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COMPANIES USING SATELLITE AND AIRBORNE REMOTE SYSTEMS FOR OFFSHORE OIL MONITORING

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Abstract

The paper presents an analysis of remote sensing satellite and airborne oil detection systems and describes the use of their capabilities in exploration programs, monitoring, emergencies by oil and gas companies.

The detection of discharges, legitimate or illegal, can be performed by remote sensing techniques from aircraft and from satellite. Satellite observations complement aerial surveillance due to their wide area coverage with regular revisiting and to some degree is considered to be less weather -dependant.

Furthermore, satellite monitoring is one of the major monitoring components for large sea areas, where other means for surveillance purposes are too expensive or not available. Aerial surveillance aircraft have the capability to carry additional equipment to quantify and classify oil spills. The combination of both may increase the deterrent effect and can assist in optimising the flight activities of the surveillance aircraft.

Two types of remote sensing systems for oil spill detection and monitoring can be defined: space platforms or satellites including onboard sensors for collecting data, and systems with sensors mounted on airborne platforms. Each type of system include a range of possible instruments onboard which operate sensing the energy in fixed parts of the electromagnetic spectrum, thus providing to determine different features of oil pollution. The satellite systems include the use of visual observations, thermal infrared (TIR) and UV imaging and satellite synthetic aperture radar (SAR). Aircraft remote sensing is based on visual observations, infrared imaging (IR), ultraviolet (UV), hyperspectral imaging, side-looking airborne radar (SLAR), airborne synthetic aperture radar (AIRSAR), down-looking thermal infrared (DTIR) and forward-looking infrared imaging (FLIR) [9]. Radar systems and airborne laser fluorosensor (ALF) are examples of active sensors and IR, UV and microwave radiometers are examples of passive sensors. All sensors must be calibrated and require highly trained personell to operate them and interpret the results. The strenghts and weaknesses of satellite and aircraft remote sensing systems are summarized on Table1.

Table 1

Platforms	Strenghts	Weaknesses
Satellite	Large field of view, spacial coverage of several km.	Long revisiting time and fixed time of overpass and high initial cost of sensors
	Ground infrastructure can be located in area of choice	Difficult to develop algorythms for detecting oil spills; cannot determine the types of oil
	No distance to the coast restrictions for operation	Predictable flight, difficult and expensive to shift once stabilized
		Absolute need of clear skies (optical and infrared sensors)
Aircraft	Equipment can be modified, updated and maintained easily	Restricted spatial coverage
	The devices are less cost by than the space ones	Require a number of resources for continuous coverage
	Flexible and manoeuverable, can fly in different hights and below clouds	Man power
	Highly visible to ships and this insreases the different effects	

Satellite observations complement aerial surveillance due to their wide area coverage with regular revisiting and to some degree are considered to be less weather-dependant. Furthermore, satellite monitoring is a major monitoring component for large sea areas, where other means are too expensive or not available for surveillance purposes. However, aerial surveillance aircraft have the capability to carry additional equipment to quantify and classify oil spills. The combination of both may increase the deterrent effect and can assist in optimising the flight activities of the surveillance aircraft. Fig.1 shows a typical case of a combined satellite and aerial surveillance system [14] .

Remote sensing is useful in several modes of oil spill control, including large area surveillance, site-specific monitoring and tactical assistance in emergencies. It is able to provide essential information to enhance strategic and tactical decision-making, decreasing response costs by facilitating rapid oil recovery and ultimately minimizing impacts for oil companies [10].

