DSIAC TECHNICAL INQUIRY (TI) RESPONSE REPORT

Unattended Ground Sensor Survey

Report Number:

DSIAC-2018-0890
Completed April 2018

DSIAC is a Department of Defense
Information Analysis Center

MAIN OFFICE

4695 Millennium Drive
Belcamp, MD 21017-1505
Office: 443-360-4600

REPORT PREPARED BY:

Scott Armistead

ABOUT DSIAC

The Defense Systems Information Analysis Center (DSIAC) is a U.S. Department of Defense information analysis center sponsored by the Defense Technical Information Center. DSIAC is operated by SURVICE Engineering Company under contract FA8075-14-D-0001.

DSIAC serves as the national clearinghouse for worldwide scientific and technical information for weapon systems; survivability and vulnerability; reliability, maintainability, quality, supportability, and interoperability; advanced materials; military sensing; autonomous systems; energetics; directed energy; and non-lethal weapons. We collect, analyze, synthesize, and disseminate related technical information and data for each of these focus areas.

A chief service of DSIAC is free technical inquiry (TI) research, limited to 4 research hours per inquiry. This TI response report summarizes the research findings of one such inquiry. For more information about DSIAC and our TI service, please visit www.DSIAC.org.

ABSTRACT

The Defense Systems Information Analysis Center (DSIAC) received a technical inquiry requesting information on current unattended ground sensors (UGSs). DSIAC staff searched open-source literature and the Defense Technical Information Center Research and Engineering Gateway for systems where little open-source information was available. DSIAC staff compiled a list of pertinent UGS systems and technologies and categorized the device specifications by sensor type(s), country, communications/network, threat detection classification(s), threat detection range, geolocation, deployment, operation time, size, weight, and power. Other specifications are provided along with a brief description of each technology.

Contents

1.0 TI Request

1.1 SUBJECT: UGS Systems and Technologies

1.2 DESCRIPTION

The inquirer requested information on air-droppable and robust unattended ground sensor (UGS) devices and systems capable of operating in remote environments.

2.0 TI Response

This document describes pertinent UGSs, which were researched by Defense Systems Information Analysis Center (DSIAC) staff for a TI request. DSIAC staff searched open-source literature and the Defense Technical Information Center (DTIC) Research and Engineering (R&E) Gateway unclassified repository for systems where little open-source information was available. The UGSs are briefly described and categorized by sensor(s), country, communications/network, threat detection classification(s), threat detection range (m), geolocation, deployment, operating time, operating temperature range (°C), size (length, width, height [LWH]), weight (oz.), and power.

UGSs include seismic, acoustic, magnetic, electro-optical (EO), and infrared (IR)/passive infrared (PIR) sensors that can detect, locate, and classify targets [1]. They provide improved threat warning and situational awareness and are typically implemented in battlefield situations [2]. United States Border Patrol has also implemented UGSs to surveil the Northern and Southern borders to efficiently detect unauthorized border crossings [3].

The importance of each specification category in the descriptions depends largely on specific mission needs. The category "sensor(s)" is one of the most distinctive categories because the sensor type identifies the properties that are detected and measured. Sensor type directly correlates to the "threat detection classification(s)" category, as the various sensors in this list are designed and implemented to meet specific detection capability needs. Seismic sensors are the most common type of sensor identified in this report. They can effectively detect threats like personnel, wheeled/tracked vehicles, and helicopters [2], which are the most common threat detection classifications in this document.

The category "communications/network" helps to identify specific devices, networks, and software that are or can be integrated with the UGS. Most UGSs identified allow for two-way communication between the user and the sensor and are self-healing/forming networks.

The category "deployment" typically identifies that a UGS must be hand-placed or can be air-dropped. Most sensors must be placed by hand, but sensors like McQ Inc.'s Air Deployed Sensor Systems can be air-dropped to measure weather conditions.

Other categories define the durability and effectiveness of the UGS depending on the environment and mission. The categories "operating time," "power," "size," "operating temperature range," and "weight" help to identify how a UGS may meet mission needs. For example, Exensor's UMRA Micro has only 5 days of operating time, but it is smaller and more lightweight than other sensors; therefore, it is designed for short missions. Many of the UGSs identified can have external batteries added to them to extend their operating time, making them adaptable in battlefield situations.

Many features of current UGSs make them adaptable to circumstances and mission needs on the battlefield; however, there are some drawbacks to current UGS technology. Most ground

sensors operate from a fixed position, and the range of communication between the UGS and the user is often limited; however, UGS technology continues to become smaller and more lightweight, and operating times and communication/detection range capabilities are improving. Future UGS systems will become increasingly mobile, and will function, charge, deploy, and relocate without requiring human intervention [4].

2.1 UGS TECHNOLOGIES

The following UGS technologies are categorized by company/organization.

2.1.1 Applied Research Associates, Inc. (ARA)

Pathfinder Expendable Unattended Ground Sensors (E-UGS) 2000

Sensor(s): Seismic
Country: U.S.
Communications/Network:
- Can operate standalone or with Integrated Base Defense Security System (IBDSS) software
- Slew-to-cue capability which integrates E-UGS with cameras
- Fly-to-cue can launch Nighthawk unmanned aerial vehicle to location

Threat Detection Classification(s): personnel, vehicles
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: 180+ days
Operating Temperature (°C): N/A
Size (LWH): ~2.5 × 2.25 × 2.5 inches
Weight (oz.): 11
Power: Internal battery
Other:
- Focused detection radii and point detection capability
- Long-range detection reporting without gateways and relays
- Line of sight (LOS), non-LOS, and beyond line of sight (BLOS) capable
- Intelligent, machine learning algorithms
- High detection rate
- Low false-alarm rate (FAR)
- Fixed site and mobile detection receipt and monitoring
- Ruggedized sensor capable of withstanding a wide range of climates and terrains

Description: ARA's Expendable Unattended Ground Sensor (E-UGS 2000) is a simple, concealable, military-grade seismic sensor that delivers intrusion alerts over long distances. The coffee-cup size sensors have been upgraded for border protection and commercial security settings and deliver the detection of footsteps or vehicular traffic to a control station miles away. E-UGS can operate as a standalone system or as a key element of ARA's IBDSS. The EGS

2000 model is available for export without International Traffic in Arms Regulations (ITAR) restrictions, is waterproof/dustproof, can be installed on any computer, can differentiate between foot and vehicle traffic, and is compatible with Android operating systems.
Source(s): [5], [6]

2.1.2 Brimrose Technology Corporation

Silhouette Profiling Optical Tripware (SPOT)

Sensor(s): PIR, long-wavelength infrared (LWIR)
Country: USA
Communications/Network:
- Wired or wireless to gateway and terrestrial network
- Devices: PC, Terra Harvest
- Software: Windows-based display software, Terra Harvest Plugin

