OIL AND GAS WORKSHOP

Satellite Earth Observation for the Oil and Gas Sector: New Technologies and Opportunities

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Offshore Plenary

Offshore oil and gas - overview of evolving requirements

Colin Grant

BP

The offshore oil and gas industry, and particularly my own company BP, has come under intense scrutiny over recent events in the Gulf of Mexico. However, the fact remains that the world needs oil and gas. Global primary energy demand is forecast to increase by 40% or more by 2030 compared to 2010. Although renewables will grow quickly, this is from a relatively low base and oil and gas will remain indispensible to energy supply over this period.

BP’s analysis indicates that the world has sufficient proven reserves for over 40 years of oil and 60 years of gas at today’s consumption rates. Much of this resource lies in frontier regions such as in deepwater and Arctic regions. In order to access, appraise and develop these potential resources, a wide variety of technology must be brought to bear and satellite earth observation is playing an increasingly important role in these developments.

The talk will focus on the stages by which oil and gas companies’ access, appraise and develop offshore resources. At each stage of the development a range of tools and techniques are employed and examples will be provided across a range of environments. Increasingly, techniques are being developed to provide integrated solutions which comprise a mix of EO data, in-situ observations and numerical modeling in order to assist decision makers.

Although advances have been made it is clear that there is room for further improvement, particularly in developments to improve the resolution of output products in both space and time. Combining EO data with other information also allows the development of innovative products and solutions and examples will be given of potential applications of a range of these.
Offshore Plenary

Offshore earth observation technologies: opportunities and limitations

Johnny A. Johannessen
Geophysical Institute, University of Bergen, Norway and Nansen Environmental and Remote Sensing Center, Bergen, Norway

Over the last 20 years Earth observations from satellites have emerged as a fundamental provider of data and information for monitoring the state and evolution of the upper layers of the marine environment. Both scientific research and operational application and services are today relying on regular access to such satellite observations, available either in offline or near real time modes. For application to the offshore oil and gas industry the satellite data and information are provided either as stand-alone products or combined with in-situ observations and models in order to deliver more comprehensive products and services as well as forecasts.

In view of the need for advancing the Earth observation based product delivery and services for the oil and gas industry in the coming years there are several constraints and limitations that need to be taken into account. Among these are the inherent characteristics of the satellite based temporal and spatial sampling, the data availability, the spatial resolution, the need for reliable reconstruction of the 3 dimensional conditions of the upper ocean and the predictive skills of the models. In addition, deficiencies in the satellite based retrieval algorithms that usually are empirical based, together with lack of systematic and sustained validation exercises, impose uncertainties on the product quality that are difficult to fully characterize and quantify.

The outlook regarding sustainable continuity of the satellite based observations combined and extended with new innovate exploration satellites are very promising. Similarly there is a rapid development in model capabilities and predictive skills. It should therefore be feasible to overcome some of the constraints and deficiencies and consequently advance the product quality and services. Perhaps closer and more consistent collaborations between the oil and gas industry, the space agencies, the scientific community and the data and service providers might be the fastest way forward. In so doing, the industries requirements could be mapped into a comprehensive satellite mission and system requirements, in-situ data demands and modelling and forecasting service capabilities and requirements.

In this presentation these issues are further highlighted in the context of conventional and innovative product retrievals including swell, crossing seas, sea level, surface currents, high resolution wind fields and sea ice and icebergs.
This talk will provide an overview of national remote sensing laws and policies around the world. The trend has been to regulate high-resolution systems differently than medium to low resolution systems, with more restrictions applying to the former. The national laws and policies seek to balance commercial interests with national security and foreign policy interests. These are the starting point for "downstream" issues including licensing derived and value-added products.
Robust ice and met-ocean data is essential for safe, reliable and cost effective offshore design and operations in areas having full or seasonal ice cover. This requirement is especially pronounced as Industry moves into relatively underexplored parts of the Arctic including Greenland and Russia. Satellite earth observation has the potential to be a game changer in these frontier regions, where data is sparse as well as to continue to play a key role in more mature regions such as offshore Sakhalin, North Caspian, and offshore Norway, US (Alaska), and Canada.

Traditionally, field measurements have been the backbone of ice and metocean data. Satellite earth observation has started to play an increasing role in data collection, but is still one of a supporting role. This emphasis on field measurements is both costly and resource intensive, typically limiting the amount of data that can be collected. Accuracy is also an issue due to discrete nature of the measurements and limited measurement points, that can under-sample spatially varying fields and lead to serious error in estimating ice and metocean conditions. Additionally, putting people in the field, while important for building a unique sensory feel for the environment, does come with significant exposure to safety hazards to field personnel.

By contrast, remote sensing data from satellites offers an attractive approach to deliver global and frequent offshore measurements of a variety of parameters needed for design and operation. Satellite data are thus able to provide synoptic measurements capturing the spatial variability of the observed field and also to monitor remote regions being physically or politically inaccessible to traditional survey. This makes these data, especially the high resolution polarised SAR data, particularly useful to complement and even enhance traditional local in-situ measurements, which are still needed for validation of the satellite products and compensate for their technical limitations. These include the satellite data interpretation as well as the current lack of information on some critical parameters such as ice thickness and ice drift. In addition, it is essential for the safety of the operations that these data can be timely delivered in a reliable way.

The purpose of this paper is to stimulate new thinking, research, and development, specifically around how Satellite Earth Observation can be turned from a supporting tool for ice and met-ocean data collection into the primary tool.
Selling EO based services to the oil and gas sector requires a good knowledge of the requirements of the sector, and as such value adders need to understand the normal structure of the client organisations, to know which products/services are appropriate to target at the various components. The market needs to be distilled into several distinct phases to reflect the normal structure of an oil and gas company. These are outlined below:-

- Pre-license
- Exploration
  - Seismic survey
  - Exploration drilling
  - Evaluation
- Development
  - Engineering design
  - Construction
- Production
- Abandonment

These functions often exist in discrete business units, either as regional business units or indeed for each field development depending on the size of the company. Therefore accessing the right person can be very difficult unless you already have extensive knowledge of the market and strong selling capability. Thus unless the client is proactive in seeking an EO solution, market accessibility is difficult.

Services provided into the sector can generally be classified in a number of ways to help understand the market.
Classification | Comments
---|---
near real time versus historical | The availability of data to support these two functions varies significantly.
Direct application versus integration | For example many EO products are assimilated into models, and the importance of these data to model accuracy is perhaps not fully recognised by the end user.
Qualitative versus quantitative | The presence of geostrophic currents features such as the Loop Current in the GOM does not provide a reliable enough quantitative assessment of current velocity. Therefore these data can only be considered to help identify spatial variability.

Example EO based services:

- Seep databases
- Pollution monitoring
- Use of satellite altimeter data in validation of hindcast wind and wave models, Direct use of satellite derived wave and wind data to support generation of operational statistics
- Use of satellite altimeter data in characterisation of historical geostrophic currents – values not absolute and have limited value in direct application in many regions
- Assimilation of range of data into forecast models / hindcast models of wind, wave, current and water levels
- Tidal models derived from satellite data
- User of SAR data in identification of presence of oceanographic phenomenon, e.g. Solitons
- Use of SAR data to investigate wave characteristics, e.g. Swell
- Sea surface temperature for process engineering
- Delineation of features such as river outflows
- Ice delineation
- Iceberg tracking – using SAR

Cost effectiveness is generally fine for oil and gas applications with the exception of SAR, particularly data programmed at short notice. To help extend SAR data sales into the Oil and Gas sector, as a near real time product, it may be worth considering a data collection programme over a number of key oil and gas basins to enable the value of frequent data collection to be promoted, rather than the adhoc acquisition that presently occurs. This could inform scientific investigation into a number of processes of importance to the offshore oil and gas industry.
Offshore Exploration

Mapping oil on the sea from space: from idea to cash flow and beyond

Dr Geoff Lawrence
The Really Easy Imaging Company Limited, Knebworth, UK

It has been over three decades since the first imaging radar satellite was launched, NASA’s ocean-observing SEASAT. Satellite radars are therefore in their young adulthood, when more is expected of them and we look to them to pay their way.