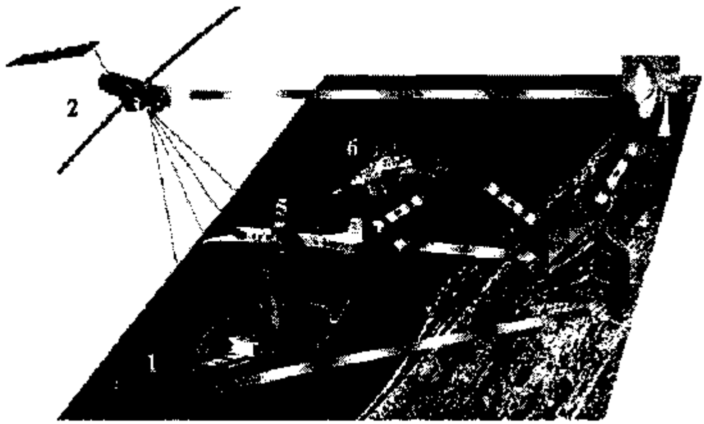

Fig. 1. Interaction diagram of the means of an integrated surveillance system to detect oil spills at sea. The oil spill (1), discharged during a ship disaster is detected by a regular SAR (synthetic aperture radar) satellite overpass (2). The oil can be detected due to the damping effect of oil on capillary waves. After transmission to the ground station (3) and data estimation (4), the aircraft (5) will be alarmed to verify the spill in terms of quantity and type with an advanced set of further remote sensing instruments. In case the quantity or the hazardousness of oil exceeds a certain threshold, the combating vessels will operate to remove the oil from the sea (6). These vessels are co-ordinated and instructed by the surveillance aircraft.

Visual observations of spilled oil from the air, along with still and video photography, are the simplest and most common method of determining the location and extent (scale) of an oil spill. Many devices employing the visible spectrum, including the conventional video camera, digital single-lens-reflex (SLR) cameras and camcorders are now available at reasonable prices. Dedicated remote sensing aircraft often have built-in downward looking cameras linked with a GPS to assign accurate geographic coordinates.

In the visible band, oil has no sharp spectral features. The similarity in the spectral signatures between oil and gas in the visible region of the spectrum explains the problems assosiated with oil slicks identification. For example, the capability of Landsat TM band 7 platform for identification of oil in water does not provide sufficient contrast to distinguish between oil and the background without intensive time processing. Oil slicks form very thin films on the sea surface and the thickness can vary from a tenth of a micron to hundreds of microns. Depending on thickness, oil spills are visualized by satellite optic sensor in colour from silver to black. The visual analysis of the image does not allow to determine oil thickness based on color and is unreliable.

Spills detection by visual observation is limited to favorable sea and atmospheric conditions and is inoperable in rain, fog, or darkness; visual observations are restricted to spill documentation because there is no mechanism for positive oil detection. Oil can be difficult to see in high seas and among debris or weeds where it can blend in to dark backgrounds, such as water, soil, or shorelines. In addition, the sun angle, glare, sea state and satellite and airborne camera view angle can affect the appearance of oil slicks [8] .

Infrared sensors, which detect infrared radiation levels given off surfaces, have been developed into relatively inexpensive sensors for ship-board and aerial observation of oil slicks.

There are airborne downward-looking thermal IR and forward-looking IR (FLIR). Thick oil (>0.003mm) appears hot or white in infrared data, middle oil thicknesses appears cool and black, and thin oil (0.0001mm) or sheens are not detected. Oil becomes 'visible' on thermal channels during daily images while at night the opposite is true- the oil body will lose heat faster than the surrounding water and will be seen as a cooler area on the image. These sensors are capable of detecting thicker parts of a slick only (>100 μm), so they are useful for guiding response to the thicker oil parts. Infrared devices cannot detect emulsions and could be combined with an ultraviolet sensor for complete imaging of both the thick and thin portions of a slick [8].

Tests of a mid-band IR system MIR (3.4 to 5.4 μm) over oil spill showed no detection in this range, however, ship scars were visible. Studies in the thermal infrared TIR (8 to 14 μm) show that there is no spectral structure in this region. Oil detection in the infrared is not positive as several false targets can interfere, including weeds, shoreline, and oceanic fronts. Infrared is reasonably inexpensive, however, and is currently the prime tool used by the spill remote sensor operator.

Since thermal imagers, also known as forward looking IR (FLIR) devices, became commercially available, they are increasingly installed on smaller and mid-size aircraft. In September 2003, a StarSAFIRE thermal imaging system with a newly developed covert action laser illuminator (CALI) started operation as part of the second German surveillance aircraft, enabling the operator to read the ships name in the absence of daylight or investigate areas of specific interest. The laser is illuminating the NIR sensitivity of the inbuilt CCD camera which normally use an IR-cut filter during daytime, blocking unwanted NIR radiation from its detector and during night time and in combination with the CALI, this NIR cut filter is removed and the laser illumination is available up to a distance of 1500 m (Fig. 2).

