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GEOSAT: Geological Industry Recommendations on Remote Sensing from Space*

The implications of a dedicated system, and of candidate systems providing stereoscopic coverage and higher resolution, are described.

(Abstract on next page)

Here at the Thirteenth Congress of the International Society for Photogrammetry we will be acknowledging the existence and contributions of space imaging systems as they apply to the developments and accomplishments of geodesy, photogrammetry, cartography, and the earth sciences. We also will be assessing the usefulness of existing space data systems and making recommendations and resolutions for future technological developments and international policies which will make tomorrow's space data more responsive to our real and critical needs.

This panel (Commission I, Panel on Space Imagery) has been convened for the purpose of reviewing what technology might be available to us, how some of it has been deployed to the benefit of the international photogrammetric community, and what space planning activities are in progress which might benefit our topographic mapping, map revision, and other national resource management needs. This last point introduces the subject of this discussion which will be the first disclosure to the international photogrammetric community of a space applications planning activity with technical goals of direct interest and importance to us.

In the United States the largest single industrial group of users of satellite imaging data has been the geologists. This group encompasses industries concerned with:

- Oil and Gas Resources
- Geothermal Resources
- Mineral Resources
- Engineering and Environmental Geology

The advantage of the space perspective to geologic analysis is obvious to all of us who routinely use aerial photography. However, the synoptic perspective alone cannot overcome or supplant the need for other critical imaging parameters such as stereoscopic observation and an object detail resolution level commensurate with the geological information of interest and of economic importance.

Knowing that these requirements are technologically achievable from space as are other parameters of geologic interest such as additional spectral bands in scanners, discrete thermal IR information, terrain structure using radar, and color photography of rocks and soils, an ad hoc Geological Committee on Remote Sensing from Space met in a Workshop in May 1976 at Flagstaff, Arizona. The meeting is now referred to as the GEOSAT Workshop.

* This paper is the complete statement prepared for the Panel on Space Imagery, moderated by Dr. F. J. Doyle and convened as part of the proceedings of Commission I during the Thirteenth International Congress for Photogrammetry in Helsinki, Finland, July 1976. As an invited panel member, Mr. Ondrejka reviewed its contents as part of an overall review of future United States Earth resource satellite technology. Dr. Henderson was organizer of the 1976 GEOSAT Workshop, co-author with G. A. Swann of the Workshop report, and is currently the President of the GEOSAT Committee, Inc.

Photogrammetric Engineering and Remote Sensing,
Vol. 44, No. 2, February 1978, pp. 165-169.

The Summary and Recommendations of the Workshop were as follows:

(1) The dwindling energy and other natural resources of the United States and the western world require new exploration tools and advances which include geologically dedicated satellite missions designed to enhance geological interpretation for use in oil, gas, mineral, and other resource exploration, engineering, and environmental planning.
(2) Industry can and should support efforts to develop several geologically dedicated satellite capabilities independently of present NASA plans which emphasize agriculture and water remote sensing. These geological capabilities initially include applications missions involving stereoscopic coverage, improved resolution (to 10 meters), additional spectral bands (especially 2.2μm), thermal IR, radar, and color (and IR color) photography.
(3) Some of the capabilities may be partially satisfied by planned Landsat satellite missions (Landsat C and Landsat follow-on programs), STEREOSAT, and early Shuttle photography, but to fully meet its geological needs industry should support additional geologically dedicated missions as determined by a geologically oriented, non-government GEOSAT organization.
(4) In order to obtain industry support to implement independently the recommended GEOSAT missions, it is further recommended that a permanent, non-government GEOSAT Committee be formed. The GEOSAT Committee will be charged with assessing the feasibility and economics of the proposed GEOSAT missions, obtaining industry support both moral and financial as needed, and determining the best operational mode for a permanent GEOSAT organization to maximize industry's efforts to cooperate and support industry-NASA missions to obtain its geological goals.

