Title: “GIS inside an independent Oil and Gas company”

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Abstract

Kerr-McGee is a large, independent oil and gas company that produces and explores for hydrocarbons around the world. It has offices in Houston, Oklahoma City, Denver, Aberdeen and Beijing. The majority of oil and gas data has a spatial component and is expensive to acquire. This paper / presentation will illustrate how Kerr-McGee uses a variety of ESRI technologies to help geoscientists find and map data quickly and efficiently.

Using ESRI technologies such as SDE, ArcMap & extensions like 3D Analyst, and ArcIMS we actively support GIS and have created a spatial data warehouse that houses over 170 SDE layers of exploration data for wells, land / lease outlines, seismic lines and polygons, culture, imagery, topographic and more. This paper outlines how and why this was accomplished and provides real-world examples on how GIS has improved mapping, data searching, and knowledge capture at Kerr-McGee.

Kerr-McGee background

Kerr-McGee Corporation is a global energy and inorganic chemical company based in Oklahoma City. We are a recognized leader in oil and natural gas exploration and production and in the production of titanium dioxide pigment. Core areas for Oil and Gas include the Gulf of Mexico, Domestic Onshore USA, the North Sea and offshore China. In 2003 we produced 271,000 barrels of oil equivalent per day and we have over 1 billion barrels in reserves. Kerr-McGee pioneered several deepwater technologies including spar and cell spar platforms for use offshore.

Challenges for upstream Oil and Gas

Several challenges exist in the exploration for oil and gas that can benefit from geographical information systems (GIS) and data management / data delivery. This paper will illustrate ways in which information technology – and GIS in particular – can provide tremendous value for oil and gas exploration.

First, data to support exploration is expensive. 3D seismic surveys can cost from $100,000 to $10,000,000 or more. Leasing of mineral rights, particularly offshore, can also be an expensive proposition. Lease rights for the Gulf of Mexico can run $500,000 (to several millions of dollars or more) and last from 5 to 10 years. By the time you obtain the lease, and the seismic data for the area of the lease, you can have invested $10,000,000 or more. Companies the size of Kerr-McGee have rights (full or partial) in dozens of leases in the Gulf of Mexico. They have annual seismic data budgets of $50,000,000 or more. Over the span of 10 years we have purchased over $500,000,000 in data assets that need to be managed. All of this on the educated hypothesis that hydrocarbons can be found on these leases and economically produced or you have sunk considerable time and investment into a ‘dry hole’! The actual drilling of a well in deepwater (> 1,000 ft) can run $25,000,000 or more (averaging $400,000 per day).

Second, there is a lot of data. 3D seismic formatted for analysis on computer workstations can be several gigabytes in size. This places intense computing demands on the information technology infrastructure used which is why oil and gas companies are often at the leading edge of computing technology. On the well data side of the equation you may deal with areas such as a single county in Texas that can have up to 20,000 wells drilled in it – each having some data to contribute to your exploration effort. A single well can produce a significant amount of data – 100’s of MB’s – when you consider drilling, logging, production, and associated documentation. Kerr-McGee has > 12 TB of data online to support its exploration and production operations.

Third, the workforce is aging for all domestic US industries, and oil and gas is no exception. The average age of an engineer / geoscientist is 49 (2004) and expected to increase. In 5-7 years it is expected that > 50% of the workforce experience will retire from our industry. That statistic alone cries out for proper data and knowledge management.

Fourth, the primary functions for geoscientists and engineers are to search for, drill and produce oil and gas. The main software packages they use support elaborate seismic interpretation, reservoir modelling and mapping capabilities and

are highly complex. The 'other' software they have to use needs to be as simple and intuitive as possible as they already have plenty of expensive and sophisticated software they need to master.

The GIS value proposition

The utilization of GIS technology is particularly well suited to oil and gas companies because the exploration for hydrocarbons is a map intensive process. Geoscientists and engineers 'live' with maps each day on their job so GIS fits perfectly into their environment. Over 80% of oil and gas data is said to have a spatial context. A well tuned GIS system can greatly enhance the speed at which a geoscientist can canvas an area to determine what data is available to them from the companies store of data assets. Nearly all companies in the independent to major/supermajor size practice the concept of asset teams that are assigned to a specific geographic area such as the Rocky Mountains, Permian Basin, North Sea, etc. As team members rotate in and out of asset teams a GIS can greatly enhance their ability to 'hit the ground running' and be a productive team member. The GIS can show what projects have been created in the area, what seismic and well assets the company has in the area, and what maps have been generated in the area. This saves all team members time in education and orientation for geoscientists as they change geographic areas and work on different asset teams.