This thermal imaging capability brings an important step towards night operation and polluter identification. It is also a sensor with a wide range of application, like SAR or border patrol, making it a perfect device for multi-role aircraft, often only equipped with basic maritime surveillance sensors [1] A disadvantage of any type of infrared detector, however, is that they require cooling to avoid thermal noise, which would overwhelm any useful signal [15].

Oil slicks have been detected using several types of optical and thermal satellite imagery but in all cases the oil position should be known in advance. Most optical satellites provide data from the visible part of the spectrum. Satellite sensors like Landsat TM (with spatial resolution of 120 m) and NOAA AVHRR provide thermal data. The SPOT platform is able to identify the sheen area of the slick due to the wider spectral bands it employs. Optical and thermal satellite imagery offers little potential for oil spill detection while SAR satellites are nowadays the most useful space system for this purpose.

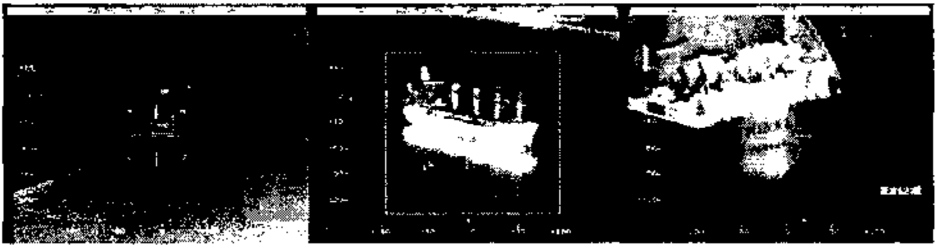

*Fig.2. Helicopter approach to a non-moving ship on the Columbia River near Portland, Oregon. **Left:** Approaching the vessel using the thermal camera and the autotracker. **Middle:** Close-up to medium field of view, still observing the IR image and using the autotracker. **Right:** Laser-illuminated stern of the ship, supplied by the CCD camera with disabled NIR-cut filter.*

At the end of the Persian Gulf War in the spring of 1991, 732 oil wells were set ablaze in Kuwait. The only source of objective information during the military conflict were the satellite images of the territory of Iraq which provided a means to locate the sources, monitor oil fires during military operations and present visually smoke plumes. Some of those wells were burning for seven, eight, nine months, the oil field fires provided air pollutant of greatest concern, environmental land and marine damage, drilling oil companies losses, Coalition military forces and people health damages. Troop reports of battlefield operations in conditions of heavy smoke and petroleum rain verified the severity of the actual exposures to the oil field fires. Equally important as a toxic exposure was the oil rain from the oil fires [13] .

The total area of Kuwait is covered by four TM scenes of approximately 185 km x 177 km . In Fig.3, oil fires and offshore oil slick are taken from the Landsat-5 Thematic Mapper, the fires appear as red dots. The black smoke plume extends south along the Persian Gulf coast as a strip about 25 kilometers wide in areas near the fires. Unburned pools of oil on the ground and oil offshore in the Persian Gulf reflect sunlight, the same way as water does, and appear as white or light toned features. Oil slicks drifted south toward the Arab Emirate States [16].

This scene of the Persian Gulf was taken hours before the Desert Storm operation began on March 11, 1991 (Fig. 4). A week later, Iraqi soldiers began blowing up Kuwaiti oil wells in response to the multinational offensive. The following image shows the dramatic development of the environmental catastrophe and the capability of the visible and IR sensors of NOAA Advanced Very High Resolution Radiometer (AVHRR) for early detection and monitoring of oil spills. Thick and thin oil layers and the boundary between water and oil were possible to detect by the IR channel, but the oil spills could not have a significant different temperature signature from the surrounding water at night. Oil spills could be detected in the visible images only under highly favourable lighting and sea conditions [2] .

Fig.3. Color infrared view of the Kuwait oil fires and offshore oil slick taken from the LandSat-5 TM

Fig.4. Scene taken fron NOAA-11 AVHRR multispectral color image of the Persian Gulf.

GIS-based risk management system uses the latest spatial information technology to store data required for oil spill risk assessment, response, planning, training and risk management. The integration of remote sensing with GIS techniques offers an effective tool for analysis in the risk management.

