INDUSTRIAL USE OF LAND OBSERVATION SATELLITE SYSTEMS

by

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ABSTRACT

The principal industrial users of land observation satellite systems are the geological industries; oil/gas, mining, and engineering/environmental companies. The primary system used is Landsat/MSS. Currently, use is also being made of the limited amounts of SKYLAB photography, SEASAT and SIR-A radar, and the new LANDSAT/TM data available.

Although considered experimental, Landsat data is now used operationally by several hundred exploration and engineering companies worldwide as a vastly improved geological mapping tool to help direct more expensive geophysical and drilling phases, leading to more efficient decision-making and results. Thus, Landsat data has no real value in itself, but in the utility of the information derived.

Future needs include global Landsat/TM; higher spatial resolution; stereo and radar; improved data handling, processing distribution and archiving systems, and integrated geographical information systems (GIS). For a promising future, governments must provide overall continuity (government and/or private sector) of such systems, insure continued government R&D, and commit to operating internationally under the civil "Open Skies" policy. If this is done, land observational systems will become integral features of developing U.S. and other nations'space station programs.

INDUSTRIAL USERS

The principal industrial users of land observation satellite systems are the geological industries; the oil/gas companies, mining companies, engineering and environmental companies. In some respects, this is paradoxical in that the major civil system, Landsat, was principally designed for use in agriculture, hydrology, and land use planning. The potential of geological use of digital landsat multispectral scanner (MSS) type data was not well appreciated by the geological community during the design phase of the Landsat program. However, industrial geologists soon recognized the inherent capabilities to improve regional geological mapping on a global basis of data derived from the Landsat system when utilized with modern computer techniques. The principal usefulness of Landsat-type data for geological application is the increased capability to recognize large earth features *through greater synoptic perspective and the development of an internally consistent worldwide digital data base which, if wisdom prevails, will be porperly archived and thus accessible to the user community for many years to come. This is vital for the geological community as geological processes are long-term. Large scale exploration efforts include long-term, multi-country, multi-season, multi-exploration model designed programs under the effects of ever changing economic commodity cycles. The bottom line for the geological industries' use of Landsat and other satellite data is its growing usefullness in increasing the efficiency of reginal geological mapping for exploraiton, engineering, and environmental applications.*

Worldwide, the geological discipline exceeds others in the use of civil land observational satellite systems. In the United States, industrial geological use of Landsat MSS and, to a lesser extent, SEASAT and SIR-A radar and Landsat/Thematic Mapper (TM) data represents about 33% of data purchased from the EROS Data Center. To this, however, must be added non-U.S. purchases by industrial and governmental users for geological purposes. U.S. geological exploration and engineering companies operate totally separately from the U.S. government, and generally in a non-cooperative, adversarial, "hands-off" relationship; however, most other industrial and particularly non-industrial countries coordinate or merge their government/industrial non-renewable resource requirements, policies, and exploration programs. Thus, the geological use of civil land observational remote sensing satellite systems approaches or exceeds 50% of all such data use worldwide.

Several levels of sophistication of data use exist within the geological industries. In 1976, eight companies had invested in in-house data processing capabilities for Landsat and other satellite data; currently there are about 80 companies worldwide who have made such an investment. Several hundred other companies have begun using Landsat data processed by the value-added service companies and/or government data/ product distribution centers, such as the EROS Data Center (EDC) in the U.S., Canada's CCRS, Australia's CSIRO, RESTEC in Japan, Spot Image in France, and others.

DATA USED

The principal data used to date is Landsat Multispectral Scanner (MSS) data. Use of Skylab and Salyut visible and color film, SEASAT and SIR-A radar, and Landsat/Thematic Mapper (TM) is less extensive because of the limited access to such data. Future use of radar, SPOT, and especially Landsat/TM data by the geological community will be extensive when such data becomes generally available worldwide.

