General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

NASA TM X- *71108*

GEOSYNCHRONOUS METEOROLOGICAL SATELLITE DATA SEMINAR

MARCH 1976

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

GEOSYNCHRONOUS METEOROLOGICAL SATELLITE DATA SEMINAR

December 8 and 9, 1975

Seminar Chairman: William E. Shenk, GSFC
Seminar Arrangements: Edward Puccinelli, GSFC
Report Compilation: Cornelius J. Callahan, GE/MATSCO

March 1976

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

GEOSYNCHRONOUS METEOROLOGICAL
SATELLITE DATA SEMINAR

ABSTRACT

This seminar was organized by NASA to acquaint the
meteorological community with data now available, and
data scheduled to be available in future, from geosyn-
chronous meteorological satellites. Twenty-four
papers were presented in three half-day sessions in
addition to tours of the Image Display and Landsat
Processing Facilities during the afternoon of the
second day. Attendees are listed in the Appendix.
A copy of this report has been furnished to each
attendee. Additional copies may be obtained from:

William E. Shenk, Code 911
Goddard Space Flight Center
Greenbelt, Maryland 20771

CONTENTS

CONTENTS (Continued)

SESSION A

SMS-ATS RAW DATA PRODUCT CAPABILITIES

INTRODUCTION

W. Shenk, GSFC

The Geosynchronous Meterological Satellite Data Seminar was organized to inform the meteorological community of the availability of measurements from the current geosynchronous satellites and to acquaint them with the information that is expected from future geosynchronous satellite systems. A series of detailed presentations indicated how the current data are processed and in what form they will be made available to users.

The Seminar covered three major areas. First, the processing systems of the Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite (SMS/GOES) and the ATS-6 Geosynchronous Very High Resolution Radiometer (GVHRR) were presented, together with the form in which the measurements will be made available. The National Space Science Data Center (NSSDC) will distribute these data to the users. Second, the GSFC analysis capabilities were presented, along with some preliminary scientific results to illustrate the utility of current geosynchronous satellite measurements. Finally, future plans for satellite systems were discussed, including plans for instruments and spacecraft, as well as for the ground processing and analysis facilities that are required for effectively utilizing the measurements.

DESCRIPTION OF SMS VISSR

J. Phenix, GSFC

GENERAL

The visible infrared spin-scan readiometer (VISSR), supplied by the Santa Barbara Research Center, operates as an integral part of the Synchronous Meteorological Satellite (SMS). The SMS is placed in orbit at synchronous altitude (35.9 by 10^3 km) in a plane orthogonal to the Earth's spin axis. VISSR provides both day and night mapping capability with a satellite subpoint resolution of approximately 900 m (0.5 nmi) in daylight and 9 km (5 nmi) at night.

Three VISSR's are presently operating satisfactorily in geosynchronous orbit: SMS-1, launched May 17, 1974 (23,000 infrared/visible pictures); SMS-2, launched February 6, 1975 (12,000 infrared/visible pictures); and GOES-1, launched October 14, 1975 (5 infrared/visible pictures on standby).

MECHANICAL

The scanner is approximately 1.52 m (60 in.) long, 0.65 m (25.5 in.) in diameter, and weighs 65kg (143.4lb). The electronics module occupies 7375 cm^3 (450 in.^{3}) and weighs 5.9 km (13 lb). The total weight of the VISSR subsystem comprises 25 percent of the in-orbit satellite weight. The structure and all three optical mirrors are fabricated from beryllium for weight and structural-optical stability.

OPTICS

Energy from the scan mirror is collected by a Ritchey-Chretien optical system. The 40.64-cm (16-in.) diameter optics has a 291.34-cm (114.7-in.) focal length and a focal ratio of f/7.2. The optical system includes a baffle that extends from the primary mirror center section to minimize the effects of scattered radiation. Energy in the visible region is collected by eight fiber optics apertures arranged at the principal focal plane of the telescope to form the defining 0.200- by 0.250-mr (field stop) linear array. The other end of the individual fibers is optically integrated with eight photomultiplier tubes having the desired 0.55- to 0.75-μm response. In addition, the prime focal plane is relayed to the radiation cooler cold plate by the use of two germanium relay lenses. The relay configuration is also used to increase the overall optical speed to f/1.28 relative to the thermal channel detectors. Two 0.126- by 126-mm

(0.005- by 0.005-in.) HgCdTe long wavelength detectors are mounted on the radiation cooler cold plate. An optical filter between the final relay lens and the detectors restricts the energy to the 10.5- to 12.6-μm wavelength bandpass.

The focus of both the visible channels and the thermal channels can be adjusted during flight by command. In the visible channel, the prism containing the fiber optics is moved back and forth in the focal plane. Each visible focus command moves the visible detectors 0.01168 mm (0.00046 in.). The thermal channel is focused by moving the relay lens system relative to the detector. Each focus command moves the relay lens assembly 0.00635 mm (0.00025 in.).

RADIATION COOLER

A radiation cooler is used to cool the long wavelength detector of the thermal channel to a nominal, controlled temperature of 95 K. The cooler is actually designed to achieve a temperature of 77 K in consideration of possible increased heat load by additional detectors for future sounder missions. The cooler has two stages plus an ambient shield. Both stages of the cooler have heaters that can be used to remove suspected contamination that might collect on the high-emissivity and high-reflectivity surfaces. Stage 1 has a 33.5-w heater and Stage 2 has a 3.0-w heater. During normal cooler operation, Stage 2 is used as a proportional heater in the servo system that maintains the detector temperature at a predetermined value. At launch, and until the satellite is in a synchronous orbit, a cover is installed over the VISSR radiation cooler. The cover is tightly sealed to the cooler sunshield to prevent contamination from entering the cooler and is removed by a pyrotechnic device on command.

SCAN-MIRROR DRIVE

The scan mirror rotates 10 degrees in 1821 steps (one step per spacecraft spin) to complete a full-Earth disk picture in 18.2 minutes. The mirror is then returned to its top-of-frame position in approximately 2 minutes. This motion is provided by one of two torque-motor encoder systems located on the minor axis of the eliptical scan mirror. In addition, this drive system possesses partial frame capability for viewing regions of interest in shorter time intervals.

