

IMSAR Radar Solutions for Maritime Applications

IMSAR LLC develops high-performance; low-Size, Weight, and Power (SWaP); low-cost airborne Synthetic Aperture Radar (SAR) systems that provide Intelligence, Surveillance, and Reconnaissance (ISR) data for multiple maritime applications, including counter drug, counter trafficking, and disaster support operations with all-weather SAR mapping and Moving Target Indicator (MTI) modes. IMSAR radars can search vast areas of ocean for moving targets, perform wide-area imaging to find stationary targets, and perform high-resolution imaging to find low Radar Cross Section (RCS) targets. In addition, our radars can process coherent change detection along beaches and shorelines to find ingress and egress points to the water.



Figure 1: IMSAR Radar System Performing Maritime Surveillance

The scalable, modular, and open system architecture of our radar systems allows for simple integration with a variety of Group 1-5 Unmanned Aircraft System (UAS) and manned platforms. All of our radar systems share the same basic system architecture and support standard inputs and outputs, which allows for interoperability with various platforms and mission systems. In their standard configuration, IMSAR Ku-band radar systems come in pod formations as shown in Figure 2.

NSP-3 (TRL 8)



NSP-5 (TRL 8)



NSP-7 (TRL 9)



Figure 2: IMSAR's Podded Radar Systems

IMSAR has extensive experience implementing standard and custom integrations of operationally proven radar systems on a variety of platforms. Figure 3 shows several integrations of the standard NSP radar pods. In addition, components can be reconfigured to accommodate custom and deep integrations, as shown in Figure 4.



Figure 3: Successful Integrations of IMSAR's Family of Low-SWaP-C Radar Systems. IMSAR has successfully increased the ISR capabilities of multiple aircraft, including (from upper left to lower right) the King Air C90, the King Air B200, the King Air 350, and the Skyfront Perimeter 8.



Figure 4: IMSAR's NSP-7 Radar System Integrated with an Optical Sensor (left) and the NSP-3 radar system components deeply integrated into the ScanEagle UAS platform (right)

Radar System Specifications

The NSP systems perform spotlight and stripmap imaging day and night, under all weather conditions, including smoke, fog and other obscurations. The low SWaP of the NSP radar systems allow for longer platform endurance and the emplacement of additional payload sensors. The NSP radar systems only require power, Ethernet, and a connection to a GPS antenna from the host platform to operate. As summarized in the table below, the NSP family of radar systems designed for Group 2-5 and manned platforms provide a low-risk, highly sustainable sensor payload for enhanced ISR data and situational awareness in maritime environments.

| Characteristics of NSP Radar Systems | | | |
|--|---|--|---|
| System | NSP-3 | NSP-5 | NSP-7 |
| Size | (2 pods) 9.5 cm diameter, 77.6 cm length, 9.5 cm height | 13.7 cm diameter 117.9 cm L x 17.5 cm H | 5.4 in diameter 147.5 cm L x 17.3 cm H |
| Weight | 3.35 kg | 7.5 kg | 10.9 kg |
| Max. Power Required | 81 W @ 28 V | 130 W @ 28 V | 275 W @ 28 V |
| Target Platforms | Group 2 UAS | Group 3 UAS | Group 4-5 UAS, Manned |
| Recommended Operating Altitude | Up to 6,000 ft Above Ground Level (AGL), mode dependent | Up to 10,000 ft AGL, mode dependent | Up to 23,000 ft AGL, mode dependent |
| Modular and Scalable Design | IMSAR radar systems are modular, which allows for the easy integration of a full system on nearly any platform. | | |
| Reduced Aerodynamic Impact | IMSAR's modular system and panelized Electronically Scanned Arrays (ESAs) allow for a slim integration, which reduces aerodynamic impact. The system has minimal drag. | | |
| Low Technical Risk | IMSAR's radar systems are Technology Readiness Level (TRL) 8-9 and require little development to support new integrations, which will drastically shorten the timeline required to become fully-mission capable. | | |
| Low Procurement Costs | Our systems' high levels of hardware and software reuse and our intentional design for high-volume manufacturing reduces overall system costs. | | |
| Low Maintenance Costs | IMSAR radar systems have an industry-leading Mean Time Between Failure (MTBF) in excess of 2,000 hours. This high level of reliability will help keep total ownership costs low over the lifecycle of the system. | | |
| Near-Real-Time Imagery | IMSAR radars can perform SAR imaging, CCD/MCD, and GMTI/MMTI that are processed and displayed in near real time. | | |
| Integrable with Payload Hardware and Software | IMSAR radar systems conform to open standards (NITF and STANAG compliant data output) and are designed with an open systems architecture to support integration with other payload sensors and capabilities. Furthermore, IMSAR systems are able to be commanded and controlled by third-party applications using our open Application Programming Interface (API). | | |