This is especially true when the GIS is tied to a reporting and exporting tool that can provide the non spatial context for data. Each oil and gas company has many specialized systems to track spatial data such as leases, well / seismic locations, etc. and non spatial data such as drilling history, production history, regulatory reporting and more. Here the GIS becomes a 'portal' for geologists, geophysicists, and engineers (GG&E) to access a variety of data without having to learn multiple systems (remember, they already have very complex, specialized software to master). A GIS based spatial portal will inventory the various data they have in their assigned area via one tool rather than several (perhaps one for logs, one for seismic, one for paleo, etc.) An easy to use GIS can identify and map data as well as provide a launch point to the non spatial data associated with assets inside the geographic area of interest.

In fact, more and more data acquired by oil and gas companies in the practice of exploration is delivered in formats specific (or at least compatible) to ESRI. We now see companies such as I.H.S. Energy, Fugro Robertsons Research, Tobin and Earth Science Associates who deliver both raw and interpreted data in the form of shape files or ArcMap project files. Other companies such as Geomark Research and the USGS host data and incorporate ESRI technology into their online product offerings. This becomes more important in the blurring of data management practices between oil and gas companies and the vendors they do business with (see the Futures section later in this paper). Because Arcview can easily incorporate so many different types of exploration data many geoscientists are using GIS more often. This can be particularly true for new ventures activities. Chris Clear, a geologist at Kerr-McGee says, "More and more of my work is in GIS because Arcview allows me to bring together many diverse types of data. Few other tools have been able to do this so quickly and easily." Indeed, much of the high level data analysis work for exploration can be done with GIS.

The use of ESRI technology by the oil and gas business has helped keep information technology support costs low by allowing them to focus on a specific GIS vendors and not having to learn or support multiple vendors. Training and deployment costs are kept focused on ESRI based solutions. Vendors also benefit because of the majority adoption of ESRI technology by oil and gas companies because they know their customers will have at least the basics of GIS technology support covered.

Spatial Data Warehousing

The widespread adoption of ESRI technology has the associated problem of how to manage so much spatial data. When you combine the previous statements of spatial data being delivered in ESRI format and the high volume of data that the oil and gas industry deals with you have the potential for a data management disaster! How do geoscientists know they are dealing with correct, up to date, qualified data when so much of it exists. We also receive data for the same well from multiple vendors – how does the data consumer determine which vendors data is 'best'?

Kerr-McGee's answer to this problem is by using effective spatial data warehousing. The spatial data warehouse 1) keeps data up to date and 2) attempts to identify the single best version of the data. This SDE based spatial data warehouse contains over 170 key layers of information consuming 180 GB of space. These spatial layers include the following types of data:

Wells – layers for header / location, operated, containing paleo, containing logs, etc.
Seismic – layers for 2D lines and 3D polygon showing the seismic asset inventory with basic header
Leases – layers for Onshore leases, GOM leases, those we own outright or have a working interest, other companies lease positions

Culture / Grid – state / county / area outlines, rivers, lakes, country outlines, pipelines, offshore platforms, roads, cities, etc.
Interpretive – layers for basins, fields, structures, etc. created by either Kerr-McGee or vendors
Imagery – 15 meter satellite imagery domestic USA, topographic, GOM seafloor

These layers are kept up to date by the information technology staff. When the data is vendor based, we ensure it is updated in the spatial data warehouse. Where it is a derivative of in-house data we have data management routines that update the layers. A variety of technologies including Unix cron, shell scripting, Safe Software's Feature Manipulation Engine (FME), and PL/SQL keep the layers updated in a fairly automated fashion.

The ArcCatalog software is being used by the advanced ArcMap user to determine / review what data is in the spatial data warehouse. The information technology group also uses email, newsletters, and short training sessions to educate the community on what spatial data is available to them. We use the terms 'Lunch and Learn' and 'Demos and Donuts' interchangeably, it just depends on the type of food you bribe them with to attend your meeting! Metadata becomes increasingly important in a spatial data warehouse. Tracking datums, vintage, authors and other information about spatial data is difficult and tedious, but goes a long way to retaining confidence in the spatial data warehouse.

