Maritime Surveillance Technologies

Market Survey Report

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FOREWORD

The National Urban Security Technology Laboratory (NUSTL) is a federal laboratory within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T). Located in New York City, NUSTL is the only national laboratory focused exclusively on supporting the capabilities of federal, state, local, tribal, and territorial responders to address the homeland security mission. The laboratory assists responders with the use of technology to prevent, protect against, mitigate, respond to, and recover from homeland security threats and incidents. NUSTL provides expertise on a wide range of subject areas, including chemical, biological, radiological, nuclear, and explosive detection, personal protective equipment, and tools for emergency response and recovery.

NUSTL manages the System Assessment and Validation for Emergency Responders (SAVER®) program, which provides information on commercially available equipment to assist response organizations in equipment selection and procurement. SAVER publications 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?" The SAVER program works with responders to conduct objective, practitioner-relevant, operationally-oriented assessments and validations of commercially available emergency response equipment. Having the right tools provides a safer work environment for responders and a safer community for those they serve.

NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER knowledge products, and coordinating with other organizations to leverage appropriate subject matter expertise. NUSTL conducted a market survey of commercially available maritime surveillance technologies. This equipment falls under the AEL reference numbers 14SW-02-RADR titled *Systems, Radar* and 14SW-01-VIDA titled *Systems, Video Assessment, Security*.

SAVER reports are available at www.dhs.gov/science-and-technology/saver.

Visit the NUSTL website at www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory or contact the lab at NUSTL@hq.dhs.gov.

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders ®

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EXECUTIVE SUMMARY

Port authorities and security agencies use maritime surveillance technologies to surveil and safeguard ports and other critical infrastructure, such as airports located near or surrounded by water. These systems use sensors, including electro-optical/infrared (EO/IR) and radar, mounted on fixed land-based platforms to collect information about specific areas on the water from a distance. Once collected, the data undergoes processing and analysis based on predetermined objectives. Subsequently, it is visualized and shared with operators or decision-makers. Maritime surveillance technologies are particularly effective in detecting small targets on the water surface, including small vessels and pleasure crafts. This capability provides agencies with situational awareness and actionable insights concerning potential safety or security hazards of small surface intrusions.

Between April 2023 and November 2023, the System Assessment and Validation for Emergency Responders (SAVER) program conducted a market survey of commercially available maritime surveillance technologies that can detect small surface intrusions on the water. The survey identified 20 products, including six EO/IR systems, seven radar systems, three software solutions, and four integrated systems. This market survey report is based on information gathered from manufacturer and vendor websites, internet research, industry publications, and a government-issued request for information (RFI) that was posted on the System of Award Management website. Performance of these products and information included in this report has not been independently verified by the SAVER program.

Products included in this report meet the following criteria:

- Can detect small surface intrusions into an established near-shore safety and security zone (e.g., a port or other critical infrastructure)

- Allow for configurable intrusion alerting

- Can operate in adverse weather conditions (wind, rain, fog, snow, etc.) during the day and night

- Designed to have a low false alarm detection rate to avoid operator fatigue or complacency

- Allow for shore-based or structure-based deployment

The purpose of this market survey is to provide information that will guide emergency response agencies in making operational and procurement decisions. Agencies should consider overall capabilities, technical specifications and limitations of maritime surveillance technologies in relation to their agency's operational needs when making equipment selections. Agencies should also consider impacts associated with integrating equipment into their power and information technology infrastructure, data management, concept of operations, and required maintenance.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Maritime surveillance technologies are employed by port authorities and security organizations to monitor and protect ports, airports, and other vital facilities situated near water. These advanced systems deploy a variety of sensors, such as electro-optical/infrared (EO/IR) and radar, positioned on terrestrial platforms to remotely gather information from designated maritime safety and security zones. The collected data is processed and analyzed in real time in alignment with specific goals before being visualized and disseminated to the relevant personnel or decision-makers. Notably, these technologies can detect and identify small targets on the surface of the water, offering critical situational awareness and valuable insights to preempt safety or security threats.

Between April 2023 and November 2023, the System Assessment and Validation for Emergency Responders (SAVER) program conducted a market survey of commercially available maritime surveillance technologies that can detect small surface intrusions on the water. This market survey report is based on information gathered from manufacturer and vendor websites, internet research, industry publications, and a government-issued request for information (RFI) — notice 70RSAT23RFI000039 — that was posted on the System of Award Management website. The U.S. Department of Homeland Security (DHS) Science and Technology Directorate's (S&T) Technology Scouting Group also contributed to the market research used in the development of this report.

This report identifies 20 products — including six EO/IR systems, eight radar systems, three software solutions, and three integrated systems — all of which meet the following criteria:

- Capable of detecting small surface intrusions[1] into an established near-shore safety and security zone (port or other critical infrastructure)

- Allow for configurable intrusion alerting

- Capable of operating in adverse weather conditions (wind, rain, fog, snow, etc.) during the day and night

- Designed to have a low false alarm detection rate that doesn't cause fatigue or complacency

- Allow for shore-based or structure-based deployment

Additional technology considerations for inclusion included automatic detection and classification capabilities, integration with existing systems (e.g., C2 software), detection of low-flying unmanned aircraft systems (UAS), data storage, retention, viewability and shareability, low frequency and remote maintenance capability, and compliance with industry standards and protocols.

Due diligence was performed to develop a report that is representative of products in the marketplace for near-shore maritime surveillance. Agencies with more expansive coastal monitoring objectives and missions may seek other commercially available technologies that provide capabilities exceeding the scope and detection range required for near-shore surveillance.

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[1] Surface intrusions include small targets such as people, kayaks, standup paddleboards, rubber rafts, jet skis, small sailing boats, fishing boats, etc.

2.0 MARITIME SURVEILLANCE TECHNOLOGY OVERVIEW

Maritime surveillance systems included in this report deploy a sensor on a land-based platform to acquire information about a given area on the water from a distance. These systems process and analyze the information they gather according to an objective predetermined by the deploying agency, then create a visualization and disseminate the information to an operator or decision-maker. The primary use case for the technologies included in this report is the detection of small targets on the surface of the water, so the information provided focuses on various sensor characteristics (e.g., type, size, weight, range) and analysis capabilities (e.g., automatic detection, classification, and alerting).

2.1 Current Technologies

The surveillance systems included in this report use EO/IR or radar as primary data acquisition sensors or fully integrated solutions that use both sensor types in tandem. In addition, some companies offer sensor agnostic software solutions that take in and analyze information acquired from third-party sensors.

2.1.1 Electro-Optical/Infrared Systems

EO/IR systems are a primary surveillance technology used in maritime security applications, such as detecting, tracking, and identifying objects on the water surface. EO/IR solutions include cameras that use imaging of near-infrared (NIR) with wavelengths of 750-1000 nanometers (nm), short-wave infrared (SWIR) with wavelengths of 1000-2500 nm, and medium-wave infrared (MWIR) with wavelengths of 3000-5000 nm, as well as visible imaging sensors (VIS) and/or laser rangefinders (LRF). The NIR spectral band is just beyond the range that humans can see and may offer clearer details than what is achievable with visible light imaging. The difference in reflectivity of certain objects, such as trees and plants, as well as reduced atmospheric haze and distortion in the NIR wavelength, enables improved detail and visibility at long ranges. SWIR cameras capture light reflected or absorbed by an object and can provide clear detail through smog, clouds, and haze. MWIR cameras detect heat emitted by the object, can excel in long-range surveillance applications, and may be less susceptible to atmospheric conditions found in marine and coastal environments. VIS technology collects visible light in the 400–700 nm range, converts it to an electrical signal, and organizes that information to render images and video streams. VIS cameras use the same spectrum that the human eye perceives and are designed to create images that replicate human vision with accurate color representation. Most LRF technologies operate on the time-of-flight principle by sending a laser pulse in a narrow beam towards an object to determine precise distances.

2.1.2 Radar Systems

Radar is a primary sensor type used in maritime surveillance applications. A radar system consists of an antenna, a transmitter for generating high-frequency radio waves, a receiver for detecting the radio waves reflected back to the antenna after bouncing off an object, and a user interface where the radar data can be displayed and interpreted, as shown in Figure 2-1. Radar detection depends on the radar cross-section (RCS) of an object, which is a function of its size, material and shape, and the object's orientation to the radar. Objects with a low RCS do not provide a strong reflection and therefore can be difficult to detect and track.

Radar solutions for maritime surveillance operate on various frequency bands, including:

- S-band radars operate on a frequency of 2–4 gigahertz (GHz)

- C-band radars operate on a frequency of 4–8 GHz

- X-band radars operate on a frequency of 8–12 GHz

- Ku-band radars operate on a frequency of 12–18 GHz

In addition to differences in operating frequencies, radar types across bands differ in their physical size and the space required for deployment. For example, X-band radar systems use smaller antennas, and their components are typically spaced closer together than S-band radars, for example, as X-bands' higher operational frequencies have shorter wavelengths. As such, many shipboard marine radars operate using X-band radars, as these systems can fit on most boats and can provide better target resolution. However, S-band radars may be better suited for surveillance in adverse weather conditions, as they generally operate more accurately in heavy precipitation or cloud cover.

