and Schwarz PR100 Portable Receiver is designed for spectrum monitoring in the field. The receiver is deployed as a standalone product in a protective case such as a Pelican case and is powered by either an external source or internal batteries. A built-in 6.5-inch screen displays spectrum plots and waterfall spectrograms. These displays, along with measurements and audio data, can be saved to an SD card for future analysis. The PR100 can also be controlled remotely and configured with an external trigger to record measurements. The PR100 Portable Receiver has a detection bandwidth of 9 kHz to 7.5 GHz with an optional extension up to 18 GHz. The dimensions of the product are 7.56 x 12.60 x 2.44 inches with a weight of 7.72 pounds. The base cost of the unit it $24,000. Units with custom configurations are $39,000.

Figure 3-11 PR100 Portable Receiver

Courtesy of Rohde and Schwarz

3.13 Rohde and Schwarz DDF007 Portable Direction Finder

The Rohde and Schwarz DDF007 Portable Direction Finder is capable of high-precision RF direction finding and high-speed spectrum scans. The product is deployed as a standalone device and can be mounted on a tripod or a vehicle. A built-in 6.5-inch screen provides a map display to help locate potential RF interference sources. The DDF007 can also save measurements to an SD card, be controlled remotely, and be configured with an external trigger to record measurements. The DDF007 Portable Direction Finder has a detection bandwidth of 20 MHz to 6 GHz for direction finding and 9 kHz to 7.5 GHz for detection. The dimensions of the base unit are 7.56 x 12.60 x 2.44 inches. The base unit and the battery together weigh 7.75 pounds. The unit costs approximately $150,000.

Figure 3-12 DDF007 Portable Direction Finder

Courtesy of Rohde and Schwarz

3.14 Rohde and Schwarz NESTOR Mobile Network Survey Software and RF Scanner

The Rohde and Schwarz NESTOR software package is designed for use with Rohde and Schwarz TSMx RF Scanner products to analyze mobile networks. Applications for the software include cellular base station coverage mapping, position estimation, and forensic analysis.

The typical configuration of the system uses the Rohde and Schwarz TSMA Scanner. This configuration has a detection bandwidth of 350 MHz to 4.4 GHz. The scanning bandwidth is adjustable from 140 Hz to 1.438 MHz. The system has a receiver sensitivity of -126 dBm at 900 MHz with a frequency resolution of 22.46 kHz.

Figure 3-13 NESTOR Mobile Network Survey Software and RF Scanner

Courtesy of Rohde and Schwarz

4.0 VENDOR CONTACT INFORMATION

Additional information on the insert product/technology included in this market survey report can be obtained from the vendors listed in Table 4-1.

Table 4-1 Vendor Contact Information

Vendor	Address	Phone Number	E-mail	Website
Alion	8193 Dorsey Run Road Annapolis Junction, MD 20701	N/A	pgiorgio@alionscience.com	https://alionscience.com
Applied Signals Intelligence	45954 Center Oak Plaza Suite 100 Sterling, VA 20166	240-463-3306	Martin.rofheart@asigint.com	https://www.asigint.com/
CRFS Inc.	4230-D Lafayette Center Drive Chantilly, VA 20151	571-321-5470	enquiries@crfs.com	www.crfs.com
Digital Global System Inc.	10000 Virginia Manor Road Suite 340 Beltsville, MD 20705	847-910-2775	sales@digitalglobalsystems.com	www.digitalglobalsystems.com
LS Telcom Inc.	5021 Howerton Way Suite E Bowie, MD 20715	201-377-6966	cjoseph@lstelcom.com	www.lstelcom.us
PCTEL Inc.	20410 Observation Drive Suite 200 Germantown, MD 20876	703-589-8818	Juan.verenzuela@pctel.com	www.pctel.com
Rapid Response Defense Systems Inc.*	12 Goodyear Suite 100 Irvine, CA 92618	949-482-1632	Fred.bouman@rrds.com	www.rrds.com
Rohde and Schwarz USA Inc.	6821 Benjamin Franklin Drive Columbia, MD 21046	888-837-8772	info@RSA.Rohde-schwarz.com	www.Rohde-schwarz.com

***Rapid Response Defense Systems is the North American distributor of the Chemring DF System**

5.0 CONCLUSIONS

With the accessibility of RF jammers increasing, first responder operations are becoming more vulnerable to this threat. RF interference sources may disrupt radio communications and the operation of sensors and other types of equipment that transmit data wirelessly.

RF detection, spectrum analysis, and direction finding equipment allows responders to detect, identify, and locate RF jamming and interference sources. Once interference sources are located, responders can mitigate the threat.

This market survey report provides information on 14 RF detection, spectrum analysis, and direction finding systems, which can detect signals on frequencies as low as 9 kHz and as high as 18 GHz. The products described in the market survey report include fixed site sensors, which can be networked for spectrum monitoring, and mobile handheld sensors with directional antennas for direction finding. Many of the systems include a display that provides spectrum analysis and location visualizations. In addition to the configuration of the products, the technologies also differ in price, detection bandwidth, scanning bandwidth and frequency resolution, detection range, and receiver sensitivity. The products in this market survey report range in price from $15,000 to $270,000.

Emergency responder agencies that consider purchasing RF detection, spectrum analysis, and direction finding systems should carefully research each product's overall capabilities and limitations in relation to their agency's operational needs.