ABSTRACT: *In the United States, the largest single industrial group of users of satellite imaging data has been the geologists. This group encompasses industries concerned with:*

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The advantage of the space perspective to geologic analysis is obvious to all of us who routinely use aerial photography. However, the synoptic perspective alone cannot overcome or supplant the need for other critical imaging parameters such as stereoscopic observation and an object detail resolution level commensurate with the geological information of interest and of economic importance.

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In mid-1976, a GEOSAT Committee, Inc. was formed to investigate and pursue the Workshop technical recommendations. The GEOSAT activity is currently sponsored by over 100 geologically-based companies including a majority of the largest in the United States.

In August of 1976, the GEOSAT Committee, Inc. was established with Dr. Frederick B. Henderson III appointed as President. As of 1977, the GEOSAT Committee is sponsored by almost 100 oil, gas, mineral, and engineering companies, including a majority of the largest in the United States. Also, as of 1977, international geologic industry participation in GEOSAT is being encouraged. At the present, there is only one prime

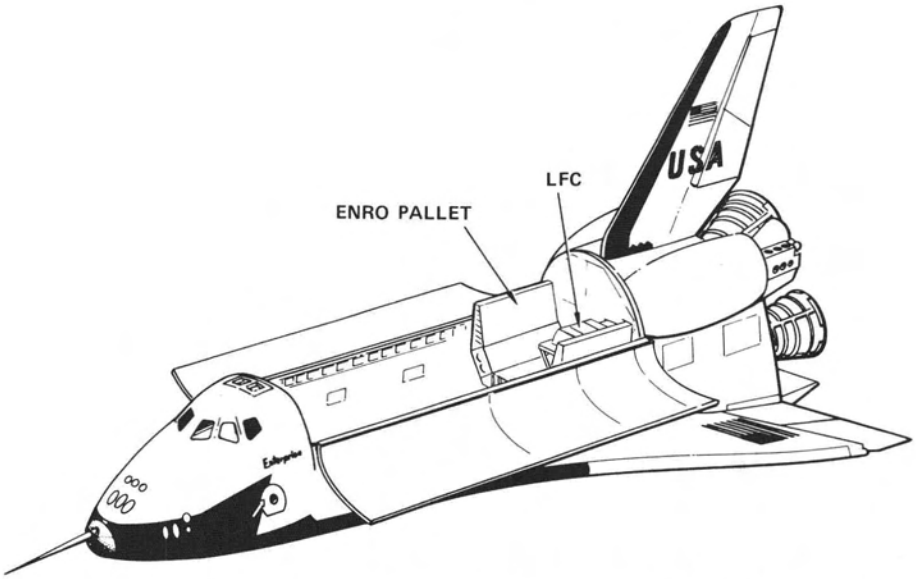

FIG. 1. The Large Format Camera (LFC) system in the Shuttle Spacecraft.

objective proposed to be stated for the GEOSAT Committee:

> The GEOSAT Committee shall be an industry sponsored committee to provide objective geologic and engineering input into the earth satellite programs.

Corollary thereto:

(a) The GEOSAT Committee shall be apolitical with no government support and conducting no lobbying.
(b) The GEOSAT Committee shall not be involved in any in-house hardware or program development, although appropriate recommendations are permitted.

The technical recommendations by the Workshop and by this unique industrial initiative contain a number of features of direct impact on the mapping sciences and business activities of the member nations of the International Society for Photogrammetry. In fact, all of the recommendations will provide improved information input to our mapping needs since space remote sensing for exploration is used along with a number of other geological tools primarily to develop better four-dimensional (three-dimensional space plus geologic time) geological maps of the Earth's land surface.