Exploration companies are always looking for ways to efficiently and cost-effectively monitor assets, make better-informed decisions and meet environmental guidelines. Oil seeps and oil-impacted soils are often too subtle to detect using multispectral satellite-based sensors because they are diluted on the surface when mixed with other materials and are of limited surface area. By contrast, airborne hyperspectral sensors have sufficient spectral resolution to identify different surface materials based solely on spectral signatures. On land, hyperspectral data has been used to delineate the extent of an oil well blowout.

Most past and current hyperspectral sensors have been airborne, with two recent exceptions: NASA's Hyperion sensor on the EO-1 satellite, and the U.S. Air Force Research Lab's FTHSI sensor on the MightySat II satellite. Several new space-based hyperspectral sensors have been proposed recently. AIG during 1995 using the AVIRIS instrument as a first attempt to broaden the use of hyperspectral data. A hyperspectral AIG/HyVista Group Shoot has been organised in the USA during 1999 using the commercial HyMap sensor [9] .

Oil and gas explorers have remained interested in the technology for many years and companies, such as Shell and ChevronTexaco are known users. Recently, effort towards detection and mapping of offshore hydrocarbon seepage has been made, especially at well-known seeps, such as those off of Santa Barbara, CA, USA. The HyMap scanner provides 126 spectral channels spanning the wavelength range from the 0.4 to 2.5mm (visible to shortwave infrared) spectral region over a 512-pixel swath. HyMap is mounted in a gyro-stabilised platform Zeiss-Jena SM2000 augmented with a Boeing C-MIGITS GPS/INS. Fig.5 (Hy Map) shows seamless data product mosaics of the 4 flight lines imaged some of the world's largest natural oil seeps located just offshore of Santa Barbara, CA covering the area of offshore production platform Holly, with different seep specific spectral components highlighted in the images [9].

A joint research project was organized by Geosat and sponsored by Chevron, Exxon and Shell in 1999. The goal of the project was to determine the viability of hyperspectral technology for detecting oil seeps (Fig. 6) [11] .

The two basic types of microwave radar that can be used to detect oil spills and for environmental remote sensing in general are Side-Looking Airborne Radar (SLAR) and Synthetic Aperture Radar (SAR).

The Side-Looking Airborne Radar (SLAR) is the primary sensor for long-range detection of oil pollution on the sea surface. SLAR sends out short pulses in the X-band perpendicular to the flight direction to left and right side of the aircraft and receives their reflection from small gravity and capillary waves up to a distance of typically 30 km, depending on wind conditions and aircraft altitude [8] .

An airborne surveillance system has been used to monitor the German territorial waters in the North Sea and Baltic Sea for oil discharges and marine pollution. A SLAR unit will cost between $700,000 to $1,000,000.

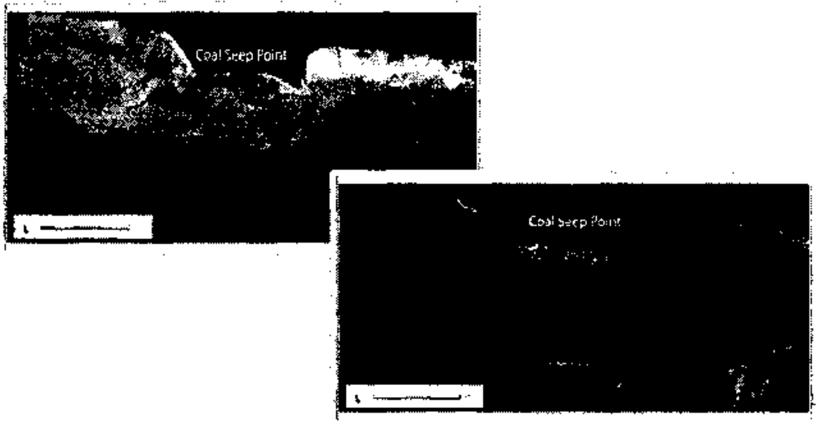

Fig.5. ***Left up -*** *'False' colour composite mosaic of the survey area highlighting different water constituents using spectral ratios in the visible and near infrared spectral region. The coastal turbid water maps in yellow while darker currents map in red/orange. Open waters are in blue colors with darker tones representing offshore currents. Darkest blue tones represent slick areas.* ***Right down-*** *Spectral component map of slick areas. The land areas, open water and kelp beds have been masked out deliberately and the remaining data spectrally processed to highlight variation.*

