sigma S6 Oil Spill Detection (OSD) System

Introduction

The growth of the marine shipping industry and off-shore oil production has increased the risk of oil pollution on the sea surface which can cause catastrophic environmental damage. Early detection and clean-up reduces environmental damage and associated cost. Radar remote sensing monitoring for oil spills in the marine environment greatly reduces the time between a spill and the start of repair and cleanup operations. The radar is then used to monitor the spills and aid an efficient and successful cleanup operation.

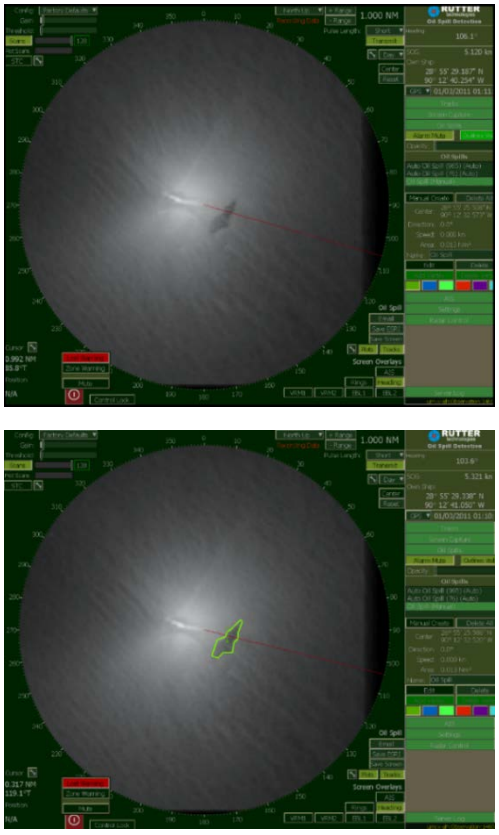

***Figure 1**: A screen shot from Rutter's sigma S6 Oil Spill Detection Response.*

Oil dampens capillary waves on the ocean surface, reducing the amount of sea clutter (the radar backscattered wave from the ocean surface) resulting in "dark patches" on the radar screen. Detection is possible when the clean waters surrounding the oil spill area reflect enough radar energy (clutter) so the radar image appears bright on the screen in contrast to the oil dampened area.

The oil spill monitoring system can be installed on a vessel, an offshore platform, or a coastal area. These systems should be capable of automatic detection, alarming, and tracking of oil slicks for quick and efficient cleanup operations.

***Figure 2**: NOFO oil on water 2013, photo taken by Baschek, Federal Institute of Hydrology, Germany.*

The *sigma* S6 OSD system is a technology that gives an enhanced two-dimensional image of oil slicks on the sea surface. It can be connected to an existing installed radar transceiver, or the Rutter Radar 100-S6. The system provides a high resolution image with 4096 video intensity levels for each pixel, detecting small contrasts between the sea surface and slick area. This is achieved using a 12-bit analog-to-digital convertor (ADC).

Figure 3 shows a scenario when the oil slick cannot be differentiated from the sea surface clutter by an 8-bit resolution radar, but the

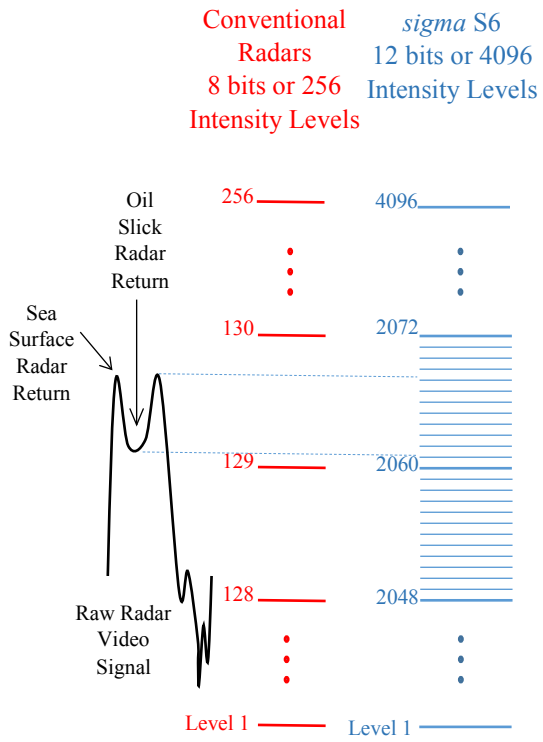

***Figure 3**: A case when the sea surface and oil spill radar return can only be differentiated by a 12-bit high-resolution radar. Both oil slick area and sea surface intensity levels are at 129 using the conventional radars (256 resolution intensity levels), while the oil slick return intensity is 2061, and the sea surface return is 2068 with a 12-bit radar (4096 resolution intensity levels).*