The majority of the spatial layers indicate what vendor or specialized data is available to them from the 'corporate store'. In the near future we plan on using technologies from Schlumberger, Innerlogix or OpenSpirit to delve into project files to provide a more proactive method of keeping project files up to date. A key workflow in oil and gas project file management is keeping the projects up to date with the latest well, seismic and other data. If you have the corporate store and the project store spatialized a GIS is a perfect tool to visually see where the project files are not up to date. Up to date project files ensure geoscientists are making decisions based on all the data they have available to them. Few things could be worse than planning to drill a well in a particular spot and finding out when you survey the site just before drilling that a well has already been drilled there! (don't laugh – it has happened to even the best oil companies)

Application integration and web services

The power of GIS is really unleashed when tied to other systems. It then becomes an integrated platform for data delivery. Remember earlier our goal was to provide as simple a system as possible to map, search, find, then report, download, print a variety of oil and gas data. Many file types exist for oil and gas data from specialized log readers, seismic section viewers, CGM/JPG map file viewers, and more. Rather than enhance Arcview or ArcIMS to have the ability to read / view all of these different data types, by interfacing them you get an best of breed solution that provides the user with the ability to move their selection from one application to another.

Examples in use or being tested inside Kerr-McGee include

- Interfacing with an electronic document management system. In our case this is Opentext's Livelink product which is our corporate standard for semi structured and unstructured data. One can be on a map, select multiple well or seismic features, and pass their identifiers into the Livelink search engine. This has also been accomplished with the Documentum product when we used it in our production environment.

- An interface to Landmark's IDIMS application which is our primary drilling reporting system. Rather than rewrite drilling reports in Crystal Reports we can tie them to ArcIMS by housing the URL to launch IDIMS in context of the well in question on the SDE based spatial business table. This allows a person to be on a map, run a filter for wells with drilling data, click on that feature and then launch into IDIMS to get the drilling report. The user does not have to have knowledge of how to start IDIMS or what report to run, it all happens for them.

- Innerlogix's ILX Viewer is a key application to search the Kerr-McGee repository for well log files. The GIS has a specified layer that tracks which wells have logs, and basic information about what type of logs it has (sonic, deep induction, etc.). The GIS user can select that well on a map, then click through to the ILX Viewer application to actually download the log file itself. Again, the user needs to know just a minimal amount of information about how to use ILX Viewer to be successful in this workflow.

- To access data that lends itself to row / column type reports we have links from the GIS into Crystal Reports, Cognos PowerPlay and Impromptu. The supported workflow is that a user can start on a map, find an operated well, click on it and jump straight into a Cognos based daily or monthly production history report.

- One very interesting application of GIS integration with data analysis is the combination of ArcMap and Spotfire. Spotfire is a powerful 'visual analytics' package that can be used for rapid and in-depth data analysis of nearly any type of row/column data. Here the user can review data in charts and tables, highlight anomalies and see where they occur on a map in real time! A common practice is have a map of the Gulf of Mexico loaded and

review in minutes geochemistry or production by producing zone and test different theories or look for similarities that would have previously taken hours.

- A key workflow mentioned before is the use the GIS to view what is available to the user in the 'corporate data store' and then download needed information into a 'project store' which would be software packages such as Schlumberger Geoframe, SMT's Kingdom, or Landmarks Openworks. Here the user desires to scan an area of interest, select data, and have the GIS create a file (or files) of spatial data that can be loaded into their project. Safe Software's FME and Spatial Direct are two products being investigated in-depth as attachments to a GIS to provide this much needed functionality.

Kerr-McGee and GIS future

We mentioned previously that geoscientists use very sophisticated mapping and interpretation software. Some of these packages can now read SDE data straight from Oracle via SDE based API calls. This reduces the need for specific data exports as mentioned in the section above and further compresses the workflow associated with moving data into project files and ensuring it is up to date! Petrosys and Landmark have recently enhanced their software to read SDE and shape files into their project work space. For companies such as Kerr-McGee that have up to date corporate data warehouses this greatly reduces the time and effort involved with keeping project files updated. Now rather than using a GIS to identify data, export the data, then import into the target package the user can just use their project software to connect to SDE and access the up to date spatial data stored there. What used to take several skill sets and hours of time now takes fewer skill sets to maintain and minutes of time. Better quality decisions can be made, and the geoscientist has increased assurance that the latest data being used. While vector based feature data is the first type accessible from software vendors, Kerr-McGee is storing more and more raster (imagery) data in its spatial data warehouse.