The synoptic, non-interventionist, global ranging, day-or-night and all-weather observing, feature-rich radar images proved ideal to mapping oil slicks. This simple idea needed substantial study and trial before oil spill observation became one of the first commercial applications to be developed once the SAR satellites ERS-1 and Radarsat-1 were routinely flying. However, although monitoring oil pollution from ships, rigs and installations has become routine, the recent Montara and Macondo well blow-outs showed that daily availability of optical satellites like MODIS proved to be more useful than SAR, in spite of cloud cover. Furthermore, there remains a disconnect between the monitoring and benchmarking role of satellite imaging and remediation of spills.

In contrast, because timing is not so critical, SAR satellites have provided a phenomenally successful way to map traces of natural oil seepage on the sea surface, and the service has been widely adopted by the oil exploration industry. The key to this success has been two decades of integration with collateral data like multi-beam swath bathymetry, seismic, weather data, gravity and petroleum geology and chemistry, to create a global database of natural oil seepage.

The fast delivery of results via internet and close collaboration with the oil industry developed for this offshore basin screening, could be adopted to better deliver oil pollution monitoring to government authorities and contractors deployed to remediate spills. To do so effectively and globally, there is need for a wider constellation of steerable satellites like TerraSAR-X and CosmoSkyMed and the SAR and ocean observing satellites planned for ESA’s Sentinel programme. Global collaboration in satellite remote sensing is also even more necessary today, so that improvement in speed of the flow of SAR data from all suppliers to interpreters and the oil industry is achieved.

Also looking ahead, if the optical super-spectral satellite of the Sentinel programme goes ahead, we will be able to develop a parallel global database of oil seepage onshore.
Offshore Exploration

Winds, Waves and Water Levels: Routine and Innovative EO-Based Services for the Oil and Gas Industry

Robin Stephens
Senior Advisor, Oceanography and Meteorology, BMT ARGOSS

Satellite earth observation provides unique and extremely important meteorological and oceanographic (metocean) information that is used to support maritime engineering design and operational planning in the oil and gas industry. From the practical perspective of a commercial service provider and commissioned research and development contractor, the presentation will explore technical and commercial aspects of operating ‘routine’ and ‘innovative’ wind, wave and water level services that incorporate altimeter and scatterometer data. Whilst innovation is important, it will be argued that there is a strong need for robust and reliable ‘routine’ technology and infrastructure to support the offshore industry, and particularly long-term continuity of service availability.

Brief case studies will be presented, based on recent experience: firstly, the development and commercialisation of a global tidal database for water levels, utilising harmonised satellite altimetry data together with in-situ measurements and numerical modelling; secondly, the implementation of operational regional scale wave forecasting models, optimised using satellite wind and wave observations; and thirdly, work on very fine resolution meteorological characterisation. The first and second case studies represent ‘routine’ technology: the development and maintenance of an infrastructure for provision of specific deliverables on a global basis, particularly focused where the offshore industry has interests. The presentation will discuss strengths and weaknesses of inclusion of altimeter and scatterometer data in the operational ‘service chain’, and will give specific examples of practical limitations that need to be overcome. The third case study considers the challenges of implementation and verification of very fine resolution meteorological characterisation. Each of the three case studies will be illustrated by practical examples of applications in the offshore industry.

The presentation will conclude with a discussion on commercial aspects of operating metocean services that incorporate EO data, and look at the changing balance between private sector and public domain offerings, and associated challenges and opportunities.
Offshore Exploration

EO-Based Ice and Iceberg Monitoring in Support of Offshore Engineering
Design and Tactical Operations

Des Power
C-CORE

The characterization of the ice environment is a necessary step in the probabilistic design approach of Arctic offshore structures. Without such knowledge, design uncertainty is high with the result being overly conservative designs with higher build costs to deal with the uncertainty associated with sea-ice and iceberg loads. In addition to knowledge of the ice environment, the addition of ice management to operations leads to a lower risk of ice impact. When ice management is considered at the design stage, additional design concepts may be considered, which may also lead to lower build costs. A critical component to an effective ice management plan is tactical knowledge of the ice environment. Both tactical and historical knowledge of the ice environment can be achieved cost effectively using Earth Observation (EO).

The mapping and monitoring of ice infested regions represents a key application area for EO, in particular synthetic aperture radar (SAR) missions. The all-weather day-and-night observation capability, coupled with the harsh Arctic environment, often make radar the only reliable information source. Space-borne SAR mapping of ice has been available since the 1970s, although routine SAR monitoring of ice was only made possible in the 1990s with the launch of ESA’s ERS-1 in 1992. This satellite also heralded in an era of large scale data archiving of radar data. In addition to chart data available through various national ice centres, there is now available an archive of almost 20 years of raw satellite radar data that can be used to create highly detailed historical maps of ice and icebergs to aid in the design process. With the increased availability of near-real-time acquisition and higher resolution satellites, SAR can be used effectively by the industry to aid in Arctic resource development through the entire design process – from initial engineering design using archived SAR data, to tactical ice management using near-real-time SAR monitoring. The increasing prevalence of SAR, along with lower data costs and more flexible data policies will lead to increased use by the industry into the future.

SAR use in sea ice mapping and characterization is a well known application used by national ice centres for ice charting. Satellites with increased resolution and multi-polarization can provide increased value to the industry by providing increased detail on sea ice features (ridges, stamukhas and rubble). SAR is also very effective at detection and monitoring of icebergs, both for tactical and strategic purposes. Recently launched SARS are now available that can detect bergy bits and growlers with a probability of detection that can exceed that of comparable airborne and ship-based microwave radar.
The presentation will take the audience through the design and operations phase of an Arctic oil and gas project and show how SAR can be used effectively to lower risk and costs.
Offshore Environmental Sustainability

Mapping coastal sensitivities using satellite remote sensing data

Catherine Sutton

TOTAL DGEP/HSE/ENV

Commitment to protect the Environment and Biodiversity has conducted Total E&P to develop tools to ensure that its working natural and social environment is well known and protected in the most appropriate manner. In particular, Total E&P activities can have an impact on coastal areas.

Mapping coastal sensitivities is based on a systematic and constantly updated approach based on the Environmental Baseline Study (EBS) which determines the basic information on local sensitivities and resources, and the Environmental Impact Assessment (EIA) which determines the potential impact of E&P activities on the natural and human environment. Furthermore, it defines the measures and technical solutions required to reduced or if possible eliminate, or compensate the impact. A monitoring of the potentially impacted areas with a focus on major sensitivities is carried out along the project life. In addition, in case of an accidental spill, sensitive areas need to be protected in priority.

At the most early stage of a Project, data collection is carried out using Satellite Remote Sensing (SRS) data with the support of the Geomatic department of Total E&P to identify most relevant images. Images are then treated and converted to give a land occupation description. Forest, biologist, cultural and social experts are involved in this data analyses to qualify the coastal ecosystems and human activities sensitive areas. A site survey is then carried out to validate the SRS data interpretation focussing on the most potentially sensitive areas identified.