PICTURE FORMAT

The VISSR is used in the spin-stabilized geostationary satellite (SMS) as shown in Figure 1. The mapping raster is formed by the combination of the satellite spin motion and a step action of the scanning optics. One raster line, corresponding to the Earth's west-east axis (longitude), is formed for each revolution of the spinning satellite, and the scanner positions
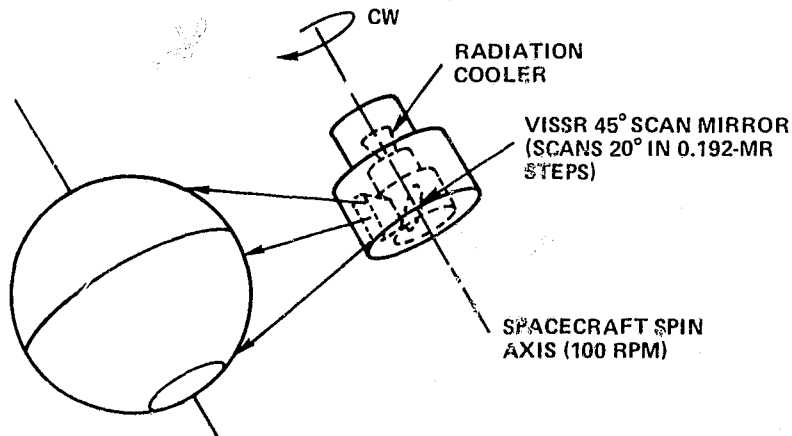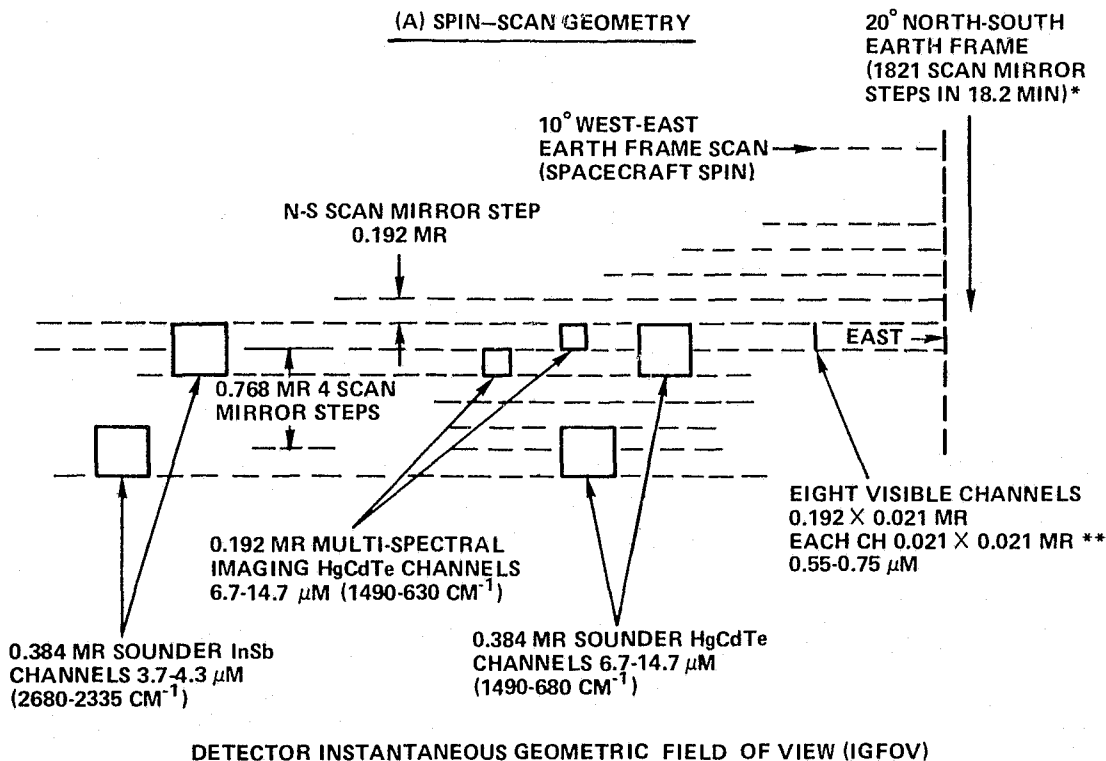
CW

RADIATION COOLER

VISSR 45° SCAN MIRROR (SCANS 20° IN 0.192-MR STEPS)

SPACECRAFT SPIN AXIS (100 RPM)

(A) SPIN—SCAN GEOMETRY

20° NORTH-SOUTH EARTH FRAME (1821 SCAN MIRROR STEPS IN 18.2 MIN)*

10° WEST-EAST EARTH FRAME SCAN (SPACECRAFT SPIN)

N-S SCAN MIRROR STEP 0.192 MR

EAST

0.768 MR 4 SCAN MIRROR STEPS

EIGHT VISIBLE CHANNELS 0.192 X 0.021 MR EACH CH 0.021 X 0.021 MR ** 0.55-0.75 μM

0.192 MR MULTI-SPECTRAL IMAGING HgCdTe CHANNELS 6.7-14.7 μM (1490-630 CM⁻¹)

0.384 MR SOUNDER InSb CHANNELS 3.7-4.3 μM (2680-2335 CM⁻¹)

0.384 MR SOUNDER HgCdTe CHANNELS 6.7-14.7 μM (1490-680 CM⁻¹)

DETECTOR INSTANTANEOUS GEOMETRIC FIELD OF VIEW (IGFOV)

(B) PICTURE DATA FORMAT (NOT TO SCALE)

NOTE: ONE INFRARED DETECTOR PAIR USED DURING EACH SCAN LINE (PERMITS USE OF UNMODIFIED SPACECRAFT MULTIPLEXER)

* NORMAL VISSR AND MULTISPECTRAL IMAGING MODE
** 0.021 X 0.021 MR GOES D, 0.020 X 0.025 MR GOES E, F

Figure 1. VISSR Atmospheric Sounder/Spacecraft Spin–Scan Geometry and Picture Data Format Arrangement

6

each successive line in the north-south (latitude) direction. Each 0.192-mr north-south axis scan step corresponds to the total field of view of the eight visible channel detectors. The 900-m (1/2 nmi) resolution in the visible region is obtained by using a linear array of eight detectors aligned so that they sweep the complete scan-line path. The instantaneous geometric field of view (IGFOV) of each of the visible channels is 0.025 by 0.025 mr, allowing 20-percent underlap between detectors for fabrication considerations. The Earth is covered in the north-south direction with 1821 successive latitude steps until 20-degree coverage is attained. The visible channel array scans the Earth first, followed by the primary infrared (IR) channel with a delay of 945 μr. After an additional delay of 419 μr, the redundant thermal sensor scans the same Earth point.

PERFORMANCE/DESIGN SUMMARY

Table 1 summarizes the VISSR performance characteristics. A more detailed discussion relative to all three VISSR's is contained in "Visible Infrared Spin-Scan Radiometer (VISSR) for a Synchronous Meteorological Spacecraft (SMS)," (Santa Barbara Research Center), T. M. Abbott, September 20, 1974.

DATA DISTRIBUTION

The VISSR provides analog signals to the SMS spacecraft, which in turn digitizes and transmits the IR and visible information to the Command and Data Acquistion Station operated by National Oceanic and Atmospheric Administration/ National Environmental Satellite Service (NOAA/NESS) at Wallops Island, Virginia. This information is stretched from 30 mps to 1.75 mps and is retransmitted through the SMS to NESS at Suitland, Maryland, where it is relayed to the Satellite Service's Central Facility. From there, both IR and sectorized visible images are transmitted through telephone lines to Satellite Field Service Stations throughout the United States.

Table 1
Performance/Design Summary

Design Parameters	Visible Channel	Thermal Channel
Number of Channels	8	1 plus 1 redundant channel
Wavelength Band of Operation, Half-Power Points	0.54-0.7 microns	10.5-12.6 microns
Instantaneous Geometric Field of View (IGFOV)	0.025x0.021 mr	0.25x0.25 mr
Collecting Aperture	1090 cm^2	1090 cm^2
Detector	PMT	HgCdTe
Size	---	0.105x0.105 mm
Response	S-20 (enhanced)	---
Scan Period	0.6 sec	0.6 sec
Dwell Time	2.4×10^{-6} sec	1.9×10^{-5} sec
Information Bandwidth (a)	210 kHz	26 kHz
Dynamic Range, Albedo (%); Target Temperature (°K)	0 to 100	0 to 315

Performance Characteristics	Visible Channel	Thermal Channel
Noise Equivalent Radiance, NEN for an Extended Source (watt cm^{-2} sterad^{-1})	---	1×10^{-5}
Noise Equivalent Differential Temperature for an Extended Source	---	3.0 K at 200 K 0.4 K at 300 K
S/N at 0.5% Albedo, for an Extended Source	3:1	
Modulation Transfer Function	0.34 at 2×10^4 cycles/rad	0.42 at 2.5×10^3 cycles/rad
V_p/V_{ss}, Target Size Equal to IGFOV's, Includes Optical Response Factors (Approximate)	0.45	0.55

Physical Characteristics	Scanner	Electronics Module
Estimated Weight	63.3 kg	6.4 kg
Size (b)	152 cm x64.7 cm (diameter)	7.3 liters
Power Requirements	20 watts	
Inflight Calibration Provisions	Visible Channel 1. Sun and Space 2. Electronics Gain and Linearity Thermal Channel 1. Sun and Space 2. Calibration Blackbody and Space 3. Electronics Gain and Linearity	

DESCRIPTION OF ATS-6 GVHRR

T. Cherrix, GSFC

VHRR SYSTEM OPERATION

The very high resolution radiometer (VHRR) is designed to operate from synchronous orbit and to continously observe cloudcover motion over a large portion of the Earth's surface. The instrument, shown in Figure 1, operates in both the infrared and visible regions of the electromagnetic spectrum. In the infrared channel, images of the full earth are generated both day and night. The instrument is capable of precise temperature measurement from which cloud height can be inferred. In cloud-free regions, surface temperatures may be observed. The visible channel provides daytime cloud images of high spatial resolution and precise albedo measurement.

