Series 1000
Small Target Detection System
Intrusion Detection Radar

Background
Typical waterside surveillance/security systems use standard marine navigational radar systems as the means of detecting and tracking targets of interest. The standard commercial marine radar is suited for detection of vessel and navigation buoy sized targets under most sea conditions, but the detection of small, low profile, targets on the sea surface is a significant challenge. The radar sensor performance characteristics as well as display processing techniques are not optimized or suitable for small target detection, especially in adverse weather and sea conditions. The protection of waterside assets from intruders such as swimmers or small boats requires significant improvements in radar detection technology.

The L-3, Klein Series 1000 Small Target Detection System features enhanced capabilities for detection of low visibility radar targets; i.e. swimmers, person in water (PIW), and small watercraft. The Series 1000 STDS is based on technology originally developed for Search and Rescue which has extensive at-sea testing. The testing results show repeatable capabilities of detecting PIW and small rubber life rafts in high sea states (3.5m waves).

L-3, Klein’s basic STDS configuration includes an enhanced capability Radar sensor, (a specially modified X-Band sensor) and the RadarPro™ Advanced Radar processor. The modularity of the system simplifies installation and is suitable for fixed base or mobile applications.

System Description
The STDS system uses an X-band 25kW transceiver with a 7 ft slotted waveguide array that turns at 80 RPM (nominal). Small objects in the water will often be obscured by waves. The fast scanner will provide more consecutive hits when the target is on top of the wave and visible to the radar. The STDS will complete more than 3 scans in the time it takes a conventional marine radar (20-24 RPM) to complete a single scan. The RadarPro™ radar processor system uses a unique multi-scan correlation processing technique. This Scan to Scan processing dramatically improves the detection of small targets in sea clutter.
**System Performance**

The advantages of the L-3, Klein Series 1000 STDS are clear when compared to conventional marine radar systems. Typical marine radar systems with a PC based scan converter/overlay processor use simple processing algorithms, with conventional manual or automatic STC. These techniques are suitable to meet IMO target detection requirements (ships, buoys landfall), but are not capable of detecting small targets in high sea clutter states. The following charts illustrate the detection capabilities for 3 target sizes in a Sea State 5 with conventional marine radar systems and the Series 1000 STDS. The 3 target samples are:

- 0.1m² and 0.25m² which represent a PIW (swimmer)
- 0.5m², which approximates a one man life raft

The high performance real-time processing used in the Series 1000 STDS samples consecutive scans from the high speed radar scanner to dramatically improve the Probability of Detection (Pd) of small, low profile targets. In the next two charts, the Pd of the three target types is shown. Chart 1 shows Pd with a conventional radar system. Chart 2 shows the improved Pd obtained with L-3, Klein’s Series 1000 STD system.

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**Unmatched Performance**

Series 1000 STDS Radar significantly out performs conventional marine radar systems
**Field Data**

Field trial data illustrates the advanced capabilities of the STD system. The images shown below were from the RadarPro™ RT radar video display.

In the test, twenty-five moored targets were deployed in a 5x5 grid. The targets were plastic spheres, varying in diameter from 0.72 to 2.8 feet, covered with a reflective mesh and sitting directly on the water. The radar cross section of the targets varied from 0.03 m$^2$ to 0.47 m$^2$, representing real-life targets varying in size from a person-in-water (PIW) to a four-man life raft. In addition, drifting targets were deployed and retrieved after each recording trip.

The below figures show data with a higher clutter background. This data was collected with a wave height of 3.1 meters. The wind was variable. The image on the left shows spiky clutter with no processing. The image on the right is with the 1000 STDS RadarPro™ processing applied and clearly shows the test targets.

![No processing applied, clutter masks targets.](image1)

![Series 1000 STDS RadarPro™ processing clearly shows small targets in clutter.](image2)
## Series 1000 STD System Features

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<tr>
<th>ECR sensor</th>
<th>RadarPro™ Advance Radar Processor</th>
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<tr>
<td>ECR – Enhanced Capability Radar sensor</td>
<td>PC Based system</td>
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<tr>
<td>25kW X-Band Transceiver</td>
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<tr>
<td>7ft Antenna Array, 0.9° horizontal beam</td>
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<td>COTS design with enhanced capabilities for small target detection</td>
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<tr>
<td>- 4-6dB improvement over conventional marine X-band radar sensor</td>
<td>- Pulse Processor matched to antenna beam pattern</td>
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<tr>
<td>- Minimum Discernible Signal (MDS) -104dBm typical</td>
<td>- Improves target S/N</td>
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<td>- System noise figure 5.5dB or better</td>
<td>- Suppresses radar interference</td>
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<tr>
<td>- High performance Log Receiver – 120dB Dynamic Range (0-max range)</td>
<td>- Reduces rain clutter</td>
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<td>80 RPM (nominal) high update rate scanner</td>
<td>8 bit 1024 x 1024 Scan Converted display</td>
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<td>Multiplexed Down-link/Up-link interface</td>
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<tr>
<td>- Simplifies remote operation via fiber or wireless link</td>
<td>- 50 targets standard</td>
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<tr>
<td></td>
<td>- Optional 1000 targets</td>
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## System Options

- Situational Awareness Display
  - Integration with Electronic Charts (ECS/ECDIS)
  - Integration of radar plots with CCTV and IR systems
  - Augmented Reality (AR) display

- Vessel Control
  - Integration of Automatic Identification System (AIS)

- Multiple Radar Sensors
  - Microwave link remote radars into system

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