Western Region Technical Attachment
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GOES I-M UPDATE

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NOAA has two types of satellites that are used to support operations. They are the Geostationary Operational Environmental Satellite (GOES) and the Polar Operational Environmental Satellite (POES). POES is a polar orbiting satellite series of spacecraft to which only a few people in Western Region (WR) have real-time access. Real-time access requires a ground acquisition and processing capacity such as the HIPS system recently installed at the San Francisco WSFO. GOES is the satellite series with which most field forecasters are familiar. GOES orbits the earth at the same speed as the earth rotates, so the satellite appears to remain stationary above the equator. The current GOES 1 through 7 series has survived well beyond its expected design lifetime. NOAA has been in the process of developing the next generation of GOES satellites, called GOES I-M, to replace the current system. There are five satellites scheduled to be built in this series, starting with GOES-I, and ending with GOES-M. This Technical Attachment (TA) will summarize some of the key differences between the current GOES series and GOES I-M. A brief description of the schedule is also provided.

It is important to note that while the National Weather Service (NWS) is one of the primary users of GOES, another NOAA agency is actually responsible for the procurement and operations of GOES. This agency is the National Environmental Satellite, Data, and Information Service (NESDIS). NESDIS, along with technical assistance from NASA, is the lead agency in procuring GOES I-M. Ford Aerospace was originally the prime GOES I-M contractor. Space System/Loral bought out the Ford Aerospace division and is now the lead contractor. ITT Aerospace/Communications division is building the imager and sounder.

While the GOES name is retained for both generations of satellites, it is important to understand that they operate in fundamentally different ways. Each design has its strengths and weaknesses. The current GOES series employs a spacecraft that rotates or spins. The imager and sounder are attached to this spinning spacecraft and, therefore, also rotate. This type of design has several unique characteristics. In space, the side of the spacecraft that faces the sun becomes very hot while the side facing toward space becomes very cold. Large temperature gradients across the spacecraft's structure can cause the spacecraft structure to distort or warp. By spinning the satellite, heat is distributed more uniformly across the spacecraft and distortion is reduced. The optics associated with the instruments shift up and down as the instrument scans the earth. Since the satellite is essentially in a zero friction environment, the spacecraft will respond with a proportional reaction opposite to the movement of the optics. Since precise navigation is important for displaying images, this wobbling effect is undesirable. By spinning the entire spacecraft, the mass of the spacecraft acts as a large gyro; but the spinning satellite also has disadvantages. On a spinning satellite, the instruments scan across the earth, then the optics rachet down; on the next revolution

the instruments scan across the earth, a little further to the south. As a result, the instruments are pointed away from earth over 90 percent of the time. Another problem is that the solar cells, which generate power, are located on the body of the spacecraft. At any one time, only a fraction of the solar cells are facing toward the sun.

GOES I-M is a three-axis stabilized spacecraft. This means that the spacecraft tries to remain perfectly stationary in space. The instrument optics move in two directions, east-west and north-south, which enable the satellite to scan the earth in a rectangular array (Fig. 1). This design also has several unique characteristics. The instruments can be pointed at the earth almost continuously (Fig. 2) which allows for more time to be spent sensing an area. This reduces signal or noise errors and provides the potential to improve the quality of the data. The advantages of a three-axis stabilized platform are that large arrays of solar cells can be deployed and aimed toward the sun. However, remaining motionless is space is a challenge. The stress and torque created by differential heating and the movement of the instrument's optics creates a challenge to maintain good pixel to pixel navigation within the image. NESDIS and the contractors have developed several approaches to help compensate for these effects.

When GOES-I replaces GOES-7, there will be changes in the types of satellite products distributed to the field. An imager is the instrument that systemically scans the earth, and produces the satellite data most commonly used by the field forecaster. In the current GOES system, the imager is capable of imaging in two channels, a 1 km resolution visible channel and a 8 km IR channel. The GOES I-M imager will be able to produce five channels. The channels are 1 km visible, 4 km IR, 8 km 6.7 micron water vapor, and two new channels. The new channels are a 3.9 micron channel which should enable the forecaster to track low-level clouds at night, and a 12 micron near IR which is sensitive to changes in sea surface temperatures. Also note that the resolution of the IR image is improved from 8 km to 4 km, which should improve the ability to delineate cloud features. The term channel is used since the instruments do not scan in precisely one wavelength, but rather in a range of wavelengths. For example, the 6.7 micron water vapor image is really an image produced from a channel that ranges from 6.6 to 7.0 microns.