The instrument normally scans a 20- by 20-degree field of view; a special operational mode permits a segment of 5 by 20 degrees to be scanned. The infrared channel measures radiation between 10.5 and 12.5 microns. In this channel, the field of view is 0.3 milliradians, which corresponds to a ground resolution of 6.7 miles (6.2 has been achieved). The infrared channel was specified as having capable of measuring 1.5 K at 200 K with a goal of 1 K at 200 K, and 0.5 K at 300 K with a goal of 0.35 K. The visible channel measures radiation between 0.55 and 0.75 microns. In this channel, the field of view is 0.15 milliradians which corresponds to a ground resolution of 3.35 miles (3.2 has been recorded). The visible-channel albedo measurement is 1 ±0.5 percent. The spatial position tolerance of each element over the entire image is 1/6-resolution element. In addition, the registration between the visible and IR channels is 1/6-resolution element. Figure 2 is a block diagram of the VHRR instrument. A scan mirror mounted at 45 degrees produces a scanning motion about two axes. The fast scan motion of approximately 20 degrees per second parallel to the equator produces alternately east-to-west followed by west-to-east Earth scans. The fast scan motion of approximately 20 degrees per 20 minutes parallel to the poles produces the south-to-north Earth scan.

The scan mirror is servo-driven. The servo utilizes brushless dc torque motors and an inductive encoder for the position reference. Both slow-scan and fast-scan servos are basically similar. Radiation reflected from the scan mirror is collected and focused by an 8-inch Dall-Kirkhan Cassegrain telescope. At the focus of the telescope, the radiation is split into two directions by an optical chopper, as shown in Figure 3. This chopper is located at 45 degrees relative to the telescope axis. The radiation reflected from the chopper passes through a relay lens, then through an infrared bandpass filter which passes 10.5 to 12.5 microns, and is focused on the infrared detector.

9

SERVO-
SCAN
PLATFORM

OPTICAL
PORT

OPTICAL
ASSEMBLY

RADIANT
COOLER AND
SUNSHIELD
ASSEMBLY

VISIBLE
CALIBRATION
PORT
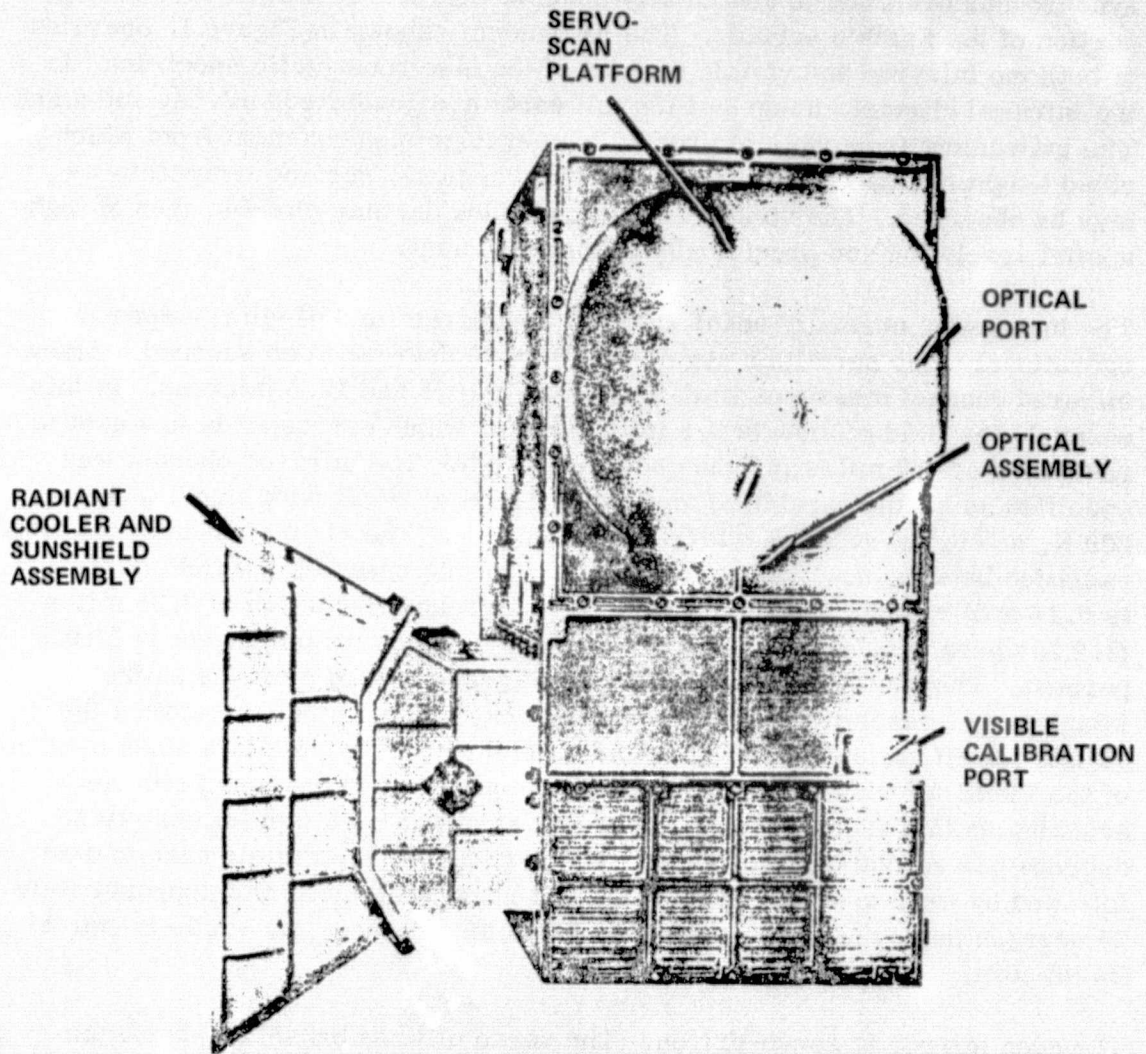
Figure 1. Very High Resolution Radiometer Optical Port View

Figure 2. VHRR Instrument Block Diagram

INFRARED DETECTOR
AND
COOLER

MIRROR
CHOPPER

SECONDARY
MIRROR

VISIBLE
DETECTOR

TEMPERATURE CONTROLLED
BLACKBODY REFERENCE

PRIMARY
MIRROR

Figure 3. Optical Detector Block Diagram

The infrared detector is a Mercury Cadmium Telluride type. While the radiation is passing between the chopper blades, the infrared detector is viewing a blackbody reference which is maintained at a temperature of 340 K. Therefore, the output of the detector is a signal proportional to the difference between the blackbody reference temperature and the temperature of the scene. The Mercury Cadmium Telluride detector is cooled to its 120 K operating temperature by a radiant cooler.

