ABSTRACT

To explore for and produce petroleum reserves, oil companies must lease mineral rights from the land owners. Historically, drafters have maintained complex linens with hand-posted polygonal lease outlines and textual attributes. Reproductions of these maps are then used by land men, geologists, and geophysicists to conduct their respective business.

To conserve manpower, and to enhance flexibility and turn-around, it has long been desired to automate this process. As a leader in the industry, Exxon has invested heavily in the development and utilization of LOMS, the Land Ownership Management System; an ISPF dialog running on an MVS mainframe which utilizes the tremendous power of SAS to input, store, manipulate, and map the multitude of information pertaining to more than 65,000 domestic leases.

This paper will present an overview of the "toolbox" of SAS routines used to maintain the LMDB (Land Management Database). Topics range from the simple polish involved in a user-friendly front-end, skimming the details of domestic leasing, elaborating on the creative application of elements of the SAS system, to the extreme of several sophisticated algorithms combining a variety of SAS data steps and procedures, and ending with a detailed, yet aesthetically pleasing multi-colored map which can be custom ordered by an end-user at any time.

HISTORY

Automation of the Lease Mapping function has long been an item of interest at Exxon. As early as 1983, a project was initiated to explore the subject. The result of this effort was a Lease Mapping prototype which was available in 1985.

This prototype integrated various existing technologies to automatically generate a Lease Map.

In 1987, another project was initiated to implement the prototype into an operational production system. By mid-year the prototype was packaged as LOMS, the Lease Ownership Mapping System, and was being used for a pilot project in the Western Exploration Division.

Results from the pilot project made several points clear. Digital mapping was indeed possible on a production basis; however, considerable time and effort would be needed to build a graphical data base. Thus a program began for drafters to capture existing lease polygon outlines and systematically replace their hand-posted linens with computer-generated maps. System development efforts continued to support and facilitate this effort.

With increasing experience, many enhancements were made to the LOMS system. Most of these were made on short order, usually in response to specific user input, and installed shortly after completion. In the Spring of 1989 a major flaw in the design of the data base was rectified; and the subsequent release of Version 2.0 in May of 1989 made great improvement in the efficiency of manual digitizing efforts.

As digital maps from LOMS began to proliferate, interest developed to map other land polygons (units, trades, prospect areas, etc.) in a similar fashion. Moreover, there was a desire to integrate lease mapping with other mapping capabilities. These objectives were accomplished during 1989, and LOMS became the Land Ownership Management System. Mapping features became part of the Comprehensive Basemap Dialog, and LOMS began to focus more on managing the graphical
Throughout the evolution of this system there was always a close communication between the development team and the user community. This process worked quite well, as user input frequently provided the impetus for further enhancements. Users readily accepted frequent changes, sprinkled with an infrequent mistake, in return for the quick response they received in addressing their problems.

During 1990, the LOMS development project began to wind down. Efforts focused on stabilizing the system and cleaning up loose ends. The final Version 3.0 was tested rigorously before installation, and the LOMS product was transferred to long-term support in September.

Today LOMS is used throughout the domestic on-shore business. Roughly 96,000 lease contracts are currently represented in the LMDB, and some 440,000 polygon vertices are maintained. It is estimated that more than 400 maps/month containing polygons from the LMDB are generated through the Comprehensive Basemap Dialog. Yet only four drafters work part time to keep the data base up-to-date.

**FEATURES**

LOMS is an ISPF dialog which gives users access to a wide variety of tools with which to build and maintain the Land Management Data Base (LMDB). The process can be broken into three major phases.

The first phase is to initialize, or refresh the data base. The headquarters Land Owner Relations department maintains an accounting data base (LANDMARC) with detailed information regarding all company leasing activity. LOMS requires just a small subset of the vast amount of data contained in LANDMARC. The job to "Refresh the LMDB" performs several functions to keep the LMDB evergreen. First, it processes leases which have been dropped or added. Second, it updates any attribute information which has been changed. Finally, it captures the narrative property description for each active lease.

The second phase is to generate graphic data; ie, polygons, for each lease. A complex batch job can be submitted that will automatically generate polygons for the majority of the leases. As part of this job, a report is generated detailing the leases which could not be completely processed. Users then use this exception report as a guide to digitize new polygons and modify existing polygons. Upon completion of an area, they will make a map, check for accuracy, and verify all polygons in the area.

The third phase is to continue to maintain the data. This involves periodically refreshing the attributes, reviewing the graphical status charts to identify problem areas, running data checking reports to detail problems in an area-of-interest, and finally digitizing the necessary corrections.

