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OPERATIONAL REQUIREMENTS AND THE GEOSTATIONARY PLATFORM

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For 22 years -- from ATS-1 to GOES-H -- a single technology has dominated imaging from geosynchronous altitudes. In 1990, with the scheduled launch of GOES-I, a major change will occur which will in turn open the way for the Geostationary Platform. The Platform may then accelerate development of the Earth Sciences and also provide research data useful for severe storm forecasts and hazard warnings. Most important of all, the Platform may solve problems that will impact the new GOES spacecraft.

ATS-1, like all but one of the ATS-series and all U.S. operational geostationary spacecraft to date, was spin-stabilized. Hundreds of pounds of gyro-rotating mass twirling at 100 RPM provided a dynamic stability that kept such moving parts as imager scan-mirrors from wiggling the spacecraft in reaction. From aboard a spinning spacecraft, a Spin-Scan Cloud Camera, and its descendants to today's combination imager-sounder*, permitted Earth observations to be made.

But the spin-scan principle has its limitations. Scan lines must be full-Earth wide, from western horizon to eastern. Changes in North-South observations must await the stepwise movement of the scan mirror. Even worse, the radiometer detectors gather photons from an Earth scene only during the short period of each rotation when the instrument views the Earth. (However, a compensating factor just as important as platform stability is that a rapidly spinning spacecraft receives almost a constant solar heating load, all day and all year.) Although a de-spun platform was later added atop a spinning satellite for the use of pointing high-gain antennas, it was not stable enough for an imager.

The need for improved observations of severe storms has led NOAA to a decision to replace spinning geostationary spacecraft with a three-axis-stabilized type (non-spinning) vehicle already common among communications spacecraft and demonstrated by INSAT. The change will begin with GOES-I. Also, the current spin-scan imager with sounder channels (VAS)* will be replaced by separate instruments capable of independent aiming. A design for each with double-gimballed

* The GOES imager-sounder now in use is called VAS, for VISSR (Visible & Infrared Spin-Scan Radiometer) Atmospheric Sounder.

mirrors frees imaging and sounding from horizon to horizon scanning. North-South mirror movement will occur without stepping between locations. The same freedom applies as well to the new sounder, but sounding is inherently a slower process, because of the low radiant energy levels involved. The slower sounder (7.5 hours for a full-disc sounding, vs. one-half hour for a full-disc image) will plod along examining storm air-mass stability, while the agile imager leaps from threatening squall line to flash-flood to nascent tornado, sampling area-rectangles perhaps 100 miles on a side. Images show the direction and speed of storm movement. Air-mass stability --the temperature and moisture structure of the near-by source-air of a potential storm -- discloses the probable severity and duration of winds and floods.

The gains achieved by staring sensors (versus intermittent looks while spinning) reduce the time for soundings almost by half (13.5 hours to 7.5 hours for a full disc). Imaging is comparably speeded. But the price paid is found in spacecraft stability. Scan-mirror movements are expected to cause apparent movement of the viewed Earth image. While NOAA's polar orbiters are comparable in size and weight to the GOES-I/M series, their stability requirements are far less severe. Spacecraft vibrations affect images in proportion to the spacecraft altitude. Low Earth orbiters look down 850 km to nadir sub-point; GOES imagers are 35,800 km above the Earth's surface; platform vibrations are thus magnified 40 times. And, for polar orbiters which move from sunlight to night during a 102 min orbit, solar heating is neither long enough in duration, nor protracted enough from any given angle, to seriously distort the structure carrying stability controls and instrument arrays. In geostationary orbits, where a spacecraft is sunlit for six months, and insolated for 12 hours without hiatus on a given face, variable thermal expansions of the structure can be significant. The impacts on control systems and on the ground-location of fields of view are serious.

I am sure we all view a Geostationary Platform as an exciting opportunity for experiments in larger spacecraft design, innovative instrument development and a renaissance in data collection for all the Earth Sciences. But there are other aspects to such a Platform. The challenges it faces are those that must be met before the capabilities of any non-spinning geostationary satellite for remote sensing can be enlarged. Even communications spacecraft are involved. For example, high-stability spacecraft will become necessary, if laser-links are to be used between spacecraft, or from space to spot-targets on the Earth, Moon or Mars.

A special problem is that of large diameter -- or large array -- antennas for microwave passive remote sensing in bands between 20 and 200 GHz. While use of the infrared "atmospheric window" for soundings is now in its third decade as an operational tool, it has limitations. Clouds, even wispy cirrus bands, block outgoing infrared radiation. Ultimately, the result is to degrade calculations of surface and cloud-top temperatures and to largely eliminate computation of soundings below cloud levels. Either of these problems is serious. Errors in sensed cloud-top temperatures result in errors in estimates of the cloud-top heights and so to the heights of "cloud drift" winds assumed from sequential images of cloud position. Loss of soundings from cloudy regions means, for the severe storm forecaster, that he is unable to see into the storm he wishes to probe. (He can have soundings from clear air nearby, but the results are less than what is needed.) By contrast, some microwave channels are able to penetrate all but the heaviest rains. By careful channel selection, we can obtain temperature stability, and rainfall as well.

Diameters for microwave antennas grow large because (a) microwave wave-lengths demand a relatively larger antenna for the same field of view than visible and thermal-IR channels, and (b) we need finer probes to examine storms. It is a cruel jest that, in general, we need only large fields of view (for global forecasting) from low-flying polar orbiters, but want 1 km resolutions or less from geostationary spacecraft. The result is a stone-wall challenge for space hardware designers. Couple to this a requirement for a microwave antenna to scan (at least over the continental U.S.), without slewing the remainder of the spacecraft (if other sensors are carried), and the magnitude of the task soars.

Our emphasis on microwave sounders does not mean that interest in IR soundings has vanished. For several years, NOAA has funded studies of the feasibility of replacing GOES sounder filter-wheel channel selectors with an interferometer. Soundings based on more and, especially, narrower spectral channels, it is hoped, will result in increased vertical resolution of both temperature and moisture profiles. (NASA is following the same road in its interest in AIRS (Atmospheric Infrared Sounder) for flight on a Polar Platform. Whether AIRS uses an interferometer or a grating spectrometer is a question to be answered more by cost or mechanical complexity, than by operational principles.)

The role of the Geostationary Platform in high-altitude spacecraft technology is unique. Since its goal is for ultra-high resolution imagers and large diameter antennas for microwave sensing, it must find solutions for the problems of spacecraft stability while faced with movement reactions and thermal loading on structures. These challenges alone, and the potential solutions required, without regard to payloads, warrant our support for the project. The proposed payload is whipped-cream, on top.

We see, in this outline of events from the first ATS geostationary spacecraft to the next generation of GOES, a symbiosis of parallel programs: NOAA's decision to seek a staring imaging system with high resolution (1 km at nadir) and precise navigation of pixels (to permit calculation of winds from clouds seen in time-sequence views) has led to space industry efforts to solve stability problems with today's technology. This available industrial know-how permits planning for a Geostationary Platform, a vehicle which requires a three-axis spacecraft for its scientific goals. Its data collection will assist NOAA serve its data users. And, most important of all in the present time-frame, the Geostationary Platform's need to surpass GOES-I in stability and navigation will allow NOAA to purchase of a better spacecraft when the need arises.

Whether or not the NASA Geostationary Platform becomes a carrier for NOAA's operational instruments, we see that the Platform will greatly enhance the information flow to the same data users that NOAA serves, and advance future space technology for operations and research.