In line with ESRI's directions for Internet based data sharing comes data products from companies like Tobin and national agencies such as the United States Geological Survey (USGS). These data services take the spatial data warehouse one step further by eliminating the need for each company to house spatial data inside their own network. With the increased speeds and reliability of Internet connections this has become a reality. Inside Kerr-McGee we have experimented with using external data services from groups such as these to provide a wider array of data to the geoscientist than was previously available. This further leverages our companies investment in information technology and data because it makes spatial data available faster than traditionally possible and reduces dramatically the I/T administration involved in making up to date spatial data available to the user community.

At the opening of this paper we discussed the significant expense an oil and gas company has in data. Exploration is a difficult, and fickle business. There are years of good times, and years of bad times for companies. It is no secret that today's oil and gas discoveries are decidedly smaller than the fields discovered over the past 20 years. Indeed it would seem all the large fields have been discovered. This difficult exploration environment has 'heated up' the mergers and acquisitions departments in many oil and gas companies. If you cannot grow through the bit, then buy already producing assets in 'core areas' of your own base of assets.

The unfortunate reality of this activity is fewer – but larger – oil and gas companies for vendors to market services, software and data. In just the last 6 years alone Kerr-McGee has acquired Oryx Energy, HS Resources, and Westport Resources. What was 4 companies is now just one. An obvious by product of this is that our vendors have fewer companies to which they can market software and data.

As for specific needs for oil and gas companies from our GIS vendors we would offer up the following requests:

- Better labeling for ArcIMS is needed. Well features on oil and gas maps generally have several labels for an individual feature. For a well this would include perhaps the API well number, well name, and total depth. These need to be 'stacked' on top of each other and provisions must be made for the accurate resolution of labeling conflicts. We refer to this as overposting. Overposting resolution involves determining where to place a label, the use of a leader line, font size reduction, and possibly intelligent abbreviations.

- ArcIMS also needs better hardcopy output capabilities. We generate many base maps from ESRI products but have always struggled with methods to get accurately scaled maps from ArcIMS in an easy to use interface. Two main approaches exist. One uses printer driver options on the client PC, the other uses print submittal from the client to a server based service. To date, both have had issues that have held up adoption of ArcIMS in the oil and gas marketplace.

Technology used

It is always interesting to see what hardware and software make up a GIS solution. Here we have outlined the basic information technology infrastructure used to sustain our GIS environment in Kerr-McGee's Houston office. Interestingly, our NT hardware investment is only about $20,000 for our web GIS, but the software and data investment is much more than that.

- ArcIMS solution
    - 2 Windows 2003 servers - Compaq Proliant DL380
        - 2 GB RAM (we have found this to be plenty)
        - 40 GB disk (plenty, data housed in SDE so minimal disk required on ArcIMS server)
        - 1 server for ArcIMS
        - 1 server for Spatial Direct/FME, Crystal Reports
- SDE runs on Solaris 2.9 on SunFire 880 8 cpu's, 16GB RAM
    - Shared with other Oracle db's
    - SDE version 8.3
    - Oracle 8.1.7.4
    - 130 GB space used by spatial data
        - 45 GB raster
        - 85 GB vector
- Arcview workstations
    - IBM NetVista (avg user), Intellistation (pwr user), Thinkpad (laptop user)
    - Windows 2000 Professional
    - 256 MB RAM minimum, 512 MB average
    - Arcview 8.3
    - 100 mbit ethernet

Summary

It is expensive to search for oil and gas. Large fields are harder to find, and competition is fierce. Data to support exploration can run into millions of dollars for a 'play'. Geoscientists rely heavily on having the best, most comprehensive data possible. Over time oil companies have accumulated huge stores of seismic and well data. Managing all this data takes strict processes and data management practices. A Geographic Information System (GIS) can be a very effective way to view the various data assets that an oil company has for an area. Using spatial data warehousing concepts ensures the various GIS systems such as Arcview, ArcIMS and other mapping packages that can read spatial data have the 'best' (up to date, accurate) data.

Web services will play an important part in the future of oil and gas data management / data delivery. Browser based GIS can be interfaced with other special and general purpose systems to report and export data. As this market grows, GIS vendors can help by further improving their web mapping solutions to have better labeling and hardcopy output solutions.

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