Radar Modes and Capabilities

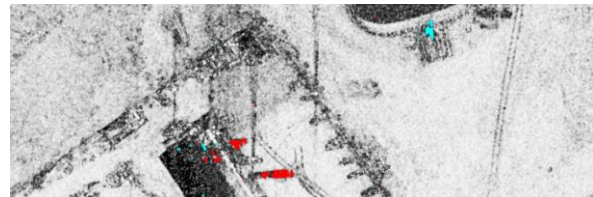
IMSAR radar systems complement other onboard sensors, such as Electro-Optical/Infrared (EO/IR), to provide valuable, actionable intelligence even in low-visibility environments. In addition, the radars can cross-cue EO/IR sensors to further identify targets of interest. Among their capabilities, the NSP radar systems can collect high-resolution SAR imagery, detect subtle changes in the landscape, and detect and track moving targets. To support maritime missions, the NSP family of radar systems are capable of multiple modes, including variable-resolution SAR imaging, Coherent and Magnitude Change Detection (CCD/MCD), Ground and Dismount Moving Target Indication (GMTI/DMTI), Maritime Moving Target Indication (MMTI), Automatic Target Recognition (ATR), and SAR Motion Video (SMV). The following high-TRL capabilities are available on the NSP family of systems.

General Radar Modes



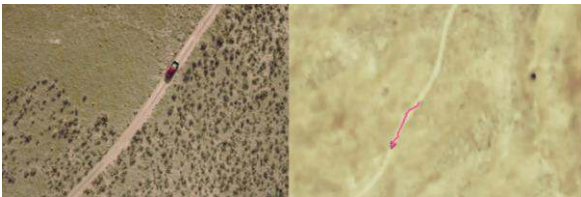
SAR Imaging

Using the movement of the airborne platform, the radar system synthesizes very large apertures to produce fine-resolution imagery. TRL-9



CCD/MCD

Compares multiple SAR images of the same area collected over time and automatically detects and highlights changes. TRL-9



GMTI/DMTI

Detects and tracks moving ground targets over a wide area. TRL-8



MMTI

Uses a wide-area search to detect and track moving targets in maritime environments. TRL-9



ATR

Uses algorithms to recognize targets or other objects based on data obtained from the sensor. TRL-6



SMV

Produces a Full-Motion Video (FMV)-like live stream of the radar imagery. TRL-8

Maritime Radar Capabilities

SMV

IMSAR has also demonstrated that the SMV mode is a valuable tool in maritime applications. IMSAR has collected SMV over maritime vessels and found the mode to be useful in finding and classifying them as well as identifying features on a larger vessel. SMV has also proved useful in assisting a Full-Motion Video (FMV) sensor maintain custody of a target in intermittent weather conditions and through maritime haze and glare. Figure 6 illustrates IMSAR SMV mode capabilities through a series of screen captures taken from real-time sensor video feeds during a side-by-side SMV and FMV data collection event monitoring large maritime targets of opportunity.