From the coastal sensitivities mapping the most vulnerable areas to oil spills are characterized and mapped.

The approach adopted is based on the simultaneous considerations of several criteria:

- Shoreline type vulnerability,
- Sensitive biological resources,
- Sensitive socio-economic resources.

Vulnerability of these criteria is assessed according to sub-criteria defined on a case by case and converted to layers included in a Geographic Information System (GIS).

Within the scope of the Operational Environmental Management and Crisis Management, the GIS provides a powerful tool for integrating and managing the environmental sensitivities for production activities and new development. GIS may also be a help for sustainable development of coastal resources, and biodiversity protection, in close cooperation between TOTAL and local authorities.
Offshore Environmental Sustainability

Operational MODIS Satellite based water turbidity monitoring for dredging operations in Woodside

Dr. Peter Hausknecht

Woodside Energy – GTO-Geomatics

Woodside operates an LNG plant on the Burrup Peninsula near Karratha in North West Australia. As part of an expansion activity for new pipeline constructions, dredging operations were conducted in Mermaid Sound, which is the adjacent ocean open water area.

As part of Woodside’s commitment to environmental management and keeping aligned with regulatory requirements a monitoring program for water turbidity was established using satellite remote sensing data.

In cooperation with EoMap, a service provider company to the industry, a methodology was developed using the MODIS satellites as the main sensors and in particular the 250m spectral channels to develop a product to allow rapid assessment of the turbidity situation in a predefined water quality monitoring area.

MODIS offers the advantage of two sensors being available Terra and Aqua, complementing each other by having a daily overpass each, one in the morning, the other in the afternoon. The data sets have radiometric and atmospheric corrections applied and use sunglint removal algorithms. Simultaneous in-situ water quality measurements at the beginning of the project allowed calibrating the Satellite measurements to NTU (Nephelometric Turbidity Units), a commonly used turbidity measure.

From starting the monitoring in October 2007 to its finish in June 2010, 420 individual data scenes were processed and delivered, many more evaluated and quality assessed for potential delivery. This is a data set delivery on average every 2-3 days through out the entire project duration. Some periods were covered with a higher frequency, in times of no dredging data was delivered only ever 4-5 days. Product and data delivery to the project was usually within 48 to 72 hours after each initial acquisition.

The project was very successful and considerable cost savings were achieved compared to alternate airborne monitoring solutions, as well as no HSE risk of airborne operations needed to be considered. Other benefits were seen particularly in times of unusual seasonal activities (wind, tides) or unusual natural events (cyclones, algae blooms), where the regular and regional spatially coherent data provided a reliable monitoring solution.
Offshore Environmental Sustainability

Earth observation in the coastal environment: multi-sensor and shallow water observations

Dr. Thomas Heege
EOMAP GmbH & Co.KG

Coastal areas are an important interface between the offshore production infrastructure of the Oil and Gas industry, and the infrastructure on land. Pipelines are crossing the submerged habitats, and dredging needs to happen to allow pipelines being built or harbours to be established. Increased Marine Vessel traffic and changes in water quality parameters affect the environmental conditions of the coastal habitats especially around new developments. Due to the ecological relevance and public awareness of the coastal environment, increased monitoring demands are requested to prevent pressures on the coastal habitats and to fulfil the regulatory requirements.

The initial baseline mapping as well as the assessment and subsequent monitoring of both natural and/or man-made pressures on these coastal environments depends on adequately resolved measurements in space and time, which remote sensing can offer. From the user point of view, product quality, continuous availability of products and services at different scales and resolutions in space and time as well as the integration into existing monitoring concepts are essential. Traditional in-situ-measurements can be integrated in spatial observations using remote sensing data allowing a much improved monitoring rather than using only point measurements. The maximum benefit hereby can be achieved using multi-sensor approaches to increase temporal coverage. This approach requires standardized, inter-operational data processing technologies, as well as access to the relevant data.

Such an approach is presented here for applications of water quality and submerged habitat mapping. The technological background of the inter-operational data processing approach and the data availability through different satellite and airborne systems is presented. The service readiness, the product quality and service elements to be improved are discussed with respect to different applications worldwide. An overview of existing operational EO services, missing service elements and technologies in development will help to evaluate the status of the service provision.

In the near future, essential improvements will be made by the synergy of various sensor types (optical/radar satellites) with in situ measurements and hydrodynamic models. These improvements are addressed with practical examples for water depth mapping and other important environmental parameters.
Offshore Environmental Sustainability

Use of satellite earth observations, in situ data and numerical model capabilities for oil spill contingency

F. Lefèvre, J.Y. Lebras, and the CLS team

CLS (Collecte Localisation Satellite), France

For over 30 years, CLS has been operating the Argos satellite-based system. This system is used to track oil spills by deploying buoys within the slicks and collecting their drifting locations.

Ocean-observing satellites are now operational and naturally occupy a major place in programs designed to manage and predict ocean and climate change. CLS has a long experience in the processing, validation, distribution and exploitation of satellite altimeter data and other remote sensing data (sea surface temperature, ocean colour). These data are used to describe the surface conditions of the ocean that have an impact on the oil spills drift.

Radar satellites (synthetic aperture radars) allow the detection of an oil spill and its extent at the surface of the sea. These Earth Observations (EO) remote sensing products are now distributed in real time and have been shown to be extremely valuable for different industrial applications at sea.

CLS is also actively involved in the development of operational oceanography systems. These systems integrate altimeter and other remote sensing data with in-situ data and ocean models to provide a real time description and prediction of the ocean state.

Based on these different techniques, CLS actually offers a fully integrated service for oil spill detection, monitoring and tracking. In a nutshell the approach is to combine:

- satellite radar imagery to detect oil spill and assess their extent (DETECTION service);
- drifting buoys (Argos satellite system) directly deployed in the spill to collect its location in real time (TRACKING service);
- wind and ocean current data (Earth Observations) with numerical models to predict the drift of the oil spill (FORECAST service).

By combining in situ data, EO data and ocean modelling capabilities, CLS provides crucial real-time and forecast information to help during an oil spill crisis.

We will illustrate our talk by presenting this service and the different elements which are based on satellite technology. We will conclude by highlighting the benefits for Oil and Gas industry of using such a service.
Offshore Transportation and Infrastructure

Operational support in ice

Wim Jolles
O&G industry ice specialist

Operational support in ice from the remote sensing perspective is achieved by the acquisition and interpretation of Satellite imagery. Naturally budgets must be checked but if those can be satisfied what is needed to place orders? The parameters entering the review start at the requirements. Is it for transiting ships, for stationary ones or for fixed drilling installations? What is the geographic location and what are the local ice features? Each combination may lead to a different set of requirements. Thereafter one can review the frequency of the supply, the resolutions and what details are required. Different ice conditions, may include rafting or formation of grounded ice, large ridges or the presence of ice drift, varying thicknesses and old ice, stamukhas and icebergs.

The end users could always receive more details, but do they always know how to interpret the images and what information should the ice charters add to the images for easy interpretation offshore? Feedback has been obtained from such users in different operating areas, which include wishes for more and higher resolution images, information of old ice or heavy ice features, ice drift or pressure and training.

Opportunities are many including the best use of multi polarization, incidence angles and good trade-offs between high resolution products and their frequency. The ability to zoom in on images on board and the reception of good quality images are key to safe and efficient operations. The selection between the many current and also planned sensors makes this a challenging environment. With more shipping in ice covered waters and more crews navigating in such waters, supply of proper images and their interpreted charts is a must. Provision of proper end products in near real time is required.