Radiation passing directly between the chopper blades goes through another relay lens—visible filter which passes 0.55 to 0.75 microns—and is focused on two silicon photodiodes. The diodes are located in a single package, one above the other. In this way, two lines of visible information are obtained simultaneously. The two output signals from the visible detectors and the signal from the infrared detector are amplified by an ac amplifier, synchronously demodulated, and filtered to the appropriate bandwidth by a low-pass filter. This analog information is frequency-modulated by a voltage-controlled oscillator. Visible channel 1 has a carrier frequency of 32 kHz. Visible channel 2 has a carrier frequency of 48 kHz, and the infrared (IR) channel has a carrier frequency of 176 kHz. The three channels are added, and the output represents the analog data output from the system. The VHRR also has a digital data output. In the IR channel, the data are read twice per each resolution element. Data are converted to 9-bit binary words by an analog-to-digital (A/D) converter.

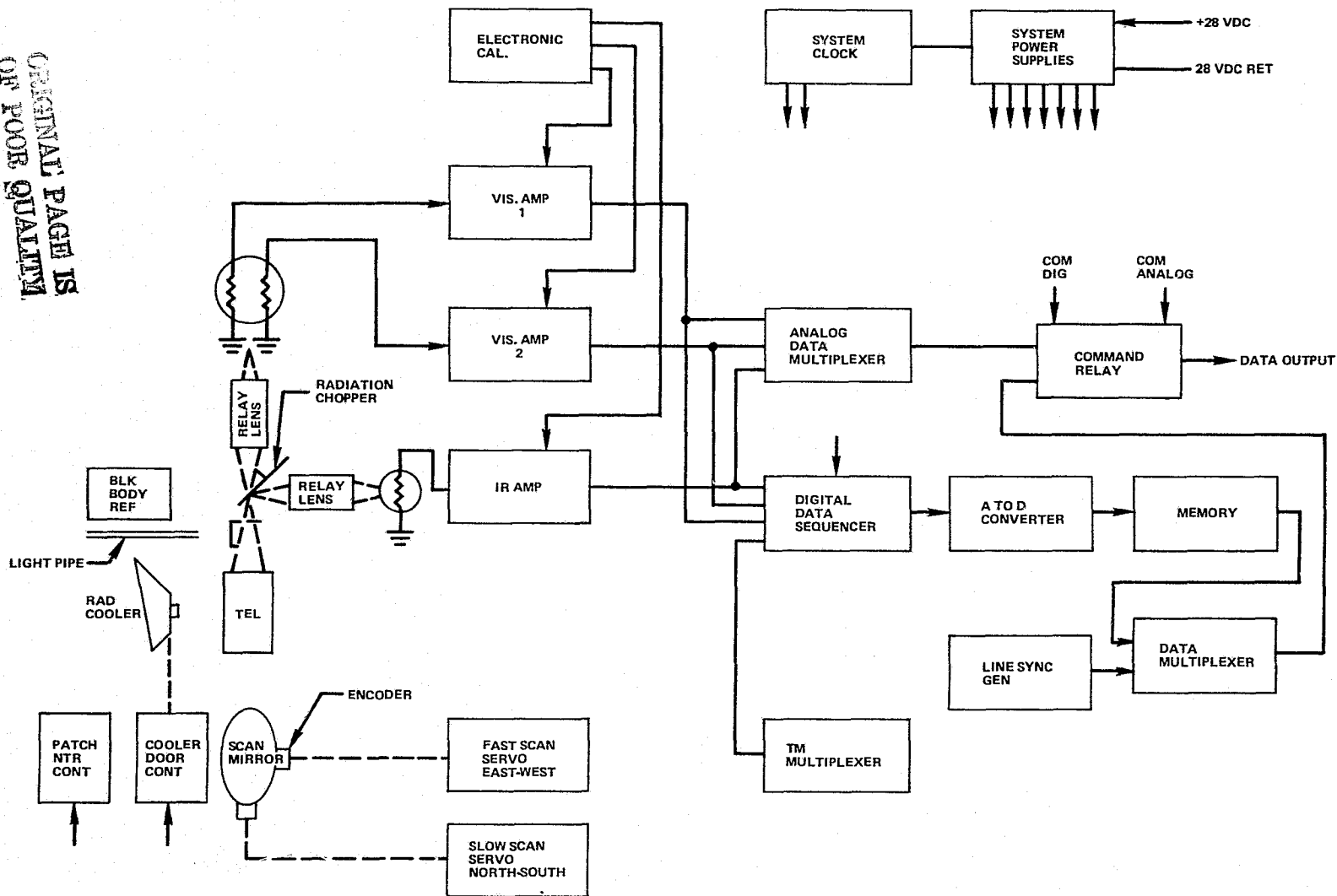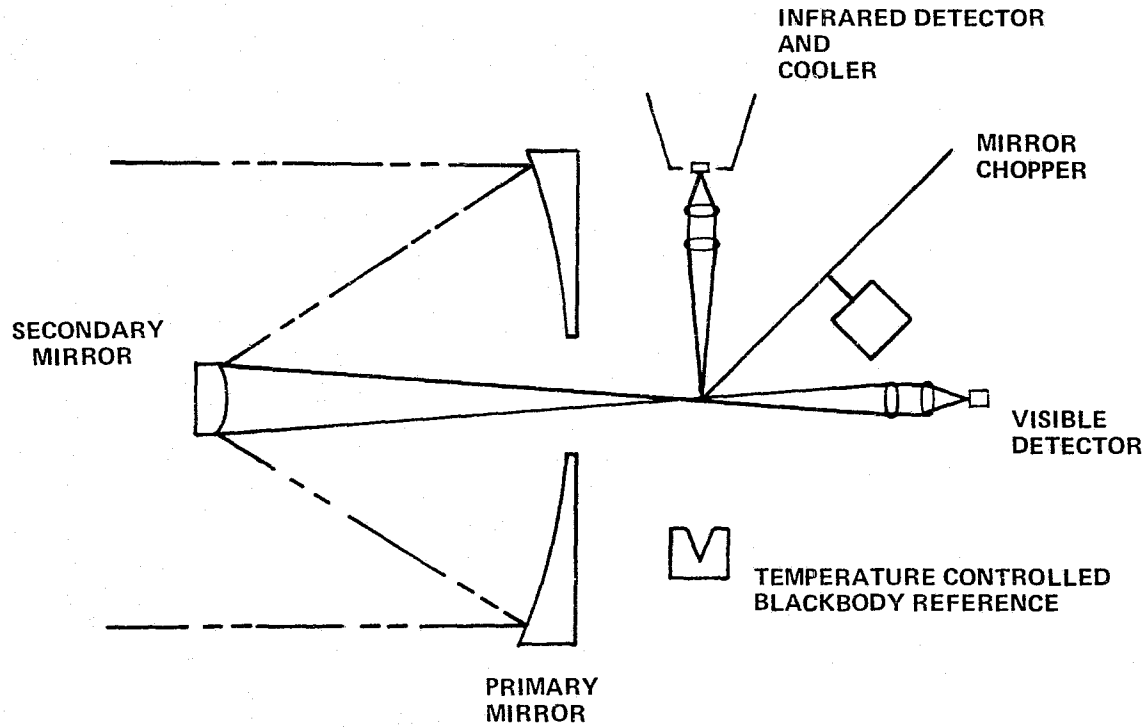One word of telemetry data is multiplexed into the main bit stream at the end of each scan line. The digital data are converted to a biphase form and sent to the command relay. On ground command, the command relay can select either the analog output or the digital output from the system.

In the visible channel, onboard calibration is accomplished by using a fiber optic light pipe. The light pipe is situated so that it periodically observes the sun. On ground command, a rotary solenoid reflects the light into the visible optical channel. In the IR channel, two calibration points are required. The first is a cold-space reference which occurs at the beginning and/or end of each scan line. The second calibration point is obtained by programming a slow-scan servo to observe the instrument optical cavity once during each scan sequence. The scan cavity contains a honeycomb blackbody surface larger than the scan mirror. Five platinum resistor thermocouples monitor the temperature of this calibration blackbody. Temperature data are transmitted by digital and analog telemetry through spacecraft telemetry channels. To ensure the linearity and accuracy of the electronic data channels, an electronic calibration circuit has been included in the system. The electronic calibration introduces a six-step calibration voltage. This calibration occurs at the beginning of each scan line.