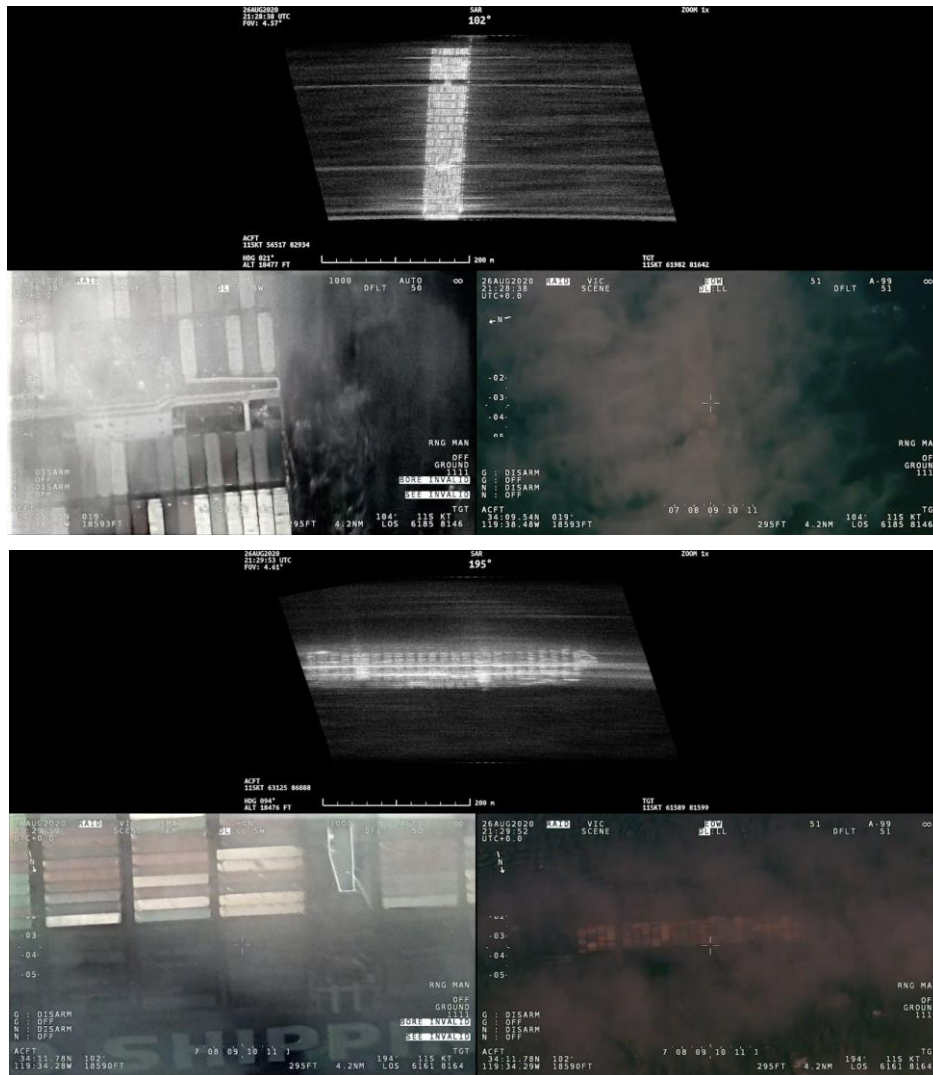


Figure 6: SMV Data Collection in a Maritime Environment. Real-time data was collected from both an IMSAR NSP radar system's SMV mode (upper screens) and an MX-15 optical full-motion video camera (lower screens) of a large vessel. Although the optical images were at times obscured by fog, the IMSAR radar penetrated the fog to obtain SMV images. (NOTE: The optical camera images show telescopic on the left and wide angle on the right).

ISAR

IMSAR has advanced our radars' multimode capabilities to include a Sector Scan mode, which will improve detection ranges and increase flexibility in mission execution, and a real-time Inverse Synthetic Aperture Radar (ISAR) processing mode, which will enable high resolution imaging of moving vessels for mensuration and classification. The ISAR mode enhancement, in which two-dimensional, high resolution images of maritime targets can be generated, is a valuable advantage in maritime applications, since it relies on the motion of targets on water rather than the movement of the radar to generate images. Figure 5 shows data processed with our ISAR capability.



Figure 5: ISAR Data from Maritime Collection with the NSP-7. These ISAR images (left: 0.1m resolution) and (right: 0.3m resolution) were taken of the craft pictured in the center, with the following specifications: 10,000' AGL, 25-degree depression/grazing angle, 4 mile standoff range, sunny conditions.