Wim Jolles is an MSc from Delft University in Ship Design and started in 1975 working in the dredging business. That took him to Canada to help build islands in icy waters maximizing the open water season and later expanding operations in shoulder seasons and in winter. Experience was gained in NA waters, Russian and recently in the Caspian Sea. Wim has been active in the Society of Naval Architects and organized a number of Icetech conferences helping to advance the technology. More recently he has represented the oil and gas industry at the IICWG meetings who met here in Frascati only 2 yrs ago.
Offshore Transportation and Infrastructure

Use of remote sensing for operational pollution monitoring, source detection and identification to support the Oil & Gas industry

O. Muellenhoff
BMT Argoss

Amongst different types of maritime pollution, mineral oil is a major threat to the marine ecosystems. Mineral oil floating on the sea surface often originates from ships, oil platforms and natural oil seeps as well as from onshore sources like refineries and industrial units. Marine oil spills pose a risk for coastlines in terms of ecological damage, socio-economic losses and influence on coastal industries.

In the last decade maritime transportation has been growing steadily. More ships also increase the potential number of illegal oil discharges. Routine tanker operations lead to the release of oily ballast water and tank washing residues. Furthermore, fuel oil sludge, engine room wastes and foul bilge water produced by all type of ships, also end up in the sea.

One of the key instruments to monitor and detect oil spills at sea are airborne or space-borne Synthetic Aperture Radar (SAR) systems. SAR systems are able to detect spills on the sea surface indirectly, because of damping the short Bragg waves. The oil film dampens these waves which are the primary backscatter agents of the incident radar beam and appear as dark patches in the SAR image. Bragg waves are induced by surface winds but are also modulated by other ocean surface features. Furthermore diverse kinds of pollution can cause slicks that are detectable by SAR (e.g. vegetable or fish oil, river runoff, drilling fluids, etc.). The SAR sensor is currently not capable of distinguishing between the different pollutants. Additionally met-ocean phenomena like wind, currents, internal waves, up-welling sea areas, algae bloom, mixing water areas, etc. appear as a dark features in a SAR images. These phenomena are called look-alikes.

Ancillary remote sensing products like Sea Surface Temperature (SST), chlorophyll-a concentration, wind-, wave- and currents conditions are providing crucial basis information for the operational pollution monitoring. The knowledge of environmental conditions as well as contextual information about slick position relative to surrounding objects (ships, maritime routes, rigs, wrecks and undersea pipelines) are in many cases essential for the definition of the probability of oil spill detections in SAR imagery.

Operational ship detection systems are implemented based upon SAR imagery since ship and ship wake signatures have been observed in the imagery. Ship detection in SAR imagery amounts to the detection of bright targets against the ocean clutter background. The potential for ship detection depends upon many factors including the local wind and wave conditions, the observation geometry, the radar frequency and polarization, and the ship size and type.
Remote sensing is a useful instrument for oil spill control, including the monitoring of huge areas, site specific surveillance and tactical assistance in emergency cases. Various remote sensing products are able to provide essential information to enhance strategic and tactical decision-making which will decreasing response costs by facilitating rapid oil recovery and finally minimizing the impact.
Offshore Transportation and Infrastructure

Never on a Monday – lessons learnt from monitoring the Deepwater Horizon accident

Richard Hall, KSAT
Kongsberg Satellite Services

Kongsberg Satellite Services (KSAT) is a world leading provider of integrated space based information for operational purposes. The main focus is on marine services derived from satellite Synthetic Aperture Radar (SAR) data integrated with additional information, such as AIS (Automatic Identification System) information both from ground-based and satellite systems. The satellites employed today include both the European ENVISAT and the Canadian RADARSAT systems. KSAT utilises the company's ground segment facilities in Tromsø (69°North), Svalbard (78°North), Grimstad, Norway (58°North) and Troll (Antarctica, 72°South), to obtain global access to the data.

KSAT began the development of the oil spill service with the launch of ERS-1 in 1992 and the service became fully operational in 1998. Today, KSAT delivers oil spill analysis within 30 minutes within their ground station coverage (2 hours outside) for both commercial and government actors in Norway, in Europe for the European Maritime Safety Agency (EMSA) and globally for other international customers. The service integrates information from satellites with additional geo-referenced information, such as platform and pipeline locations, as well as natural oil seeps, and source identification.

To set-up a new monitoring area with a new customer there is typically a 3-6 months commissioning phase (with the first images being available within a month) to ensure that the data and information are delivered in the best way for the end user and the end-user is fully trained in the understanding the results delivered.

In April 2010, KSAT received a phone call requesting help to provide images over the Deepwater Horizon position.

This talk will

· Give an overview of the co-operation in Norway between the national agencies and commercial actors in monitoring for oil spills and illegal discharges in the North Sea.

· Describe how KSAT responded to the request by setting up a service within 48 hours.

· The lessons learnt from this incident, with comparisons to how a similar incident may be handled in Norway.
Offshore Transportation and Infrastructure

Radar observation of oil platforms

Susanne Lehner

DLR

Offshore activities need information on meteo-marine parameters for optimal siting, estimation of production, maintenance schemes and short term weather prediction.

With the platforms moving further offshore precise information on extreme weather conditions are of importance.

Synthetic aperture radar (SAR) is capable of providing information on meteo marine parameters over the ocean in all weather conditions and independent of sunlight. Algorithms have been developed to retrieve wind speed, sea state, currents, oil spill coverage and underwater topography from SAR data at different frequencies and polarizations.

A new generation of high resolution radar satellites with a resolution around 3 meters yield the possibility to investigate environmental phenomena in variable areas near the coast and around the platforms. The data can be distributed in near real time.

In this paper it is demonstrated how remote sensing data are used at several offshore platforms

In examples we demonstrate the wind field estimation over several European wind farms, sea state measurements at the oil platform Ekofisk and observations of the formation of sea ice around offshore constructions.

Using the shoaling of ocean waves the underwater topography is estimated in order to facilitate planning for new constructions. This work was performed using optical and radar data in synergy over an area at the Australian west coast.
Offshore Transportation and Infrastructure

Earth Observation in coastal zone met-ocean design criteria

Cees de Valk
BMT ARGOSS

Some oil and gas facilities such as LNG terminals are located in the coastal zone. Establishing Met-ocean design criteria in coastal waters poses its own challenges. Waves and currents are transformed when moving from deep water to the shore. Also, certain phenomena occur only, or mostly, in the coastal zone such as katabatic winds, sea breezes and coastal jets, tides, river outflow plumes and fronts, surf, rip currents, infra-gravity waves, bed-load sediment movement and associated seabed evolution, just to name a few.

Earth Observation (EO) data, for example from microwave sensors as radar altimeter and scatterometer, provides valuable information about the offshore climate. Because sampling is fairly sparse, these data are used mostly in conjunction with numerical model hindcasting.

In the coastal zone, the variability of weather and sea state is generally much larger, so even when the footprint is small enough and contamination from the land surface is limited, a sample will be representative for a smaller area than would be the case further offshore. Work to improve EO measurements near the coast is ongoing in several places.

Usually coastal waves and currents and meso-scale weather are derived either by in-situ measurement or by employing high-resolution numerical models receiving boundary conditions from global models. EO data such as radar altimeter and scatterometer data are used mainly to verify these boundary conditions.

In addition, radar and visual-wavelength imagery can be used for detecting relevant phenomena and their spatial variability. In particular during the initial stages of a project, qualitative information from imagery is highly valuable, particularly to identify any dominant physical processes, complementing any locally available experience and documents. Examples are coastal wind patterns, internal waves, and sea surface wave propagation into shallow water.