***Figure 4**: NOFO oil on water 2013, photo taken by Baschek, Federal Institute of Hydrology, Germany.*

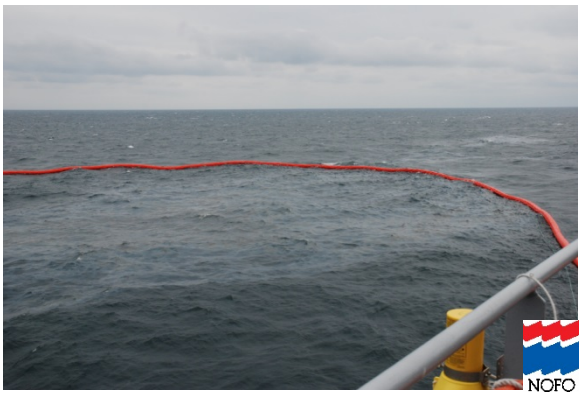

***Figure 5**: NOFO oil on water 2013, photo taken by Baschek, Federal Institute of Hydrology, Germany.*

difference can be detected by using a 12-bit resolution radar.

In order to enhance the image quality and oil slick detection, the *sigma* S6 OSD system uses image processing techniques such as scan-to scan and pulse-to pulse integration.

sigma S6 OSD automatically alerts the operator with visual and audible alarms if there is a suspected oil slick in the detection range. The slick is then automatically outlined on screen, allowing movement of the slick to be predicted based on past movement and automatic on-screen volume calculations. In order to speed oil recovery time, the *sigma* S6 OSD can identify the thickest area of the slick through its volume

overlays to indicate areas with higher concentrations of oil.

The *sigma* S6 OSD system helps oil spill response vessels to operate day or night in all various weather conditions, aiding visibility of the oil slick in rain and fog.

Table 1 and Table 2 show the available features and options of the *sigma* S6 OSD system.

Lowest Cost

The *sigma* S6 OSD system can be connected to an existing radar system. This eliminates the cost of buying additional radar hardware, installation, and maintenance. Rutter offers the lowest purchase and maintenance price for its OSD systems, based on feature content, on the market.

Detection Range

The maximum range of any radar based Oil Spill Detection system can be theoretically determined using simulated clutter returns for a given radar configuration. The clutter power decays as a function of range, and at certain range, it drops below the noise floor of the radar receiver. The approximate maximum detectable range is the range where the clutter return signal is approximately 3 dB above the noise level. Since the antenna height is directly proportional to the clutter power, high antenna altitude is recommended during installation. A radar with vertical polarized antenna, such as Rutter's Vertical Polarized Antenna, also offers a stronger clutter return than other polarizations. Figure 6 shows the theoretical sea clutter power as a function of range received by a standard X-band marine radar. The noise level of the receiver depends on the receiver noise figure and it remains constant as a function of range. The higher the sea state, the larger the detection range becomes. The antenna altitudes in Figure 6(a) and Figure 6(b) are 40 m and 15 m, respectively. The results show that the higher antenna altitude, the larger sea clutter power.

