5. OIL POLLUTION IN THE SEAS AROUND INDIA

AND

APPLICATION OF REMOTE SENSING FOR ITS

DETECTION AND MONITORING

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INTRODUCTION

For a country like India with a long coastline, surrounded by busy shipping lanes together with growing number of offshore oil fields, pollution from oil is a continuous threat. Besides tanker accidents, offshore drilling and discharge of the refinery waste, the major source of oil pollution is the intentional dumping of bilge and bunker washings from the tankers.

Two main oil tanker routes which originate in the Gulf countries cross the Northern Indian Ocean. One of them goes via Mozambique Channel, round South Africa to the Western hemisphere. The other one is along the Exclusive Economic Zone (EEZ) of India, round Sri Lanka across the southern Bay of Bengal through the Malacca strait to far East and Japan. Nearly 511 million tonnes of oil and its products were transported along these routes through the Arabian Sea and the Bay of Bengal in 1987, thus exposing some of our coastal areas to
the risk of pollution.

PRESENT STATUS OF OIL POLLUTION

Observations on oil slicks, floating petroleum residues (tar balls), dissolved/dispersed petroleum hydrocarbons along these two tanker routes and tar on beaches of India are in progress since 1975. Observations on oil slicks showed that the number of occurrences of oil slicks are the highest along the two tanker routes as compared to the other areas. The percentage of positive reports on oil slicks varied from 0 to 75%. Observations on floating petroleum residues (tar balls) from the Northern Indian Ocean indicated their occurrence predominantly in the Arabian Sea and the Southern Bay of Bengal (0 - 69.7 mg/m²). These tar particles have a residence time of 30-73 days. Studies on several beaches of the West Coast of India gave a deposition of 750-1000 tonnes of tar like residues from April/May to September/October.

Observations on dissolved/dispersed petroleum hydrocarbons in the upper 20 m of the Arabian Sea and the Bay of Bengal gave a range of 0 - 74.4 ug/l. Higher concentrations were observed mainly along the tanker routes and in the coastal regions. A few observations carried out on petroleum content in the sediments and zooplankton gave a range of 4.4-12.4 ug/gm and 10.0 - 107.5 ug/gm dry weight respectively. Studies in the
Bombay High region showed that waters upto 20 m depth main­
tained an almost steady level of dissolved/dispersed petro­
leum hydrocarbons in spite of continuous exploration and ex­
ploitation activities in this region.

There has been a gradual reduction in tanker traffic
across the EEZ of India from 1978 to 1987. This has resulted
in an apparent reduction in oil pollution.

Oil spills will continue to happen unless steps are
taken to curtail them. Although some positive steps are being
taken as regards detection of accidental spills, the proceedings
adopted are inadequate at night and in poor weather conditions.

A synoptic view of a large coastal sea region like that
of India cannot be achieved economically and efficiently by
using land based observation stations or patrol boats. Remote
sensing from satellites for oil spill surveillance has largely
been discounted for various reasons such as: (i) excessive
cloud cover over coastal regions, (ii) inadequate resolution
for oil spill management purposes and (iii) too long interval
between consecutive passes over the same region. The problem
can be effectively tackled by airborne remote sensing with
suitable sensors to work by day or by night and in all weather
conditions. These sensors provide more objective information
about the location and size of an oil slick than visual obser­
vations.
OIL SPILL MONITORING AND SURVEILLANCE SYSTEM

Ideally an airborne oil pollution monitoring system should be able to detect, quantify and classify oil in the sea. Since no single instrument can meet these requirements, it is necessary to compose a package of sensors.

The system package used for monitoring and surveillance of oil comprises of various equipments for different stages such as:

a) DETECTION
   - Side Looking Airborne Radar (SLAR)
   - Infrared/Ultraviolet Line Scanner (IR/UVLS)

b) QUANTIFICATION
   - Passive Microwave Radiometer (MWR)

c) CLASSIFICATION
   - Laser Beam Fluorosensor (LFS)

A brief description and working principle of each sensor is described.

DETECTION

Side Looking Airborne Radar (SLAR): The SLAR is for detection of oil on the sea surface and is capable of surveying a large area in a short period of time. SLAR's used for oil
pollution monitoring typically cover a range of 25-30 km on each side of the aircraft with an uncovered area underneath equal to approximately twice the flight altitude. It can be used by day or by night and in all weather conditions. SLAR imagery is produced by directing a beam of microwave radiation at the sea surface and measuring the strength of the reflected signal. Oil slicks can be detected because they damp out capillary waves and reduce the amount of backscatter and as a result oil appears as a dark area on the radar display. An oil spill makes the sea surface considerably smoother than the surface of the surrounding unpolluted water. The smooth surface gives less radar backscatter and oil slick will appear as a dark area on the radar image.

The SLAR's ability to cover a large area within a short time is unmatched by any other sensor. As an example, an aircraft moving at ground speed of 400 km/hour will cover an area of more than 25,000 sq.km/hour for oil pollution monitoring and considerably more for some other applications.

Automatic target positioning is one of the most useful features of the SLAR. The operator uses a light pen to mark an interesting feature in the imagery and its geographic position is displayed in the data block. A small white circle identifies the feature which has been targeted. It is also possible to expand a particular part of the imagery so that it can be examined in more detail. The only major limitation of
the SLAR as an oil pollution detection device is its inability to see oil below the sea surface. Although SLAR does not produce any information about the slick thickness, it does indicate the total extent of the slick.