To elaborate on a few of the most relevant recommendations and to identify specific Space mission opportunities where we might see these recommendations realized, we should briefly consider the following:

(a) Stereoscopic coverage and improvements in ground resolution together with recording on color or color infrared film would optimally dictate a photo-optical

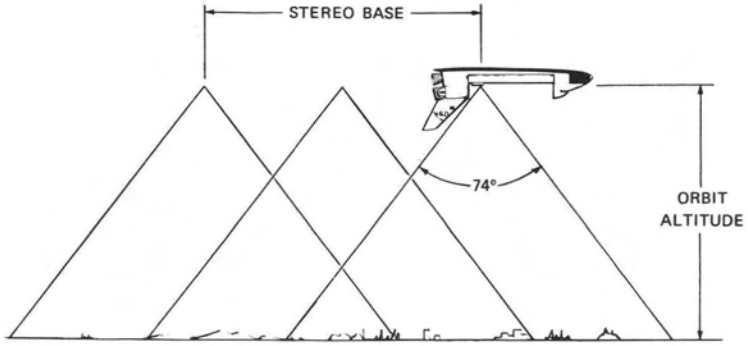

FIG. 2. The stereoscopic coverage geometry of the Large Format Camera.

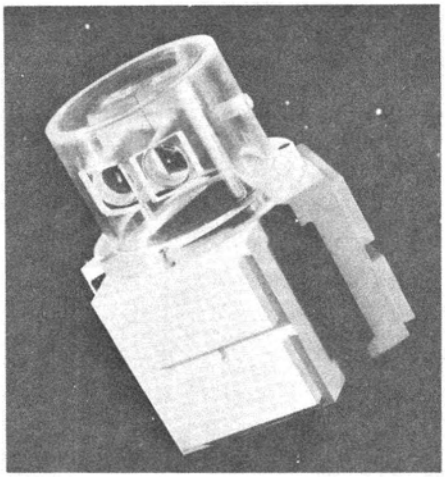

FIG. 3. The Multimission Modular Spacecraft with a twin LFC system.

camera and logically a wide angle, vertical photogrammetric camera for maximum user acceptance. Such a sensor would obviously take advantage of a manned, frequent-data-return and film replenishment space mission such as the NASA Shuttle Space Transportation System and the ESA Spacelab on Shuttle. Both NASA and ESA have photogrammetric cameras under consideration. Figure 1 illustrates a camera installation in the Shuttle bay and Figure 2 depicts the object space geometry of the NASA Large Format Camera (LFC). Figure 3 illustrates a free-flying camera carrying satellite, i.e., the Multi-Mission Modular Spacecraft, which can be deployed, retrieved, and replenished by the Shuttle STS. The principal technical characteristics of the LFC are a calibrated 30 cm focal length lens, 23 cm by 46 cm format with calibrated fiducial systems permitting the optional selection of 23 cm by 23 cm formats, and a nominal photo-optical resolution of 10 to 20 meters from an orbital altitude of 260 kilometers. Deployment of the LFC could be as early as 1979.

(b) Stereoscopic coverage and improvements in present resolution levels also can be achieved with a pair of electro-optical cameras which would provide single spectral band digital data such as stereo/imagery for conventional stereoscopic image interpretation or after suitable digital image processing and re-formatting, for stereo interpretation of existing and future Landsat material. The GEOSAT Workshop recommended such a system (STEREOSAT, Figure 4) for a near-polar sun-synchronous orbit as part of the Scout-Applications Explorer Mission program. The STEREOSAT ground resolution - effective instantaneous field of view (EIFOV) would be approximately 17 meters. Launch of such a system into a Landsat type orbit could be as early as 1981.

(c) Synthetic Aperture (side-looking) Radar provides geologists with topographic, geomorphic, structural geological, and surface roughness information and is particularly useful in areas where continuous coverage is difficult or impossible to obtain with other types of imagery. As mappers we are well acquainted with the value of SLAR from projects such as RADAM in Brazil.