In addition to operating on different bands, radar systems can also operate using different types of signals. The most commonly used marine radar is pulse radar, which transmits short-duration, high energy pulses that provide both long-range detection and enhanced target resolution. Rather than pulses, some maritime radar solutions leverage high-frequency surface wave radar (HFSWR) or frequency-modulated continuous wave (FMCW) radar technologies. HFSWR is a long-range radar technology that uses surface wave propagation and can estimate velocity based on Doppler data. FMCW is a radar system that measures both distance and velocity of moving objects by continuously varying the frequency of the transmitted signal using a modulating signal at a known rate over a fixed period of time.

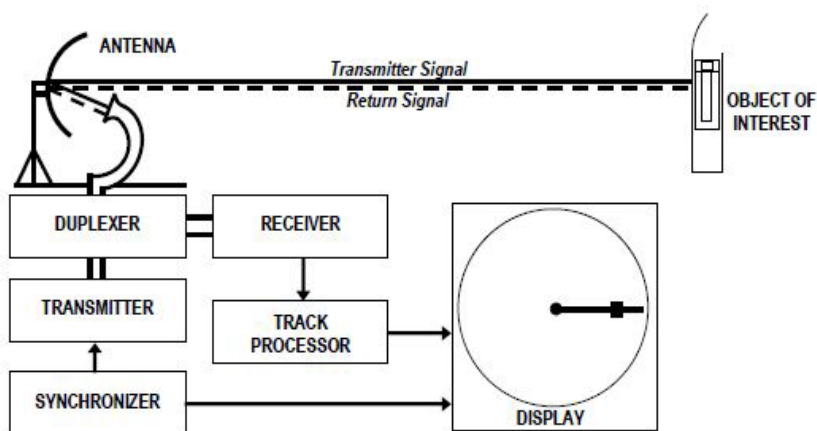Figure 2-1 Small Target Radar Detection System Block Diagram

2.1.3 Software Solutions

As a companion to third party sensors, software solutions designed for maritime surveillance can be used for real-time object detection and tracking. Software solutions and corresponding user interfaces can provide visual and audible alerts, store and timestamp data, and enhance overall situational awareness.

Artificial intelligence (AI) is an emerging technology that allows computer systems to perform human tasks, has multiple uses in surveillance system software including analyzing images, videos, and data from sources to identify risks, objects, and people. AI can also increase situational awareness due to its capabilities to analyze patterns, identify specific ship types and sizes, or detect and monitor a vessel's location and speed in real time. AI software can also provide satellite with the capacity to detect and track maritime vessels in poor weather conditions. Due to the intricacy of the maritime environment, however, using AI may also lead to an increase in false positive and false negative detections. The lack of standards and regulations on AI integrations may also lead to vulnerabilities in the software such as hacking, cyberattacks, and privacy concerns.

2.2 Applications

Maritime surveillance technologies that are capable of small target detection can be deployed by agencies as a standalone solution or as a subsystem of a larger integrated solution. The way these technologies are used depends on an agency's mission, use cases, and area of operations. Some agencies, such as port authorities, use vessel traffic services (VTS), which are "shore-side systems that range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to extensive management of traffic within a port or waterway" [1]. A VTS typically includes inputs from land-based sensors and other information sources, such as automatic identification systems (AIS)[2], to monitor and manage vessel traffic [2]. However, surveillance technologies are still needed as a supplement to VTS to detect small targets on the water surface that are not required to or choose not to broadcast AIS information due to size, neglect, or nefarious reasons.

2.3 Use of Grant Funds for Certain Telecommunications and Video Surveillance Equipment or Services

The John S. McCain National Defense Authorization Act for Fiscal Year 2019 (NDAA), Pub. L. 115-232, Section 889 (NDAA) prohibits the use of federal funds, including loan and grant[3] funds, to obtain or acquire certain telecommunications technologies manufactured by certain entities or to enter into contracts with entities that use those technologies. The Office of Management and Budget (OMB) published regulations at 2 C.F.R. § 200.216 to clarify the application of the NDAA to the use of federal grant funds to procure or obtain certain telecommunications equipment or services.

Effective August 13, 2020, federal grant recipients and subrecipients (i.e., **non-federal entities**) are prohibited from obligating or expending loan or grant funds to procure or obtain[4] the following "covered telecommunications equipment or services":

- Telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities)

For the purpose of public safety, security of government facilities, physical security surveillance of critical infrastructure, and other national security purposes, video surveillance and telecommunications equipment produced by:

- Hytera Communications Corporation

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[2] Automatic identification systems (AIS) transponders can provide position, identification, and other information about the ship to other ships and to coastal authorities automatically.
[3] This also includes cooperative agreement funds.
[4] Nor may they extend or renew a contract to procure or obtain or enter into a contract to procure or obtain the covered equipment or services.

- Hangzhou Hikvision Digital Technology Company
- Dahua Technology Company
- or any subsidiary or affiliate of such entities
- Other entities identified by the Secretary of Defense

The restriction also applies to systems that use the covered equipment or services as a substantial or essential component, and to subsidiaries or affiliates of those listed above[5]. See https://www.federalregister.gov/d/2020-17468/p-877.

Costs associated with covered equipment and services are "unallowable" for grant funding. Grant recipients are responsible for ensuring funds are used only for allowable costs, and would be obligated to refund the government for unallowable costs. The Federal Emergency Management Agency (FEMA) issued FEMA Policy #405-143-1, Prohibitions on Expending FEMA Award Funds for Covered Telecommunications Equipment or Services (Interim) for further guidance on the Section 889 prohibitions. Additionally, OMB issued frequently asked questions (FAQs) on the topic.

For **federal** entities, FEMA published interim rules amending the Federal Acquisition Regulation[6].

2.4 Cybersecurity Considerations

Cybersecurity considerations for maritime surveillance systems includes access control, operational security (OPSEC), and signal interference.

Access control rules for both physical and cyber access to any and all maritime surveillance systems should be enforced. Access control rules also apply to any systems on the network that can be accessed remotely. Physical access should be limited to necessary personnel only. For further information on access control see the guidelines in the National Institute of Standards & Technology (NIST) Special Publication 800-53 [3], the Department of Justice's IT security policies, and the Federal Bureau of Investigation's (FBI) Criminal Justice Information Services (CJIS) Security Policy [4].

OPSEC should also be considered when planning the implementation and use of maritime surveillance technology systems. Information about the type(s) of sensors used in maritime surveillance, their physical or geographical placement, their limitations and specifications, and similar information should be protected from accidental disclosure or enumeration reconnaissance. Strong OPSEC rules will limit the disclosure of sensitive information that could be used to circumvent important early warning and alerting systems.

Signal interference that could negatively impact reliability and operability should also be considered when purchasing and deploying any maritime surveillance system. Common public and private signals, such as cellular, radio, and other wireless, could reduce the effectiveness of any maritime surveillance technology solution that operates in the same signal range, such as 2–5 GHz wireless. Maritime surveillance systems that are affected by these common signal ranges can also be intentionally targeted to degrade or completely stop their functionality. When deploying radar, agencies should consider frequency management and regulations set forth by the Federal Communications Commission and the National Telecommunications and Information Administration [5].

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[5] As well as telecommunications or video surveillance services provided by entities or using equipment described above.
[6] www.federalregister.gov/documents/2019/12/13/2019-26579/federal-acquisition-regulation-prohibition-on-contracting-for-certain-telecommunications-and-video and www.federalregister.gov/documents/2019/08/13/2019-17201/federal-acquisition-regulation-prohibition-on-contracting-for-certain-telecommunications-and-video.

2.5 Additional Considerations

One of the major challenges for marine surveillance is "sea clutter." Sea clutter comes from various sources including reflections from the sea surface caused by scattering from waves, swells, and spray due to rough seas and wind and reflections from rain or snow. If UAS detection is also of interest, the number of birds in coastal regions can also create a large amount of clutter. These increases in background noise make it harder to detect small targets, while also increasing the false alarm rate as well as lowering the operational range for detecting distant targets. "Heuristic clutter mitigation" uses both machine learning (ML) and heuristic approaches in radar signal processing to improve the detection of low radar cross-section targets and reduce the false alarm rate.

2.6 Standards

MIL-STD is a prefix introducing a standard that helps achieve interoperability in objectives outlined by Department of Defense (DoD), and each standard is a method of testing a product. The MIL-STD-810 standard test methods address confidence in the environmental worthiness and durability of material system design; products with MIL-STD-810 certifications may be able to withstand certain environmental hardships, such as altitude and temperature shocks, humidity, salt, and fog, among others. The standard outlines analysis and test criteria tailored to a material and its environmental life cycle, stating how to evaluate its performance when exposed to environmental stresses, demonstrate compliance with contractual requirements, and identify deficiencies in the material. The current version, MIL-STD-810H, superseded MIL-STD-810G [6].