Other Maritime Patrol Characteristics

IMSAR's NSP radars have demonstrated their performance as effective Maritime Patrol Radar systems with the following characteristics:

- Provide right- and left-facing coverage areas scanning up to +/- 60 degrees in azimuth for a total of up to 240 degrees azimuth coverage, installation dependent (Figure 7)
- Provide a Maritime Moving Target Indication (MMTI) mode capable of performing focused and wide-area searches (Figure 8)
- Provide high-resolution SAR imagery of maritime and littoral environments (Figure 9)

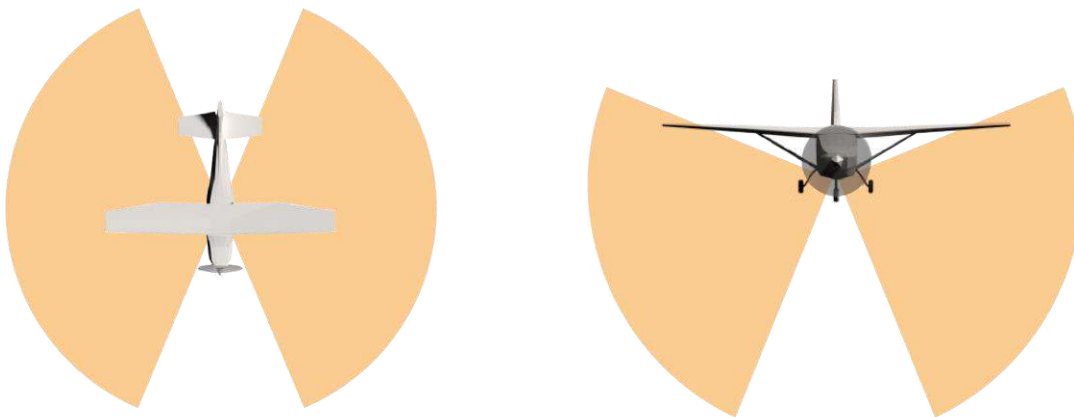


Figure 7: The Dual-Sided Scanning Capability of the NSP Family of Radar Systems, Shown in Azimuth (left) and Elevation (right)



Figure 8: (Top) Detection and Tracking of Vessels, with AIS Data to Corroborate. MMTI mode uses Doppler to automatically search for, detect, and track moving targets and other objects in maritime and littoral environments. MMTI can be used to perform a focused search by commanding the radar to continuously monitor a preselected area of interest, or perform a wide-area search in which the radar uses a scan pattern to search a wide area. NOTE: The targets depicted in this diagram were targets of opportunity, and the detection ranges do not represent the maximum ranges of IMSAR radar system capabilities.



Figure 9: Actual SAR Ocean Imagery from an IMSAR Radar System. This image shows the radar’s ability to produce real-time high resolution SAR imagery products useful for detecting and locating surface vessels in the scene.

IMSAR Radar Performance

In maritime and littoral environments, IMSAR has tested the performance of its MMTI mode. The performance data below represents predicted performance of the NSP-3, NSP-5, and NSP-7 MMTI modes against relevant targets of interest based on actual data obtained during internal testing.

| MMTI Predicted Performance* | | | | | | | | | |
|-----------------------------|-------------|-------------------|---------------------------------|-------------|-------------------|---------------------------------|-------------|-------------------|---------------------------------|
| System | NSP-3 | | | NSP-5 | | | NSP-7 | | |
| Target Type | Range (NMI) | Swath Width (NMI) | Coverage (NMI ² /Hr) | Range (NMI) | Swath Width (NMI) | Coverage (NMI ² /Hr) | Range (NMI) | Swath Width (NMI) | Coverage (NMI ² /Hr) |
| Raft | 3.5 | 3 | 150 | 6.5 | 6 | 480 | 9 | 8 | 1200 |
| Fishing Boat | 4.8 | 4.1 | 205 | 8.5 | 8 | 640 | 12.5 | 11 | 1650 |
| Yacht | 8.3 | 7.7 | 385 | 14.5 | 13.5 | 1080 | 21 | 19.5 | 2925 |
| Container Ship | 17.5 | 15.5 | 775 | 30 | 27 | 2160 | 41 | 38.5 | 5775 |
| Super Tanker | 35.5 | 33.5 | 1675 | 55 | 51.5 | 4120 | 73 | 69 | 10,350 |

*Assumption for NSP-3: Operating Altitude = 3,000 ft; Speed = 50 KTAS; NSP-5: Operating Altitude = 6,000 ft; Speed = 80 KTAS; NSP-7: Operating Altitude = 18,000 ft; Speed = 150 KTAS

Radar Interfacing and System Configuration

IMSAR’s graphical and intuitive Lisa 3D Command and Control (C2) and Processing, Exploitation, and Dissemination (PED) software enables an operator to control the radar, cue other onboard sensors, and integrate with the platform’s mission system for real-time data processing (Figure 10). IMSAR has also developed a radar control and data-display Application Programming Interface (API) to support integrations with popular third-party mission management software programs.