Threat Detection Classification(s): Animal, personnel, vehicle, cargo truck, etc.
Threat Detection Range (m): 23–152
Geolocation: N/A
Deployment: N/A
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: 5VDC, 3A
Other: Spectral Range: 7–14 microns
Description: The SPOT system is a compact UGS designed for operating in harsh environments, and can capture and classify the silhouettes of mobile targets. The sensor uses LWIR 2D array and signal processing techniques to determine when relevant targets are in view, and to classify the targets. SPOT's main features include minimal power consumption, reflection optics, wide focal depth of field, a variety of communications capabilities, a passive thermal profiling system, and low transmission bandwidth sizes (ranging from 200 to 1500 bytes).
Source(s): [7]

2.1.3 Domo Tactical Communications (DTC)

Nugget Phase 3

Sensor(s): Pressure, magnetic, seismic, PIR, video
Country: USA
Communications/Network:
- Bidirectional communications

- Ultra-high frequency sensor-to-sensor node, very-high-frequency (VHF) sensor node to gateway to local destination or distribution node, distribution node to terrestrial network
- Can integrate with external sensors
- Compatible with mission commander software
- Provides remote monitoring of node status, alarms displayed, and network management
- Devices: PC, mission commander handheld/personal digital assistant (PDA)
- Networks: Gateway, terrestrial

Threat Detection Classification(s): Intruder detection (personnel, vehicles, etc.)
Threat Detection Range (M): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: 90 days
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: 2 lithium D cells
Other: Antitamper
Description: The Nugget Phase 3 is a fully portable, weatherproof surveillance sensor system that can be used to identify potential perimeter incursions and enhance tactical awareness. Internal and external sensors are used to classify and confirm targets, connecting with a Gateway Node to send an alarm signal to the mission commander (handheld device/PDA). The VHF Sensor Network Node can send and receive alarms from up to 32 different external wireless transmitters. Constant updates can be sent to the mission commander, and the node can adapt over the wireless network to meet changes in detection. The Nugget MkIII can activate up to four other devices, using its four bidirectional configurable input/output connections to connect to devices like commercial or door sensors.
Source(s): [8]

2.1.4 Digital Barriers

RDC UltraMesh+

Sensor(s): Seismic
- Can be connected to other remote cameras and/or PIR sensors for threat visual confirmation
- Can be connected to wireless hubs to form a complete, integrated surveillance solution

Country: United Kingdom
Communications/Network:
- Ad-hoc, self-forming, self-healing network
- Nodes transmit alarms back to master node, which can be connected to EdgeVis Shield surveillance hub for camera integration and backhaul of alarms

- Master node serves as communications gateway for direct connect to laptop or interface into cellular, Satellite Communications (SATCOM), or other networks via EdgeVis encoder

Threat Detection Classification(s): Personnel, vehicles, digging activity
Threat Detection Range (m):
Geolocation: Global positioning system (GPS) node logging
Deployment: N/A
Operating Time: 6 months on STAR (single-hop) mode, 4.5 months on Mesh (multi-hop) mode
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): < 17.6
Power: Single lithium D-cell
Other: Intelligent networking, low FAR
Description: RDC UltraMesh+ is a UGS system that detects, classifies, confirms, identifies and tracks human, vehicle, and digging activity. UltraMesh+ is designed around low-power, mesh-networked communications that are self-healing/forming. The sensors are lightweight and have a screw design with an internal antenna. They are portable, rapidly deployable, easily concealable, adaptable, cost effective, and can be integrated with remote cameras and wireless surveillance hubs. Alternative sensor nodes allow connection of external sensor types to extend the applications of the UltraMesh+ platform. Nodes transmit alarms back to a master node, which can also be connected to EdgeVis Shield surveillance hub for camera integration. The sensor can operate in temperatures ranging from -20°C to 70°C, and it can detect personnel up to 30 m, vehicles up to 100 m, and digging up to 30 m.
Source(s): [9]

2.1.5 Elbit Systems

Tactical Reconnaissance and Surveillance Enhanced System (TREASURES)

Sensor(s): Seismic, acoustic
Country: Israel
Communications/Network:
- Ad-hoc, self-forming, self-healing network
- Remote sensor configuration and programming of additional sensors, effectors, relays and hubs
- Uses communications unit devices and gateway/backhaul communications unit for range extension

Threat Detection Classification(s): Personnel, vehicles
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: Smart All-terrain Networked Detectors (SAND): >730 days; TALOS, Miniature Tactical Radar (MTR): Indefinite (solar-powered); Backhaul Communications Unit: 60 days

Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: Solar panel, internal battery
Other:
Description: TREASURES detects, classifies, and tracks human and vehicular targets on any terrain and in all weather conditions. The system is small, lightweight, and it requires a short deployment time and low maintenance. It is flexible, enabling easy integration with third-party sensors; subsystems; and command, control, communications, computers, and intelligence (C4I) systems. It uses a network of "in-house" developed sensor clusters, with intelligent communication, sensing technologies, and data analysis capabilities. The modular system components are as follows:

- SAND: Sensor designed for real-time, BLOS human/vehicular target detection.
- Seismic Acoustic Multi-Detector (OCEAN): Sensor designed to detect/classify humans/vehicles/vehicles direction with reduced FAR and wind interference.
- Unattended Ground Radar (TALOS): This device is designed to track humans/vehicles, using energy generated from its integrated solar panels. It is omnidirectional with a wide vertical field of view (FOV).
- MTR: Device designed to track humans/vehicles, featuring integrated solar panels, long detection ranges, and wide sectoral/vertical FOV.
- Miniature Imaging Detector (MID): Device designed for visual recognition, using a day/night imager (Color charge-coupled device [CCD]/Thermal) with video motion detector (VMD) capabilities and video transmission growth potential.
- Chameleon 2: Covert sensor designed for day/thermal video, with inner pan capabilities and high-resolution coverage.
- Communications Unit: Device designed for ground networked communication that can be used as a control station hub, can facilitate the attachment of additional detectors, and act as a relay for communication range extension.
- Gateway/Backhaul Communications Unit: F1/f2 relay deployed in the field for range extension of communication.

Source(s): [10], [11], [12], [13].

Primrose Wireless Sensor Networks

Sensor(s): Acoustic, radar, seismic, visual camera
Communications/Network:
- Multihop, ad-hoc self-forming, self-healing bidirectional wireless ad-hoc network
- Networks can be joined to form very large networks
- Sensors transmit data to regional controllers
- Controllers route data to command and control (C2) center for storage and analysis

Threat Detection Classification(s): Personnel, vehicles, etc.
Threat Detection Range (m): N/A
Geolocation: N/A

Deployment: Ground level
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: N/A
Other:
- Highly scalable
- Low FAR
- High detection rate
- Field proven
- Fully operational

Description: The Primrose wireless sensor networks are standalone, self-powered, spatially distributed, remotely monitored sensors that can detect and track the movements of people, vehicles, etc. Primrose provides BLOS coverage in even complex terrain. Numerous Primrose networks can be connected to monitor larger zones, and they can be easily customized to meet a variety of mission needs.
Source(s): [11], [14]