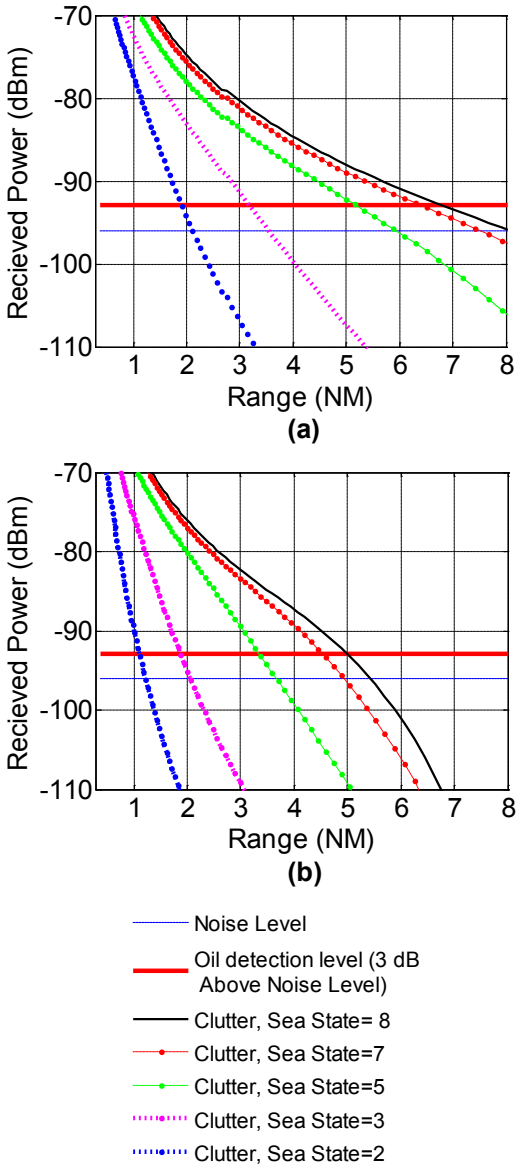

***Figure 6**: Theoretical sea-clutter power received by an X-band Radar when the antenna altitude is (a) 40m, (b) 15m at different sea states. Radar parameters are: PRF=3 kHz, Peak Power=25 KW, Pulse Length=50 ns, Noise Figure=5 dB, Antenna Azimuth Beamwidth= 1°, Antenna Vertical Beamwidth= 24°, IF Bandwidth=20 MHz.*

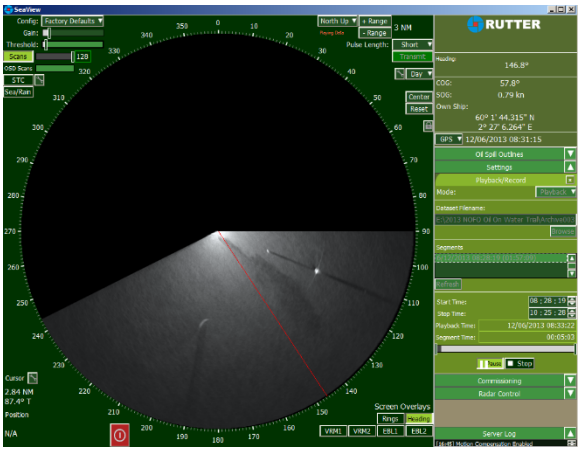

***Figure 7**: Radar image of the oil slick area 3.5 hours after the spill.*

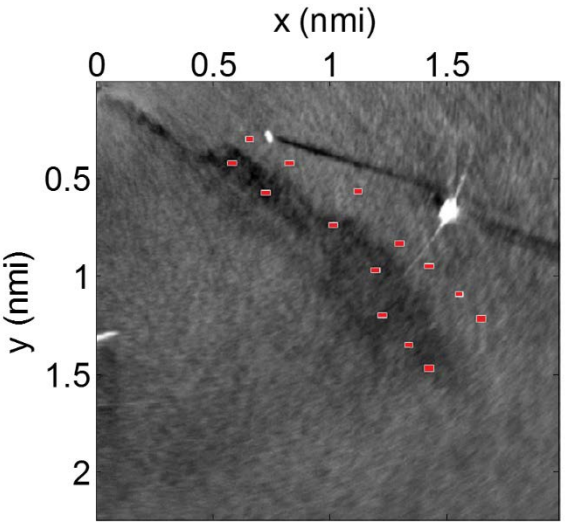

***Figure 8**: A close-up view of **Figure 7** showing the oil spill area. The red marks show the location of the points where the probability of detection is calculated.*

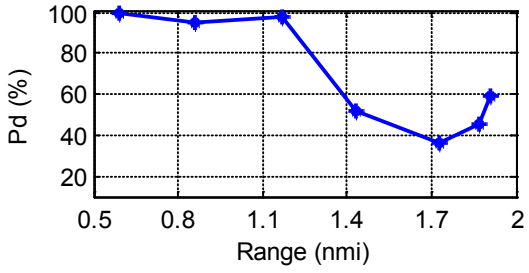

***Figure 9**: The probability of detection versus range for Pfa= 10^{-5}, obtained using 30 minutes of radar data.*

Field Trial and Experimental Probability of Detection

A recent NOFO (Norwegian Clean Seas Association For Operating Companies) oil-on-water trial took place between 10-14 June 2013 in the Frigg area located 230 km north-west of Stavanger between the continental shelves of the UK and Norwegian borders in North Sea. In one experiment, a spill consisting of 15 cubic meters of oil emulsion (35% crude oil, 5% heavy fuel oil, 0.35% benzene, and 0.7% n-hexane) was released in the ocean with a sea state of 3. A Rutter Radar 100-S6 was installed on the Esvagt Stavanger with an antenna height of 18 m above sea level. Figure 7 shows the radar image recorded 3.5 hours after the spill was initiated. The probability of detection was obtained for this experiment at several locations at different distances using recorded raw data. Figure 8 shows the close-up view of the spill area and the location of the points (shown in red) which were used to calculate the probability of detection. In order to calculate the probability of detection, points on the spill area are compared to the points on the clean waters surrounding the oil infected area. Figure 9 shows the calculated probability of detection (Pd) versus range calculated using 30 minutes of radar data when the probability of false alarm (Pfa) is 10^{-5}. The results show that the probability of detection is higher at closer range. This is expected since the clutter power is stronger at closer range causing more contrast between the oil spill areas and surrounding clean waters. It is also noted that the reduced amount of the clutter by the oil spill area depends on the thickness and texture of the oil film. At the points with equal range where the spill is heavier, a better contrast between the oil

spill area and surrounding clean waters is usually observed.