Additionally, MIL-STD-461 establishes electromagnetic interference (EMI) test procedures for military equipment; its most recent revision in MIL-STD-461G, released in 2015 [7].

3.0 PRODUCT INFORMATION

This section provides information on 20 products, including six EO/IR systems, eight radar systems, three software solutions, and three integrated systems.[7] Table 3-1 provides general characteristics and specifications of the products, which are listed alphabetically by manufacturer. The information in section 3.0 has not been independently verified by the SAVER program.

Below are definitions of the product information in Table 3-1, listed in column order.

System Type refers to the type of primary sensor used to monitor a specified area and detect small targets on the surface of the water.

Automatic Detection refers to the capability of the system to collect and interpret information about the environment to discern the presence of a target object without input from a human operator.

Object Classification refers to the capability of the system to assign a detected target object to a specified category according to its characteristics, such as vessel, drone, human, etc.

Configurable Alerts refers to whether the user has the ability to customize the system's detection thresholds and/or the way in which they receive notification of a detection.

Detection Range refers to the minimum and maximum distances at which the system can detect a target object, given in meters or kilometers.

Size refers to the system's overall dimensions given in inches (as length, width, and height when available) in a ready-to-use configuration.

Weight refers to the total weight (in pounds) of the surveillance system components.

Power Requirements refers to the input power (in volts) and power consumption (in watts) of the system in operation.

Manufacturer's Suggested Retail Price (MSRP) indicates the cost of the complete system (unless otherwise indicated) in U.S. dollars, rounded to the whole dollar.

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[7] In this report, "integrated systems" refers to available products that come with multiple sensors, typically a primary and secondary sensor(s), and a processing unit to achieve detection, tracking, and identification capabilities.

Table 3-1 Product Comparison Matrix

Manufacturer and Product	System Type	Automatic Detection	Object Classification	Configurable Alerts	Detection Range	Size	Weight	Power Requirements	MSRP
Controp USA, VICTOR	EO/IR		✓		3–20km	--	349 lb	220 VAC 1200 W	*See 3.1.1*
Edge Autonomy, Octopus E180	EO/IR	✓	✓	✓	1.4–12.4 km	7.1" x 8.9"	7 lb	40–160 W	$231,000
Electro Optical Industries Inc., Spynel	EO/IR	✓	✓		8–48km	14.9" x 21.6"	86 lb	24 VDC	$450,000
Innovative Signal Analysis, Inc., WAV Surveillance	EO/IR	✓	✓		≤ 3 km	33.6" x 18.7" x 24.3"	95 lb	24 VDC	$499,000
Optics 1, VIGY Engage	EO/IR	✓	✓	✓	1–20km	--	77 lb	28 VDC	$200,000
Sea Machines Robotics, Artificial Intelligence Recognition Identification System (AI-RIS)	EO/IR	✓	✓	✓	5m–4km	Camera: 6.18" D x 14.17" L	18 lb	8–48 VDC 300 W	$27,900
Aerostar, HiPointer 100	Radar	✓		✓	≤ 55km	24.5" D x 10" H	33 lb	15–48 VDC 150 W	$190,000
Echodyne Corps, EchoShield	Radar	✓	-		150m–25km	16.7" x 13" x 7"	39 lb	21.5–33 VDC < 250 W	$130,000
ElbitAmerica MATR-X Radar, Multi Mission	Radar	✓	✓	✓	200m–20km	20.5" W x 15" H x 8.5" D	59 lb	16–33 VDC 340 W	--
Helios Remote Sensing Systems, Helios Multi-function, Multi-mode Radar System	Radar	✓		✓	30m–>10km	--	165 lb	500 W	--
Israeli Aerospace Industries, ELTA Group ELM-2112 Persistent	Radar	✓	✓	✓	15m–30km	28.4" W x 10.9" D x 47.2 H	25 lb	28 VDC 500 W	$160,000–$250,00

Manufacturer and Product	System Type	Automatic Detection	Object Classification	Configurable Alerts	Detection Range	Size	Weight	Power Requirements	MSRP
Coastal & Ground Surveillance Radar									
SRCTec LLC, SR Hawk Surveillance Radar	Radar	✓	✓	✓	≤ 34 km	24.25" x 11.5" x 22"	< 45 lb	22–32 VDC 95 W	--
Terma Inc., SCANTER	Radar	✓	✓		30m–89km	16.6" x 16.6" x 18.3"	57 lb	110–440 VAC	--
Accipiter Radar Corporation, Marine & Air Surveillance Radar System	Integrated	✓	✓	✓	22m–50km	Enclosure: 48'' x 48'' x 48'' Antenna: 96" (8')	425 lb	110–120VAC, 60Hz, 50A 220–240VAC, 50Hz/60Hz, 30A	--
BigBear.ai, Arcas	Software	✓	✓	✓	--	--	--	--	--
Charles River Analytics, Awarion Autonomous Lookout System	Software	✓	✓	✓	--	--	--	--	--
Time Zero, TZ Coastal Monitoring	Software	✓		✓	--	--	--	--	*See 3.3.3*
IEC Infrared Systems LLC, Raptor	Integrated	✓	✓	✓	250m–30km	--	223 lb	120 VAC 300–1500 W	$725,000
Picogrid, Picogrid Platform	Integrated	✓	✓	✓	1m–1 km	79" x 142" x 79"	728 lb	100 W	--
Reid Marine Electronics LLC, Maritime Detection and Surveillance System	Integrated	✓		✓	100m –2km	39.37" x 39.37" x 39.37"	<75 lb	12 VDC	--

✓ indicates a capability of the product.

A blank field indicates a product does not have the capability.

-- indicates no data is available.

3.1 EO/IR Systems

3.1.1 Controp USA, VICTOR (Speed ER + Tornado ER)

Visual identification combined target observation remote platform (VICTOR) uses advanced imaging systems with AI and ML assistance to allow a single operator the ability to monitor an area without constant hands-on attention. The VICTOR system combines Controp USA's Speed ER and Tornado systems to provide a 360-degree security zone with automatic target detection, recognition, and tracking. The Speed ER captures video clips before interrogating further threats. The Tornado LR automatically detects land and maritime targets using IT sensors and real-time video algorithms. The system can be used in temperatures ranging -20 to 50 degrees Celsius. The VICTOR does not require internet connection.

Figure 3-1 VICTOR

Image Credit: Controp USA

Detection & Classification
- Minimum detection range: ~50 m.
- Maximum detection range: 3–5 km small targets (e.g., kayak), 20 km for boats and larger targets.
- Detects and classifies persons onboard boats, jet skis, and aircrafts.
- Counter-unmanned aircraft system (C-UAS) applications and filters can be developed to trigger alarms for airborne targets.
- Humans must command the interrogation camera.

Data Storage & Retention
- Data is stored at local machine or computer station. DVR is available as an additional option.
- Command and control (C2) software can be used for standalone operations. Data can be shared with other users and additional screens for advanced analytics.

Alerts
- Visual and audible alarms can be triggered for regions of interest. The alarms are configurable: users can assign alarms to each alert area based on target classification. Operators can manually create unlimited alarm areas.

False Alarms
- Video motion detection (VMD) sensitivity can be adjusted to reduce false alarms.

Maintenance
- Lenses needed to be cleaned monthly.
- The calibration process takes 5–10 minutes to reposition the sensors and conduct drift calibration of the gyros.
- User or manufacturer can remotely access the system to conduct troubleshooting. Remote software updates are completed through scheduled sessions.

Warranty, Training, & Cost
- Purchase includes a one-year warranty that covers hardware issues and system and component failures. Standard extended warranty can be added for 10% of the system cost per year.

- Customer service is available during regular business hours. For 24/7 support, point of contact information can be provided.
- Remote, onsite or on campus training is available for all systems.
- Speed ER costs $500,000 and the Tornado LR costs $550,000. Contact vendor for VICTOR package pricing.
  - Pricing does not include PC add-ons such as hard drives, and peripherals that are provided by third party sources.
- Speed LR and Speed ER are available on General Services Administration (GSA) schedule, but Tornado has not yet been added.

3.1.2 Edge Autonomy, Octopus E180

The Octopus E180 is an EO/IR surveillance system that uses a global shutter electro-optical (EO) sensor and middle wave infrared (MWIR) sensor for long-range tracking. The system can operate during the day and night and can function under all weather conditions. The operating temperature ranges from −40–55 °C. System can be connected to internet to obtain maps or can operate without internet connection.

Figure 3-2 Octopus

Image Credit: Edge Autonomy

Detection & Classification
- Detection range: up to 8.6 km for a human target.
- Detects people, animals, aircrafts, watercrafts, land vehicles, fire and unmanned aircraft systems.
- Automatically detects and tracks multiple moving targets of two and more pixel size.