Infrared Ultraviolet Line Scanner (IR/UVLS) : IR/UV line scanner provides high resolution spill detection directly below the aircraft and can be used as an additional sensor. In linescan systems, imagery is produced by scanning successive strips of the sea beneath the aircraft as it moves forward. The optical system focuses radiation onto detectors which are sensitive to infrared and ultraviolet wavelengths thus building up an image from adjacent scan lines.

The IR detects thermal differences between oil and water while UV detects reflective differences between water and oil. The UV sensor detects the entire area covered by oil and enables slick dimension to be determined. It also provides for discrimination of false alarms occurring in the IR channels due to the surface thermal gradients (ship wakes). Since oil absorbs very strongly relative to water in the UV spectrum, oil on the sea surface will appear in strong contrast to the surrounding non-polluted water, even at a thickness of a few micrometers. In contrast, the thicker layers will be detected by IR sensor. It is therefore possible to point out the position of the biggest concentration within the spill area.
UV sensor can be used during daylight and in conditions of good visibility whereas IR sensor will operate by day and by night and will not detect oil in rain or fog.

QUANTIFICATION

Passive Microwave Radiometer (MWR): After having detected and determined the position of an oil slick, the next step is to establish the amount of oil by measuring its aerial extent and thickness. Again, it is desirable to have a sensor which operates under all weather conditions and during both day and night. The passive microwave radiometer satisfies these requirements as far as oil on the sea surface is concerned.

A passive microwave radiometer measures brightness temperature which potentially contains information about atmosphere and surface parameters that could be retrieved using multi-frequency measurement. The apparent microwave brightness temperature (measured by MWR) is greater in the region of an oil slick than in the adjacent unpolluted area by an amount depending upon the slick thickness. As the thickness of the oil film increases, the apparent microwave brightness temperature at first increases and then passes through alternating maxima and minima due to the standing wave pattern of the sea surface. By using two or more microwave frequencies, thickness ambiguities introduced by the oscillations may be removed and the film thickness determined.
By using two frequencies, such as 15 GHz and 37 GHz, it is possible to determine oil thickness from 1.0 to 4.0 mm. A MWR system with a scanning antenna can be configured to produce a brightness temperature contour map from which the volume can be determined.

It is quite common in cases of larger oil spills that more than 90% of the oil is confined in a compact region comprising less than 10% of the area of the visible slick. A MWR can therefore be a useful tool in assisting oil combating vessels in the clean-up operation by pointing out the biggest oil concentration within the spill area.

Because of MWR's unique ability to quantify oil under all weather conditions during both day and night, it may be used to determine whether an oil slick detected by the SLAR is sufficiently significant to justify an oil combating vessel being sent to the scene for a clean up operation. The radiometer may therefore be used to save costly shiptime and prevent false alarms.

CLASSIFICATION

Laser Beam Fluorosensor: Classification dealt with here concerns discrimination between oil categories (light fuel, heavy fuel, crude, etc.) and the determination of oil types (i.e. Arabian light crude, Kuwait crude, Bombay High crude, etc.),
The Laser Fluorsensor (LFS) enables the remote classification of oil according to main oil groups. Oils are known to absorb strongly in the ultraviolet end of the spectrum. A portion of this energy is re-emitted at longer wavelengths and this is known as fluorescence, which enables oils to be remotely detected. Three parameters — fluorescence intensity, emission spectrum and lifetime of the emitted signal are sufficiently characteristic of a particular oil to enable its differentiation from other oils and hence, its classification.

The Laser Fluoresensor is an active sensor which means that it provides its own source of illumination. For oil pollution classification a narrow beam of ultraviolet light is emitted co-axial with the receiver optics, which collect the fluorescent light from the target. The fluorescent return signal at wavelengths longer than the laser wavelength, is detected by a range gated spectrum analyser. Time-gating the detector in synchronisation with the backscattered radiation pulse permits the system to be operated in full daylight. Classification of oil is very useful for the response team to identify the methods of recovery or dispersal. For other applications such as identification of an intentional oil spill, an airborne photographic camera linked to the aircraft navigation system for time and position annotation may be useful to produce evidence of an oil spilling vessel's unlawful activity.
A summary of sensors capabilities is given in Table I. All these sensors are interfaced to a video monitor which gives realtime presentation of the imagery inside the aircraft. A complete set of navigational data such as date, time and aircraft position, heading and altitude is displayed on all the imagery. A standard video cassette recorder can be used to record all the imagery for replay after landing. These data also can be transmitted in realtime to a shore based pollution control centre or an oil combating vessel, using a powerful VHF down link system.

REFERENCES


Observations on oil slicks & other floating pollutants every 5° square in the Indian Ocean. The upper values indicate the occasions of the absence of oil slicks while lower values indicate the occasions when oil slicks were sighted. (1975-1982)
<table>
<thead>
<tr>
<th>SENSORS</th>
<th>REAL TIME</th>
<th>DAY</th>
<th>NIGHT</th>
<th>NEAR ALL-WEATHER</th>
<th>QUANTITY (THICKNESS)</th>
<th>CLASSIFICATION</th>
<th>SUBMERGED OIL</th>
<th>GOOD RESOLUTION</th>
<th>MAPPING</th>
<th>LONG RANGE (LARGE AREA)</th>
<th>DATA LINK TO GROUND</th>
<th>DOCUMENTATION INCL. POSITION</th>
<th>FREQUENCY / WAVELENGTH</th>
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<tbody>
<tr>
<td>Laser Fluoresensor</td>
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