Useful quantitative information at these fine scales is much harder to obtain. Radar imagery can provide reliable surface wind information at resolutions of about one km but for most other phenomena, the range of environmental conditions permitting imaging is rather limited, so there are issues with reliability. Geometric properties of phenomena remain probably the most easily measured. Further developments in this area would best be directed toward verification and improvement of fine-scale model hindcasts.
Onshore Plenary

Onshore oil and gas - overview of evolving requirements

Richard Eyers
Shell Exploration and Production

This presentation will set the scene for the day’s presentations, reviewing the gradual adoption of earth observation techniques by the oil and gas sector, and focusing on some of the new challenges which need to be addressed.
Onshore Plenary

Onshore earth observation technologies: opportunities

Hermann Kaufmann
GFZ German Research Centre for Geosciences

This talk will provide an overview on earth observation opportunities in the context of onshore oil and gas industry issues and therewith set the frame for further lectures and discussions within this specific session. The presentation is subdivided in several parts that comprise the services that have been provided in the past, the challenging requirements of the users and the future opportunities offered by new and emerging EO-systems and related state-of-the-art computing methods and facilities.

In this regard, sensors operating in different wavelength ranges at various spatial, spectral and temporal resolutions from the visible to the microwave range are addressed and discussed against the background of the oil and gas application and influencing surface parameters. Further addressed are different approaches in exploration strategies, accompanying activities and measures to be taken in case of damage control and rehabilitation. Complementary geophysical techniques like gravimetric and magnetometric analyses are addressed as well.

Concluding the overall findings, there will be information about the possibilities and constraints of the different techniques and methods used, if and how the latter may be solved in the future and what operating and upcoming innovative EO-systems do offer to the oil and gas industry.
Remote sensing data are a powerful tool to map properties of the earth surface and the earth crust from a global scale to local targets. However, the information obtainable from these data depends on the type of data acquired.

This paper studies different types of remote sensing data from optical through microwave to gravity data and highlights their benefits and limitations. We will present methods for extracting information from single and multiple satellite images and show how information from the ground can enhance the value of remote sensing data. Examples for integration of information from the surface to the top of the crystalline basement will conclude the presentation.

The focus of this paper is on geological and geophysical mapping with the aim to use remote sensing data to build realistic geological models of the subsurface. The interpretation uses the concept of geomorphology for the integration of different types of remote sensing data with surface geophysical data.
Onshore Exploration

Using remote sensing data for the prediction of logistical and data quality risks, in land seismic operations

Dave Holmes, Andreas Laake and Andrew Cutts
WesternGeco

Remote sensing offers the unique ability to view the earth’s surface without actually being in contact with it. The technology provides a low cost approach to aiding the planning and acquisition of a land seismic survey by utilising multi-spectral satellite data and digital elevation models (DEM). These data sets can be combined to create several maps, such as slope evaluation and terrain estimation.

The importance of using a geographic information system (GIS) to store and process the imagery in a geo-referenced format has been demonstrated by Laake and Cutts (2007). A GIS based approach, which extracts geomorphology information from digital elevation models, generates the following risk maps for use in seismic survey design and acquisition planning:

- Logistics planning: areas that are rough, rocky, have uneven terrain or extreme soft ground will provide significant logistical issues.
- Impact of the terrain on data quality: terrain edges and escarpments represent sources for scattering as do geomorphologic boundaries; areas of low surface velocity usually bear a high risk for attenuation of high frequencies and ringing of trapped modes.

This paper will provide examples using data from the Western Desert of Egypt including surface geological sampling and correlation with seismic data. The results demonstrate that the interpretation of remote sensing data allows the prediction of risks associated with land seismic acquisition.

Onshore Exploration

Geological mapping using earth observation data for onshore oil and gas exploration

Michael Hall
Infoterra

The use of Earth Observation (EO) data for geological mapping applications is well established and has made a significant contribution to Oil and Gas exploration. Many areas of active exploration have a lack of existing geological mapping at a suitable scale or accuracy. EO based geological mapping has a number of benefits; allowing fieldwork and seismic acquisition to be targeted to specific areas of interest, assessment of large geographic areas often with difficult access and placing site specific field observations in their wider spatial context. In well exposed areas a detailed understanding can be gained of structural features, including fold style, fault classification, bedding dip angles, fracture orientation and stratigraphy.

A variety of optical sensor can be utilized depending on the application and mapping scale. Typically, studies involve the spectral discrimination offered by satellites such as Landsat and ASTER with their important spread of spectral bands particularly in the Short Wavelength Infra-Red (SWIR), with a greater emphasis on the imagery provided by the suite of high spatial resolution satellites for license block evaluations. Thermal imagery can also play an important role in identifying potential onshore seeps.

RADAR offers the advantage of cloud penetration and the enhancement of subtle topographic relief in vegetated areas, particularly with the careful selection of acquisition parameters including wavelengths and polarisations to maximise and enhance the geological information available. Longer RADAR wavelengths sensor such as L band PALSAR, in area of suitable ground conditions, can also provide geological and hydrological information in the shallow subsurface.

In addition digital elevation models play an important role in combination with other EO dataset and are required for visualization, cross section generation and 3D geological modelling.

A new generation of satellites will be key to the future of EO based geological mapping. These satellites include the 12m global elevation models offered by TanDEM X, Landsat 8 and Sentinel-2 with their range of suitable spectral bands and an increase in availability of high resolution imagery.
Onshore Exploration

Hyper-spectral remote sensing for oil and gas: There is no end to what it can (not) do

Freek van der Meer & Harald van der Werff

University of Twente, Enschede, Netherlands

The Faculty of Geo-Information Science and Earth Observation (ITC) of the University of Twente provides international postgraduate education, research and project services in the field of geo-information and earth observation. The department of Earth Systems Analysis uses remote sensing and GIS technology on a number of societal issues, including sustainable use of earth resources and mitigation of natural and man-induced disasters. A particular focus is on obtaining physical measurements of the Earth surface, using airborne and space-borne hyper-spectral sensors in the optical and thermal windows, which is aided by shallow geophysics as well as spectral field and laboratory measurements.

In the past, ITC has been involved in several projects related to the Oil and Gas sector. The range of posed questions and requested deliverables was quite wide, varying from delivering standardized products, such as mineral maps without any geological expert interpretation, to studying the possibilities of complete monitoring systems, for example for underground pipeline transport.

This presentation gives an overview of our activities in the last decade, starting with the research questions and deliverables that were originally asked. We will show data processing techniques that have been newly developed or improved in the process to answer these questions, and show some of the results that have been obtained. Despite the progress that we made in Earth observation technology, a number of issues are still to be solved, not only from a pure scientific perspective, but also in the light of developing operational monitoring and exploration techniques. The presentation will hence conclude with a discussion on where, from a scientific point of view, difficulties exist that currently limit the use of Earth Observation in the Oil and Gas sector.
Onshore Exploration

Gravity fields

Ole Baltazar Andersen

DTU Space

During recent years a dedicated effort has been put into improving existing high resolution global marine gravity fields in order to enhance their coverage and accuracy and several global fields are available today like (i.e. KMS02, DNSC08, DTU10, Sandwell and Smith, NTU 01, GSFC00).