**LAND MANAGEMENT DATA BASE (LMDB)**

The LMDB is a SAS data base containing many members. First there are a variety of relational data tables strategically arranged in a hierarchial fashion. And there are also a number of ancillary data files accessed by the LOMS system. Finally, the LMDB contains several graphics catalogs and a SAS/AF® applications catalog. Simultaneous access to the LMDB is controlled through the SAS/SHARE® server.

The focal point of the data base is the file of leases obtained from the LANDMARC accounting database. This table contains the Exxon lease number, gross and net acres, audit trail information, and other lease attributes. Several members of the "Polygons" table can be assigned to one Lease. In addition to lease number, the polygon header file contains the lat/lon limits of the polygon, the number of points, and audit trail information. The points file contains observations for each vertex of a polygon. These three files maintain a hierarchial relationship by using a one-to-many match-merge with by-processing on a key variable.

In a similar hierarchy, each lease can have several "Subs" as a result of joint property ownership. The "Subs" file contains information
about the landowner and the terms of that specific lease contract. Each Sub can be assigned to one or more lease blocks. And the company responsibility center file contains the hierarchy of department, division, project, and play to which each block is assigned.

Lease data is the primary element of the data base. However, other land polygons, and their points, are also maintained in the data base. These polygons can be of various types (units, trades, fields, prospects, etc). There are a series of different attributes files, and each polygon is linked to the appropriate record in one of these attribute files.

**GENERATING LEASE POLYGONS**

The primary outcome of the Lease Mapping Prototype was the ability to convert narrative property descriptions into polygonal coordinates. Initial estimates were that 60 to 80 percent of all leases could be automatically processed. Later enhancements pushed the range to 80 to 90 percent. And in many areas less than 5 percent of the leases would report exceptions.

There are several key ingredients to this process. First, most domestic on-shore leases are described according to basic Jeffersonian surveying standards. Second, the LANDMARC data base contains the narrative property description for all Exxon leases. For standard Jeffersonian leases, the narrative description has been parsed, and the fielded values are also available from LANDMARC.

Third, cartographic data has been purchased from vendors, thus providing access to the coordinates (in universal latitude and longitude units) of reference surveying positions. A special subset of the cartography, containing coordinates for just the Jeffersonian sections, is maintained in the LIPS file for each state. Finally, a program (MAINIO) was obtained which could translate standards Jeffersonian aliquot parts into polygons.

Here is an example to clarify the process: A lease is described as “Township 3N/4E; Section 1, S/2, S2N2, Lots 1-4”. LOMS preprocessing identifies lots 1-4 as standard lots and translates them into the four quarter-quarters: NENE, NWNE, NENW, NWNW. These aliquot parts are then passed to MAINIO, which first finds the lat/lon corners of 3N/4E Section 1 from the LIPS file. From these four corner posts, MAINIO can subdivide the section, creating a rectangle for the south half (S2), another for the south half of the north half (S2S2), and so forth. The six rectangles are then passed through the POLYCOMB program, which recognizes that they are all adjacent and combines the polygons into one large polygon covering all of Section 1.

Although the final output for this example is simply a square connecting the four corners of Section 1, it highlights some of the sophistication needed to process complex legal descriptions. The possibility of coincident leases creates additional problems. Perhaps, in the above example, another lease covered just the S/2 of Section 1. Then we would like to generate two coincident lease polygons for the S/2, and another independent polygon for the remaining N/2 of the first lease. Special algorithms in the SAS code to pre-process the fielded property descriptions will handle this situation.

**UNIQUE ALGORITHMS**

To facilitate processing and analysis of data in the LMDB, a number of interesting algorithms were developed. What these have in common is the process by which they were developed. The catalyst would be a question, problem, or need identified by the user community. Preliminary ideas would be evaluated with some exploratory data analysis using the SAS Display Manager. Then the final product would be packaged and installed in the system.

One of the most interesting algorithms is used to annotate lease polygons on a basemap. This is described in more detail in another of our papers. Other algorithms are used to identify coincident, nearly coincident, touching, and overlapping polygons as part of the data checking reports. Yet another algorithm is used to generate polygons which circumscribe a set of clustered points, such as the field outline around a set of wells. And the most complex algorithms...
are used to parse and process Jeffersonian property descriptions and generate lease polygons.

DIGITIZING OPTIONS

To build and maintain the graphical data points in the LMDB, it is paramount to have access to digitizing tools. These are used to generate latitude and longitude coordinates for the vertices of polygons which are stored in the LMDB. The heart of the LOMS system is the POLCAP polygon capture program.

POLCAP is an interactive graphics program designed to run in an MVS mainframe environment, and is currently being packaged as a SAS User Procedure. The source code is PL/I and makes calls to both GDDM graphics functions and ISPf display and tutorial routines. POLCAP is driven with a mouse, and uses point-and-click features.