An IMSAR radar system consists of an aerodynamic pod or other customized configuration containing the radar components, an imagery processing server, and a mission computer with Lisa 3D software installed for radar control and data analysis. All of these system components are linked through a simple Ethernet connection. As shown in Figure 11, we have a variety of server options to meet the requirements of manned and unmanned maritime ISR missions.



Figure 10: Lisa3D C2 and PED User-Interface. In Lisa 3D, sensor data can be overlaid on an existing 3D optical map or represented with icons to make data easy to understand. Operators can annotate and mark sensor data, and Lisa 3D will automatically highlight the annotations and marks on the map, timeline, and calendar.

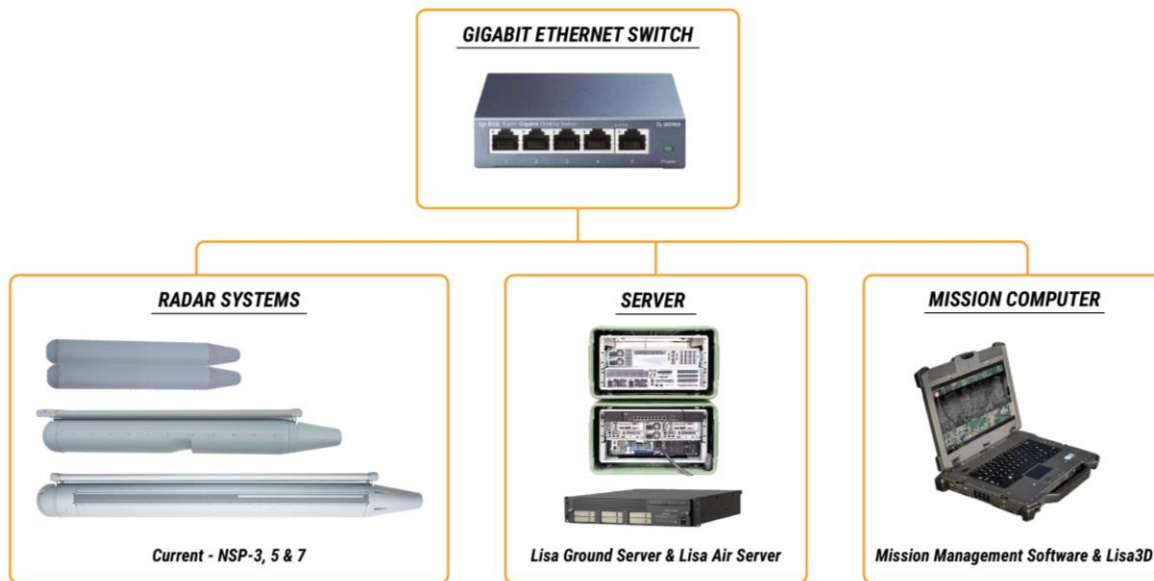


Figure 11: Complete IMSAR Radar System

Potential Applications

With their multiple capabilities, the NSP family of radar systems are ideal sensors to perform a variety of maritime applications:

| | | |
|----------------------------|-----------------------------------|---|
| Counter Drug | Maritime Patrol | Search & Rescue / Disaster Support |
| Range Clearing | Convoy Overwatch | Force Protection |
| Oil Spill Detection | Counter Trafficking | Illegal Fishing |
| Ice Flow Monitoring | High Value Target Tracking | Battle Damage Assessment |

Democratizing Radar

At IMSAR, we are democratizing radar by making it more usable, affordable, and accessible than ever before. Contact us for further information about our radars' capabilities and how to integrate onto your platform:



Neil Bailey
Director, Deployment Services

T 801.798.8440
F 801.798.2814
C 317.696.7960

940 S 2000 W #140
Springville, UT 84663

neil.bailey@imsar.com