Future use of civil land observational satellite data will be highly dependent on the successful development of a strong, multi-level, value-added industry. Users of these data will always have differing requirements for data products. Some users will require only low cost film products, such as standard false color composite Landsat imagery. Others will require only Computer Compatible Tape (CCT) format data for their in-house data processing systems. However, many other users will require various project oriented, processed and/or interpreted data products provided by the value-added service industry. This industry will also provide significant amounts of derived proprietary information to the exploration community on a high price and/or participatory basis.

The development of a strong multi-level value-added industry is paramount to the development of a commercial market for a U.S. civil land observational satellite system. Both will be dependent on the existence of an extensive cooperative network of worldwide ground receiving stations capable of acquiring and archiving, processing and distributing Landsat, SPOT, and other satellite data under an international "Open Skies" policy of non-exclusive, timely access to basic data at an equitable cost.

HOW DATA IS USED

Historically, Skylab and Landsat data were initially treated as glorified aerial photography. The geological use of aerial photography with visible and color infrared film began in earnest in the 1920's. Even today, it is a rare geologist who does not use available aerial photography in his field work. Such photography allows an overview of the geology which assists the geologist in mapping on the ground. It 'tells him' where to go to do his job efficiently. It allows him to better see the forest while mapping the trees. Satellite data, such as that derived from the Landsat system, allows the geologist to map even more efficiently than does aerial photography over much larger regions. In addition, Landsat data being digital can therefore be merged with other geophysical, geological, and geographical data sets, and contains more derivable information than does film data. This is expecially true for the increased spectral information from the Landsat/TM shortwave infrared bands. The Thematic Mapper increases the geologist's ability to discriminate rocks and soil minerals from satellite data more efficiently than by standard field sampling and mapping techniques.

To extract the maximum information available in Landsat data requires access to interactive computer capabilities and to basic field work. Satellite data and the information derived therefrom can greatly assist the geologist in organizing and implementing field mapping. However, only by interacting with field validation can the maximum information content of Landsat and other satellite data be obtained.

For example, in the joint NASA-Geosat Test Case Program field study over ASARCO's Silver Bell, Arizona porphyry copper deposit, Landsat and airborne Thematic Mapper (ATM) was acquired and evaluated. Basic empirical algorithms designed to locate iron oxide (MSS-type data) and clay alteration (TM-type shortwave infrared data) were used to outline the main zone of alteration and mineralizaiton contining the economic copper ore body. This application of the ATM system (equivalent to the Landsat/TM spectral bands) was accomplished in less than 1/1000 of the time it took ASARCO to map the zone in the field using standard techniques.

This basic but simple application can be greatly improved by 'ground truthing' in the field by making actual ground field spectrometer measurements of specific rock, soil, alteration, and mineralization areas of specific interest. The original data is further processed with ground measured radiance values and the data is reprocessed to produce more detailed imagery. In the Silver Bell example, the field verification and further enhancement produced imagery which accurately discrimated and mapped 19 different rock, soil, alteration, and mineralization areas from the original simple iron oxide/clay alteration imagery.

In addition, Landsat digital data is operationally integrated or merged with other digital geophysical, geochemical, geological, and geographical data. The "Geocoded Information Systems" (GIS's) stack various digital information bases in order to mutually enhance the information and interpretation potential of the individual data bases. For example, a Geosat member oil company recently merged enhanced Landsat data with digitized analog synthetic aperture radar (SEASAT SIR-A data) and gravity mapping in a unique and rapid location of a successful discovery oil well in a generally difficult and commonly cloud-covered area of Indonesia. Individually, these data were not definitiveas to the location of the oil producing geologic structure, but when combined, the structure was easily discernable and a successful discovery well drilled under otherwise difficult circumstances. It is important to understand that Landsat data was used as but one of several data information tools that led to the high-risk decision to drill what turned out to be an oil discovery.