2.1.6 Exensor

UMRA Mini MK1

Sensor(s): Seismic, acoustic
Country: Sweden
Communications/Network:
- Bidirectional radio-frequency (RF) communications (up to 1-km LOS) and connection to terrestrial networks
- Flexnet sensor platform provides self-configuring, self-healing mesh network
- Remote sensor configuration
- Software: UMRAwin software provides map-based C2
- Devices: Laptop, PDA
- Networks: Terrestrial, mesh
- Multiple gateways can be introduced to increase range
- Supports data exchange with radios operating at other frequencies
- Supports map-based Graphical User Interface (GUI) on laptops or PDAs

Threat Detection Classification(s): Personnel (single/multiple), vehicles, helicopters, improvised explosive device (IED) emplacement
Threat Detection Range (M): N/A
Geolocation: Internal GPS for self-location

Deployment: N/A
Operating Time: 30-days (integrated batteries), 90 days (external batteries)
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): 33.5oz., or 950 g
Power: Internal rechargeable Lithium-Ion battery, external battery
Other:

- Antitamper/lift protection
- Covert antenna
- Built-in, short-range radio

Description: The UMRA Mini MK1 sensor is a miniaturized UGS that detects and classifies movement of people, vehicles, helicopters, and IED placement. The Mini MK1 has a built-in, short-range radio with a covert antenna, and the system communicates over a mesh network. The sensor self-heals, self-configures, and can be adapted remotely. It can also be integrated with other sensors/systems.
Source(s): [15]

UMRA Mini MK2

Sensor(s): Seismic, acoustic
Country: Sweden
Communications/Network:

- Bidirectional RF communications (up to 1-km LOS) and connection to terrestrial networks
- Flexnet sensor platform provides self-configuring, self-healing mesh network
- Remote sensor configuration
- Software: UMRAwin software provides map-based C2
- Devices: Laptop, PDA
- Networks: Terrestrial, mesh
- Multiple gateways can be introduced to increase range
- Supports data exchange with radios operating at other frequencies
- Supports map-based GUI on laptops or PDAs

Threat Detection Classification(s): Personnel (single/multiple), vehicles, helicopters, IED emplacement
Threat Detection Range (M): N/A
Geolocation: Internal GPS for automatic positioning
Deployment: N/A
Operating Time: 50 days (1 year available)
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): 26.5
Power: Internal rechargeable battery
Other:

- Antitamper/lift protection
- Whip antenna
- Radio

Description: The UMRA Mini MK2 sensor is the latest-generation UMRA Mini MK1, which is a miniaturized sensor that detects and classifies movement. The Mini MK2 has an improved battery life and is lighter than the MK1. It has a covert/discreet whip antenna and advanced noise filtering.
Source(s): [15]

UMRA Micro

Sensor(s): Seismic
Country: Sweden
Communications/Network:
- Flexnet sensor platform provides self-configuring, self-healing mesh network
- Device: Laptop, PDA
- Software: UMRAwin
- Network: Mesh

Threat Detection Classification(s): Personnel (single/multiple), vehicles, helicopters, IED emplacement
Threat Detection Range (M): N/A
Geolocation: N/A
Operating Time: 5 days
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): 17.6
Power: Internal rechargeable battery
Other:
- Antitamper/antilift protection
- Typical use is for early warning and as a trigger for other sensors
- 360°detection

Description: The UMRA Micro is a seismic sensor designed similarly to the UMRA Mini, but it is specifically designed for short-term missions. The sensor has a shorter operating time and reduced capability; however, the UMRA Micro is smaller and more lightweight than the UMRA Mini MK1 and MK2. The Micro provides 360° detection and classification of personnel and vehicles.
Source(s): [15]

2.1.7 L-3 Communication Systems-East

REM-Sense: Battlefield Anti-Intrusion System (BAIS) AN/PRS-9A

Sensor(s): Seismic, acoustic, magnetic, and IR options can be connected
Country: USA

Communications/Network:
- Bidirectional RF communications with 15-km range (SEIWG-005C Compliant, 138–153 megahertz (MHz) band, wireless local and remote programming, sensor/transceiver (S/T) configurable as radio repeater)
- Remote sensor configuration and software updates
- Devices: Hand-Held Monitor/Transmitter (HHM/T)
- Network: Wireless

Threat Detection Classification(s): Personnel, wheeled/tracked vehicles
Threat Detection Range (m): tracked 0–450 m, wheeled 0–350 m, personnel 0–75 m
Geolocation: N/A
Deployment: N/A
Operating Time: 130 days at 1,000 alarms/day (lithium-ion batteries); indefinite operations (external power)
Operating Temperature (°C): -40 to 71
Size (LWH): 7.6 × 4.2 × 2.1 inches
Weight (oz.): 24
Power: Four 9V lithium batteries, external battery
Other:
- Antitamper/antilift protection
- Low FAR
- Typical use is for early warning and as a trigger for other sensors
- Altitude: Operating 15,000 ft., nonoperating 35,000 ft.
- Humidity: Operates in 95% relative humidity
- Immersion: Survives 1 hr in 1 m of water with 27°C differential
- Sand/Dust: Resistant to 20 miles per hour (mph) winds (dust), 40 mph winds (sand)
- Salt Fog: Resistant per MIL-STD-810F, Method 509.4
- Shock: Resistant to 1-m drop

Description: The AN/PRS-9A BAIS provides early-warning detection and threat classification of vehicles/personnel and is designed to support small tactical units up to company level forward-operating base security. The magnetic sensor option detects metal objects/vehicles and provides travel direction and speed estimates. The system comprises one HHM/T and a set of three seismic/acoustic S/Ts that provide two-way communication to allow for remote wireless programming while the sensors are deployed. The S/Ts can accept IR/magnetic detection sensors to provide information such as a target count.
Source(s): [16]

REM-Sense: Battlefield Anti-Intrusion System (BAIS-i)

Sensor(s): Seismic
Country: USA
Communications/Network:
- Bidirectional RF communications up to 2-km LOS (or farther using repeaters) (SEIWG-005C Compliant, 138–153 MHz band)
- Wireless local and remote sensor configuration, software updates
- Device: HHM/T
- Network: Wireless

Threat Detection Classification(s): Personnel, wheeled/tracked vehicles
Threat Detection Range (m): Tracked 0–550 m, wheeled 0–400 m, personnel 0–100 m
Geolocation: N/A
Deployment: N/A
Operating Time: 200 days (at 1,000 alarms/day)
Operating Temperature (°C): -30 to 71
Size (LWH): 3.0 × 2.5 × 1.55 inches
Weight (oz.): 8
Power: Two 3.6V lithium AA batteries
Other:
- Low FAR
- Antitamper
- Military-qualified
- Altitude: Operating 15,000 ft
- Non-operating 35,000 ft
- Humidity: Operates in 95% relative humidity
- Immersion: Survives 1 hr in 1 m of water with 27°C differential
- Sand/Dust: Resistant to 20 mph winds (dust); 40 mph winds (sand)
- Salt Fog: Resistant per MIL-STD-810F, Method 509.4
- Shock: Resistant to 1-m drop