The newest global gravity field is the DTU Space (DTU10GRA) 1-minute grid. This field have been derived from double retracked satellite altimetry from mainly the ERS-1 geodetic mission data augmented with new retracked GEOSAT data and ERM data from i.e. ENVISAT which has significantly enhanced the range determination and hence the gravity field accuracy. This gravity field is the first high resolution altimetric gravity field to cover the entire Arctic Ocean all the way to the North Pole. Comparisons with other older gravity fields show accuracy improvement of the order of 20-40 %. The accuracy improvement is particularly large for coastal and Polar Regions where the accuracy improvement in many places is of the order of 40-50% and even more compared with older global marine gravity field. This is achieved by a combination of retracking, enhanced processing and the use of the new EGM2008 geoid model. In this presentation the accuracy of these new global gravity field are assessed and the general improvement in global gravity field determination from satellite altimetry is presented along with evaluation against marine data.
Onshore Exploration

Detecting traces of hydrocarbons onshore from space – can we succeed?

Nigel Press

Fugro NPA

We know most hydrocarbon accumulations leak gaseous and sometimes liquid components. Intuition tells us we might be able to detect the primary or secondary effects of such leakage with space-borne sensors, but results to date are far from conclusive. The presentation will consider the background to this and review some of the more promising tests, including the latest airborne experiments, as a basis to scope out a way forward for the satellite approach.
Onshore Environmental Sustainability

Remote sensing in support of Chevron’s environmental stewardship

Authors: Scott Hills¹, Marty Evans², Jim Ellis³

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Chevron uses a wide variety of remote sensing technology to support efforts to establish environmental baselines, monitor change, communicate with agencies and partners, and plan Health, Safety, and Environmental (HES) operations. The data types include multispectral imagery of varying spatial resolution; InSAR, LiDAR, historic aerial photography, and airborne/satellite hyper-spectral data cubes. The data are processed to help map vegetation, land cover/land use, topography, encroachment, ground deformation, oil, soils, and infrastructure. Chevron’s remote sensing capability has evolved from an R&D staff in the 1980’s to a centralized operations staff in the 1990’s and is currently a distributed model with expertise spread across staff and business units (BUs). HES functions benefit by finding ways to make use of expensive remote sensing data acquired by BU engineering and exploration groups for major capital projects, operations, and acquisition and divestiture projects. Currently, BU application of remote sensing products is largely focused on short-term decision making and relies on the local HES staff’s familiarity with the imagery and its interpretation.

Chevron’s environmental stewardship is managed through an Operational Excellence Management System (OEMS) which meets all the requirements of both the ISO environmental management systems standard (ISO 14001) and the Occupational Health and Safety Assessment Series requirements for occupational health and safety management systems (OHSAS 18001). Chevron’s OEMS is complemented by Environmental Performance Standards (EPS) in our exploration and production organization. OEMS includes required standards and processes that address many environmental aspects. A Next Generation Remote Sensing (NextGen RS) Project was initiated in 2010 by Chevron Energy Technology Company to develop guidance, standards, and tools to help BUs fulfill the EPS requirements. Further, the project hopes to provide the enterprise with consistent imagery application guidelines for HES staff that help them accomplish both their short and long term business planning needs. The team executing this project includes staff, BU employees, and one external expert. The team is documenting best practices; evaluating tools, work processes, and training; and plans to implement a web-based image and map viewer to simplify access to Chevron data by internal customers. The NextGen RS Project team is scoping collaborative development opportunities for industry standards relating to remote sensing products and services. Such an effort could help streamline communication with regulatory agencies, align support organizations’ products and services with industry needs, and improve coordination and communication with both partners and community-based organizations.
Testing hyper-spectral remote sensing monitoring techniques for geological CO₂ storage at natural seeps


British Geological Survey

CO₂GeoNet is a network of 13 European institutes researching underground carbon dioxide (CO₂) storage as part of an FP6 European Commission project.

World projections of energy use show that fossil fuel dependency will continue to 2030 and beyond; but sustainability will need CO₂ emissions reducing by 60% by 2050. Capturing CO₂ from industrial point sources and storing it underground is a very attractive route to making cuts in CO₂ emissions. The rocks under the North Sea have a theoretical capacity for storing over 800Gt of CO₂. It has been demonstrated that one of the main concerns with the geological storage of CO₂ would be the possibility of leakage from the storage site. As such it is important to have proven CO₂ monitoring techniques in place before any large scale European storage would commence.

One of the joint research areas of CO₂GeoNet is that of testing remote sensing monitoring technologies for potential CO₂ leaks. This work has been carried out in an area near the town of Latera in Lazio, Italy. This geothermal area, in a collapsed volcanic caldera, has long been known to have natural gas leaks and as such acts as a natural analogue to a leaking geological store of CO₂. Since 2005 the indirect detection of CO₂ via its effect on vegetation health has been studied, results of this work were presented at the GRSG 2006 AGM.

We are now building on this work by investigating direct hyperspectral methods for the detection of the CO₂ gas itself. This new and exciting work relies upon data acquired by the ASIA HAWK sensor mounted on board the NERC ARSF survey plane. Since this is a new application for a new sensor we were able to negotiate a flight over the BGS campus to test the sensor, the design and implementation of this experiment will be discussed. A description of the continuum interpolated band ratio processing technique and limitations will be presented along with the results.

In September 2007 HAWK hyper-spectral data was acquired for the Latera test site, during this campaign ASD field spectrometer data were gathered, both for calibration purposes and also to try and characterise the spectral signature of the gas mixture. Following essential pre-processing we applied the same CIBR processing technique as was developed during the BGS experiment. The results of the processing will be presented.
Onshore Environmental Sustainability

Multi-sensor data integration in O&G business

Lutz Petrat, Hélène Lemonnier, Michael Hall

Spot Infoterra

Earth Observation (EO) data gained increasing importance in the oil and gas business in the last decades: Improved availability of multiple, independently operating sensors, with a range of specifications regarding type, spatial resolution and repetition rate offers data for a large variety of different products and services. Sensors can be used as a single data source or in an integrated manner in applications supporting daily O&G business. Off-the-shelf availability of data and products, but also the capability of on-demand data acquisition and production are existent for fulfilling the requests of O&G customers. Data and products are adaptable to the specific requirements of end users in order to support and also improve/optimize oil- and gas production related activities. Value added products and services derived from EO data are the key to the successful support of oil and gas related activities.

This contribution describes the potential of space-borne remote sensing sensors to support daily operations and phases of development: Phases range from the initial feasibility study undertaken in-house at the operator's facilities, exploration activity in the field, field development with regards to the construction of necessary infrastructure and the production phase itself. Finally, the use of EO data and derived products during the abandonment of a site or the re-use of an exploited field for storage (e.g. of natural gas or CO₂) is possible. In each phase, data from different sensors can be used either directly or to derive value added products for supporting and improving daily activities. Data and products in the overview range from the usage of pure satellite imagery and data to its derived products including topographic maps, digital elevation or surface models, structural geological maps and surface movement maps. The use and advantages offered by combining optical and radar sensors are discussed. The aspect of rapid delivery of data and services is also addressed as it has a high importance especially for reactive needs.
Onshore Environmental Sustainability

High resolution, high accuracy, stereo satellite elevation mapping for oil and gas exploration and development

Gerry Mitchell

PhotoSat

Elevation maps, accurate to better than 50cm in height, are being produced from 50cm stereo photos from the new GeoEye-1, WorldView-1 and WorldView-2 satellites. These stereo satellite elevation maps and the accompanying 50cm precision orthophotos are being used in a wide variety of oil and gas exploration and engineering applications. The accuracy of the stereo satellite elevation mapping has been assessed using thousands of ground survey points and by direct comparisons to LiDAR surveys. BP conducted an evaluation of stereo satellite elevation mapping for stakeless 3D seismic surveying in Libya in June 2010. In this evaluation the stereo satellite elevation mapping was compared to the surveyed elevations of thousands of 3D seismic geophone stations and vibrator points.
Onshore Transportation and Infrastructure

Satellite EO for onshore structure design and operations

N. Fournier
Shell Exploration and Production

Meteorological and ice data is required to design appropriately and operate safely worldwide at onshore locations. The traditional approach to gather these data is through in-situ measurements which is very costly and resource intensive. In addition, an important limitation of this approach is that it relies on local data, which can under-sample spatially varying fields and lead to serious error in estimating the meteorological and ice conditions.