Most field forecasters do not directly use GOES sounder products. Generally, the sounder dwells over an area at a much slower rate and scans in many more channels. The sounder is used to produce soundings and derived products for use in NMC models and by other special user groups. However, one very popular exception has been the 6.7 water vapor imagery which is currently produced by the GOES-7 sounder. In GOES I-M, the 6.7 water vapor channel is moved into the imager. The GOES I-M sounder scans in 19 channels or wavelengths. In the current GOES series, the imager and sounder could not be operated independently. As a result, sounding data were not available for NMC when special rapid scans were required for severe weather operations. In the GOES I-M series, the imager and sounder can be operated independently.

There is one area where the GOES I-M will not be better than the current series. To improve the signal to noise resolution of the sensors and, therefore the quality of the images, the GOES I-M imager actually scans slower than the current GOES system. To provide a rough comparison, GOES-7 can produce a full disk image in about 18 minutes. Engineering estimates for GOES-I indicate that a full disk image will take approximately 26 to 29 minutes.

This slower scan speed is partially offset by the ability of GOES-I imager to scan smaller areas, such as the United States. The GOES satellite is a resource used by a large and diverse domestic and international community. There have been several meetings to develop a scan strategy that can produce both rapid scans of the U.S. to support NWS warning operations, (i.e., 15 minute) and yet produce the required full disk imagery.

GOES I-M has suffered many schedule setbacks during development. The three-axis stabilized platform presented many new problems that had to be overcome. As a result, the program is well behind the original schedule. However, GOES-I is now completing its last series of integrated vacuum and thermal tests. The current target date for launching GOES-I is April 1994. However, the reader is cautioned that there are still many activities that are required to be completed before the spacecraft can be launched. The April 1994 launch date should be viewed as a target date.

Since this is the first spacecraft in the series, the checkout period is fairly extensive once the spacecraft is in space. NESDIS has developed an extensive operational readiness and product assurance plan to thoroughly check out the spacecraft. NESDIS and NASA will be testing and calibrating the instruments and navigation system. These are important tests, since NESDIS needs to discover any flaws, develop procedures to correct the operational data, and modify the remaining four spacecraft before they are launched. GOES-I will not be available operationally to the user community for approximately the first six months after launch. This six-month checkout period can be reduced if the tests go better than anticipated or some other exigency occurs. We will continue to update the field on the launch schedule and operational readiness testing through updates published in the WR Staff Notes.