Data Storage & Retention
- Original videos are compressed and stored in a processing computer or storage device. All data is stored using robot operating system (ROS) bagging that enables playback. Track data is stored in an SQL database on the graphical user interface (GUI) back-end server.

Data Viewability & Shareability
- Data is captured through direct feeds and retained on 32GB storage or stored on cloud services. Data can be viewed and shared via Ethernet and RS232.

Alerts
- Alerts when new targets are identified are available to a control room or operator. Human targets are signified with a blue circle while vehicles and vessels are signified with a red box. System alerts are configurable to user needs.

Maintenance
- Firmware and software updates are pushed to the payload quarterly. Humidity cartridges should be replaced every 300 hours of usage and purging of nitrogen every 300–500 hours.
- Maintenance and operational manuals are available to maintain the payloads.

Warranty, Training, & Cost
- System has a one-year warranty on any defects.
- One- or two-day training is available and add-on customer support is available as an option. A customer service number is available for customers who purchase Octopus EO/IR.

- Costs $231,000 which does not include laser illuminator nor laser range finder.
- Product is not on the GSA schedule.

3.1.3 Electro Optical Industries Inc (DBA: HGH USA), Spynel

Spynel is an infrared search & track (IRST) system that uses a rotating thermal head camera and the Cyclope software to detect track and classify targets. Snow and rain conditions affect the detection ranges. Spynel can be integrated with WinTAK and other C2 software and can operate without internet connection.

Detection & Classification
- Maximum detection range: 2 km for swimmers; up to 8km for small objects (such as kayaks, stand-up paddle boards); to 48 km for vessels.
- Automatic classification through AI system "Gaia."
- Automatic detection through Cyclope software.
- Drone detection is available.

Figure 3-3 Spynel

Image Credit: Electro Optical Industries Inc

Data Storage & Retention
- Data is stored locally using a server where data can be saved or deleted immediately.

Data Viewability & Shareability
- Data is viewed through Cyclope software or Motion-JPEG server.

Alerts
- Alerts are displayed on an XML feed that includes time, latitude, bearing, longitude, speed, date, and magnetic variation.
- Users can configure alerts through Cyclope software.

False Alarms
- Uses AI and ML to reduce false alarms.

Maintenance
- Maintenance recommended to be conducted every two years.
- Updates are available remotely via internet or physical key.

Warranty, Training, & Cost
- One -year warranty included. Additional 12-month warranty available for $45,000/year.
- Customer service is available Monday–Friday, 7am–5pm.
- Operational training is available remotely and in person.
- Cost of $450,000 includes sensor, MJPEG server, software, and licenses.
- Product is not on the GSA schedule.

3.1.4 Optics 1, VIGY Engage

VIGY Engage is an EO/IR camera surveillance system that can be installed on a maritime vessel or land-based tower. The system uses a modular payload that includes a mid-wavelength infrared thermal imager (MWIR), a laser range finder, and automatic video tracking capabilities. The VIGY Engage can operate during the day and night and in adverse weather conditions. The system can operate without internet connection.

Figure 3-4 VIGY Engage

Image Credit: Optics 1

Detection & Classification
- Detection range: up to 20 km.
- Automatically detects small objects, such as kayaks and stand-up paddle boards and UAS.
- System classifies vessels for detection on the water.

Data Viewability & Shareability
- Data can be viewed locally or transmitted either wirelessly (with internet connection) or via landline to security operations center.

Data Storage & Retention
- Data can be stored locally or transmitted to a cloud service per user needs. Onboard storage can be attached based on end-user requirements.

Alerts
- Visual and audio alerts are available and can be integrated into a common operating picture.
- System alerts can be configured to meet user's needs.
- Alert sensitivity level can be configured with minimal system modification.

False Alarms
- Uses object detection of shape and motion to minimize false alerts.

Maintenance
- System updates can be done locally or remotely.
- Routine maintenance on internal components is based on operational conditions such as weather, dust, and heat.

Warranty, Training, & Cost
- EI/OR camera has a 90-day warranty.
- On-site training is available.
- Customer service is available via phone and email. Customer service is available 24/7 with an additional cost.
- MSRP: $200,000 for the sensor. Additional accessories such as a station can increase total cost by $50–$100k.
- Product is not on the GSA schedule.

3.1.5 Sea Machines Robotics, Artificial Intelligence Recognition Identification System

The Sea Machines Artificial Intelligence Recognition Identification System (AI-RIS) is a camera-based computer vision sensor that provides situational awareness when deployed at sea or from a static shore-based location at height of 20 ft. or higher. AI-RIS consists of a camera and processing unit to optically detect, track, classify, and geolocate (i.e., give relative range and bearing) surface targets in real time. AI-RIS can integrate with thermal and IR camera systems and video management systems via ethernet or wireless connections.
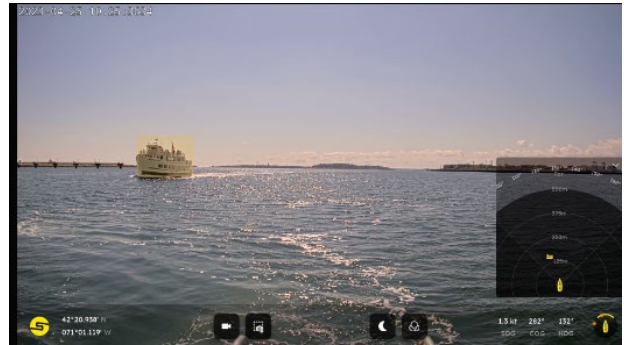

Figure 3-5 Sea Machines AI-RIS

Image Credit: Sea Machines Robotics

Detection & Classification
- Detection range: 5 m to 4 km.
- Automatic object detection.
- Current classification categories: power vessel, sailing vessel, miscellaneous objects, marine mammals (whales), buoy, containership, day marker, kayak, human, and tugboat.

Data Viewability & Shareability
- Produces computer vision output data using any communication channels, including internet protocol (IP)-based radios, satellite communications (SATCOM), Iridium satellite network, etc.
- Data is viewable in 4K (3840 x 2160) with a frame rate of 30 fps.
- Data can be shared or viewed in real time depending on the communications node.

Data Storage & Retention
- Data is retained in the processor and can be uploaded to the cloud or to a hard drive.

Alerts
- The user can set predetermined guard zones and have audible alerts sounded when a vessel crosses into the zone.

False Alarms
- Detections below a prescribed "confidence" score will not populate.

Maintenance
- Sea Machines provides quarterly software updates remotely and provide a systems user and maintenance guide.

Warranty, Training, & Cost
- Sea Machines offers a one-year warranty for the AI-RIS camera and processor.
- Sea Machines provides on-site or remote installation support and 24/7 remote customer support.
- Costs $27,900 with optional accessories available: multi-functional display screen ($3,300) and installation cables ($200).

3.1.6 Innovative Signal Analysis, WAV Surveillance System

The Innovative Signal Analysis (ISA) WAV Surveillance System is a patented EO/IR (medium wave) image-based sensing camera system. WAV surveillance system can operate in adverse weather conditions. The system can be integrated with common operating systems and does not require internet connection to operate.

Detection & Classification
- Maximum detection range: 3 km for unmanned semi-submersible vehicles.
- Detects kayaks, canoes, unmanned semi-submersible vehicles, and remotely operated surface vehicles. Detection and geo-location are performed automatically.
- Uses external AI and ML systems to classify objects.

Figure 3-6 WAV Surveillance System

Image Credit: Signal Analysis

Data Viewability & Shareability
- Data is viewed through Live Interactive Viewer 2.0 (LIV2).
- Data and metadata can be accessed using application programming interface (API).

Data Storage & Retention
- Data is captured, stored, and retained locally.
- System can be configured to enable through virtual private network (VPN) and cloud.

Alerts
- Alerts are configurable to meet user preferences.
- Alert sensitivity level can be configured with minimal system modification.

False Alarms
- Detection algorithms can be configured to maximize detection and minimize false alarms.

Maintenance
- System upgrades and maintenance can be performed remotely by ISA.
- Calibration is only necessary if system is uninstalled for maintenance.

Warranty, Training, & Cost
- MSRP price includes one year of hardware and warranty and software support. Extended warranties are offered after first year. Cost varies based on level of support requested and type of installation. ISA provides site diagnostics, troubleshooting, and call support.
- Training services are included in the purchase of the system.
- Costs $499,000 and includes WAVcam visible light sensor, MWIR sensor, power supply unit, processing server, archive server, C2 software, and LIV2 web-based viewer.
- Product is not currently on the GSA schedule, but process is pending.

3.2 Radar Systems

3.2.1 Aerostar, HiPointer 100

The Aerostar HiPointer 100 is an X-band radar capable of providing port security, surveillance, and situational awareness in the marine environment. For marine operation, the HiPointer automatically adjusts sensitivity based on sea states. Its tracking algorithms run autonomously to track targets in the sea and air domains. Radar data is acquired, processed, and visualized on Aerostar's C2 software, vStorm. The HiPointer integrates with third party C2 systems and external sensors and data sources including EO/IR camera systems, navigation feeds, AIS, and ADS-B signals.