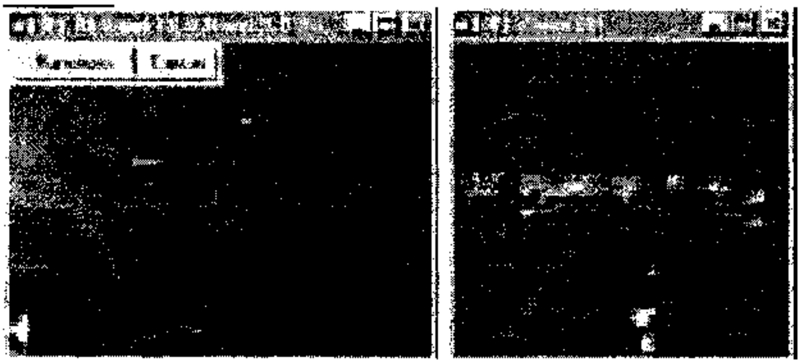

Fig.6 . A wharf where an oil spill was documented in 1992. Hyperspectral imaging detects oil-impacted surfaces (red) along the edge of the wharf.

Satellite Synthetic Aperture Radar (SAR) is shown to be an important tool for oil spill remote sensing because it is the only sensor that can be used over large areas and that can 'see' at night and through clouds or fog. This "all-weather" operation and the wide swath width provided by the available SAR satellites have been the major reasons why satellite-based SAR has been most commonly promoted for operational detection of oil slicks.

There are presently three SAR satellites in orbit with global coverage: RADARSAT, ERS-2 and ENVISAT. These provide revisit times for most places on the globe that are impractically long and irregular for operational sensing of a given spill. RADARSAT has a repeat cycle of 24 days for coverage of a given area of latitude, while ENVISAT and ERS-1 have revisit frequencies of 35 days and have the ability to image surface oil seeps remotely with wide swath coverage (typically 100 x 100km scenes for ERS and 165 x 165 km for Radarsat Wide1) [8].

Monitoring illegal oil discharges is thus an important component in ensuring compliance with marine protection legislation and general protection of the coastal environments. Fast delivery SAR products are proving to be of great value in the optimisation of airborne surveillance resources, due to the large area they can image at any one time. Size, location and dispersement of the oil spill can be determined using this type of imagery.

The Arabian Gulf region is the largest offshore oil development area in the world producing over 27% of the world's oil in 2000. The area also holds 65% of the world's oil reserves. The study area has one of the busiest and most important tanker shipping lanes in the world; more than 40 % of the world's total oil transportation passes through the region. The oil sludge, released by tankers cruising in the Arabian Gulf is estimated to be around 8 million metric tons per year, representing 60 % of the total pollution in the area. The Japan Oil Development Co., Ltd. (JODCO) with the collaboration of the Japanese Information Centre for Petroleum Exploration and Production (ICEP) have supported the Satellite Image Processing project of the offshore waters of the United Arabian Emirates (UAE) [4].

A total of more than 300 frames of ERS-1/2, Landsat-7 ETM, JERS-1 SAR, Terra ASTER, RADARSAT, and Space Shuttle images derived from different platforms that covered most of the offshore water of the UAE have been used (required within the period 1980's and early 2001). Attention has been focused on the area of the offshore from Abu Dhabi to Ajman with analysis using seven ERS-1/2 C-band SAR images including 2 tandem mode

24-hour interval image observed on 24 April, 29 May and 30 May 1996 (**Fig.7**). Observed slicks and bright spots in the 3 images acquired on different dates are confirmed as leakage oil slicks from same oil production platforms. In addition, known well location correspond to the leaking pints as well. Oil platforms and ships are observed as brilliant punctual reflectors in the background generally indistinguishable unless the well locations are superimposed on the images. This detection depends on the sea conditions, incidence angle increasing provide more contrast on the SAR image among the ship and the sea, it is possible to detect the ship trace depending on the size and speed of the ship. A ship can be distinguished by the presence of short, faint lines suggesting that the slicks are ephemeral surface events from a moving source, probably oil spills from a passing vessel moving down from north to south [4].