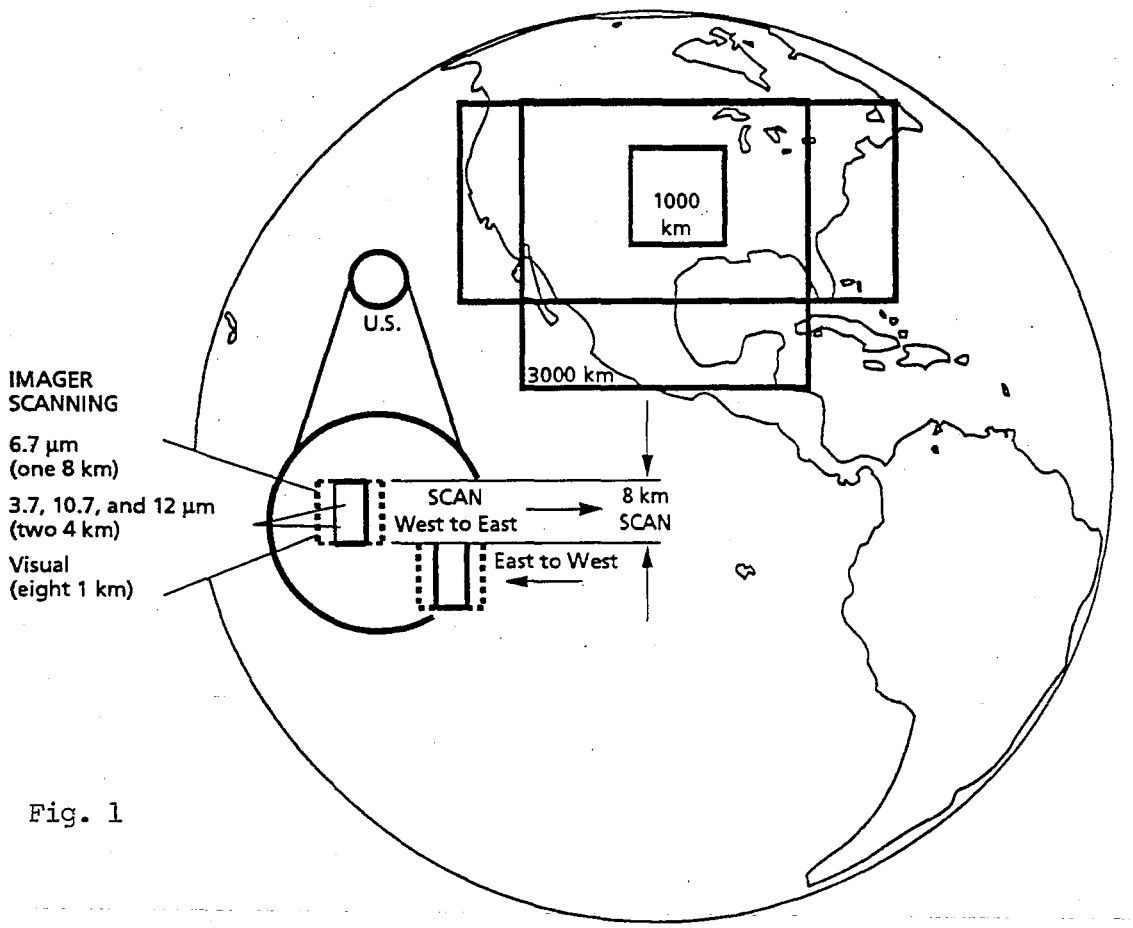

Fig. 1

Spacecraft On-Orbit Configuration

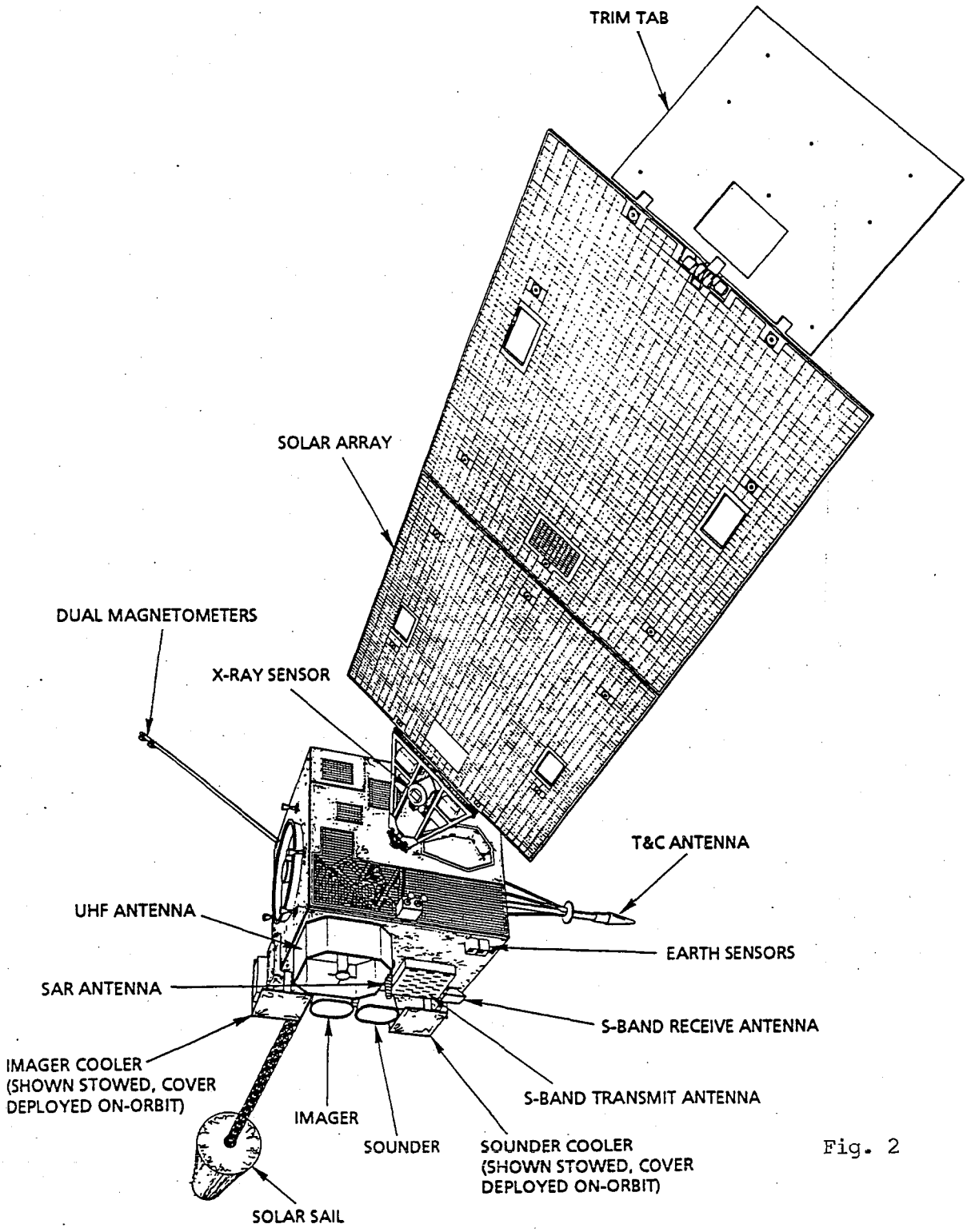

Fig. 2