By contrast, remote sensing data from satellites offers an attractive approach to deliver global and frequent onshore measurements of a variety of parameters needed to design and operate:

- Rainfall
- Lightning
- Dust concentration and visibility
- Cloud cover
- Ozone and trace gases
- UV radiation
- Solar radiation
- Ice and snow cover

Satellite data are thus able to provide synoptic measurements capturing the spatial variability of the observed field and also to monitor remote regions being physically or politically inaccessible to traditional survey. This makes these data particularly useful to complement and even enhance traditional local in-situ measurements, which are still needed for validation of the satellite products and compensate for their technical limitations. Indeed, some instruments have a limited spatial resolution and sampling capability as well as the inability of optical sensors to see through clouds. Technical challenges can also arise with:

- The format of the data;
- The interpretation and analysis of the data;

In addition, on one hand, for R&D study, it is of vital importance to future generations that we maintain a clean, historical archive that can be used to compare future measurements. It is also useful that simple tools are provided to read the data. On the other hand, for operational purposes, the timeliness of the delivery of the Near-Real-Time data is essential to ensure the effectiveness and safety of operations.
MDA GSI has been delivering operational Interferometric Synthetic Aperture RADAR (InSAR) based oilfield deformation surveys for over 15 years to the oil and gas industry. The variety of InSAR measurements we provide industry delivers the requisite reliable, timely, accurate and repeatable surface deformation measurements that help them balance fluid pressures at the reservoir level. Not all reservoirs are suitable for InSAR monitoring: such reservoirs may include primary production from great depth (e.g. >5,000 m), or those having a thick limestone cap rock. However, a large number of oil and gas fields and Carbon Capture and Sequestration (CCS) sites are suitable to InSAR monitoring programs: these are typically shallower (<2,000 m) or have had Enhanced Oil Recovery (EOR) schemes applied to sand or diatomaceous reservoir formations. Whatever the vegetation and land cover type, CCS scenario and/or EOR hydrocarbon production scenario, there exists an InSAR approach to meet industry’s needs.

In Salah (Krechba) gas field and CCS site in Algeria has been very active in operationally capturing and sequestering CO2. Five years ago a Joint Industry Project (JIP) was created to investigate procedures and establish best practices for sequestering techniques and monitoring injection sites. Three injection wells to a deep (2,000m) saline aquifer were drilled and the injection of commercial volumes of CO2 was established. Monitoring began immediately to monitor the fate of the injected CO2 for compliance reasons. Early into the monitoring program InSAR processing was recognized as a viable technique to monitor the surface expression of the injected CO2. Since 2008 MDA GSI, in conjunction with Pinnacle Technologies, has been contracted to apply advanced InSAR techniques to further resolve the ground motion observed over the injection sites.

MDA GSI has perfected an interferometric Network Inversion approach that effectively removes atmospheric noise and enhances the deformation signal over the Krechba site. The surface expression identified through the Network Inversion processed InSAR program was confirmed by the structures identified at the reservoir level from a 2009, 3D Seismic program. Pinnacle have installed Tiltmeters and GPS to provide a higher resolution / verification immediately around the injection site of one well. Information from these installations should be available starting late 2010.

Objectives met by the JIP Monitoring program include:
1. Provided assurance that secure geological storage of CO2 can be cost-effectively verified and that long-term assurance can be provided by short-term monitoring.

2. Demonstrate to stakeholders that industrial-scale geological storage of CO2 is a viable GHG mitigation option.

3. Set precedents for the regulation and verification of the geological storage of CO2, allowing eligibility for GHG credits

Understanding fluid movement, or containment, at the reservoir level is critical to effectively managing subsurface oil and gas or CCS assets. Finding cost effective technologies to do this is equally important. Pinnacle and MDA GSI have partnered to integrate and deliver cutting edge technologies that provide solutions for EOR and CCS operations worldwide.
Onshore Transportation and Infrastructure

Innovative applications of satellite interferometry in the oil & gas industry

Alessandro Ferretti(1), Giacomo Falorni(3), Fabrizio Novali(1), Fabio Rocca(2), Alessio Rucci(2), Andrea Tamburini(1)

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EO capabilities have experienced significant advances in recent years regarding both the accuracy to which ground deformation can be measured and what can be interpreted from resulting data. Satellite borne radar interferograms provide ground displacement measurements to millimeter accuracy, providing an improved understanding of reservoir behaviour and prediction of future performance, with obvious economic benefits. Surface deformation monitoring can provide valuable constraints on the dynamic behaviour of a reservoir enabling the evaluation of volumetric changes and fluid migration within the reservoir through time. As it will be shown in this paper, satellite InSAR data have already been successfully used for reservoir monitoring in CO2 sequestration experiments, EOR activities, Underground Gas Storage (UGS) monitoring, and environmental assessments.

Amongst traditional reservoir monitoring techniques, the latest interferometric SAR algorithm (SqueeSAR™, the second-generation PSInSAR™ analysis, developed by TRE) is gaining increasing attention for its unique technical features and cost-effectiveness, by exploiting both point-wise permanent scatterers and distributed homogeneous scatterers. This new approach allows a significant increase in the spatial density of measurement points, as well as an improved quality of the deformation time series.

As far as the space segment is concerned, the availability of an increased number of X-band satellite radar sensors, characterized by higher sensitivity to surface deformation, higher spatial resolution (down to 1 m), and better temporal frequency of acquisition (down to a few days, rather than a monthly update) has further improved the quality of the results. The Sentinel-1 A/B mission will represent another milestone for all InSAR applications, making possible the analyses of very large areas with short repeat cycles.
Onshore Transportation and Infrastructure

Object-based automated image analysis for the oil and gas industry

Christian Hoffman, Ralph D. Humberg and Caroline Rogg

Trimble Navigation Limited

With a continuous data downstream and the rapid collection of EO (Earth Observation) data the necessity of automated information extraction from huge amount of data within a reasonable timeframe has increased significantly. It has been proven that the OBIA (Object Based Image Analysis) approach is suitable to succeed in automated information extraction tasks. The OBIA approach in combination with the client-server based high throughput environment implemented in the eCognition platform has been successfully used for numerous tasks and projects.

Some of these projects using the OBIA eCognition Enterprise platform have showed the potential to serve for the oil and gas industry. The main areas of work Trimble GeoSpatial Munich did can be further categorized into marine monitoring, infrastructure change detection and site monitoring. Different EO data was used to suit the specific purpose.

Whereas marine monitoring and infrastructure change detection on large areas typically is done by using space borne optical or SAR (Synthetic Aperture Radar) data, site monitoring is done on a much higher spatial resolution using manned or unmanned airborne platforms.

Within this framework, eCognition is used in research, pre-operational and operational workflows.

Two examples shall be presented.