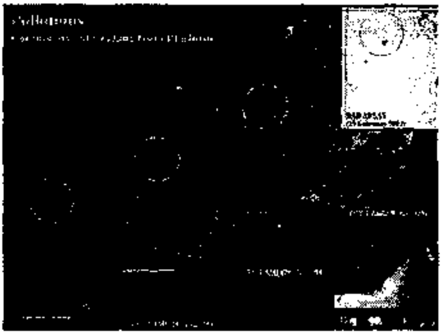

Fig.7. ERS-1/2 SAR images including 2 tandem mode 24-hour interval image observed on 24 April,29 and 30 May1996.

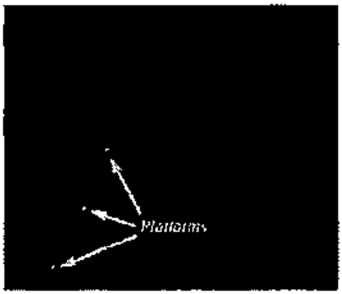

Fig.8. RADARSAT data © Canadian Space Agency 1997. Received by the Canada Centre for Remote Sensing

Three oil drilling platforms can be seen in this RADARSAT image **on** Fig.8 off the northwest coast of Australia. The dark trails in the water in the east and northeast of the scene may indicate surface oil pollution from the production platforms [3].

Influx of oil from tankers and offshore oil operations are major causes of pollution in the marine environment. According to statistics of the US Coat Guard (1990), sources of oil in the sea are classified into 6 categories. By far the highest contributor to oil pollution in the ocean, about 52%, result from a mix of materials and waste which make up urban runoff and discharge from land-based industrial plants. Another 19% of the oil in the sea is directly attributable to world oil industry. Two per cent of this occurs in spills from rigs and platforms during the exploration and production phases, and only 5 % of oil pollution in the oceans is attributable to accidents involving oil tankers. The remaining 13 % of hydrocarbons in the oceans is absorbed from the atmosphere by particle settlement and rain-wash.

According to the European Space Agency (1998), 45% of the oil pollution comes from operative discharges from ships. When taking into account how frequent such spillages occur, controlled regular oil spills can be a much greater threat to the marine environment and the ecosystem than larger oil spill accidents like the Prestige tanker (carrying N77,000 ton of fuel oil accident at Galice, northwest coast of Spain in 2002) (**Fig.9**) and the Sea Empress supertanker (**Fig.10**) [5] .

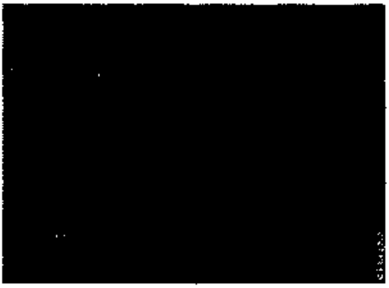

Fig.9. A satellite image of November 20, 2004. This SAR image shows tanker, Prestige, 100 km off the Spanish coast. The ESA'ENVISAT ASAR was operating in its wide-swath mode covering an area of approximately 400 km by 400 km.

Fig.10. The Sea Empress, a 147,000 ton supertanker accident the south of Wales February 15th, 1996. Seven days later, RADARSAT captured this image, clearly delineating the remaining oil slick. The spill appears on the image in black tones.

In June 2004, the Russian oil company "Lukoil" launched the exploitation of D-6 oilfield on a platform raised on the Russian Baltic shelf. Obviously, the least accident on the oil platform or pipelines connecting platform with coast terminal is capable of causing an ecological disaster in the region. In order to control the situation and to take timely measures and operationally predict the propagation of pollution in the case of disaster, experimental monitoring of the area using satellite remote sensing has been established.

The ESA's ERS-2 and ENVISAT radars conduct remote sensing of the sea surface and send back medium or high resolution images in emergency situations (after a large oil spill has been detected), wide swath (from 100 to 500 km) and keen sensitivity to sea surface roughness.The D-6 platform's location point will appear on the images regularly, 19 times a month, on the average. Most of these spills are produced by ships. No spills caused by leakage from oil exploitation installations have been detected. This is an evidence of the platform's ecological safety guaranteed by modern technologies used in its construction and operation.

