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Research Article

ROLE OF GEOINFORMATIC ENGINEER AND APPLICATIONS OF GEOINFORMATICS IN OIL & GAS EXPLORATION

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ABSTRACT

Geoinformatics is the integration of different disciplines dealing with spatial information. The advent of Satellite Remote Sensing and subsequent development of Global Positioning System (GPS) and Geographical Information System (GIS) have made significant changes in surveying and map making. Geomatics is also a similar term that encompasses Geoinformatics; it is a field of activity that integrates the acquisition, processing, analysis, display and management of spatial information. The most established market in the geoinformatics is in the area of natural resources in exploration of oil & gas. Satellite and air-brone Remote Sensing technologies aids in the selection and development of oil and gas exploration areas around the world as well as in the areas of oil spill mitigation and remediation and use of orthorectified satellite images, it provides insight on the selection of areas to plan 2D or 3D seismic surveys for an exploration drilling program as well as aiding in the process of environmental and operational safety hazards to minimize the HSE risks. There is currently no other technology that matches or exceeds the capabilities of remote sensing and its necessity in the oil industry. GIS provides a tool for oil and gas operators to effectively and efficiently manage development for the protection of resources and optimal production. Global Process Systems (GPS) is a global provider of technology-based "design and build" process facilities solutions for the upstream oil & gas industry.

INTRODUCTION

Geoinformatics Combines geospatial analysis and modeling, development of geospatial databases, information system design, human-computer interaction and both wired and wireless networking technologies; and uses geo-computation and geo visualization for analyzing geoinformation. (1) the geoinformatics engineer (GE), who use mathematical theory and praise measurements for the collection and distribution of geospatial data, plays a significant role in the oil and gas industry. The GE would play in the recent discovery in oil and gas. This is because the GE is required in the planning and execution of nearly every form of activities at the upstream, midstream and downstream; for example offshore and onshore construction, exploration and engineering foe the production and dissemination of oil and gas. The GE embraces the disciplines of photogrammetry and remote sensing (RS), land and engineering surveying, geographic information system (GIS), cartography, geodesy, hydrography, cadastral surveying and land information management(4).

Application and Methods Used By Geoinformatics Engineers

Geographic Information system (GIS)

Geographic Information System (GIS) are powerful computer-based tools used to enter, maintain, store, distribute, and analyze geospatial data. GIS and associated spatial analyses deal with quantitative location of features and their associated attributes. GIS have been implemented across abroad range of research, science, business, and government applications.GIS are particularly effective for managing natural resources (14, 19). As the development of oil and gas resources expands in the onshore and offshore, so does the need for spatial data and awareness of development impacts. GIS can be utilized to document and examine the potential and observed effects of oil and gas development on all impacted resources including: water, wildlife, cultural/historic, habitat, air quality, socioeconomic, vegetation etc (3).

1. ***Data index maps–*** one of the most common uses of GIS in the petroleum sector is in delivering easy-to-use digital maps that enable oil company staff to see what data is available to them, so that they can drastically reduce the amount of time they spent looking for the

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information they need to do their work. Often such maps are delivered using web-based GIS application that require little or no training to use, and show all data of interest side-by-side in a single interface (23).