Description: The BAIS-i is a UGS designed for the border surveillance of fixed-base operations and mounted and dismounted units. The system consists of an HHM/T and a set of seismic sensors. Each seismic sensor has an integrated seismic transducer and a VHF whip antenna. The sensors have programmable mission durations and upgradable software and are compact and lightweight.
Source(s): [17]

REM-Sense: Intelligence, Surveillance and Reconnaissance (ISR)

Sensor(s): Seismic, acoustic, magnetic, IR
Country: USA
Communications/Network:
- Two-way RF communications up to 6 km (SEIWG-005C compliant, 138–153 MHz band), which can be extended an additional 6 km when the seismic/acoustic sensor is used as a relay device
- Can be extended worldwide with SATCOM/cellular relay
- Remote sensor configuration
- Each sensor can be configured as a radio repeater or a combined sensor/radio repeater
- Network: Wireless
- Device: HHM/T

Threat Detection Classification(s): Personnel, armed personnel, wheeled vehicle, tracked vehicle
Threat Detection Range (m): Tracked 0–450 m, wheeled 0-350 m, personnel 0–75 m
Geolocation: N/A
Deployment: N/A
Operating Time: 130 days at 1,000 alarms/day (9V batteries), 1,000 days (extended battery pack-BA-5390/5590), 850 days (extended battery pack-2 lantern batteries)
Operating Temperature (°C): -40 to 71
Size (LWH): 7.6 × 4.2 × 2.1 inches
Weight (oz.): 24
Power: 9V batteries, or extended battery pack
Other:
- Antitamper
- Low FAR
- Altitude: Operating 15,000 ft; nonoperating 35,000 ft
- Humidity: Operates in 95% relative humidity
- Immersion: Survives 1 hr in 1 m of water with 27°C differential
- Sand/Dust: Resistant to 20 mph winds (dust); 40 mph winds (sand)
- Salt Fog: Resistant per MIL-STD-810F, Method 509.4
- Shock: Resistant to 1-m drop

Description: The REM-Sense ISR is a UGS that delivers reliable passive detection and classification and can determine the direction of travel of personnel/vehicles. The system uses three basic sensors and signal processing in conjunction with operator display software to estimate count, direction of travel, target location, and speed. The sensors have low FAR, upgradable software, are compact and lightweight, offer flexible configuration, and work with a small HHM/T to graphically depict target activity.
Source(s): [18]

REM-Sense: SENTINEL Sensor System

Sensor(s): Seismic
Country: USA
Communications/Network:
- Two-way RF communications up to 2 km LOS (SEIWG-005C Compliant, 138–153 MHz band) or farther using repeaters
- Remote wireless programming
- Device: SENTINEL Monitor
- Network: Wireless

Threat Detection Classification(s): Personnel, wheeled vehicle, tracked vehicle
Threat Detection Range (m): Tracked 0–350 m, wheeled 0–250 m, personnel 0–50 m
Geolocation: N/A
Deployment: N/A
Operating Time: Up to 270 days at 1,000 alarms/day, or 365 days at 400 messages/day
Operating Temperature (°C): -30 to 71
Size (LWH): 3.25 × 3.0 × 1.65 inches
Weight (oz.): 8
Power: Rechargeable lithium-Ion batteries
Other:
- Antitamper
- Low FAR
- Programmable mission durations
- Waterproof/dustproof

Description:
The SENTINEL Sensor System delivers early-warning intrusion detection and threat classification of vehicles/personnel for situational awareness applications. It is available for export without ITAR restrictions. The system consists of one monitor and a set of mini Seismic-SENTRY sensors that operate constantly, and their detection ranges can be adjusted. The sensors have integrated seismic transducers and VHF whip antennas. The battery can be charged with a USB cable. The sensors have low FAR, upgradable software, and offer flexible configuration. They are compact, lightweight, and waterproof/dustproof.
Source(s): [19]

Tactical Remote Sensor Systems (TRSS) Imager II System

Sensor(s): Seismic, acoustic, magnetic, PIR; EO and IR cameras
Country: U.S.
Communications/Network:
- Interoperable with existing sensor communications devices
- Communications range can be extended by using RT-1847 radio repeaters
- Cameras can be remotely triggered
- Includes TRSS-compatible, low-band transceiver and high-band transmitter
- Devices: TRSS Handheld Programmer Monitor, PC

Threat Detection Classification(s): N/A
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: N/A
Other: N/A
Description: The TRSS Imager II system detects targets for imaging, captures them, and automatically selects the best images for transmission. The Imager can be programmed before being deployed, or remotely commanded with the TRSS Handheld Programmer Monitor.
Source(s): [20]

2.1.8 Lockheed Martin

Self-Powered Ad-hoc Network (SPAN)

Sensor(s): Acoustic, seismic; port to plug in seismic, magnetic, weather, etc. sensors
Country: USA
Communications/Network:
- Camera activated upon sensor detection
- Networks: Wireless; dynamically reconfigurable intelligent mesh network; SATCOM option
- Device: Ruggedized handheld computer
- Self-forming, self-healing network; 200 m plus local communication range
- Multiple backhaul communication options

Threat Detection Classification(s): Personnel, vehicles, etc.
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A

Operating Time: 330 days operating time (with 1 hr per day of sunlight); 60 days without energy harvesting
Operating Temperature (°C): N/A
Size (LWH): 1 × 3 × 1 inches (2–3 cubic inches depending on configuration)
Weight (oz.): 6–8
Power: Thin-film energy-storage cells; solar- and thermal-energy harvesting; replaceable battery

Other:
- Sensors disguised as natural features, such as rocks
- Handheld application provides map displays, sensor alert displays, query capabilities, sensor-processing parameter configuration, and platform GPS integration

Description: The SPAN system contains a small ground sensor designed to provide constant surveillance to support a variety of applications like border protection and structural monitoring. SPAN is a mesh network that uses proprietary algorithms to reduce the FAR, and cues cameras/ unmanned vehicles/engineers to study areas that require attention.
Source(s): [21], [22], [23]

2.1.9 McQ Inc.

Air Deployed Sensor Systems

Sensor(s): Remote Miniature Weather Stations (RMWS); RemoteSense surveillance sensors
Country: N/A
Communications/Network: Devices–RMWS support system: points communications antennas to relay data via satellite
Threat Detection Classification(s): Temperature, humidity, barometric pressure, visibility, and wind speed and direction
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: Air-drop capable
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight: N/A
Power: N/A
Other: Unretarded drop from fixed-wing and rotary-wing aircraft, parachute deployment; automatically rights itself and deploys solid-state sensor pod

Description: McQ Inc.'s Air Deployed Sensor System includes a RMWS that drops from an aircraft and deploys a solid-state sensor pod from the ground to provide temperature, humidity, barometric pressure, visibility, and wind speed/direction readings. The system also

includes a RMWS support system that can deploy/point antennas to relay data via satellite, and RemoteSense surveillance sensors that can be airdropped in camouflaged packages.
Source(s): [24]

iScout

Sensor(s): Seismic, acoustic, magnetic, PIR
Country: N/A
Communications/Network:
- Two-way, wireless, point-to-point RF radio
- Self-forming network; RF link to local user handheld
- Long RF link to multiple repeaters and terrestrial networks
- Remote network gateway to central monitoring site
- Operators can reconfigure sensors remotely over the network
- Networks: RF wireless, terrestrial