Figure 3-7 HiPointer Radar Systems

Image Source: Aerostar

Detection & Classification
- Detection ranges: 8–13 km for a small boat; 15–35 km for a medium boat; and 40–55 km for a large boat.
- Can perform correlation with digital nautical chart (DNC) data.
- Object classification is possible when paired with an EO/IR multi-sensor; if so, detection tracks are passed off for identification and classification (slew-to-cue).

Data Viewability & Shareability
- Data can be viewed within the web-based vStorm GUI.
- Detection, tracking, and classification data can be exported and viewed within integrated C2 systems.
- Data is also available on ports connected to a transmission control protocol/IP (TCP/IP) network in various formats.

Data Storage & Retention
- Track data is stored locally for up to 36 hours of playback.
- Track data can be archived to an external hard drive.

Alerts
- Areas of interest or "alert zones" can be setup and any tracks detected in those areas will produce a visual and audible alert.
- System alerts are configurable: detected tracks can be drawn on a map or through interface control document (ICD) commands and latitude/longitude coordinates.

False Alarms
- The system uses a constant false-alarm rate (CFAR)[8] approach to radar thresholding and will autonomously adjust based on sea state and weather conditions.

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[8] "Solutions to false-alarm problems involve implementation of CFAR schemes that vary the detection threshold as a function of the sensed environment." See Radartutorial. "Constant False-Alarm Rate."

Maintenance
- Designed for long operation between maintenance cycles, with a mean time between failure (MTBF) of 25,000 hours.
- Software troubleshooting can be conducted remotely.

Warranty, Training, & Cost
- Includes standard one-year warranty from time of shipment that covers all hardware against defects in materials or workmanship. Extended warranty (additional 12 months) available for purchase.
- Aerostar training program includes classroom-style, hands-on instruction, and an evaluation of operations and maintenance proficiency.
- MSRP: $190,000 with discounts available at quantities of 5, 10, 25, and 50.
- Product is not on the GSA schedule, but government pricing is available, contact Aerostar directly for more information.

3.2.2 Echodyne, EchoShield

Echodyne's EchoShield is a software-defined, medium-range, pulse-Doppler, cognitive 4D radar operating in the Ku-band (15.4–16.6 GHz). EchoShield can detect ground, coastal/ maritime, and air threats simultaneously. Echodyne offers tailored waveforms for various mission sets, including ground surveillance, C-UAS, coastal, airspace management, and on-the-move, for classification through a decluttered data stream with metadata about tracked objects. The EchoShield uses dense Tx/Rx cells to create accurate spatial data for sensor fusion, C2 interfaces, and other intelligent systems and platforms. The radar has integrated with various partners using EO/IR, radio frequency, microwave, and other technologies to include communications such as mesh network radios.

Figure 3-8 EchoShield

Image Credit: Echodyne

Detection & Classification
- Minimum detection range: 150 m.
- Maximum detection range: 25 km depending on radar cross section (RCS) with 3 km for sUAS, 8 km for a human walking, and 11 km for a vehicle/vessel.

Data Viewability & Shareability
- Data can automatically be pushed to a common operating or C2 system.
- Once connected to a C2 or radar user interface instance, the radar data can be enabled, displayed, and/or recorded.
- The radar data – including detections (1 MB/s), measurements (1 MB/s), tracks (27 kB/s), and/or raw data (40 MB/s) – can be ingested via one or more APIs.

Data Storage & Retention
- Radar data is recorded and stored on user's computer or tablet.

Alerts
- The radar is capable of visually displaying the detection and track to alert the operator or secondary sensors as part of an integrated system.

False Alarms
- Parameters are adjustable to reduce false alarm rates.

Maintenance
- Maintenance includes basic cleaning of radar and cables as well as maintaining software/firmware, which can be executed remotely.

Warranty, Training, & Cost
- Maintenance and support are 7% of the system cost, paid annually; includes access to the latest version of radar firmware, additional off-radar software, and priority support.
- A two-day on-site course with one instructor for eight students is available for a fee.
- Professional service available by hourly rates.
- MSRP: $130,000 per panel with 90° azimuth coverage.
- Product is not on the GSA schedule, but DHS Indefinite-Delivery, Indefinite Quantity (IDIQ)pricing is available.

3.2.3 Elbit America, MATR-X Radar, Multi Mission

The MATR-X Radar is a small, active electronically scanned array (AESA) X-Band (9–10 GHZ) radar designed to provide simultaneous air, ground, and maritime surveillance. It can detect, track, and classify thousands of objects from very small UAS to large vessels in high-clutter environments. Modular, self-contained AESA radar panels can be quickly repaired or replaced in the field. No external processing hardware or enclosure is required. A single panel is a fully functioning radar; linking panels together extends detection ranges and widens the staring field of view. It can be easily deployed on a small tower.

Figure 3-9 MATR-X Radar integrated with external sensors

Image Credit: Elbit America

Detection & Classification
- Minimum detection range: 200 m.
- Maximum detection ranges: 20 km for larger vessels
- Automatic object detection.
- Current classification categories: person, animal, watercraft, unmanned aerial vehicle (UAV), and aircraft.

Data Viewability & Shareability
- All messages from the radar are sent to the C2 via ethernet.
- Designed for common operating system (COP) integration, the system has a mature and robust ICD.

Data Storage & Retention
- Data is stored in the integrated COP or C2 system. No data is stored on the device other than buffer data.

Alerts
- All alerts are programmable via the C2 system.

- Alerts configurability depends on the C2 system's capabilities.

False Alarms
- MATR-X uses advanced AI/ML algorithms to qualify the tracks and classification, mitigating false alarms.

Maintenance
- If secure web connectivity access is provided, all maintenance can be performed remotely.

Warranty, Training, & Cost
- A one-year warranty covers all parts and labor but is limited to factory repair (not field repair).
- Customer service and training for customer operator and installation are provided with purchase.
- Pricing information not provided.
- Product is not on the GSA schedule.

3.2.4 Helios Remote Sensing Systems, Inc. Helios Multi-function, Multi-mode Radar System (HMMR-X3)

The Helios Multi-function, Multi-mode Generation-3 radar system, HMMR-X3, is a modular, portable, multi-domain X-band radar system. HMMR-X3, an AESA radar, provides detection, location, and tracking of moving targets on the surface as well as small airborne targets. The HMMR-X3 is also designed to provide weather surveillance data when in one of its weather monitoring modes. HMMR-X3 is capable of scanning 360 degrees in azimuth, while electronically scanning ± 45 degrees in elevation. Operator-specified sector scanning is also supported. HMMR-X3 is normally tripod mounted for portability and rapid relocation but can easily be mounted at fixed locations. HMMR-X3 uses modern high-speed digital processing, which promotes modularity and operational flexibility. A number of different output data formats, which can easily be integrated into existing systems, are supported.

Detection & Classification
- Minimum detection range: 30 m.
- Maximum detection ranges: > 10 km for small surface-based or small airborne target.
- Automatic object detection.
- Object classification currently under development. When completely implemented the classifications will be surface target (ground based or watercraft), airborne, surface vehicle, human, animal, or clutter.

Data Viewability & Shareability
- Several viewing and sharing options can be supported depending upon end-user needs.
- Currently uses a plan position indicator (PPI) display, for which geographic maps with detections and tracks can be superimposed.
- HMMR-X3 can send detection and track information to any number of external systems, if required. One of the current output formats is Cursor-on-Target (COT), which provides compatibility with the Android team awareness kit (ATAK).

Alerts
- HMMR-X3 alerts for detections and tracks. Alerts can be correlated to a specific geographic region.

False Alarms
- False alarm rate is affected by the detection threshold setting as well as false alarm control mechanisms in the tracker.

Maintenance
- Maintenance at regular intervals is recommended. General health of the radar system can be monitored remotely, while hardware issues must be dealt with in person.

Warranty, Training, & Cost
- Pricing and warranty information will be provided on an individual basis depending upon performance requirements and optional capability required.
- Helios can provide customer service and training agreements on an individual basis as required.
- Product is not on the GSA schedule.

3.2.5 Israeli Aerospace Industries, ELTA Group, ELM-2112

The ELM-2112 family consists of several high-resolution X-band linear-frequency-modulated continuous-wave staring radars that can be used simultaneously for ground and sea surface surveillance. The system has very high sub-clutter visibility and extremely high Doppler resolution. Up to four stationary planar arrays (90 degrees each) provide up to 360 degrees coverage. The radars can be combined with E/O sensors and function in adverse weather conditions.

Figure 3-10 ELM-2112 Family

Image Credit: IAI ELTA Group

Detection & Classification
- Minimum detection range: 15 m.
- Maximum detection ranges: 2 km for swimmer, 22 km for rubber boat, and 30 km for sailboat.
- Automatic object detection.
- Current classification categories:
    - For coastal applications, classification by size (i.e., very small, small, big, large, very large).
    - For ground applications, classification by type (i.e., person or vehicle).
- Some radars have a 3D C-UAS capability enabling UAS detection.