2. ***Block Ranking–*** Ranking opportunities via quantitative analysis using all available information require data integration on a massive scale, and so it is usually seen as too time consuming to carry out on a regular basis. However, GIS provides the perfect environment in which to rapidly evaluate and grade oil and gas licenses or lease blocks (23, 27). It provides a unique way of mining large quantities of different type of data in order to help make a decision and many companies employing GIS for this analysis believe that it give them a competitive edge in license acquisition
3. ***Land Management–*** the way GIS stores information as attributes allows a 'land man' to map key lease data such as lesser names, lease expiry dates, working interest(WI), overriding royalty (OR), overriding royalty interest (ORRI), net revenue interest (NRI) and gross/net acreages. Mean while centralizing all land management data an enterprise GIS environment helps enormously when generating the reports that are requirement by regulators (23, 31).
4. ***Well Planning–*** GIS is being used increasingly for well planning, particularly with the rise of unconventional resources such as shale gas, shale oil and coal bed methane. Not only can GIS be used to plan well pad patterns around multiple surface drilling constraints, but its unique spatial analytics can be used to optimize drilling patterns to calculate the most efficient drilling configuration (2, 6).
5. ***Field operations–*** An emerging use of GIS is in using flying sensor technology to gather on-demand high resolution imagery across a field location in order to survey a site. This allows companies to regularly monitor sites and to identify and manage change, without having to commission expensive satellite data capture.
6. ***Environmental monitoring–*** Given the current focus on shale play development, it is essential that companies are able to accurately monitor environmental changes associated with operations (23).GIS is invaluable in this regard, able to integrate and visualize time stamped data against a base lined case, e.g. using regularly updated DEMs to help detect subsidence caused by extraction of the resources.
7. ***Pipeline routing–*** Building pipelines to carry petroleum products is capital-intensive, so determining the optimum route is critical. This is non-trivial task that can be significantly simplified through the use of 'least-cost path analysis' –a process that identifies the route of least resistance between a source point and destination, based on the effort required to pass through cells in one or more cost raster datasets, such as slope (based on a DEM) and land-cover. Studies have shown that GIS-based least cost path analysis can produce more environment friendly routes, as well as reducing costs by up to 15% (23).
8. ***Vessel tracking–*** GIS can be useful for tracking valuable assets, especially those that are mobile, such as vehicles and boats. Knowing the precise location of vehicles and vessels is essential for the timely delivery of goods and services, as well as for efficient emergency response.
9. ***Emergency response–*** GIS is becoming increasingly important in response to emergencies such as oil spills and gas explosions, both in mitigation planning and response management. Data loaded into a GIS can be made available to all stakeholders regardless of their physical location (e.g. to workers in the field on mobile devices), and even to the public. This leads to better decision making during emergency response situations, and improved public relation (23).
10. ***Pipeline monitoring –*** pipelines need to be continually monitored to check for leaks and geo-hazards, and to manage and track inspections, the frequency of which is often a regulatory requirement. An emerging use of GIS is in integrating the map with digital video, often acquired using remote vehicles on the seabed, enabling engineers to see sections of pipeline and monitor hazards affecting the installation.

Remote Sensing

The term remote the sensing means of the Earth's surface form space by making use of the properties of electromagnetic waves emitted, reflected by the sensed objects, for the purpose of improving natural resources management. Remote sensors collect data by detecting the energy that is reflected from earth. These sensors can be on satellites or mounted on aircraft (5, 30). Remote sensors can be either passive or active. Passive sensors respond to external stimuli. They record natural energy that is reflected or emitted from the earth's surface (25). The most common source of radiation detected by passive sensors is reflected sunlight. In contrast, active sensors use internal stimuli to collect data about earth. For example, a laser-beam remote sensing system projects a laser onto the surface of earth and measures the time that it takes for the laser to reflect back to its sensor. Understanding what's happening beneath earth's surface is important for accurate reservoir and flow modeling, which leads to more-informed production decisions and the ability to produce more energy for less. The importance of such understanding helped refine magnetic and gravimetric data-collection methods as well as associated analysis tools for these data sources (28, 32).

The significant potential to expand the use of such remote sensing data in the solution of environmental problems. The main directions are: monitoring of ration use of associated petroleum gas (detection of all gas flares and volumes of burned gas), monitoring of soil pollution (detection of areas of oil pollution, assess of the extent of pollution, planning of reclamation activities and assessment of their efficiency, detection of potential areas of pipelines corrosion), monitoring of status of sludge pit (inventory of all sludge pit, assessment of their liquidation), monitoring of technogenic impact (detection of changes), upgrading of a geospatial database (topographic map of not less than 1:50000scale) (8).

LiDAR (Light Detection and Ranging)

New data sources pave the way to think outside the box in how remote-sensing data are used across all disciplines within the O&G industry. For example, surface obstructions such as dense forest have historically been obstacles to finding geologic faults that would otherwise be exposed. But LiDAR sensors calculate multiple returns form an active laser scanner thousands of times per second, resulting in a 3-D representation of the ground (Fig-1). Pulses of light sent from a scanner may bounce off a tree or other object, or they may find the ground (7, 26). As a result, faults that were previously undetected are easily revealed. LiDAR is used for high-resolution surface modeling to augment ground surveys.