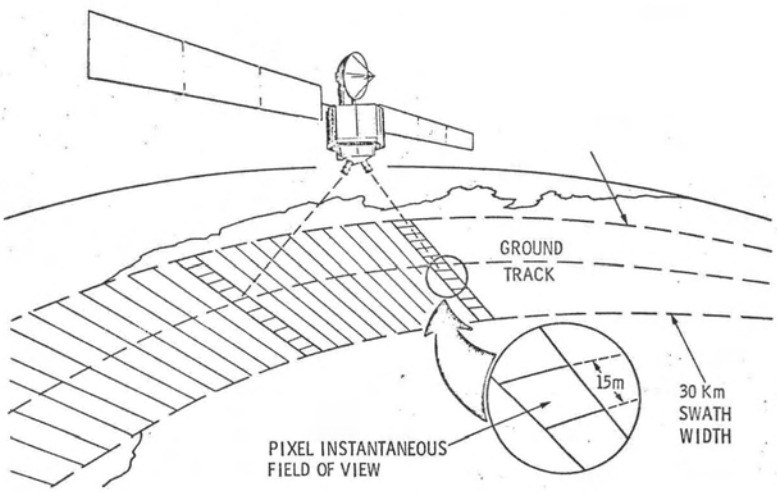

FIG. 4. Stereosat image geometry. (Preliminary Stereosat concept by the Jet Propulsion Laboratory.)

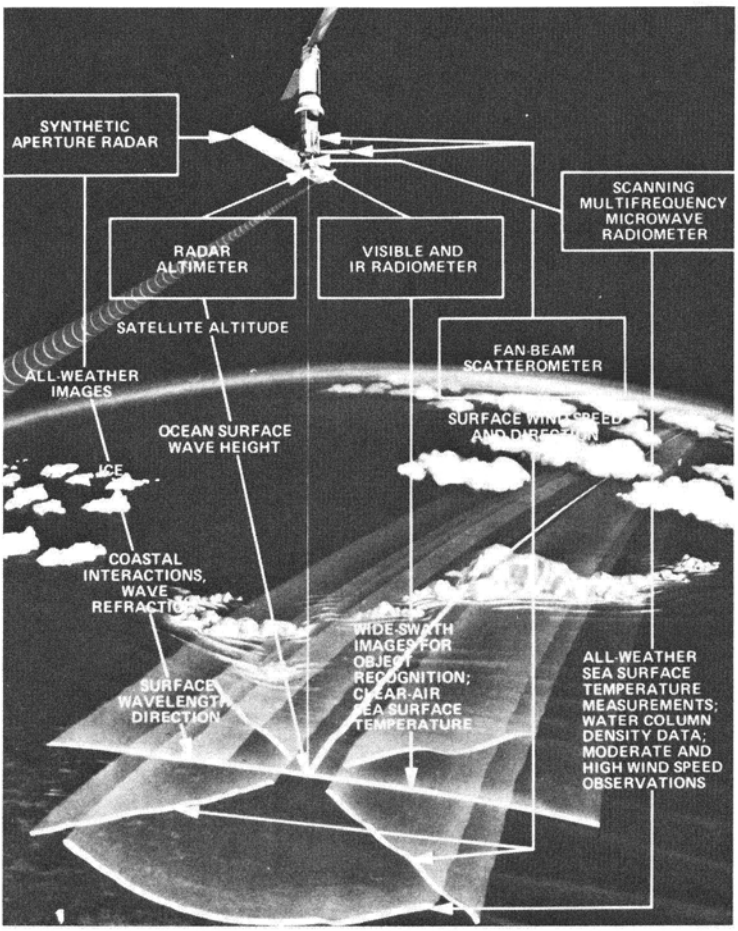

FIG. 5. Seasat spacecraft will utilize five primary instruments to conduct oceanographic research. (Courtesy of NASA.)

Although not optimized for land surface information, a synthetic aperture radar (SAR) will be part of the SEASAT mission (Figure 5) scheduled for launch in early 1978. This coherent L-band active microwave system is intended to acquire seastate information at a nadir angle of 20 degrees. However, a similar SAR is planned as an experiment aboard an early (1979) Shuttle flight with a nadir angle of 50 degrees to acquire all-weather data on geology and other land features. This experiment also has been endorsed by the GEOSAT Workshop.

Although not as relevant to our topographic mapping needs and therefore not elaborated on in this discussion, the GEOSAT recommendations concerned with additional multispectral bands and more discriminating thermal IR bands will be of interest to us as supplementary land-use mapping data.

As an international body of nations and organizations involved in critical operational mapping and survey tasks, we must recognize and encourage the initiative of earth science industry groups such as GEOSAT so that future earth resource satellite systems are responsive to collecting appropriate earth data as soon as possible.