Data Viewability & Shareability
- Data must be viewed in playback on the GUI application, called Human-Machine Interface (HMI).
- Data is not encrypted but ELTA's propriety format is used.

Data Storage & Retention
- Data is captured on premises by the radar's HMI.
- A hard disk can be used to download data.

Alerts
- The solution is connected to a C2 system with alert zones that can be set by the user.
- Alerts can also be configured for different operational conditions and time zones.

False Alarms
- All the detection algorithms in the system can be configured to maximize detection and minimize false alarms.

Maintenance
- The system is maintenance-free.
- Twice-yearly inspections are recommended for the safety of the mechanical connections.

Warranty, Training, & Cost
- A one-year warranty is included with purchase.
- Training is offered. Customer service can be reached through ELTA North America during regular working hours (EST).
- The price is $160K–$250K, depending on the model and the installation requirements; this includes the product itself without associated accessories or services.
- Discounts may apply for quantity purchased.
- The product is available on GSA schedule.

3.2.6 SRC, SR Hawk Surveillance Radar

The SRC SR Hawk is a Ku band radar that performs ground, coastal, and low-flying aircraft surveillance. The pulse Doppler radar detects, tracks, and classifies targets including marine vessels and aircraft to support port, harbor, and perimeter security. The radar is operational in marine environments and adverse weather conditions including rain, fog, steady winds up to 35 mph and gusts up to 45 mph, moderate snowfall, and extreme heat. The SR Hawk integrates with C2 systems, optical sensors, and other security systems.

Figure 3-11 SR Hawk Surveillance Radar

Image Credit: SRC

Detection & Classification
- Minimum detection range: 50 meters.
- Maximum detection ranges: 12 km for a single person, 15 km for a rubber raft, 25 km for a small vessel, and 34 km for a large vessel.
- Automatic object detection.
- Classification categories include personnel, vehicle, helicopter, clutter, bird, UAS, tracked vehicle, and unknown. In the "port and harbor" mode, classification categories also include small vessel and large vessel.

Data Viewability & Shareability
- Operable via C2 integration and directly, using the HawkView GUI. The included software can control up to eight radars and view detections and tracks in a three-dimensional (3D) viewer.
- Includes multiple network connections that are configurable to share data to various sources, including web server.
- Communicates over various protocols, including SEIWG 0101B, ASTERIX, and COT.

Data Storage & Retention
- Detection data and system logs are automatically captured on the internal system computer, which typically stores more than one month data as well as log files under continuous use.
- All detections and tracks are stored in a KMZ format.

- Files are accessible via a web browser connection to the radar from which they can be transferred to be retained externally.

Alerts
- Provides detection and track alerts automatically.
- Alarm zones are configurable for specific locations and missions: zone types include inclusion, exclusion, port and harbor, and alarm (audible).
- With the HawkView operational software, users can enable audible alerts. HawkView also allows the user to color code and display time for alerts.

False Alarms
- Exclusion zones can be applied to remove false alarms from areas of non-interest.
- A "port and harbor" mode is available to reduce false alarms from waves up to sea state 3.
- Configurable minimum detection velocity for slow-moving targets and windblown clutter.
- Weather filter to reduce false alarms associated with adverse weather.
- Configurable filtering for repetitive detections in a single range, azimuth, or velocity location.

Maintenance
- System does not require periodic hardware or software maintenance.
- Software updates required by agency cybersecurity protocols can be performed remotely, including changes to the operating system.

Warranty, Training, & Cost
- The SR Hawk comes with an initial one-year warranty that covers defects in material and workmanship. Extended warranties are available up to 10 years in one-year increments.
- SRCTec offers up to five days of operation and maintenance training, including classroom lectures and hands-on practical exercises. Training delivery is contract specific.
- The SR Hawk radar is available in multiple equipment configurations that vary in price. For specific pricing, contact inquiries@srcinc.com.
- The product is available on GSA schedule.

3.2.7 Terma, SCANTER

The Terma SCANTER radars, including the 2000, 5000, and 4000 series, provide a solution for coastal surveillance. The SCANTER 2000 is an X-band, 2D, coherent pulse compression radar. The SCANTER 2000 series offers detection of small targets in all weather conditions and is suited for VTS, river, and inner port surveillance. Target tracking, via the Terma ET2 tracker, is available as an embedded option. The SCANTAR integrates with existing and third-party systems using all industry standard protocols. Unlike the 5000 and 4000 series, the SCANTER 2000 does not provide air coverage.

Figure 3-12 SCANTER Radar Solutions for Coastal Surveillance

Image Credit: Terma

Detection & Classification
- Minimum detection range: 30 m.
- Maximum detection ranges: 48 nautical miles (nmi) (SCANTER 2000); and 96 nmi (SCANTER 5000).
- SCANTER automatically detects and tracks targets with imbedded ET2 Tracker.
- Object classification is an add-on capability with categories including vessels, birds, drones, and aircraft (depending on radar series).

Data Viewability & Shareability
- Data is available through Terma's proprietary Radar Service Tool and the user's C2 system.

Data Storage & Retention
- Data is retained within the transceiver.
- Radar detection video and/or track target information is shared to the C2 system.

Alerts
- SCANTER with imbedded ET2 Tracker automatically alerts the C2 system of tracks and detections.
- Alert outputs are configurable based on the end-user requirements.

False Alarms
- False alarm mitigation is based on algorithms within the radar video and tracking processing.

Maintenance
- Annual visual inspections of the antenna and oil level are required.
- Terma can access the radar remotely, with customer approval, to perform updates and make requested changes to the operating parameters.

Warranty, Training, & Cost
- Terma provides a standard warranty of 12 months upon issuing the site acceptance test or 18 months upon shipping.
- Customer support is offered through service level agreement contracts, 24-hour global operational support centers, and ad hoc support.
- Pricing is not publicly available.
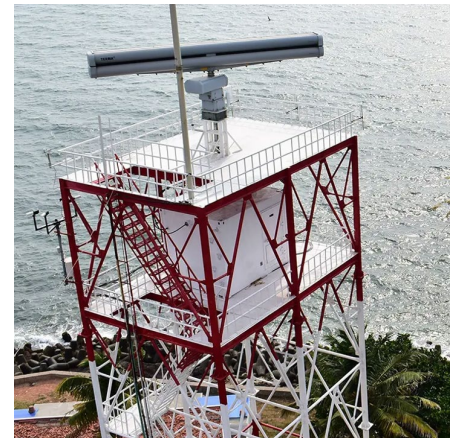- Product is not on the GSA schedule.

3.3 Integrated Systems & Software Solutions

3.3.1 Accipiter Radar Corporation, Coastal Surveillance Radar System (NM1-8A)

The Accipiter NM1-8A is a software-definable[9] coastal surveillance radar system designed to detect small and large vessels and low-flying aircraft of all sizes, including drones. The system includes the radar and electronics, digital radar processors, radar remote controller, radar data manager, power management, and data communications components housed in a protective enclosure. The standard NM1-8A system includes a Furuno X-band solid-state radar sensor with applicable array antenna; other radar sensors and antennas are available based on mission requirements. The NM1-8A can be integrated with additional radar sensors to expand coverage, cameras to increase awareness, AIS, automatic dependent surveillance broadcast (ADS-B), and third party C2 systems.

Figure 3-13 NM1-8A Security Radar

Image Credit: Accipiter

Detection & Classification
- Minimum detection range: ~22 m (based on height of deployed sensor).
- Maximum detection ranges: 50 km for large maritime targets.
- Automatic object detection.
- Classifies targets through Accipiter's digital radar processing (DRP) and post-processing software primarily based on target size, speed, heading, and behavior.

Data Viewability & Shareability
- Live tracks and alerts may be accessed through the Accipiter browser-based COP or through an existing C2 system.
- Multiple users may be simultaneously logged in to the COP with various credential-permitted feed and alert configurations.
- Communications with an external network from the radar system are encrypted via HTTPS/TLS1.2/TLS1.

Data Storage & Retention
- Accipiter's radar data manager stores the tracks and track updates, with a capacity of approximately three years of captured data on board.
- Data can be replicated in real time and stored externally when connected to an Accipiter M3 Target Information System.

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[9] "A software-defined radar is a versatile radar system, where most of the processing, like signal generation, filtering, up- and down conversion etc. is performed by a software." See IEEE. "Software defined RADAR a state of the art." 2010.

Alerts
- Multiple communication options available for real-time alerting.
- Targets that enter a user-defined area or alert zone will light up on a map underlay and an audio indication will sound.
    - Following the alert, pre-defined actions can be taken automatically.
- Alerts can be sent via email or text to operators for response.