In such applications, Landsat and other satellite data are used most efficiently in poorly known areas by looking for large geological structures that might contain energy or mineral resources. Similarly, it is used in large scale engineering projects. Once exploration prospects or engineering projects are identified, they become site-specific and airborne and surface field techniques are utilized prior to ultimate drilling decisions. However, in many international exploration *and engineering programs, Landsat and other satellite data are widely used for logistical field support and program planning. Some examples are the use of Landsat to monitor sand dune encroachment on desert drilling operations, the use of radar and Landsat data to monitor sea-ice and weather conditions affecting offshore exploration and oil company sea transport, the use of Landsat spectral bands' water penetration to map offshore coastal bathemetry to plan safe and efficient marine seismic exploration, and the use of Landsat in pipeline routing and environmental monitoring of surface mining land reclamation.*

The cost of utilizing Landsat and other satellite data varies with the degree of sophistication of the data user. Of the 80 companies who presently have in-house data processing capabilities used for geological applications, 58 are members of The Geosat Committee. In general, these systems cost $1-2 million to establish. In 1983, a poor exploration year financially speaking, the average Geosat Committee member company budgeted $1.2 million to operate their system, with 8-10 people directly employed.

In addition to the marked increase in the number of exploration and engineering companies with in-house Landsat digital data processing capabilities during the last seven years (from 8 to 80), the management acceptance of this new exploration technology is rapidly developing. Whereas most of the Corporate Members of The Geosat Committee were either establishing the systems or using them in a research and development mode in 1980, today almost all of their Landsat application activities are directed towards and funded by active field exploration and engineering regional and project groups throughout their corporate organizations.

In evaluating the use of civil land observation satellite systems, it is important to remember that the data itself has no intrinsic value. It is literally the proprietary 'value' of the information enhanced or derived from the basic Landsat *data as it can be integrated into successful exploration or engineering programs that is operationally supported by management. Usually,* *management positively evaluates the use of such data and the information derived therefrom in terms of cost savings through increased efficiencies of geological mapping and logistic applications as part of total exploration or engineering operations.*

An example is the successful use of Landsat data over Venezuela by the Bechtel Corporation. Bechtel's client required the location of a deep water port as a part of a large construction project. Standard engineering practice called for a bathemetric survey of 100 kilometers of the Venezuelan coast. The minimum bid was $150,000; however, use of Bechtel's then newly installed Landsat processing capability produced an offshore map of shallow and deep water areas which assisted in determining a suitable port site. The use of Landsat data and the subsequent on-site verification of the near-shore deep water cost about $10,000, resulting in a savings of about $140,000 for Bechtel's client.

FUTURE REQUIREMENTS

For the future, the exploration and engineering communities will, as will the industrial agricultural community, require continuation of the present Landsat/Thematic Mapper program to acquire this vital spectral data set on a worldwide basis. The acquisition of such a data base will probably require the equivalent of at least two or more Landsat/TM-type systems past the presently orbiting and ailing LANDSAT-4. There are also requirements for higher spatial resolution (10-20 meter) and Landsat compatible digital stereoscopic data which will hopefully be provided by the French SPOT system in 1985 and the Japanese JERS system in 1990. Global Synthetic Aperture Radar (SAR) requirements will hopefully be met by the European Space Agency's ERS-1 in 1987, and by Canada's RADARSAT and the Japanese JERS-1 in the 1990's.

Equally important as the development of satellites and space sensors is the need for additional and improved ground receiving station capabilities coupled with improved computer capabilities for handling the increased amounts of digital data produced by these new satellite systems.

With respect to the U.S. government role in the future of industrial use of civil observational satellite systems, several decisions need to be made as soon as possible. The U.S. government must recognize its responsibility to commit to a continued U.S. system whether or not such a system can be successfully commercialized in this decade. The government must also recognize its responsibility to continue to support high-risk exploratory research and development in satellite remote sensing technology. Perhaps most importantly, it must continue its worldwide leadership in maintaining the international acceptance of the "Open Skies" policy for non-discriminatory access to basic data throughout the world. The alternative is resource intelligence competition and international chaos.

If the U.S. and other free world governments maintain these civil land observational satellite system policies, the outlook for their further industrial use is most promising. If the development of the use of these data is continued, then they will undoubtedly become an operational application of future U.S. and other space stations.