RADARSAT International (RSI) has signed a multi-year, multi-satellite oil spill and oil seep monitoring contract with the Marine North East Region (MNE) of PEMEX Exploration and Production (PEP) of Mexico in establishing a maritime surveillance strategy for the Gulf of Mexico, including offshore oil seep exploration and environmental monitoring. PEP produces 3 million barrels of oil and 4,500 billion cubic meters of gas daily, ranking fourth in international production capacity. It will use RADARSAT-1 and ENVISAT imagery as well as RADARSAT-2 imagery when it becomes available. The contract includes imagery acquisition, processing, interpretation and services designed for oil spill and seep detection. Using this multisatellite program, PEP-MNE will be able to maximize imaging opportunities over their area of interest [17].

It is important to recognize that potentially damaging discharges of crude oil or petroleum products can and do occur at every point in the oil production and transportation system. The costs resulting from a spill are numerous and include economic, social, recreational, and ecological losses. The cost of recovering or eliminating oil offshore is typically 10 to 100 times less than removing the same oil from shorelines. On March 24, 1989, the tanker Exxon Valdez grounded on Bligh Reef in Prince William Sound carrying 53 million gallons of crude oil. Federal agency costs for the EXXON VALDEZ 1989 cleanup season alone were $110 million. EXXON's response costs exceeded $2 billion. Union Oil of California spent $13 million to clean up the oil and settle claims resulting from a 6,300 gallon oil spill from a near shore pipeline in south-central California in 1992 [19]. The conclusion is that the potential ecological disaster in the area of oil exploration is very dangerous and the regular monitoring of oilfields based on satellite SAR is very effective means of oil spills primary detection and tracking [6,12].

A number of limitations with Satellite SAR for oil spill detection have been recognised for some time. SAR systems rely on the detection of surface roughness and wind speed. Detection is difficult or impossible for some oil types. SAR images are also known to return many "false positives" for oil slicks caused by natural phenomena which generate patches of similar appearance. Automatic analysis of SAR images is not applied routinely yet. Several algorithms based on application of different approaches are suggested, realized and tested.The major limitation in the use of satellite remote sensing in the monitoring of oil slicks is the relatively 'poor' temporal resolution of the higher resolution near polar orbiting satellites. SPOT and RADARSAT have the ability to aim its sensor toward a designated area (at low incidence angles RADARSAT cannot differentiate slicks from sea water but the images will require extensive geometrical correction as the images are off nadir). A single satellite cannot provide the necessary cover of the area. Therefore SPOT should be used in conjunction with other satellites, such as Landsat. At present the two SPOT satellites have the ability to provide frequent data coverage of the higher latitudes. The same is true for the current SAR satellites, using the ERS and RADARSAT platforms in tandem it will be possible obtain greater number of slick images for a given period of time.

SAR is the preffered radar technology and a unit cost between \$2,000,000 to \$4,000,000.

The line scanning microwave radiometer (MWR) enables quantitative assessments of detected oil slicks by analysing the radiant emission from the sea surface and oil slicks at two or three frequencies for avoidance of interference (18.7, 36.5 and 89 GHz with geometrical resolution respectively 22 m, 11 m and 5 m) and allow to determine the thickness and volume for thicker and thin layers. This detection method has not been very successful in the field, however, as several environmental and oil-specific parameters must be known. In addition, the signal return is dependent on oil thickness but in a cyclical fashion [8] .

The microwave scatterometer is a device that measures the scattering of microwave or radar energy by a target. The main disadvantages include the lack of discrimination for oil and the lack of imaging capability.

Airborne Laser Fluorosensor (ALF) [9] seepage detection system is a seep detection system that uses a sophisticated, solid state laser to generate UV light which is pulsed from a low flying aircraft. The laser induces fluorescence in any fresh hydrocarbons on the sea surface. Due to the differences in the composition, the fluorescence spectra of different oils show variations with respect to the spectral form and the intensity of the fluorescence observed. Flying height is typically 80 m (to 600 m) and flying speed is typically 270 km/h. A surface swath width is 100 m at 300 m flight altitude conical scanner for two-dimential mapping of the sea surface.