Threat Detection Classification(s): Personnel, vehicles, speech recognition
Threat Detection Range (m): N/A
Geolocation: Internal GPS for automatic positioning
Deployment: N/A
Operating Time: 14 days (AA batteries); 3 months (external battery); solar option allows indefinite operation
Operating Temperature (°C): -40 to 60
Size (LWH): 3.5 × 2.5 × 1.25 inches
Weight (oz.): 8
Power: 2x AA battery, external battery, solar power
Other: Waterproof case
Description: iScout is a compact, remote surveillance sensor. It is easy to deploy and conceal and can interface with other systems including OmniSense to match changing operational needs.
Source(s): [25], [26]

2.1.10 Millennium Sensor, LLC

P3 Mobile Remote Sensing System MRSS w P3-100 sensors

Sensor(s): Seismic
Country: USA
Communications/Network: Microwave; backhaul via operator radio, cellular or SATCOM
Threat Detection Classification(s): N/A
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: 30 days

Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: Rechargeable lithium-ion battery
Other: N/A
Description: The MRSS uses 8-16 P3-100 sensors (microwave point sensors) with a range of 300 yd (with the CP-Close Protection model), and can extend this range to 500 yd (with the ER-Extended Range model).
Source(s): [27]

Microwave Point Sensor (MPS)

Sensor(s): Microwave
Country: USA
Communications/Network:

- Sensors transmit 457 m
- P3-140B15 model has a modular antenna if greater range is needed
- Devices: Body-worn monitor with repeater

Threat Detection Classification(s): N/A
Threat Detection Range (m): Detects movement primarily from the front of the sensor; sensing zone is 3–3.5 m from the face of the sensor
Geolocation: N/A
Deployment: N/A
Operating Time: 30 days
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: P3-140B15 model can connect to an external power source for increased operating time
Other: N/A
Description: The MPS is a motion sensor that detects motion best from its front. The sensor can detect movement through many nonmetallic building materials such as sheetrock, wood, glass, etc. There are two different models of the MPS: the P3-140 and the P3-140B15. Both models are available in ruggedized housing,
Source(s): [27]

TSS Tactical Seismic Sensor

Sensor(s): Seismic
Country: USA
Communications/Network: N/A
Threat Detection Classification(s): Personnel, vehicles
Threat Detection Range (M): Personnel 0–30 m, wheeled vehicles 0–90 m, tracked vehicles 0–120 m

Geolocation: N/A
Deployment: Ground spike
Operating Time: 18 months; on-station time for the TSS is 1½ years based on a 1% duty cycle of 55 activations per day.
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: Rechargeable
Other: N/A
Description: The TSS is designed for long-term monitoring of trails and access points. The sensitivity of the sensor can be adjusted for different soil conditions. The TSS comes in two models: the P3120 and the P3-120B15.
Source(s): [27]

Tactical Vibration Sensor (TVS)

Sensor(s): Vibration
Country: USA
Communications/Network: N/A
Threat Detection Classification(s): Vehicles and other access points where vibrations can occur
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: 18 months per charge
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: Rechargeable
Other: N/A
Description: The TVS is designed for rapid deployment to temporarily monitor vehicles and other access points. The sensitivity can be adjusted by the operator.
Source(s): [27]

IR Optical Tripwire (IROT)

Sensor(s): IR
Country: USA
Communications/Network: N/A
Threat Detection Classification(s): N/A
Threat Detection Range (m): 0–29
Geolocation: N/A
Deployment: N/A
Operating Time: N/A

Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: Internal battery; P3-300B15 model features modular antenna and external power capabilities
Other: N/A
Description: The IROT is an IR tripwire that features ease of deployment and a wide-beam system that allows for an offset angle of up to 22°. It is channel-specific and consists of a receiver and transmitter. The IROT comes in two models: the P3-300 and the P3-300B15. Both come with a ruggedized aluminum housing and deploy 29 m apart. The P3-300 features a modular antenna and external power capabilities to allow for greater operating time and greater reporting distance.
Source(s): [27]

Long Range Optical Tripwire (LTOT)

Sensor(s): IR
Country: USA
Communications/Network: N/A
Threat Detection Classification(s): N/A
Threat Detection Range (m): 0–228
Geolocation: N/A
Deployment: N/A
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: N/A
Other: N/A
Description: The LTOT is an IR tripwire that features ease of deployment and a wide-beam system that allows for an offset angle of up to 12°. It is channel-specific and consists of a receiver and transmitter. It comes in three models: the P3-310B15, P3-320, P3-320B15. The models feature ruggedized aluminum extrusion housing and have an internal battery. The P3-310B15 offers the shortwave IR wavelength, which isn't detectable by standard night vision gear, and the sensors deploy 228 m apart. The P3-320 deploys 228 m apart and features the capability for external power. The P3-320B15 comes with external power capability and a modular antenna and the sensors deploy 35 m apart.
Source(s): [27]

2.1.11 Northrop Grumman

Scorpion II

Sensor(s): Seismic, magnetic, day/night vision, EO, PIR, IR
Country: USA
Communications/Network:
- Modular, scalable, open-interface architecture allows use with many commercial off-the-shelf products
- Sensors and a wide variety of communication links
- Wired or wireless RF local communications
- Remote, bidirectional, secure universal communications gateway can transmit data to distributed users
- Data from separate sensor groups can be combined to form a common operational picture (COP)
- Networks: VHF burst ad-hoc network, iridium satellite link, wireless

Threat Detection Classification(s): N/A
Threat Detection Range (m): 30–100
Geolocation: N/A
Deployment: N/A
Operating Time: 180 days plus (6 months)
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: Internal battery
Other: Long, short, and point-blank range target recognition, EO and IR sensors enable target classification and GPS location for targets from 5 m to 1.2 km away

Description: The Scorpion II is a UGS that detects and assesses threats using various sensor and camera technology that can be communicated with from over 2 km away. Data from the separate sensor groups and camera can be combined to form a COP. The system is small, concealable, designed for short-/long-term duration, and capable of adding communications and sensors for operational flexibility.
Source(s): [28]

2.1.12 Physical Optics Corp.

Micro Weather Sensors (MWS) and Advanced Micro Weather Sensors (AMWS)

Sensor(s): Imaging, weather
Country: N/A
Communications/Network:

- Network: Iridium satellites
- SATCOM transmitter sends data to C2
- Expansion port allows for laptop connectivity

Threat Detection Classification(s):

MWS: Temperature, pressure, humidity, cloud ceiling, wind speed, wind direction, angular tilt, visibility, dust accumulation, lighting, global position, visual imagery, compass readings, precipitation amounts, present weather

AMWS: Cloud base height, cloud amount

Threat Detection Range (m): N/A

Geolocation: Self-locating GPS

Deployment: Hand-placed, air-dropped

Operating Time: 90 days or more

Operating Temperature (°C): N/A

Size (LWH): N/A

Weight (oz.): <64

Power: Internal, replaceable battery

Other: Camera for 360° images

Description: The MWS is a low-cost, lightweight, ruggedized UGS that is designed to give a complete, current, and accurate weather picture. The sensor supports real-time weather reporting, and its capabilities can be expanded using other technology like laptops, external power, and other remote sensors. It has 22 weather sensors to provide continuous weather monitoring. It can measure and calculate temperature, pressure, humidity, cloud ceiling, wind speed, wind direction, angular tilt, visibility, dust accumulation, lighting, global position, visual imagery, compass readings, precipitation amounts, and present weather. The AMWS improves upon the MWS with the addition of integrated ceilometers to measure cloud base height and cloud amount, augmenting the data to support aviation and ground missions.