SERVO OPERATION

The first command, Servo Power ON (or Reset), causes power to be applied to the servo system, clears all memory elements and initiates the servo reset-slew mode (Figure 4). The duration of the reset-slew modes is 2 minutes and 56 seconds. During this time, the scan mirror is servo-driven about two orthogonal axes (yoke or slow scan on vertical field and gimbal or fast scan on horizontal field) toward mechanical stop or index positions. This is necessary to establish the absolute position of the mirror with respect to the optical port. The position feedback device for each servo is a 360-pole inductosyn that has a 2-degree cycle. The slow-scan servo is driven at 5/8 degree per second until an electrical stop senses when the slow-scan index position has been obtained. At this time, the slow-scan servo is nulled and stopped, and no additional slow-scan sequencing is initated until the reset-slew time has elapsed. Operation for the fast-scan servo is essentially the same, except that it is driven at 75/1024 degrees per second. When the reset-slew mode times out, the mirror will have been referenced to the optical port for a full-Earth view if the satellite is directed toward Rosman, N. C. If the satellite is directed toward the Equator, the mirror will have to be offset in the slow-scan axis before an untruncated full-Earth view can be obtained. This necessitates servo coordinate commands. Earth views resulting from the four possible combinations of satellite coordinates and servo coordinates are shown in Figure 5. The second servo command, Rosman or Equator, enables the scan-mirror slow-scan axis to be offset from the mechanical stop. If Rosman is given, no offset occurs. If Equator is given, the slow-scan servo of the mirror will be slewed to an offset position 6 degrees away from the mechanical stop.

The selection for either of these two commands must be made during the 2-minute 56-second reset time period, and, if no selection is made, Rosman will be selected automatically. If Equator has been selected, the offset slew will occur at the completion of the reset time period. This completes the offset slew mode. The third step, in preparation for a scanning sequence if other than a full-frame scan is desired, requires selecting the desired sector field from the nine available. The sectors are encoded with four command lines as shown in Table 1. This selection must also be made during the 2-minute 56-second reset time period, and, if no selection is made, the scan will set up for a full field automatically. If a sector selection (other than sector 1) is made in either coordinate system, the slow-scan axis of the mirror will be driven to the new starting position at the end of the offset slew mode. This completes the sector slew mode and enables the servo to enter a scan sequence. Both servos will hold the mirror in a state of readiness at the commanded start position until the scan command is given. If the scan command has been given during the reset time period, a scanning sequence will start immediately at the completion of reset slew, offset slew, or sector slew depending on the

15

COMMAND

ACTION

① SELECT "POWER ON" OR "RESET" → RESET → RESET SLEW

② SELECT COORDINATES → ROSMAN   EQUATOR → OFFSET SLEW

③ SELECT SECTOR → 1   2   4   8 → SECTOR SLEW

④ SELECT SCAN → SCAN → SCAN SEQUENCE

CALIBRATE   NOT A COMMAND → CALIBRATE SEQUENCE

SERVO OFF

⑤ SELECT AUTO OR SINGLE → AUTOMATIC   SINGLE

AUTO   SINGLE

SERVO OFF AT END OF CALIBRATE SEQUENCE
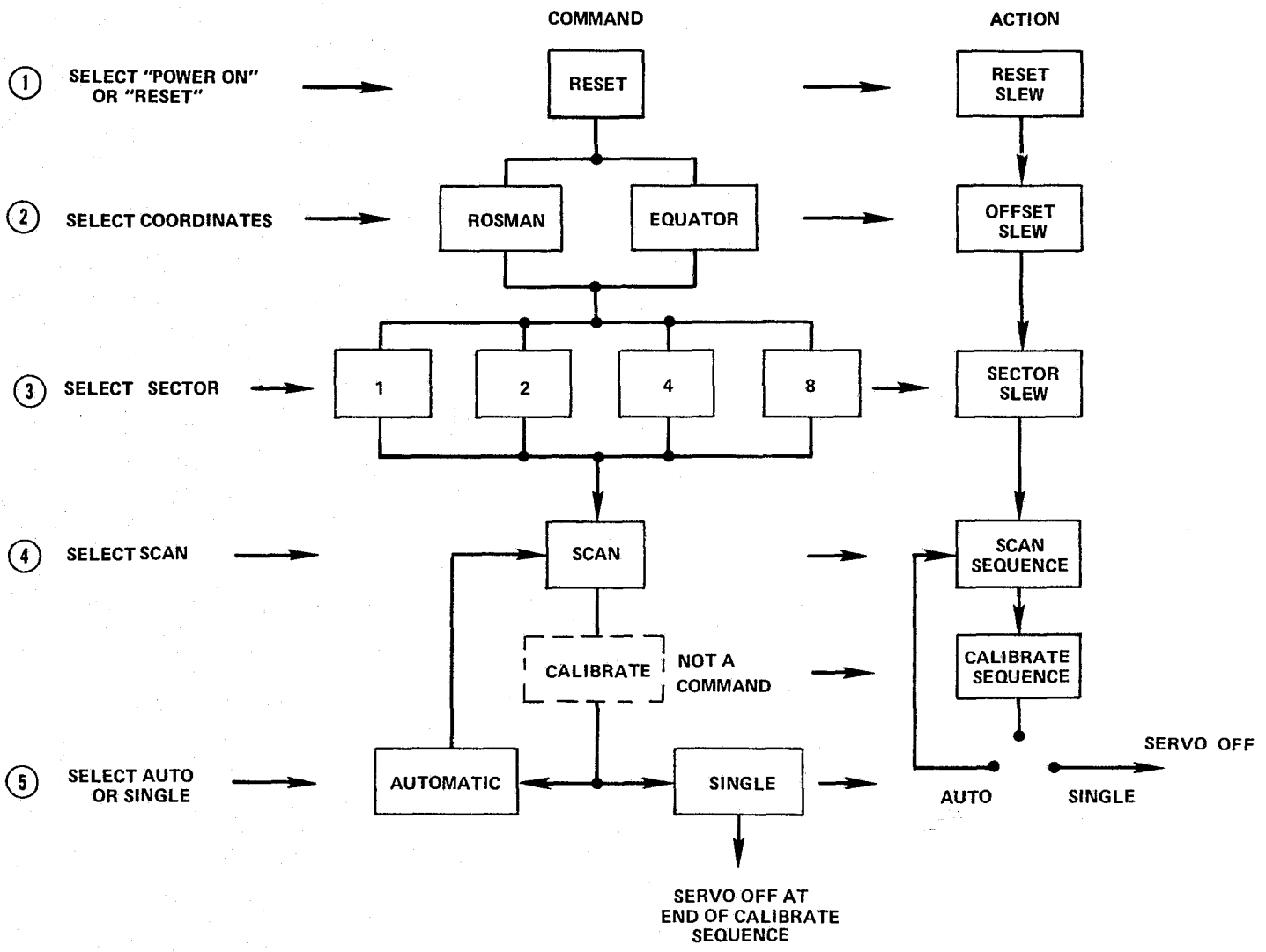
Figure 4.   Servo Command Sequence and Action
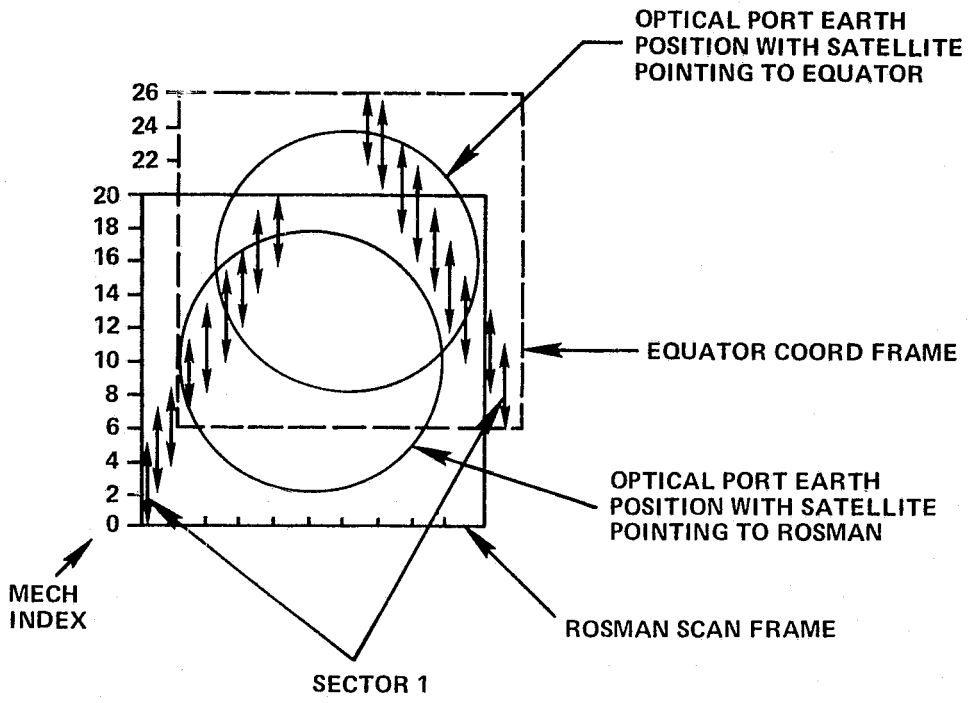
SERVO COORDINATES SELECTED	SATELLITE POINTING	FULL-FRAME VIEW
ROSMAN	ROSMAN	◻
ROSMAN	EQUATOR	◻
EQUATOR	ROSMAN	◻
EQUATOR	EQUATOR	◻

