# Homeland Security
Science and Technology

TechNote

Small Boat Intrusion Detection Systems with Radar

Ports are subject to threats such as terrorism, piracy, illegal immigration, smuggling, and arms trafficking. The capability to detect, identify, and classify targets of interest in the maritime environment is critical to countering such threats. Standard marine navigational radar systems can detect large vessels but are often not suitable for small target detection, especially in adverse weather conditions or rough seas.

Small boat intrusion detection systems with radar capabilities can be used to protect port facilities from waterborne intruders such as surface swimmers, manually-propelled watercraft (e.g., kayaks and rafts), and small motorized boats. Utilizing specialized radar systems coupled with processors specifically designed for tracking, these systems are able to detect and track potential waterborne threats and signal an alarm when warranted. By providing this tracking capability and an early warning, small boat intrusion detection systems with radar enable port security personnel to respond quickly to deter a potential threat.

Technology Overview

Small boat intrusion detection systems with radar capabilities are comprised of, at a minimum, a radar system, track processor, computer with applicable software, and a display for viewing the data captured by the detection system. The radar system consists of a rotating antenna system, duplexer, transmitter, receiver, and synchronizer. A block diagram showing the interconnectivity of the individual components is shown in Figure 1.
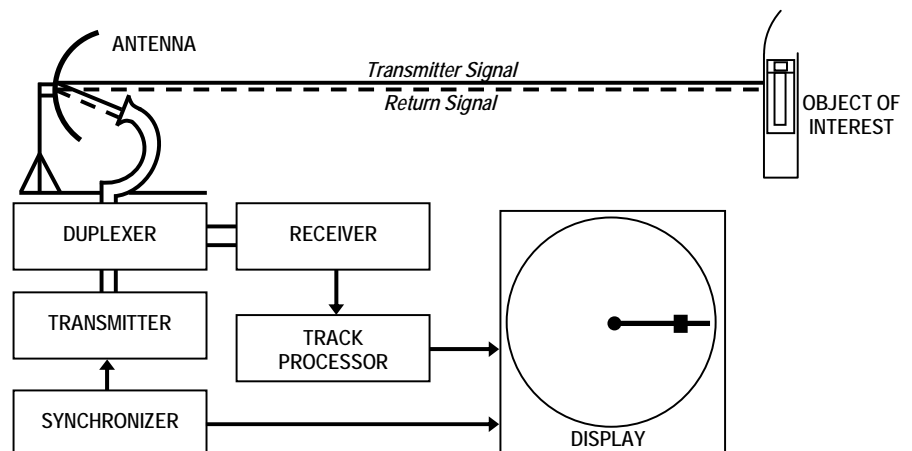
Figure 1 Small Boat Intrusion Detection System Block Diagram

An overview of each component in a small boat intrusion detection system follows:

- Transmitter: the transmitter creates pulses of electromagnetic energy at specific intervals that are then passed to the antenna for transmission.
- Receiver: the receiver detects the electromagnetic signals reflected by a target and received by the antenna system.
- Duplexer: a duplexer is a switch that allows a single antenna to be used to both transmit the signals from the transmitter and receive the reflected signals.
- Synchronizer: the synchronizer ensures that components connected with the radar system operate in a timed relationship for range determination.
- Antenna System: the antenna system sends the pulse from the transmitter, receives the reflection of the pulse from the object of interest, and relays this reflected pulse to the receiver.
- Track Processor: translates the data from the receiver and uses algorithms to determine if a detected object warrants alarm notification and plots any objects of interest.

Sometimes, a transceiver integrates the functions of the duplexer, transmitter, receiver, and synchronizer. Some radar systems also include video cameras and video recorders.

Most small boat intrusion detection systems with radar operate within the X-band radio frequency. The X-band frequency range is from 7 GHz to 12.5 GHz. Antenna arrays on a small boat intrusion detection system turn up to three times faster than the standard marine navigational radar system of 20-24 rotations per minute. Because of X-band's short wavelength and the fast scanning of the antenna, smaller targets can be identified and detected. This is especially important in rough seas since small targets can be obscured by waves.

When the transmitted signal hits an object, a portion of the signal bounces off the object and is received by the antenna system, like echoes. The duplexer passes these echoes through the receiver to the track processor. The track processor calculates the distance to the target by timing how long it takes the radio wave echoes to return and uses signal processing algorithms to try to identify the nature of the detected object. By masking out stationary objects and analyzing motion patterns, these systems are typically able to filter out objects, such

as pelicans and buoys, while still recognizing objects of interest, such as small boats.

By analyzing the track history, the track processor can determine and display the previous track of the object and an estimated direction of travel. If the track processor determines that the signal represents an object of interest, the information is sent to the display device to be plotted.

Information Display

The display for a small boat intrusion detection system is typically a computer monitor and may also include a dedicated radar display unit, as shown in Figure 2. The information that is typically displayed for each detected object includes position, distance, direction of travel, speed, closest point of approach, and estimated time of arrival. With certain software, the radar image can overlay a coastal or port/harbor map.

Users can designate alarm zones and set the system to signal a visual or audible alarm when objects enter the zones. These alarms can include information such as time to target, speed, and direction of travel.

Figure 2 Radar Display

Applications

Small boat intrusion detection systems with radar can be employed as a component of an overall waterside security strategy, as well as aid search and rescue efforts because of the ability to scan and detect small objects.

Small boat intrusion detection systems with radar have numerous current and future applications for federal, state and local agencies. The U.S. Navy and Coast Guard use them to protect their bases and federal and local law enforcement agencies use them to protect against activities such as illegal immigration, organized crime, weapons trafficking, smuggling, and terrorism. These systems can also be used by fish and wildlife agencies in their fight against poaching and trespassing.