Source(s): [29], [30], [31], [32], [33]

2.1.13 Qual-Tron Inc. (QTI)

Mini Magnetic Sensor (MAGH)

Sensor(s): Magnetic

Country: USA

Communications/Network: Compatible with Enhanced Mini Intrusion Detection System (EMIDS) and Mini Intrusion Detection System (MIDS)

Threat Detection Classification(s): Armed personal, vehicles

Threat Detection Range (m): 1–3 m for armed personnel, 10–30 m for vehicles

Geolocation: N/A

Deployment: N/A

Operating Time: 4–8 months (243 days), life can be extended with optional equipment

Operating Temperature (°C): -20 to 65

Size (LWH): 4.0 × 2.1 × 1.5 inches

Weight (oz.): 9.4
Power: 9V DC battery
Other: N/A
Description: The MAGH detects the passage of magnetic objects. It can operate in temperatures ranging from -20 to 65°C and is vibration-, shock-, and water-resistant. The battery life can be extended with optional equipment, and the sensor is available in three models with different sensitivity ratings/detection ranges. The models include MAGH 13D0456 Magnetic Sensor (Normal), MAGH-20 13D0456-1 Magnetic Sensor (-20 dB), and MAGH-40 13D0456-2 Magnetic Sensor (-40 dB).

Source(s): [34]

Passive Infrared Sensor (PIRH)

Sensor(s): PIR
Country: USA
Communications/Network: Compatible with EMIDS and MIDS
Threat Detection Classification(s): Personnel, vehicles
Threat Detection Range (M):
- 30 m for personnel
- 50 m for vehicles
- Range reduced for heavily clothed/wet targets.

Geolocation: N/A
Deployment: N/A
Operating Time: 4–8 months (243 days), Life can be extended with optional equipment
Operating Temperature (°C): -20 to 65
Size (LWH): 3.0 × 1.0 × 1.0 in.
Weight (oz.): 6.4
Power: 9V DC battery
Other: N/A
Description: The PIRH detects humans/vehicles, monitoring a 5° FOV. It is designed to be stake-mounted and can be adjusted using an encapsulated gain setting switch. The range is reduced for targets that are heavily clothed or wet. It can operate in temperatures ranging from -20 to 65°C and is vibration-, shock-, and water-resistant.
Source(s): [34]

Mini Seismic Sensor (MSSH)

Sensor(s): Seismic
Country: USA
Communications/Network: Compatible with EMIDS and MIDS
Threat Detection Classification(s): Personnel, vehicles
Threat Detection Range (m):

- 10–30 m for personnel
- 50–100 m for vehicles
- Range depends on soil composition

Geolocation: N/A
Deployment: N/A
Operating Time: 4–8 months (243 days); life can be extended with optional equipment
Operating Temperature (°C): -20 to 65
Size (LWH): 4.0 × 3.2 × 1.5 in
Weight (oz.): 8.8 (without batteries)
Power: 2x 9V DC battery
Other: N/A
Description: The MSSH detects vibrations via a geophone within a range of 10–30 m for humans and 50–100 m for vehicles depending on the soil composition. The sensitivity/ detection range can be adjusted by a 10-position switch, allowing for the reduction of the FAR. It can operate in temperatures ranging from -20 to 65°C and is vibration-, shock-, and water-resistant.
Source(s): [34]

EMIDS

Sensor(s): N/A
Country: USA
Communications/Network: Devices: MMCT Transmitter, MMCR Hand-Held Receiver, MSRY Relay
Threat Detection Classification(s): N/A
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: N/A
Other: Antitamper
Description: EMIDS is a multichannel, synthesized system capable of monitoring up to 999 sensors. It is available in three frequency ranges: low band 138–153 MHz with 600 channels, mid-band 154–162 MHz with 1600 channels, and high band 162–174 MHz with 1,920 channels. The system provides additional data messages, including sensor fault alarm, sensor directional information, transmitter tamper alarm, health, transmitter test, and low-battery messages.
Source(s): [35]

MIDS (Modified) (MIDS-II)

Sensor(s): N/A
Country: USA
Communications/Network: Devices: MXMT-II Transmitter, MPDM-II Hand Held Receiver, MRLY Relay
Threat Detection Classification(s): N/A
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: N/A
Other: N/A
Description: MIDS-II is a single-channel, fixed-frequency system capable of monitoring up to 999 sensors. It provides additional data messages, which include sensor fault alarm, directional information, transmitter test, and low-battery message. An "on/test" switch is included on the transmitter.
Source(s): [36]

2.1.14 Textron Systems

MO-1045 Node

Sensor(s): Seismic
Country: USA
Communications/Network:
- Devices: two-way RF radio for sensor-to-sensor, antenna
- Gateway-to-sensor of up to 5 km without repeater (options up to 10 km)
- Self-forming, self-healing network
- Remote sensor configuration and software updates

Threat Detection Classification(s): Personnel, vehicles (detection triggers IR imaging)
Threat Detection Range (m): N/A
Geolocation: Self-locating/positioning
Deployment: N/A
Operating Time: 30 days
Operating Temperature (°C): N/A
Size (LWH): 4.1 × 3.0 × 5.7 inches
Weight(oz.): <16
Power: Three AA lithium batteries
Other: N/A

Description: The MO-1045 Node is a portable, small, lightweight seismic sensor node for temporary missions. It can be networked with other external transmission control protocol/internet protocol (TCP/IP)-based sensors/networks. RemoteView (and the cloud-based version, RVcloud) geospatial intelligence software provides network, node, and gateway health; near-real-time change detection and track history; communication link quality and tamper data; adjustment of system configurations and sensitivity settings; map-based 3D LOS analysis to help identify areas of vulnerability; and annotated maps can be delivered to the iCommand C2 system. RemoteView Pro can perform terrain analysis, multispectral imagery analysis, and synthetic-aperture radar (SAR) imagery analysis. RVConnect provides real-time interoperability between RemoteView and Esri's ArcGIS to support data and geospatial analysis.
Source(s): [37]