Figure 5. Earth Views Relative To Satellite Pointing and Servo Coordinates Selected

Table 1
Sector Field Command Lines*

Sector Command	1	2	4	8	Degrees Rotation From Mechanical Index Position			
					Rosman Coordinate		Equator Coordinate	
					SS Start	SS Finish	SS Start	SS Finish
Full Frame	0	0	0	0	0	20	6	26
1	1	0	0	0	0	5	6	11
2	0	1	0	0	2	7	8	13
3	1	1	0	0	4	9	10	15
4	0	0	1	0	6	11	12	17
5	1	0	1	0	8	13	14	19
6	0	1	1	0	10	15	16	21
7	1	1	1	0	12	17	18	23
8	0	0	0	1	14	19	20	25
9	1	0	0	1	16	20	22	26

*Choose desired sector by selecting corresponding binary weighted sector command. Allowable combination shown above. All other combinations (for example, 1, 1, 1, 1) will result in selection of sector 8 or 9.

command selection preceding the scan command. A scanning sequence consists of a viewing sequence and a calibrate sequence. In the scan viewing sequence, both servos of the scan mirror are driven and coordinated so that a two-dimensional field is scanned. First, the fast-scan servo drives the mirror from the fast-scan index position about the gimbal axis at a rate of +10 degrees per second for 1.2 seconds. Then, at that time, the fast-scan servo reverses direction, and the slow-scan servo will increment the entire gimballed mirror assembly 1 arc-minute in a positive direction about yoke axis. The fast-scan servo now drives the mirror back about the gimbal axis at -10 degrees per second for 1.2 seconds, and, when this scan line is completed, the slow-scan servo again increments the gimballed mirror 1 arc-minute in the same positive direction. This coordinated drive continues until the entire field of interest is scanned. At the completion of the viewing sequence, the calibrate sequence is initiated. In this sequence, the fast-scan servo positions the fast-scan axis of the mirror to the center of its active scan range, and the slow-scan axis of the mirror is driven at a constant velocity of 5 degrees per second in a positive direction until it is illuminated by a blackbody calibration target on the

instrument sidewall perpendicular to the plane of the optical port. When this occurs, the slow-scan velocity reverses direction and slews the mirror at -5 degrees per second back to the last commanded start position while the fast-scan servo drives the mirror from its center position to its fixed start position. This completes the calibration slew sequence and the scan sequence. Operation at this time is determined by the state of the auto-single circuits. The fifth step in the command sequence requires selecting auto or single. This selection can be made at any time, and, if no selection is made, auto will be selected automatically. If auto is selected, another scan sequence will be started. If single has been selected, servo power will be removed at the completion of the scanning sequence.

GROUND DATA PREPROCESSING AND ACCOUNTING SYSTEM

P. McKowan, GSFC

This discussion contains an overview of the data handling procedures required for handling image data before the information becomes available to outside users. Included in this discussion are the following subject matter:

a. ATS-6 VHRR Data Reduction System

b. ATS-6 VHRR Data Base

c. SMS/GOES VISSR Data Reduction System

d. SMS/GOES VISSR Data Base

For information concerning the SMS/GOES subject matter, refer to "Data Processing Plan for Synchronous Meteorological and Geostationary Operational Environmental Satellites," NASA/GSFC X-565-75-276, October 1975.

Reference material for the ATS-6 very high resolution radiometer (VHRR) processing system can be found in "Guide for Experimenter Tapes," No. CSC/TM-75/6222 published by Computer Sciences Corporation, December 1975.

DIRECT READOUT GROUND STATION OPERATIONS

H. Ausfresser, Westinghouse

The Direct Readout Ground Station (DRGS) is the prototype of a highly mobile and transportable satellite tracking system developed under NASA sponsorship to receive, record, and display the high-resolution meteorological data transmission from low-orbiting satellites such as Improved TOS Operational Satellite and from geosynchronous satellites such as Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite (SMS/GOES).

The DRGS consists of a trailer-mounted 18-foot-diameter tracking antenna and two tractor-trailer type vans, one an electronics van and the other a support van. The electronics van contains a receiver, demodulator, video processor rack, antenna control rack, two Ampex tape recorders, and laser-beam film recorder display unit and its associated control rack. The support van contains storage space for tapes, film, spares, and support equipment. The support van also provides administrative and repair work spaces.

The DRGS is located near the Baltimore-Washington International Airport. From March 1 through October 31, 1975, the DRGS was used to support the Severe-Storm Analysis Program, operating on a 24 hours-a-day, 7 days-a-week schedule. The primary mission of the DRGS during this period was to acquire the data transmissions of the SMS satellites and to make magnetic tape recordings of the data received. Tape recordings were made on the hour and half-hour except for periods of scheduled maintenance. Approximately 2400 tape recordings were made during this period and were delivered to the National Aeronautics and Space Administration for analysis.

ANALOG-TO-DIGITAL CONVERSION

W. Stallings, GSFC

The analog-to-digital conversion process is performed on the A-3 data processing system located in the Data Processing Branch of the Information Processing Division of the Goddard Space Flight Center (GSFC). The function of the A-3 system is to convert the visual and infrared spin-scan radiometer (VISSR) analog data recorded on analog tape at the direct-readout ground station (DRGS) site to digital data recorded on computer-compatible tape so that the data can be further processed on large-scale general-purpose computers. This process is known as digitizing.

The input to the A-3 system is the VISSR data recorded on wide-band instrumentation tape at the DRGS site. The format of the data is serial pulse-code modulation (PCM) nonreturn to zero (NRZ-S). Five images are normally recorded on each tape. The output tapes from the A-3 system are 1600 character-per-inch computer-compatible tapes that contain 260 scan lines of VISSR data (infrared plus visible). One input analog tape, if fully digitized, would result in approximately 30 digital tapes. The throughput capability of the A-3 system is 80 pictures (260 scan lines each) per 40-hour shift. The system is currently operating for two shifts on VISSR data.

