# *Commentary*

## Concept Outline
## Development, Processing, and Utilization of Civil Satellite Data for Mapping and Global Change Analysis

### Assumptions

That civil satellite systems such as demonstrated by Landsat and SPOT will continue to fly. That Landsat 7 (or equivalent) will include a mapping (stereo) capability. That such systems will be recognized as a public service, and the data made available to all at reasonable[1] prices. That the civil Earth sensing satellites have fully justified their continued existence and are now recognized as an essential element of man's monitoring and understanding of this Earth and the changes thereto.

### Image Reference Database

During the next 20 years, multispectral data in the 10- to 30-m resolution range (pixel dimension) can continue to be expected from SPOT and Landsat. Other European and Japanese systems may also be making sizable data contributions of similar resolution. (AVHRR and other "Met. type" satellites can do the same thing in the 0.7- to 1-km resolution range.) All such systems are, in effect, providing data from which a global image reference database can, in part, now be developed. Such a database is nothing more than a precise orthographic digital image map of the Earth's surface in which every picture element (pixel) is defined as a fixed, uniformly sized cell on an accepted map projection such as the Universal Transverse Mercator (UTM). For many areas cell sizes as large as 100 m, or even 1 km, are adequate, but for developed areas 10 m or smaller cell sizes are needed. The image reference data base is independent of any given source data, but each (UTM) cell is defined by a simple number or group of numbers which indicate the *solar reflective response* of the cell under generally accepted conditions. Thus, the single most important response of a given cell might be that obtained around the time of the equinox(s) with a sun elevation in the order of 30° and in a panchromatic wave band of 0.5 to 0.7 μm. The number describing this relative response should be simple, perhaps a single digit, ranging from 0 to 7. In areas where the near-infrared response[2] or seasonal differences are critical, the cells must also carry additional sets of appropriate numbers. Such data sets, once established, provide a base by which the data from most remote sensing systems, ranging from aerial photography to the Earth sensing satellites, can be correlated[3] in an *automated or semi-automated mode*. The differences indicated by such correlation would immediately indicate areas of change on the Earth's surface—even though the specific change may not be readily identified. Because most remote sensing systems are currently nothing more than a record of selected solar reflectance, the image reference database becomes a fundamental tool of remote sensing, change detection, and thus global change. Data from side-looking radar (SLAR) will also correlate with the solar induced response of many high contrast boundaries; thus, the image reference database can be used to transform the radar data into its orthographic (planimetrically correct) form.

### Procedure

Once the image reference database has been locally demonstrated, plans should be made for its expansion—eventually to cover all land, shallow seas, and ice-covered areas. Today, image reference databases can be developed for areas generally devoid of relief, and those areas of relief where an adequate digital elevation model (DEM) is available. Unfortunately, this leaves sizable areas of the Earth's land area that lack a DEM. The most promising solution to this problem is the flying of a good stereo satellite such as proposed by the U.S. Geological Survey (USGS) and Department of the Interior for a Landsat follow-on. If this is done and the data made generally available at reasonable prices, there is reason to believe that a meaningful DEM of most of the Earth's land areas can be developed in about a 10-year period. Assuming Landsat 7 is launched in 1996, we can foresee a global image reference database developed by about 2006. Although selected changes in the Earth's surface—and in effect global change—can be noted today, the systematic detailed study of global change by remote sensing can hardly be made operational until 2006, and then only if the steps indicated above are initiated today. Radar interferometric systems are also theoretically capable of developing a usable DEM from aircraft or satellite. However, such systems are still in the experimental stage with their operational feasibility yet to be demonstrated.

### Role of the Image Map

An image reference database would, of course, be stored in digital form and be suitable for conversion to image form. This digital form would be fine for the TV media and all others who can view the digital data. However, Earth scenes frequently warrant printing and distribution in hard copy form. For example, the National Geographic Society is preparing an AVHRR image map of the Earth for their October '90 magazine. Thus, over 10 million copies of this satellite image of the Earth will be distributed. The image maps printed in newspapers from weather satellite data are another example of where the space image warrants publication in hard copy. Even when the area involved is limited and imaged at relatively large scale, the need frequently warrants hard copy distribution. The satellite image has several distinct advantages over the aerial photograph for such applications. It is near orthographic, already color separated in digital form, and lends itself to the very rapid and efficient conversion into geometrically precise image map form. By correlation of newly acquired space data to the described image reference database, accurate image maps can be prepared and published in a matter of days (if not hours). When Landsat (ERTS) first flew an image map (Lake Tahoe, 1:1,000,000-scale) which met National Map Accuracy Standards, it was published only 15 days after data acquisition. Once operational procedures are established for image-map production, this time period could be greatly reduced. No one can expect high-resolution space data to be available immediately following an event that needs recording, but with systems like Landsat, SPOT, and others in orbit, suitable data will normally be available within a weeks time. If one more week is allocated for the hard copy production, image maps could be made available within two weeks after an event which warrants their production on a priority basis. A listing of a few of the places and events that have warranted image mapping by Landsat was published on page 105 of the January 1989 issue of *Photogrammetric Engineering and & Remote Sensing*—to which should be added the Arabian Peninsula as of the summer of 1990. The image map is not merely a means for illustrating a significant event which has altered the Earth's surface or its cover. A properly prepared image map is a *complement* to the conventional line map by depicting land-use and land-cover conditions absent from the line map. Moreover, the speed with which an image map can be made makes it possible to provide up-to-date data which simply isn't feasible with line maps. The image map is a simple tool for the display and dissemination of global change information.

### Summary

Mapping the Earth from space is an accepted concept that should now move from the experimental to the operational stage. The technical problems have all been analyzed and resolved. All that remains is the solution to the political and financial aspects. Because there is general agreement that this Earth warrants a good model and continued observation, it is hard to believe that these aspects will not also be resolved. The United States, through Landsat, has initiated a magnificent program in this regard and is now in a position to develop it, with international support, into a fully operational system—"for the benefit of all mankind"—the slogan used to describe the original Landsat (ERTS) program.

*—Alden P. Colvocoresses*
*Past President ASPRS, 1988–1989*

[1]The term "reasonable" is used to denote a price based on reproduction and handling cost which provides for maximum distribution as a public service.

[2]Recent work by Pat Chavez, USGS, indicates that the near-infrared (0.7 to 1.0 μm) may be preferred to the visible (0.5 to 0.7 μm) for topographic (three-dimensional) delineation of many areas.

[3]Correlation as used herein refers to the spatial matching of two sets of data covering the same area of the Earth's surface.

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