MO-2730 Node

Sensor(s): Seismic
Country: USA
Communications/Network:
- Devices: two-way RF radio for sensor-to-sensor, antenna
- Gateway-to-sensor of up to 5 km without repeater (options up to 10 km)
- Self-forming, self-healing network
- Remote sensor configuration and software updates

Threat Detection Classification(s): Personnel, vehicles (detection triggers IR imaging)
Threat Detection Range (m):
Geolocation: GPS; self-locating
Deployment: N/A
Operating Time: 730 days plus
Operating Temperature (°C): N/A
Size (LWH): 5.7 × 5.7 × 12.2
Weight (oz.): N/A
Power: N/A
Other: N/A
Description: The MO-2730 Node is a self-contained seismic sensor node for long-term use. It can be buried, and minimal maintenance is required. RemoteView geospatial intelligence software provides network, node, and gateway health; near-real-time change detection and track history; communication link quality and tamper data; adjustment of system configurations and sensitivity settings; and map-based three-dimensional LOS analysis to help identify areas of vulnerability. Annotated maps can be delivered to the iCommand C2 system.
Source(s): [37]

Imager Node

Sensor(s): IR camera
Country: USA

Communications/Network:
- Network: Wireless
- Camera activated upon sensor detection

Threat Detection Classification(s): N/A
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): 3.5 × 3.5 × 4.0 inches
Weight (oz.): N/A
Power: N/A
Other: N/A
Description: The Imager Node is a wireless IR camera that is triggered by sensor nodes to capture images within the FoV. It can deliver three simultaneous images that appear to the user as a video without the bandwidth and latency issues of video.
Source(s):
- Proprietary; see https://www.textronsystems.com/missions/isr to request more information [37].

Tactical (outdoor) UGS (T-UGS) and Urban (indoor) UGS (U-UGS)

Sensor(s): Acoustic, seismic, IR, chemical, biological, nuclear radiation
Country: USA
Communications/Network: Sensor fields include a gateway node to provide sensor fusion and a long-haul interoperable communications capability for transmitting target or situational awareness (SA) information to a remote operator, or the COP through the Future Combat Systems (FCS) Brigade Combat Team (BCT) Joint Tactical Radio System (JTRS) Network.
Threat Detection Classification(s): Personnel, vehicles, radiation
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: Hand-placed, air-dropped
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: N/A
Other: Developed as part of the Army's Brigade Combat Team Modernization (BCTM) program in 2010, but never implemented.
Description: T-UGS and U-UGS are part of the FCS reconnaissance and surveillance architecture. They are designed to provide the warfighter with early warning and increased SA.

T-UGS is primarily used outdoors and is designed as a modular set of customizable, multimode sensors. It provides a recoverable sensing capability, is tailored to mission requirements, and can fuse data internally to confirm detection, classification, and location.

U-UGS is designed primarily for operation indoors, obtaining situational pictures in urban settings. Hand-emplaced by soldiers or ground robots, the system enables a small unit to monitor environments such as caves, corridors or stairwells, sewers, culverts, and tunnels.
Source(s): [38], [37]

Advanced Remote Ground Unattended Sensor (ARGUS) and Advanced Air-Delivered Sensor (AADS)

Sensor(s): Acoustic, seismic, IR imaging
Country: USA
Communications/Network:
- Network: SATCOM (will provide communications between the deployed sensor and the common workstation established to receive and process data)
- Two-way SATCOM transceiver to data center, can cross-cue other intelligence, surveillance, and reconnaissance (ISR) assets while activity occurs
- Can be integrated into the overall Battle Management C2 (BMC2) architecture
- Compatible with TRSS cryptography

Threat Detection Classification(s): personnel, vehicles, RF emissions trip
Threat Detection Range (m): N/A
Geolocation: GPS
Deployment: Hand-placed, air-dropped
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight: N/A
Power: N/A
Other: N/A
Description: The ARGUS/AADS system improves the warfighter's ability to detect/react to targets in near real time. It can cross-cue with other ISR assets and is equipped with a sensor suite, software applications, sensor signal processor, a two-way satellite communications transceiver, a storage device, GPS, and a battery power supply.
Source(s): [39]

2.1.15 UC Berkeley

Smart Dust

Sensor(s): Weather
Country: USA

Communications/Network:
Devices: Bidirectional RF (20-m local communications range)
Network: Wireless, laser with micro-electromechanical sensor (MEMS) beam steering (20-km plus range)
Threat Detection Classification(s): Temperature, humidity, barometric pressure, tilt and vibration, light intensity, magnetic field, etc.
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: Air-drop capable
Operating Time: 7-days continuous operation, 730 days at 1% duty cycle
Operating Temperature (°C): N/A
Size (LWH): 1 × 1 ×1 mm
Weight (oz.): N/A
Power: N/A
Other: N/A
Description: The Smart Dust Project's goal is to demonstrate a complete sensor/communication system in a 1-mm^3 package. The project is related to Berkeley Tiny OS and Analog Devices' SmartMesh.
Source(s): [40], [41], [42], [43]

2.1.16 Air Force Research Laboratory (AFRL)/Multisensor Exploitation Branch (IFEC)

Steel Sniffer

Sensor(s): N/A
Country: USA
Communications/Network: N/A
Threat Detection Classification(s): Chemical, radiological, toxic/explosive materials
Threat Detection Range (m): N/A
Geolocation: N/A
Deployment: N/A
Operating Time: N/A
Operating Temperature (°C): N/A
Size (LWH): N/A
Weight (oz.): N/A
Power: N/A
Other: N/A
Description: The objective of this project is to use existing spectrometry and radiological measurement technologies in the Steel Rattler and Steel Eagle framework. The purpose is to provide a new family of collectors for detecting, measuring, and reporting the presence of chemical, radiological, toxic, and explosive materials in battlefield areas. Steel Sniffer provides

an integrated spectrometry and radiological measurement system to detect, warn, report, and display chemical, biological, radiological, nuclear, and explosive (CBRNE) and toxic industrial material (TIM) threats and effects in battlefield areas.
Source(s): [44]

References

[1] "Future Combat Systems (FCS) Overview." Army Programs. http://www.dote.osd.mil/pub/reports/FY2006/pdf/army/2006fcsoverview.pdf, accessed April 2018.

[2] Huang, J., Q. Zhou, X. Zhang, E. Song, B. Li, and X. Yuan. "Seismic Target Classification Using a Wavelet Packet Manifold in Unattended Ground Sensors Systems." Basel, Switzerland, July 2013. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3758609/, accessed April 2018.

[3] Homeland Security. "Written Testimony of MGMT Under Secretary Claire Grady, and CBP Acting Deputy Commissioner Ronald Vitiello for a House Committee on Homeland Security, Subcommittee on Border and Maritime Security hearing titled "Bang for the Border Security Buck: What do we get for $33 billion?" https://www.dhs.gov/news/2018/03/15/written-testimony-mgmt-under-secretary-and-cbp-house-homeland-security-subcommittee, 15 March 2018.

[4] "Small Form-Factor, Relocatable, Unattended Ground Sensor." SBIR STTR, 29 November 2017. https://www.sbir.gov/sbirsearch/detail/1413899, accessed April 2018.