Information on the A-3 system, data formats, and quality reporting can be found in "Data Processing Plan for Synchronous Meteorological and Geostationary Operational Environmental Satellites (SMS/Goes)," P. L. McKowan, NASA/GSFC X-565-75-276, Section 8, October 1975.

DATA PROCESSING AND QUALITY CONTROL

G. Vincent, GSFC

A "VISSR Processing Form" is used to detail the specific tapes, pictures, and scan lines to be processed by the Data Processing Branch. The picture requested is digitized (analog/digital conversion) on the A-3 digitizing line (Figure 1) where a quality printout is output, along with a 9-track intermediate digital tape. This intermediate tape is input to the Univac 1108 computer where the pre-edit phase is accomplished. The output of the Univac 1108 includes accounting cards, quality cards, quality listing, and a 9-track digital pre-edit (PED) tape.

The primary items checked on the quality printouts are label information, scan-line quality and quantity, infrared (IR) bits in error, and visible (VIS) bits in error. The first quality check is determination that the requested picture was digitized. This is established by the quality summary printout, which shows the date of the run and identifies the station, analog tape, and file numbers and start, stop, and elapsed times for picture scan lines. The quality of the picture is judged by the number of incorrect and missing scan lines; by the total number of IR bits in the PN sequence, the number of IR error bits and the resulting percentage of IR error bits, and the IR deep-space values in error; and by similar statistics in the visual and infrared spin-scan radiometer (VISSR) portion of the data. The complete printout for the first and second passes are shown in Figures 2, 3, and 4. (Figure 4 demonstrates "Passed" and "Failed" quality checks.)

Quality problems are usually caused by intermittent difficulties with the recording system and techniques, by recording and processing operator errors, and frequently by degraded data. Any picture that fails the quality criteria is resubmitted to the A-3 line for redigitization. If the picture fails the quality criteria a second time for the same reason, no further redigitization attempts are made. The picture is released for further processing with a notation of the problem encountered and that this is the best quality data available. If it is determined that the A-3 A/D line cannot process a picture, the project engineer is asked to check the picture data to verify the conclusion.

From February through November 1975, 498 pictures were processed of which 159 were IR and 339 were both VISSR and IR. To record these pictures, 1626 tapes were required.
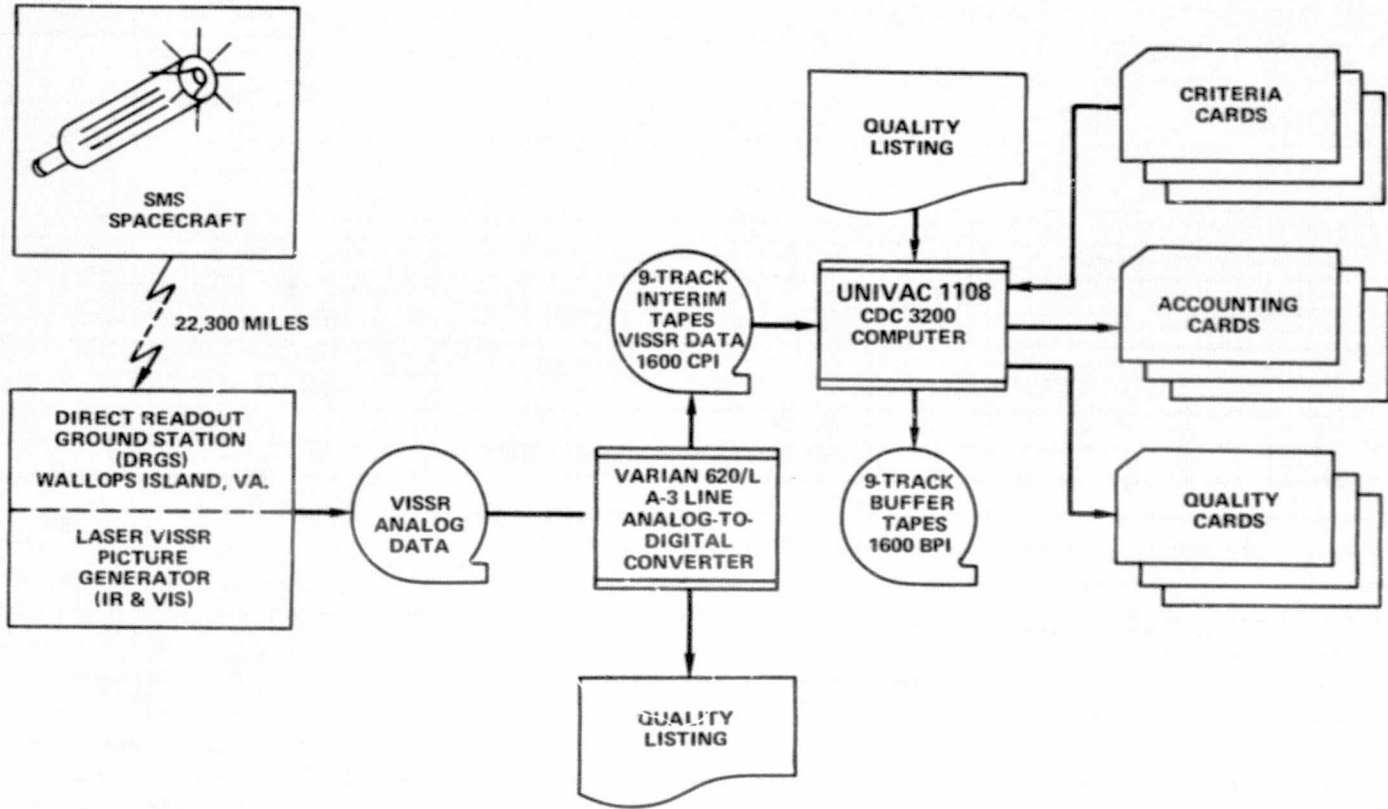
Figure 1. VISSR Data Flow

24

```
                              MEu2  PICTURE DATA

                              PASS (1) QUALITY SUMMARY


SATELLITE   STATION   ANALOG   ANALOG   BUFFER   BUFFER   RECORDED   DIGITIZED   PICTURE
  IDENT      CODE      TAPE     FILE      TAPE     FILE     YYMMDD      YYMMDD      MODE
  ME02       DRG      037665            7665422            750529     750918       A


DIGITAL       DIGITAL        ELAPSED   RECORDS   RECORDS   PERCENT DATA   DROP    PARITY
START TIME    STOP TIME       TIME     EXPECTED   OUTPUT   RECOVERED      LOCKS   ERRORS     LAST SCAN     BAD HITS
HH MM SS FF   HH MM SS FF    SECONDS                                                                       IR     VIS

                                                                                             431
                                                                            END OF TAPE REACHED  19 09 31 00
19 08 21 00   19 09 31 00       70     1983.     2007     100.00       0       14             549          0       0
```

```
 432  433  434  435  436  437  438  439  440  441  442  443  444  445  446  447  448  449  450  451  452  453  454  455  456
 457  458  459  460  461  462  463  464  465  466  467  468  469  470  471  472  473  474  475  476  477  478  479  480  481
 482  483  484  485  486  487  488  489  490  491  492  493  494  495  496  497  498  499  500  501  502  503  504  505  506
 507  508  509  510  511  512  513  514  515  516  517  518  519  520  521  522  523  524  525  526  527  528  529  530  531
 532  533  534  535  536  537  538  539  540  541  542  543  544  545  546  547  548  549 1000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
10000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000100001000010000
```