False Alarms
- The DRP provides digital signal processing including adaptive clutter, multipath and sidelobe suppression, masking, plot extraction, interacting multiple model/multiple hypothesis tracking (IMM/MHT), and digital scan conversion for standard plan position indicator (PPI) radar displays, and echo trails displays.

Maintenance
- Accipiter recommends routine scheduled maintenance once or twice annually, depending on sensor.
- Applicable cybersecurity and software updates, tuning, and health monitoring are conducted remotely.

Warranty, Training, & Cost
- Standard one year, return-to-factory warranty.
- Extended warranty periods, on-site spares and repairs, and 24/7/365 customer service available.
- User support and training at the customer's site, or remotely, is provided as part of system commissioning.
- Several Accipiter radar systems and maritime domain awareness feeds are available on GSA schedule.

3.3.2 BigBear.ai, Arcas

Arcas Computer Vision (CV) is a software that uses forensic full motion video (FMV) for multi-vessel detection, classification, and tracking with EO and IR streams. In addition, the software has capabilities for feature identification (including weapons and personnel), vessel geolocation, and optical character recognition in real time. It does not require an internet connection to operate. The system can operate with water on the camera lens, partial object occlusion, and challenging lighting conditions. Arcas can operate during the day and night.

Figure 3-14 Arcas

Image Credit: BigBear.ai

Detection & Classification
- Detection range of 1m to several km dependent on the size of the vessel type of interest.
- Tracks objects across videos and provides alerts with positions and classifications.
- Detects and classifies over 20 vessel classes, including kayaks, canoes, jet skis, stand-up paddleboards, maritime vessels, fishing vessels, yachts, passenger carriers, hospital ships, submarines, and unmanned aircraft systems.

Data Viewability & Shareability
- Data is annotated on live or archival video streams.
- Video streams can be pushed back to and played on any user interface or COP capable of displaying video.

Data Storage & Retention
- Original or annotated video streams can be saved if required.
- The storage requirements vary by video size and frame rate.

Alerts
- Provided through messages in JSON format, alerts include detection descriptions, object classifications, and timestamps.
- Alert sensitivity level can be configured by users with minimal system modification.

False Alarms
- Users can set custom detection thresholds on a per-class basis.
- Confidence and time thresholds can be customized to reduce false alarm rate.

Maintenance
- Software maintenance is not required.
- Models can be updated through remote network connection.

Warranty, Training, & Cost
- Training support services provided with purchase.
- Contact BigBear.ai for pricing.
- Product is not on the GSA schedule.

3.3.3 Charles River Analytics, Awarion Autonomous Lookout System

The Awarion Autonomous Lookout System is a computer vision system that uses EO and IR video streams to detect, classify, and track objects. The detections are displayed on a web-based GUI. The system can operate 24 hours, through day and night and in all weather conditions, including rain and fog. The system does not require internet connection to operate and conduct analysis. The Awarion software can be purchased as a standalone product or as part of an integrated camera system.

Figure 3-15 Awarion Autonomous Lookout System

Image Credit: Charles River Analytics

Detection & Classification
- Detection range is sensor dependent. Awarion has detected small buoys out to ~400 m and cargo ships out to ~10 km from a height of ~10 m.
- Detects and classifies small objects, cargo ships, cruise ships, fishing boats, jet skis, animals, and people.
- Awarion can integrate an automatic identification system (AIS) receiver with an additional cost.

Data Storage & Retention
- Original videos are compressed and stored in a processing computer or storage device.
- Detection data is stored using ROS bagging that enables playback. Track data is stored in an SQL database on the GUI back-end server.

Alerts
- For each detection, the ROS sends a message that includes the object's class, location, size, direction, speed of travel, and snapshot.
- The alerts can be changed minimally within the GUI settings. Additional modifications may be available via software updates.

False Alarms
- Threshold for "low confidence" can be adjusted to reduce false alerts.

Maintenance
- New software versions are regularly released; the process of updating software can be performed by any software engineer.

Warranty, Training, & Cost

- Training support services are provided with purchase.
- Available accessories are built around several EO/IR camera models.
- Awarion offered for monthly lease with variable cost based on the selected hardware and software customization.
- The product is available on GSA schedule.

3.3.4 TimeZero, TZ Coastal Monitoring

Time Zero Coastal Monitoring (TZCM) consists of scalable software modules used for maritime domain monitoring along coastlines and harbors. TZCM can integrate radar, GPS, AIS, and Echosounder sensors from Furuno as well as thermal and night vision cameras from FLIR and AXIS. The software solution can operate in adverse weather conditions during the day and night. It does not require an internet connection to operate, however, using an internet connection provides the system and the user with additional information such as AIS vessel photos, maritime traffic AIS data, and weather information from the National Oceanic and Atmospheric Administration.

Figure 3-16 TimeZero Coastal Monitoring

Image Credit: TimeZero

Detection & Classification
- Detects small objects such as kayaks and UAS using appropriate monitoring zones.
- System can be configured for automatic detection, zone detection, or manual detection and acquisition.

Data Viewability & Shareability
- Data can be viewed in the TZCM user interface on a local PC, remote tablets, or through a remote or local C2 site.
- Track data can be exported in standard formats such as GPX, TZX, and KML.

Data Storage & Retention
- Data can be captured and stored on internal memory, external drives, or cloud storage. Conventional installation uses hard disk drives of 2–5 TB.

Alerts
- Visual and audible alerts area are available through SMS, email, and through the command strip.
- Alerts are configurable.

False Alarms
- TZCM and Furuno radars can be configured to reject below-threshold alarms.
- The software uses rule classification to prevent multiple alarms from the same target.

Maintenance
- Software maintenance and calibration can be performed remotely. Software security updates are available through direct download.
- Hardware maintenance is confined to regular radar magnetron replacement based on original equipment manufacturer (OEM).

Warranty, Training, & Cost
- Customer service is available by phone, email, and a web portal to submit support requests.
- A two-year warranty is included for parts and labor for all software components and Furuno sensors. An extended warranty is available from Furuno for Furuno sensors.
- TZCM maintenance and service is $2000/year per license.
- Training is available at $1850 per trainer per day.
- Cost is $15,750 for a software license with one radar, CM1R. A CM2R license, which includes two radars, costs $36,750. Either suite is configurable with Furuno light marine or other commercial radars (radars sold separately). The command center module costs $21,000 and the TORRMD record and replay module costs $10,500.
- Product is not currently on the GSA schedule, but process is pending.

3.3.5 IEC Infrared Systems, Raptor

The Raptor system includes a Ku-Band, pulse-Doppler radar and long range thermal and visual cameras. IEC's IntrudIR Alert software integrates output from radar, thermal, and visual cameras, as well as unattended ground sensors and allows a single operator to configure, calibrate, and operate the sensors. The Raptor can surveil an area of 175 square miles.

Figure 3-17 Raptor System

Image Credit: IEC

Detection & Classification
- Minimum detection range: 250 meters.
- Maximum detection ranges: 12 km for a person, 20 km for a car, and 32 km for a truck.
- Automatic object detection.
- Classification categories include person, animal, boat, car, truck, and drone.

Data Viewability & Shareability
- IEC video management system is available with serial or IP control architecture.

Data Storage and Retention
- IEC video management system, on-premises or cloud.

Alerts
- Alerts on designated intrusions, set by operator.

False Alarms
- Uses heuristic clutter mitigation.

Maintenance
- Raptor uses line replaceable payloads, which do not require any tools to remove and replace.
- Software can be updated remotely if needed.

Warranty, Training, & Cost
- System comes with a one-year full warranty. Extended warranty available for 15% of total purchase price per year.
- Full 24/7 360 customer support.
- Set-up and customer training with travel and training reimbursement required.
- Price of $725,000 includes RAPTOR with single set of IntrudIR Alert middleware, M8 Werewolf HD IP positioner camera kit assembly, SR Hawk radar (including mount and 100 ft cable set), 900mm HD thermal payload with laser range finder, 800mm HD visual payload, 12" pedestal, 100 ft cable set, and storage/transport cases.
- Product is not on the GSA schedule.

3.3.6 Picogrid, Picogrid Platform

Picogrid Platform is an integrated hardware and software solution that combines visual, thermal, and radar sensors from companies such as Axis, FLIR, and Echodyne as well as AI. The platform uses AI/ML to optimize the output of the sensors for maritime applications. It is compatible with OEM and third-party sensor modules and supports both Open Zero-Trust API and over-the-air software upgrades. All hardware on the Picogrid Platform uses powder-coated aluminum designed to provide weatherproofing and saltwater resistance and has been tested in corrosive marine environments, including Cat 5 winds, 120 F° heat, and snow. The system is powered by a 1 kW solar power architecture with a seven-day battery backup for continuous operation. It may also be connected to shore power.

Figure 3-18 Picogrid Platform

Image Credit: Picogrid

Detection & Classification
- Minimum detection range: 0.9 m.
- Maximum detection ranges: 900 m for standard configuration, up to 5.5 km meters with advanced sensor (person 1.2 km, vehicle 3.3 km).
- Automatic object detection.
- Classification categories include person, commercial vessel, recreational vessel, floatation device, military vessel, or vehicle.
- The technology can detect UAS when an additional sensor package is added.
- Picogrid plans to collaborate with the DoD to integrate the Air Force's proprietary vessel detection dataset into their system.