[5] ARA. "E-UGS: Expendable Unattended Ground Sensors." https://www.ara.com/sites/default/files/docs/EUGSOneSheet092514.pdf, accessed April 2018.

[6] ARA. "Pathfinder." https://www.ara.com/pathfinder/overview, accessed April 2018.

[7] Brimrose. "SPOT Unattended Ground Sensor (UGS)." http://www.brimrosetechnology.com/products/Unattended_Ground_Sensor.html, accessed April 2018.

[8] DTC. "Nugget MkIII VHF Sensor Network Node." 2016, http://www.domotactical.com/wp-content/uploads/2016/08/DTC_Nugget_Brochure_web.pdf, accessed April 2018.

[9] Digital Barriers. "Remote Ground Sensors." 2017. https://www.digitalbarriers.com/technology/remote-ground-sensors/, accessed April 2018.

[10] DSIAC. "Elbit Systems' Treasures – a Network of Unattended Ground Sensors." https://www.dsiac.org/resources/news/elbit-systems-treasures-network-unattended-ground-sensors, 13 August 2015.

[11] Elbit Systems. "Unattended Ground Sensors." http://elbitsystems.com/product/unattended-ground-sensors/, accessed April 2018.

[12] Elbit Systems. "UGS." http://elbitsystems.com/products/land-systems/ugs/, accessed April 2018.

[13] Elbit Systems. http://elbitsystems.com, accessed April 2018.

[14] Elbit Systems. "C4I Systems." http://elbitsystems.com/pdf/primose/, accessed April 2018.

[15] Exensor. "UGS: UMRA Mini MK1." http://www.exensor.com/product-category/?cat=ugs, accessed April 2018.

[16] L-3 Communication Systems-East. "AN/PRS-9A Battlefield Anti-Intrusion System (BAIS)." https://www2.l3t.com/cs-east/pdf/datasheets/bais.pdf, 21 August 2013, accessed April 2018.

[17] L-3 Communication Systems-East. "Battlefield Anti-Intrusion System BAIS-i." https://www2.l3t.com/cs-east/pdf/datasheets/baisi.pdf, 20 November 2015, accessed April 2018.

[18] L-3 Communication Systems-East. "Intelligence, Surveillance & Reconnaissance (ISR) UGS." https://www2.l3t.com/cs-east/pdf/datasheets/baisisr.pdf, 2 December 2015, accessed April 2018.

[19] L-3 Communication Systems-East. "SENTINEL Sensor System." https://www2.l3t.com/cs-east/pdf/datasheets/Sentinel.pdf, accessed April 2018.

[20] L-3 Communication Systems-East. "TRSS Imager II." https://www2.l3t.com/cs-east/pdf/datasheets/TRSS%20Imager%20II.pdf, 28 March 2007, accessed April 2018.

[21] Lockheed Martin. "Self Powered Ad-Hoc Networks (SPAN): Perpetually Powered Unattended Ground Sensors." http://www.millennialnet.com/MillennialNet/media/Technology/Datasheets/SPAN-Brochure.pdf, 2010, accessed April 2018.

[22] Lockheed Martin. "Self Powered Ad-Hoc Networks (SPAN): Ultra-Low Power, Remote Unattended, Ground Sensing Surveillance System. http://www.millennialnet.com/MillennialNet/media/Technology/Datasheets/LMSPANfactsheet.pdf, 2011, accessed April 2018.

[23] PR Newswire. "Lockheed Martin Links Ground Sensor Network with Unmanned Aerial Vehicles for Enhanced Threat Protection." Lockheed Martin, 21 October 2013, https://news.lockheedmartin.com/2013-10-21-Lockheed-Martin-Links-Ground-Sensor-Network-With-Unmanned-Aerial-Vehicles-For-Enhanced-Threat-Protection, accessed April 2018.

[24] McQ Inc. "Air Deployed Sensor Systems." http://www.mcqinc.com/solutions/airdrop.php, accessed April 2018.

[25] McQ Inc. "iScout: The next scouting legend." http://www.mcqinc.com/products/iscout.php, accessed April 2018.

[26] McQ Inc. www.mcqinc.com, accessed April 2018.

[27] Millennium Sensor, LLC. http://www.msensor.com/, accessed April 2018.

[28] Northrop Grumman. "SCORPION II Unattended Target Recognition Systems." http://www.northropgrumman.com/Capabilities/SCORPIONII/Pages/default.aspx, accessed April 2018.

[29] Northrop Grumman. "SCORPION II Unattended Ground Sensors." http://www.northropgrumman.com/Capabilities/SCORPIONII/Documents/scorpion2.pdf, 2012, accessed April 2018.

[30] POC. "Sensor Systems." http://www.poc.com/solutions/sensor-systems/, accessed April 2018.

[31] POC. "MWS – Micro Weather Sensor Product Information." http://www.poc.com/solutions/sensor-systems/mws-micro-weather-sensor/, accessed April 2018.

[32] POC. "MWS Micro Weather Sensor." http://www.poc.com/media/23649/mws_ds_rev5_fnl_web_1.10.2017.pdf, accessed April 2018.

[33]. Broderick, T. "Air Force Awards Special Operations Military Sensor Deal." Defense Systems, 14 November 2016, https://defensesystems.com/articles/2016/11/14/dronekid.aspx, accessed April 2018.

[34] POC. "AMWS – Advanced Micro Weather Sensor Product Information." http://www.poc.com/solutions/sensor-systems/amws-%e2%80%93-advanced-micro-weather-sensor, accessed April 2018.

[35] Qual-Tron Inc. http://www.qual-tron.com/Home, accessed April 2018.

[36] Qual-Tron. "QTI Intrusion Detection Systems." http://mcbordersecurityinc.com/page2.html, accessed April 2018.

[37] Textron Systems. http://www.textronsystems.com/missions/isr, accessed April 2018.

[38] admin. "AN/GSR-9/10 Family of Unattended Ground Sensors (UGS)." Defense Update, 14 October 2009, https://defense-update.com/20091014_ugs_angsr.html, accessed April 2018.

[39] TEXTRON Systems. "ARGUS/AADS."
http://www.bfbreakthroughdesign.com/textron2/textronsystems_surveillance_argusaads.htm,
accessed April 2018.

[40] Pister, K, J. Kahn, and B. Boser. "SMART DUST." http://www-bsac.eecs.berkeley.edu/~pister/SmartDust/, accessed April 2018.

[41] UC Berkeley and MLB Co. "29 Palms Fixed/Mobile Experiment." Marine Corps Air/Ground Combat Center (MCAGCC), Twentynine Palms, CA,
http://robotics.eecs.berkeley.edu/~pister/29Palms0103/, accessed April 2018.

[42] Berkeley WEBS. "TinyOS." https://people.eecs.berkeley.edu/~culler/nest/, accessed April 2018.

[43] Analog Devices. "SmartMesh" http://www.linear.com/dust_networks/, accessed April 2018.

[44] AFRL. https://www.wpafb.af.mil/, accessed April 2018.