Example 1: Pipeline monitoring using unmanned aerial vehicles (research project under EU sponsorship). This project named “iNTeg-Risk” is assessing and evaluating the risk of new technologies. With the demand of pipeline operators to monitor thousands and thousands of kilometres of pipeline, efficient ways to perform this monitoring task have to be found. Unmanned aerial vehicles together with an efficient semi-automated processing and information extraction chain show the potential to providing a solution within that context.

Example 2: Operational oil spill detection from SAR imagery. Due to the “spectral” characteristics of an oil spill in an image derived from SAR data, a stable classification algorithm was created to identify such oil spills. By an intuitive html-based reporting system it was shown that the results of such a complex analysis task
can be directly ingested into an end-user environment/tool. While this operational example deals with natural oil spills, the same methodology is planned to be adapted for oil disasters like the currently existing one in the Caribbean Sea which could provide a fast, efficient and near-realtime monitoring solution for a very large area.

The success of such monitoring projects relies on a continuous availability of suitable EO data. Limiting factors for the use of optical data is the occurring cloud cover which can be almost permanent in certain regions of the world. The usage of more less weather independent SAR data can reduce this effect.

With an increasing number of space-borne platforms, the availability of appropriate data is increasing. The OBIA methodology, which simulates the human visual perception, is well suited to be transferred and adapted amongst different platforms and sensors with similar or comparable specifications. The efforts to adapt an existing information extraction strategy to another platform or sensor can therefore be reduced.

Currently, the Oil and Gas industry doesn’t seem to be fully aware of the potential and benefits of automated image analysis workflows and therefore, the effort to convince people within the industry to participate in larger projects is still quite high. We see ESA’s role in developing a positive political framework to facilitate an intense co-operation of the Oil and Gas industry and the EO industry.

Pricing of EO data very often is the limiting factor for initial projects, especially if a high continuation rate is necessary. Free access to data during the development phase and/or a subscription-based pricing in operational mode instead of a per-item pricing would be beneficial to increase the productivity of a service or system into a profitable margin.

Additionally, free and open data for a specific sensor would lead to the development of many more applications developed by various users for that specific sensor which would leverage the revenue for the data provider in a similar way than having a large per-item pricing.
Onshore Transportation and Infrastructure

Monitoring oil and gas facilities: use of natural reflectors and artificial corners

Authors: A. Arnaud, G. Cooksley, M. de Faragó, J. Garcia Robles,

Altamira Information

InSAR based ground motion monitoring of oil and gas facilities, including pipelines, plants and LNG terminals, contributes to production planning and the safety of operations. Factors such as seismicity, landslides, coastal erosion or anthropogenic effects such as the oil and gas activities themselves may cause infrastructure to be affected by ground motion, which may in turn pose a threat to the surrounding population and wildlife, or the efficiency of the infrastructure itself. The PSI technique is an efficient tool for assessing and monitoring the effects of the aforementioned on the infrastructure and the surrounding area.

The PSI technique requires the presence of stable reflectors to provide reliable measurements. Infrastructures have the advantage of providing a large number of “natural” measurement points, thus allowing the radar eye to capture information over the zone of maximum interest. For instance to monitor pipelines it is common to use stable points to view the evolution of ground motion over time as the pipeline itself usually provides good persistent scatterer return.

The presence of PSI measurements over infrastructures provides information of interest for the safety of the infrastructures themselves. Additionally, the information gathered on ground by studying infrastructures at oil exploitation sites provides data on reservoir behaviour. Thus, the PSI points provided by the infrastructure are not only used to monitor its own safety, but also as a source of information to better understand the evolution of the reservoir.

Likewise, studying a wider area of interest provides crucial information for the integrity of the infrastructure in question. In many cases, knowledge of the ground deformation in the area surrounding the infrastructure can help to identify and mitigate hazards.

For instance, it is often more important to monitor ground motion over a landslide-prone area near a pipeline rather than just the pipeline itself. In cases where no PSI points are available on this area of interest, Artificial Corner Reflectors (ACR) may be installed to guarantee reliable measurement points.

ACRs consist of a durable and stand-alone metal construction. ACRs can be added to the facilities’ surroundings and to areas of the site where there are no natural reflectors, such as areas that have dense vegetation or snow cover. ACRs are
adapted to difficult weather conditions, such as snow, rain and ice storms in order to assure constant measurement points.

Monitoring of oil and gas facilities often requires customized approaches that involve studying motion of the infrastructure itself as well as ground deformation of the surrounding area. The PSI technique applied over natural or artificial reflectors offers a full portfolio of solutions that may also be integrated with other sources of information such as GPS data, to provide an all-weather, long-term, cost efficient solution.
Onshore Transportation and Infrastructure

Coordinated use of earth observation and UAVs for infrastructure security, safety, and environmental protection

Rob Reid
MDA Systems Ltd

As the world’s reliance on energy continues to grow, the need to survey and protect the oil and gas assets that facilitate this growth increases. In many cases, these assets are located in remote, hostile, and inhospitable environments that make the surveillance and protection requirements of major energy companies a significant challenge.

This talk describes an approach to address such challenges. The concept is to exploit wide-area space-based surveillance to cue airborne assets such as UAVs to respond rapidly and economically to environmental and infrastructure threats.

UAVs are a relatively new technology to the Oil and Gas Industry. While widely and very successfully used by militaries around the world, they have found very limited use in the oil and gas industry: limited to experimentation and trials, and some limited use for ice reconnaissance and exploration.

Infrastructure security, an obvious off-shoot from the military applications and successes, is an immediate application for UAVs to monitor and protect pipelines, pumping stations, refineries, offshore platforms, and seaborne transport vessels.

What makes UAVs suitable for these purposes in the context of the oil and gas sector? UAVs provide a number of advantages over manned aircraft and other methods of surveillance:

1. UAVs safely allow for extended flight while reducing risk to humans in difficult terrain
2. UAVs’ covert capability allows operators to observe from a distance
3. The Quality of data collected by UAVs can be extraordinary (typically video, but could be still imagery, or other)
4. UAVs can provide very precise adherence to pre-defined flight patterns

Two hurdles impede the widespread use of UAVs in civilian applications, including the oil and gas sector:

- Airspace clearances, for most types of UAV operations in most parts of the world
- Economics.
Much has been written, and work is progressing on many fronts, with respect to the first topic. But for the most part, all but the smallest UAVs are still more expensive to operate than small, manned civil aircraft. This talk will discuss the tradeoffs of finding economical ways to operate UAVs, and approaches whereby UAVs could be used in a coordinated fashion with remotely-sensed Earth Observation data to improve the effectiveness of the UAVs and thereby address the economic side of the equation.

The economics of UAV ownership and operation range dramatically as a function of:

- Aircraft size and sophistication (equipment cost and maintenance personnel), and
- Operating environment

We will review the numerous inter-related capability and cost tradeoffs influence the economics UAV ownership and operation:

- Range
- Revisit frequency
- Required availability and reliability of service
- Timeliness of sensor data delivery
- Type of objects, situations, and conditions to be observed
- Operating location

The tendency amongst the above characteristics is toward more capable systems (i.e. larger range, more frequent, better sensors, more reliable, more remote and/or difficult operating conditions). Then as those characteristics drive toward either larger or more aircraft and systems, the demands for operations staff and infrastructure generally increases.

This talk will describe how the above capabilities influence the capabilities of an unmanned system, and the cost tradeoffs associated with each. By introducing the use of space-borne sensors, one can improve the effectiveness of UAV assets, thereby reducing some of the UAS performance requirements, and thereby improving the economic feasibility. Integrated planning systems will permit intelligent use of these layered surveillance assets, and modern analysis systems will permit the concurrent and coordinated analysis of the space-acquired imagery with the airborne data.