The ALF acquisition system performs using excimer laser at 308 nm for the analysis of oil and organic pollutant (MkII system, Barringer's Fluoroscan) and the newest MkIII with NdYAG laser at 266 nm with 176 recorded channels and records fluororsensor data at the 50 Hz acquisition rate.

ALF detects oil sea surface films that may be too thin for satellite or other airborne methods and detects oil spills below the sea surface; estimates the oil volume - quantity and type of oil, identification of the oil through its spectral form; can be used during day and night if the visibility is sufficient and within certain limits is practically independent of the sea state. ALF gives information about hydrocarbon source, charge rates, trap integrity and oil degradation, helping reduce risk in further exploration of the area.

Airborne laser fluorosensor (ALF) survey was flown by World Geoscience in the Timor Sea, Australia in 1997 for BHP Petroleum and joint venture partners using the ALF MkIII system to detect natural oil seepage over the permit in an effort to refine the petroleum prospectivity assessment. The survey covers a triangular area over the northern two thirds of the permit and extends about 60km north to south and nearly 50km east to west, a total of 285 fluorescence anomalies (fluors) are picked out of the 1,751,550 recorded spectra in the final interpretation [9] .

Conclusions

Remote sensing is a critical element for an effective response to marine oil spills. Remote sensing data can provide information to enhance strategic and tactical decision-making, decreasing response costs by rapidly determining oil exact location and ultimately minimizing impacts. Spills detection by visual observation, despite of the low price and common use, is limited to favorable sea and atmospheric conditions, there is no mechanism for positive oil detection. The infrared devices are commercially available at affordable prices, for ship-board and aerial observation of oil slicks. There are airborne downward-looking thermal IR and Forward-Looking Infrared (FLIR). These sensors can 'see' the oil slick

during day and night, detecting thicker parts of a slick only. This thermal imaging capability brings an important step towards night operation and polluter identification. Satellite sensors like Landsat TM and NOAA AVHRR provide thermal data and oil slicks can be detected but in all cases the oil position should be known in advance. Optical and thermal satellite imagery offers little potential for oil spill detection while SAR satellites are nowadays the most useful space system for this purpose. The Side-Looking Airborne Radar (SLAR) is the primary sensor for long-range detection of oil pollution on the sea surface. Fast delivery Satellite Aperture Radar (SAR) products are proving to be of great value in the optimisation of airborne surveillance resources, due to the large area they can image at any one time. Regular monitoring of oilfields, oil influxes from tankers and offshore oil operations, illegal oil discharges, operative discharges from ships based on satellite SAR is very effective for companies means of oil spills primary detection and tracking and oil spills incidents prevention. As oil becomes harder to find, pursuit of fractured reservoirs and subtle signs of hydrocarbons at the surface and sea surface will receive increased attention. Airborne ALF system and hyperspectral hydrocarbron mapping are the insights of detection oil seeps source on the sea surface because of their high effectiveness and should be used in conjuction with GPS and aircraft inertial systems which allow pinpointing the oil's location and other airborne geo-data sets.

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ИЗПОЛЗВАНЕ НА СПЪТНИКОВИ И САМОЛЕТНИ СИСТЕМИ ЗА ОТКРИВАНЕ НА НЕФТ В МОРСКИТЕ ЗОНИ

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Резюме

Докладът представя анализ на спътникови и самолетни системи за дистанционно търсене на нефт и използване на техните възможности от нефтени и газови компании за проучвателни програми и при

аварийни изтичания и разливи, както и при други извънредни ситуации.

Тези системи взаимно се допълват и спомагат за комплексно наблюдение с различна разделителна пространствена способност и повторяемост на получаваната информация.

Мониторингът от спътници е един от основните компоненти за наблюдение на обширни морски зони, което за другите типове платформи може да се окаже прекалено скъпо, особено за проучвателни цели.

При самолетите пък, на борда може да се монтира допълнително оборудване позволяващо по прецизно откриване на нефт и определяне на количеството и вида на нефтените петна. Така че, само съвместното им използване може да спомогне за постигане на най–добри резултати при големия спектър от задачи, свързани с мониторинга на обширните водни пространства.