Detecting Oil Using Combined Radar and Infrared (IR) Sensors

Integrated X-band radar and infrared OSD systems can improve the oil slick detection and the efficiency of the cleaning operation. The Rutter *sigma* S6 OSD system can pass the location of detected slicks automatically to IR camera for verification of oil by operators.

Rutter SeaFusion

Vessels and platforms often have multiple blind spots that require multiple radar antennas to provide complete coverage. Several radars can be configured to cover a specific area, with sector blanking enabled in areas where blind spots occur. Rutter's SeaFusion product combines the data from these radars, merging the images into a full two-dimensional image that covers 360 degree view of the platform with oil spill detection capability.

Benefit Summary

- Real-time automatic detection of oil slick, alarming, and tracking
- Drift prediction of oil slick based on spill historical data
- Automatic volume calculations
- Identifying the thickest area of the slick for fast recovery
- Detect and monitor oil day or night in all weather conditions
- Connect to existing radar systems or use the Rutter Radar 100-S6
- Used worldwide by costumers
- Tested during NOFO oil-on-water clean-up trials
- Cost savings

Testimonials

Norway, Godafoss spill

...the Rutter's Oil Spill Detection radar has been used and proven its capabilities during the oil spill in South-eastern Norway. It is still in use, and has made it possible to recover oil from the surface in low-light and during night conditions.

Med vennlig hilsen, Kjetil Aasebø, Capt NoCGV Harstad, February 22, 2011

Table 1: Standard features of OSD products

Description↓ Product→ ● - Standard Feature / ○ - Option / Blank - Not Available	OSD-500	OSD-300	OSD-100	OSD-500 +STD	OSD-500 +ICE
Oil Spill Detection	●	●	●	●	●
Ice Detection					●
Small Target Detection				●	
High Definition Radar (HDR)	●	●	●	●	●
Automatic Oil Spill Outlining	●			●	●
Oil Spill Tracking (Direction and Speed)	●			●	●
Manual Oil Spill Outlining	●	●		●	●
Oil Spill Volumetric Calculations	●			●	●
Screen Recording - Screen Shots (.jpg & .png) and Movie Files (.avi)	●	●	●	●	●
Tracking Software (Oil Spill Targets)	1000			100	100
Tracking Software (Small Targets)				900	200
Scan Averaging	128	64	64	128	128
Unlimited Remote Clients	●	●		●	●
Single Client Only			●		
Below options are present but can be disabled if not needed					
ESRI Shapefile Output (Used for GIS input)	●	●		●	●
Cursor Serial Port Output (Used for IR camera input)	●	●		●	●
TTM NMEA Serial Port Output (Used for IR camera input)	●			●	●
TTM NMEA Serial Port/TCPIP Output (Used for ECDIS input)	●			●	●
AIS Input	●	●	●	●	●
Wind Anemometer Input	●	●	●	●	●
Echo Sounder/Water Depth Input	●	●	●	●	●
Speed Log Input	●	●	●	●	●
Hardware					
IEC 60945 Marine Approved PC	●	●	●	●	●

Table 2: OSD Options that are chargeable with some additional cost

Description↓ Product→ ● - Standard Feature / ○ - Option / Blank - Not Available	OSD-500	OSD-300	OSD-100	OSD-500 +STD	OSD-500 +ICE
Chart Underlay	○	○		○	○
Rutter Radar Control	○	○	○	○	○
OEM Radar Control (Looked at upon request)	○	○	○	○	○
Raw Data Recording	○	○		○	○
Dual Mode Plot Extractor (Small Targets)				○	
SeaBridge - Multi Client - Low Bandwidth Communication Link	○	○		○	○
SeaFusion - Multi Radar - Single Display	○	○	○	○	○
Aptomar Securus Interface	○			○	○
Hardware					
IEC 60945 19" Desktop or Console mount monitor	○	○	○	○	○
IEC 60945 23" Desktop or Console mount monitor	○	○	○	○	○
IEC 60945 Desktop or console mount keyboard/trackball	○	○	○	○	○
25kW X-Band upmast transceiver	○	○	○	○	○
8' Horizontally Polarized Antenna	○	○	○	○	○
8' Vertically Polarized Antenna	○	○	○	○	○