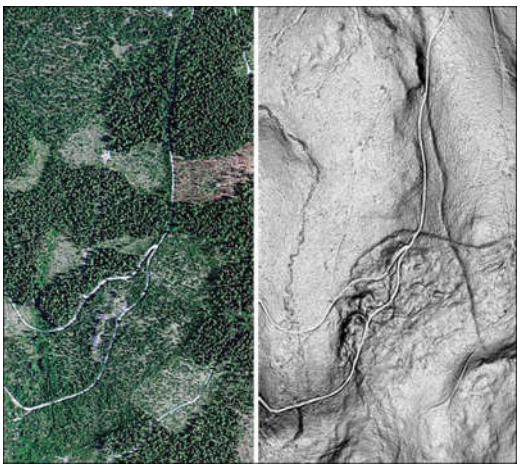

Fig 1 Light Detection and ranging image

SAR (Synthetic Aperture Radar)

SAR data also are incredibly useful, because they can be used day or night and can also penetrate clouds (Fig-2). In addition, SAR images collected by the same sensor at different times enable the use of inter ferometric processing (In SAR), which is used to measure displacement to a very high degree of accuracy.

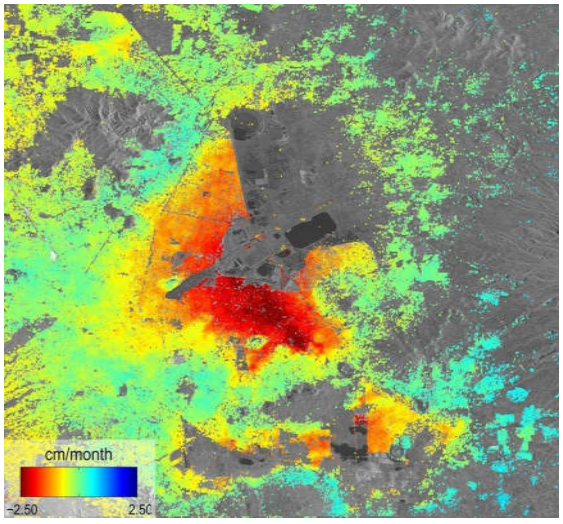

Fig-2 Synthetic Aperture Radar

SBAS (Small Baseline Subset)

Higher granularity of change can be measured using SBAS processing, which takes advantage of small spatial and temporal orbital separation between the sensor and images, making millimeter-scale displacement measurements a reality (Fig-3).

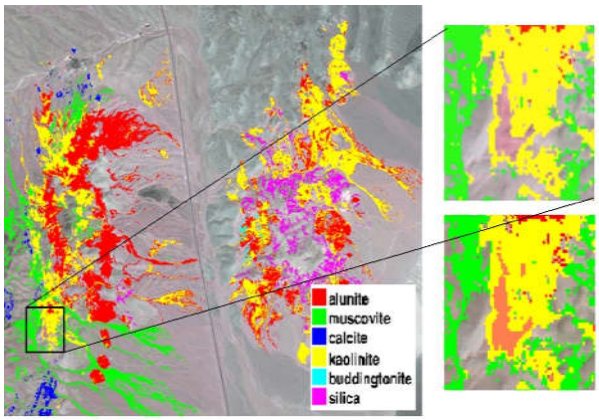

Fig-3 Small Baseline Subset

Global Positioning System (GPS)

The global positioning system is a satellite-based navigation system consisting of a network of 24 orbiting satellites that are eleven thousand nautical miles in space and in six different orbital paths. The satellites are constantly moving, making two complete orbits around the earth in just less than 24 hours (10, 24).

GPS provides the tools oil and gas companies need to track crews, heavy equipment, and other valuable assets. GPS tracking technology gives you a look into your vehicle operations even when they are hundreds of miles away. With GPS, you can direct your fleet to specific point of interest; overlay GIS mapping data and monitor refueling activities.

- Know when the refueling vehicle is active
- Improve worker productivity
- Monitor speeding and unauthorized vehicle use
- Locate all assets and equipment
- Enable quick, just-in-time deliveries
- Increase productivity in the field
- Optimize performance, safety and reporting
- Improve logistics
- Reduce maintenance costs

Photogrammetry

Photogrammetrists take aerial photos and use them to create detailed maps of large areas in a very short time and for land inaccessible by foot [27]. A more sophisticated technique, called stereophotogrammetry, involves estimating the 3D coordinates of points on an image [28]. In addition to mapping a waterway‘s coastline for the activities of the oil and gas industry, Photogrammetrists can learn more about topography, vegetation, and existing structures. Photogrammetrists use images to detect the contours of the land and the height of objects on the surface. Photogrammetry is used in different fields, such as topographic mapping and design of onshore and offshore facilities, engineering, quality control, police investigation, and geology and archaeology explorations to quickly produce plans of large or complex sites; and by the meteorologists as a way to determine the actual wind speed. To mention a few, [29-31] employed RS and photogrammetric techniques in making varied types of topographic maps.