Data Viewability & Shareability
- Authorized users or API key holders can access, view, and share data.

Data Storage & Retention
- Data can be stored locally or in the cloud based on customer requirements.
- The data is encrypted using AES-256 (in transit and at rest).

Alerts
- Alerts are configurable based on time, object, location, and area of interest.
- Picogrid Platform's alerts are customizable and can be received via C2 software, push alerts, SMS, and email.

False Alarms
- The system limits false alarms by allowing sensitivity levels to be adjusted.

Maintenance
- Picogrid considers the platform low maintenance as it is self-powered and has a tamper-resistant full-metal construction.
- An interval of one-year is recommended for the preventive maintenance interval.
- Most maintenance is conducted remotely including automatic updates to software.

Warranty, Training, & Cost
- System comes with an all-inclusive two-year license.
- Purchase includes 24/7 online training and customer support at no additional cost.

- The cost of the solution is dependent on the sensor package used.
- The product is not available on GSA schedule.

3.3.7 Reid Marine Electronics, Maritime Detection, and Surveillance System

The Maritime Detection and Surveillance System (MDSS) is a pod system based upon low power/high performance (LPHP) thermal imaging and radar technology. Each MDSS pod has a multi-sensor long wave infrared EO/IR pan-tilt-zoom camera, solid state radar dome, GPS, wind speed/direction indicator, barometer and temperature sensors, AIS, and a cellular router for connecting to first responder dedicated networks. Each pod connects to a software platform designed exclusively for camera and radar maritime integrations with the ability to record from each device. The low-power nature of this design allows for temporary or permanent installations using a lithium power unit (LPU), which provides primary or backup power and is rechargeable using solar panels or shore-based power.

Detection & Classification
- Minimum detection range: 90 m.
- Maximum detection ranges: ~ 2 km for detection of 2.3 m x 2.3 m target.
- Automatic object detection.
- No object classification.

Data Viewability & Shareability
- Data is viewed on a PC Workstation and can be shared over the local network or via mobile VPN for streaming video to patrol vessels/vehicles.
- The IP video from the pod EO/IR system is Open Network Video Interface Forum (ONVIF) Profile S-compliant. Video can be ported to a third-party vendor management system (VMS) or streamed to Blue Force vessels/vehicles patrolling or responding to incidents.

Data Storage & Retention
- Data is captured on the LAN workstation and retained to local hard drives.
- Data can be configured for cloud-based storage.

Alerts
- Visual and audible alarm for operator relays to trigger guard zone lighting; SMS and email alerts also available.
- Alerts are configurable.

False Alarms
- Automatic radar plotting aid defines an actual target rather than video analytic detection. Typically, any object detectable by radar and entering a guard zone is a target of interest.

Maintenance
- Periodic system maintenance is required to provide optimal system performance: each pod should be inspected and cleaned as necessary but monthly intervals should be observed for salt deposit removal and EO/IR optics cleaning. LP/HP pods with MWIR EO/IR sensors will require periodic cryogenic cooler maintenance. Uncooled microbolometer EO/IR sensors used by LP/HP pods do not require maintenance.
- Software can be updated remotely as needed.

Warranty, Training, & Cost

- A 90-day warranty for the on-board MDSS system includes remote and on-site service, training, and new product replacement. Training is provided on-site at MDSS commissioning for installed and mobile solutions and is based on user requirements. Extended system support warranties and additional training are available and tailored to meet individual requirements.
- A two-year MDSS component warranty includes remote troubleshooting and repair of system components.
- Customer support includes email communication with phone support follow-up as needed (7am-7pm PST) within 24 hours of initial request. Emergency on-call support for critical infrastructure available.
- To provide accurate pricing for permanent installed systems, Reid requires a site survey, as the MDSS is scalable and configurable to individual requirements.
- Product is not available on GSA schedule.

4.0 MANUFACTURER AND VENDOR CONTACT INFORMATION

Additional information on the products included in this market survey report can be obtained from the companies listed in Table 4-1.

Table 4-1 Manufacturer and Vendor Contact Information

Company	Website	Address	Phone Number	Email Address
Accipiter Radar Corporation	www.accipiterradar.com	40 Centre Drive, Suite 300 Orchard Park, New York 14127	716-508-4432	info@accipiterradar.com
Aerostar International LLC	aerostar.com	2231 Crystal Drive, Suite 515 Arlington, Virginia 22202	605-331-3500	info@aerostar.com
BigBear.ai	bigbear.ai	6811 Benjamin Franklin Drive Columbia, Maryland 21046	410-312-0885	info@bigbear.ai
Charles River Analytics	www.cra.com	625 Mount Auburn Street Cambridge, Massachusetts 02138	617-491-3474	contactus@cra.com
Controp USA	contropusa.com	20501 Seneca Meadows Germantown, Maryland 20876	253-929-4381	contropusa.com/contact-us
Echodyne Corps	www.echodyne.com	12112 115th Avenue NW, Suite A Kirkland, Washington 98034	419-202-2405	info@echodyne.com
Edge Autonomy	edgeautonomy.io	831 Buckley Road San Luis Obispo, California 93401	571-531-9631	support@edgeautonomy.io
Elbit America	www.elbitamerica.com	4700 Marine Creek Parkway Fort Worth, Texas 76179	682-300-1169	homelandsecuritysolutions@ elbitsystems-us.com
Electro Optical Industries Inc.	hgh-infrared.com	1240 E Campbell Road, Suite 200 Richardson, Texas 75081	972-694-7082	eoi@eoiir.com
Helios Remote Sensing Systems Inc.	www.heliossensors.com	52 Geiger Road, Suite 2 Rome, New York 13441	315-356-1661	heliossensors.com/contact

Company	Website	Address	Phone Number	Email Address
IEC Infrared Systems LLC	www.iecinfrared.com	7803 Freeway Circle Middleburg Heights, Ohio 44130	317-294-6622	info@iecinfrared.com
Innovative Signal Analysis Inc.	www.wavcam.com	3301 East Renner Road, Suite 200 Richardson, Texas 75082	214-709-4988	www.wavcam.com/contact
Israeli Aerospace Industries, ELTA Group	www.iai.co.il/about/groups/elta-systems	100 Yitzhak Ha'nassi Boulevard Asdod, POB 330, Israel	+972 50 665 6371	www.iai.co.il/about/groups/elta-systems
Optics 1	www.optics1.com	2 Cooper Lane Bedford, New Hampshire 03110	805-358-3644	sales@optics1.com
Picogrid	picogrid.com	113 Main Street El Segundo, California 90245	650-395-8327	solutions@picogrid.com
Reid Marine Electronics LLC	N/A	27 W. Anapamu Street, Suite 413 Santa Barbara, California 93101	805-637-9104	peter@reidmarine.com
Sea Machines Robotics Inc.	www.sea-machines.com	226 Causeway Street, Suite 601 Boston, Massachusetts 02114	757-589-3260	sales@sea-machines.com
SRCTec LLC	www.srcinc.com	5801 East Taft Road North Syracuse, New York 13212	315-663-5425	www.srcinc.com/forms/contact.aspx
Terma Inc.	www.terma.com	3200 Windy Hill Road SE, Suite 1500E Atlanta, Georgia 30339	571-699-6298	info@terma-us.com
TimeZero	www.coastalmonitoring.com	16100 NW Cornell Road Beaverton, Oregon 97006	503-579-1414	info@mytimezero.com

5.0 CONCLUSIONS

Maritime surveillance technologies are used to monitor and protect ports and other critical infrastructure, for instance airports, that are near or surrounded by water. Surveillance systems that can detect small surface intrusions on the water provide agencies with situational awareness and actionable information regarding potential safety and/or security hazards. Advancements with AI and ML allow for detection alerts to occur automatically, which decreases the burden on operators. Solutions can be deployed by agencies as a standalone solution or as a subsystem of a VTS or other larger solution as a supplement to detect small targets.

This market survey report provides information on 20 products, including EO/IR, radar, software, and integrated systems. All but one of the solutions is capable of automatically detecting small targets on the water, and many provide some type of classification of the detected target. Additionally, 75% of the products allow for configurable alerts that can be set according to an agency's preferences and protocols. Reported prices for the 20 systems herein range from $15,750 to $725,000. Due to the various solution types, product pricing is highly variable and typically requires additional outreach to the vendor. The size, weight, and power requirements of these systems are also highly variable depending on the modality of the primary sensor and inclusion of additional sensors. Although EO/IR and radar systems are described separately in this report, many solutions with a primary sensor of one type can integrate additional sensors of the other.

Emergency responder agencies should carefully research the overall capabilities and limitations of maritime surveillance technologies in relation to their agency's operational needs when making equipment selections.

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