The basic functionality of POLCAP is to build new or edit existing polygons. Recently, enhancements have been added for contour lines. Drafters, the primary LOMS users, will spend hours each day working in POLCAP to maintain their graphical data. They use the various data processing and checking options to obtain information as to what graphical elements need to be added or changed.

There are various methods available to capture graphical data by tracing over existing maps. A generic import feature is available in LOMS to load these digitized polygons into the LMDB. Thereafter, any touch-up editing is done using POLCAP.

REPORTING OPTIONS

A number of reporting options are available to give the LOMS user the needed information. Some of these reports give users information to answer questions or solve problems, while others invoke data checking algorithms to identify problem areas in the data base. Since there are too many details to discuss here, suffice it to say that these reporting options give users ready access to information and analysis they need to leverage their efforts to more accurately and efficiently manage the data in the LMDB.

GENERIC AREA-OF-INTEREST (AOI) ROUTINES

Many of the LOMS features require specifying the desired area-of-interest. The generic AOI routine offers a number of options to identify a subset of the database.

One of the options is list input. Many of the data checking reports create output files containing lists of leases or polygons with problems. These lists can then be used to select an AOI for digitizing. Another set of options allows for tabular selection from the hierarchical structure of project, play, block, and lease.

The final set of options allows users to select an area based upon geographic limits. Users can specify a box in universal latitude & longitude coordinates. If preferred, they can specify limits in X/Y units, along with the appropriate projection system for coordinate transformation. Or they can interactively zoom-in on a window using the ISOLATE feature.

MONITORING TOOLS

To effectively manage the contents of the data base, great care was taken to install a variety of monitoring devices. For every function performed on the LMDB, audit trail information is maintained recording who did it and when. This information has proved vital to trace problems with the data, and periodically "erasing" changes which were made erroneously.

One of the key reporting options is to analyze the current status of the data base. This report details the amount of unfinished work remaining in various categories, and generates a series of graphic status charts that can be viewed on-line. Review of these charts can be used to monitor progress toward building the LMDB, to identify an area in need of maintenance work, or simply to inform a map-maker of the currency of
From various information in the LMDB, the status report is able to identify seven levels of completeness for each lease. Initially, when a new lease is entered into LANDMARC, LOMS creates an entry in the attributes file but does not have any polygons for the lease. Then an attempt is made to automatically generate polygons, which may be complete or incomplete. Next, a drafter may digitize changes to the lease polygons. Finally, the drafter will make a map and verify the accuracy of the lease polygons.

In each of these steps, the lease is promoted to a higher status level. Obviously, the objective is to finish digitizing polygons and verify all of the leases. However, at any given time, an active area might have a number of leases at each of the levels of completeness. Occasionally, after a lease has been verified in LOMS, there will be changes to the lease entered into LANDMARC. LOMS will identify this situation and automatically demote the lease status from verified to re-verify.

CUSTOM ORDERED MAPS

Lease mapping options are available as part of the Exxon Comprehensive Basemap Dialog. This dialog, developed by the APEX Software Simplification team, integrates a wide variety of mapping features previously available into one comprehensive application. All of the data preparation and display is handled by SAS tools available in Exxon's Common Computing Environment. Features for mapping of lease and other land polygons, originally available in LOMS, were migrated into this system.

With the Basemap dialog, end-users can "order" a customized map which they build by layers. First they select the desired mapping limits, or area-of-interest. Then they set up the borders and title box area and select the appropriate cartographic background data. If desired, they can display well locations on a map, or seismic data, or contours, or polygons, or any other division or user specific options.

For each of the layers selected, users have a variety of options to control the final display. For example, lease polygons can be shaded in a variety of fashions. One color scheme indicates the type of holding, lease or fee. Another differentiates exploration from production acreage. And another option allows for shading according to date of expiration.

CONCLUSIONS

Time and space constraints have necessitated very brief descriptions of some very complex issues; however, we hope this paper has demonstrated several points. From LOMS, the end-users have been given access to a sophisticated set of tools through a simplified, user-friendly dialog. These tools have automated some very tedious and time consuming manual tasks. And they promote consistency and accuracy of the data contained in the Land Management Data Base.

Furthermore, we've mentioned the process by which this system evolved. General specifications were set at the beginning of each phase of the project. Then, the rapid prototyping approach was used to explore viable options. And continuous interaction with the customers assured that the final product met both their needs and expectations.

Finally, we've noted how the power and flexibility of the SAS system made it possible to deliver a viable product on a timely basis. Exploratory data analysis with the SAS Display Manager greatly facilitated the rapid prototyping of new features. And the combination of data base, statistical analysis, and graphics tools integrated in the SAS system gave us easy access to a powerful range of capabilities.

REFERENCES


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