Hydrographic

Hydrographic information facilitates delineation, establishment, administration and sustainable development of national maritime, coastal zones and resources. The GE provides hydrographic charts for the transport infrastructure in the oil and gas industry; suitable anchoring zones close to port; competitive nature of the international trade routes with ports at their hubs. Reference [22] statement on hydrographic survey explains the significance of survey in offshore activity benefited by policy makers, industries, engineering, geologists, biologists, research groups, heritage and protection. FIG (2011) reports on the economic benefits of Hydrography

Engineering Surveying

The GE analyses and solves surveying engineering problems related to the oil and gas industry by applying basic principles of mathematics, science and engineering. The GE uses modern surveying engineering techniques, skills, and tools to identify, formulate and solve surveying engineering problems. The GE is able to solve surveying engineering problems, particularly the planning, design, establishing horizontal and vertical control, land use design, boundary determination, mapping and field layout that meet standards of accuracy and precision; keeping in mind cost, time, safety and quality needs, and objectives. Demand is increasing for deformation monitoring to ensure the stability of aging infrastructure and structures pertaining to the oil and gas industry. With expensive construction and natural occurrences, it is critical that the technology and solutions is available for the Ghanaian oil and gas industry. The GE with expertise in Engineering Surveying ensures precision carried at all levels in construction and monitoring. During pipeline maintenance checks, the GE employ can employ Trimble solutions for deformation monitoring provide powerful analysis tools to detect and review motion over time for evaluating the health of pipelines. More detailed pipeline condition information can be rapidly collected using 3D Scanning and modeling tools.

Cadastral Surveying

Cadastres play a key role in society and lie at the basis of economic growth, poverty reduction and mitigation of climate change effects [13]. Reference [13] added that property rights, land registration and cadastral mapping are the foundations for tenure security, land and credit markets, land-use planning, and taxation. Cadastral surveying will promote these activities at the upstream, midstream and downstream categories. Research carried out by Transparency International confirms that the land sector is among the most corrupt sectors worldwide; the payment of bribes for land allocation and registration is commonplace in many countries, while in others 'grand corruption', in the sense of large-scale theft of private and state land [13]. Thus, employing the expertise of the GE in cadastral surveying can improve transparency in land administration making corruption visible for the public at large and less easy for offenders in the oil and gas industry. Land registrars and GE together with professional ethics promotes sustainable management of onshore and offshore facilities. The GE who is involved in land administration with sound knowledge of technical subjects like data acquisition, database technology and data distribution, and adopting other business subjects such as process design and workflow management, planning and control; all covered with a good sense of politics; can go a long way to promote the activities of the oil and gas industry [13].

Geodetic Surveying (Satellite Geodesy)

The GE employs Geodetic Surveying to determine the size and shape of the Earth, and the precise location of points on its surface. Geodesy is closely connected to astronomy and has been used to guide the great sailing ships and water traffic in the oil and gas industry. With the GPS, the GE (or Geodesists) can tell the exact position of an object on the Earth's surface usually within a centimeter. GPS is also used for guiding space satellites and airplanes, to track the movement of ships, planes, oil rigs, trucks, trains, etc. and to help locate people who need assistance [25]. The satellite navigation (or satnav) system provides autonomous geo-spatial positioning with global coverage. GE study geodynamical phenomena such as crustal motion (movements of the continental plates), tides, and polar motion. GE provides the basic coordinate control networks for surveying through very precise surveying techniques such as precise leveling, satellite altimetry, GNSS positioning, gravity measurements and so on.

CONCLUSION

The roles of the GE in the oil and gas industry are enormous. The GE plays a role in the upstream, midstream and downstream activities of the oil and gas industry; either at the start (geophysical and geochemical survey), during or end of exploration (reservoir estimation, reservoir evolution & reservoir management and maintenance) and construction (rigs platforms in onshore and offshore). The GE enters the projects area first to make survey; the GE continues to be on site during construction; and finally the GE re-surveys and maps the existing area after construction. GE survey data will reduce the risk in oil and gas activities and time consumption method.

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