Figure 2. Pass I Quality Summary Printout

SMS-A PICTURE DATA

PASS (2) QUALITY SUMMARY

DATE OF RUN 01/30/75

SATELLITE IDENT	STATION CODE	ANALOG TAPE	ANALOG FILE	RECORDED YY DDD	START SCAN LINE	STOP SCAN LINE	DIGITIZED YY DDD	ANALOG DECK	BUFFER TAPE	BUFFER FILE	PICTURE MODE	I = INFRARED A = MODE (A) B = MODE (B) C = MODE (C)
ME01	WSP	00501	01	74 219	0500	0523	74 302	C	5012111	01	A	

DIG BUFFER START TIME	DIG BUFFER STOP TIME	ELAPSED TIME	PREDIT FILE START TIME	PREDIT FILE STOP TIME	ELAPSED TIME	PREDIT TAPE	PREDIT FILE	LINE ID	OPER ID	DIGITAL DECK	SHIFT NUM	BUFFER PARITY ERRORS
22 05 31	22 05 45	00 00 13	22 05 31	22 05 45	00 00 13	5012111	01	C6	33	7	1	0001

RECORDS INPUT	RECORDS OUTPUT	PERCENT DATA RECOVERED	PARTIAL RECORDS	FILL RECORDS	INCORRECT SCAN LINES	MISSING SCAN LINES	PERCENT PICT PROCESSED	TIME BIAS GMT VS DOC.	PREDIT PARITY ERRORS
00408	00216	100.00	N/A	N/A	0000	0000	001.31	0001	0000

IR ERROR BITS PN SEQUENCE	TOTAL IR BITS PN SEQUENCE	PERCENTAGE OF IR ERROR BITS	VIS ERROR BITS PN SEQUENCE	TOTAL VIS BITS PN SEQUENCE	PERCENTAGE OF VIS ERROR BITS	DOC. TIME DISCONTINUE	GMT TIME DISCONTINUE
000044	0085988	000.05	000000	1891515	000.00	0002	0000

==*== COMPUTED ONLY FOR IR DATA ====

TIME DECODER FLAGS

			EST. PE FROM PN SEQUENCE	EST. S/N RATIO DB	FILE QUALITY INDEX	IR ERROR RECORDS	VISIBLE RECORDS	IR DATA RECORDS
GOOD FLGS	BAD FLGS	PCENT BAD	05.1X10-4	07.5	090.76	0015	0192	0024
1 0216	0000	000.00						
2 0216	0000	000.00	IR START TIME DDD HH MM SS	IR STOP TIME DDD HH MM SS		WRONG LENGTH RECORDS	DROP LOCKS	
3 0000	0216	100.00	219 22 05 31	219 22 05 45		0000	0000	
4 0216	0000	000.00						
5 0216	0000	000.00						
6 0216	0000	000.00						

CR2 CARD -- E01A052950000200202020205000500205000500050005000500   74217C2

02R CARD -- ME01WSPG501 21C02R50121 40807220522051012111 0500 0523   XXXXXX   3041029

05D CARD -- ME01WSP0501 21C05D012111   133C06   050130

07B CARD -- ME01WSP0501 21C07B01211-   0

P5E CARD -- ME01 74 807 WSP 005011 741029 1 1 1 1 1 1 1 219 220531 220545 A N 0500 0523 Y VR

Q/H CARD -- ME01WSP005011C7421901211100   7953179545021610000001310020000000000574302A3CC

HARDWARE TIME FLAGS DEFINITIONS

1 LEAST SIGNIFICANT COMPARSION
2 MOST SIGNIFICANT COMPARSION
3 INPUT LOW (FLY-WHEEL) MODE
4 TIME DECODER SYNCHRONIZATION
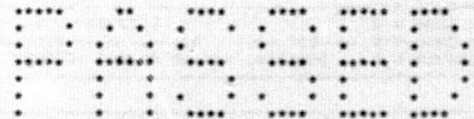5 DATA OUTPUT REGISTER RESET
6 PRESET TIME DECODER OUTPUT

Figure 3. Pass II Quality Summary Printout

26

THS-B PICTURE DATA

PASS 12) QUALITY SUMMARY

DATE OF RUN 10/03/75

SATELLITE IDENT	STATION CODE	ANALOG TAPE	ANALOG FILE	RECORDED YY DDD	START SCAN LINE	STOP SCAN LINE	DIGITIZED YY DDD	ANALOG DECK	BUFFER TAPE	BUFFER FILE	PICTURE MODE	I = INFRARED
WE01	WSP	01016	J	74 251	0070	0330	75 189	A	0161111	1	A	A = MODE (A) B = MODE (B) C = MODE (C)

DIG BUFFER START TIME	DIG BUFFER STOP TIME	ELAPSED TIME	PREDIT FILE START TIME	PREDIT FILE STOP TIME	ELAPSED TIME	PREDIT TAPE	PREDIT FILE	LINE ID	OPER ID	DIGITAL DECK	BUFFER NUM	DRIFT ERRORS
74 01 03	74 03 39	00 02 36	74 01 03	74 03 39	00 02 36	0161111	1	U1	N/A	0	1	0000

RECORDS INPUT	RECORDS OUTPUT	PERCENT DATA RECOVERED	PARTIAL RECORDS	FILL RECORDS	INCORRECT SCAN LINES	MISSING SCAN LINES	PERCENT PICT PROCESSED	TIME BIAS GMT VS DOC	PREDIT PARITY ERRORS
04437	02349	100.00	N/A	N/A	0000	0000	14.33	N/A	0000

IR ERROR BITS PN SEQUENCE	TOTAL IR BITS PN SEQUENCE	PERCENTAGE OF IR ERROR BITS	VIS ERROR BITS PN SEQUENCE	TOTAL VIS BITS PN SEQUENCE	PERCENTAGE OF VIS ERROR BITS	DOC TIME DISCONTINUE	GMT TIME DISCONTINUE
0000002	0997250	.00	0000002	20800020	.00	000300	N/A

------ COMPUTED ONLY FOR IR DATA ------

TIME DECODER FLAGS			WRONG LEN RECORDS	EST. PE FROM PN SEQUENCE	EST. S/N RATIO DB	FILE QUALITY INDEX	IR ERROR RECORDS	VISIBLE RECORDS	IR DATA RECORDS	DROP LOCKS
GOOD FLGS	BAD FLGS	PRCNT BAD	0000				0000	2008	0261	0000
1 2349	00000	.00								
2 2349	00000	.00		IR START TIME	IR STOP TIME	IR DEEP SPACE ERRORS			VIS DEEP SPACE ERRORS	
3 2349	00000	.00		DDD HH MM SS	DDD HH MM SS	WHOLE LINE	LEFT SIDE	RIGHT SIDE	WHOLE LINE	LEFT SIDE	RIGHT SIDE
4 2349	00000	.00		251 14 01 03	251 14 03 39	0020	0020	023A00	0000	0000	0000
5 2349	00000	.00								
6 2349	00000	.00								

CR2 CARD — WE02A05295000020022020205000500020500050005005005005001000 — 7421702

O2R CARD — WE01WSP1016-11C02R01611 4090014011403101611 0070 0330 XXXXXX — 3050708

O5D CARD — WE01WSP1016-11C050001011 — 100001 — 061003

O7D CARD — WE01WSP1016-11C07D010211

PRE CARD — WE01 TS0708 WSP 010161 TS0708 1 1 1 1 1 1 1 251 180103 148939 A M 0070 0330 O VR

O/N CARD — WE01WSP1016 1C07251010111 0 — 5046350010254491800001630005000000020007010001A0

HARDWARE TIME FLAGS DEFINITIONS

1 LEAST SIGNIFICANT COMPARISION
2 MOST SIGNIFICANT COMPARISION
3 INPUT LOW ONLY WHEEL MODE
4 TIME DECODER SYNCHRONIZATION
5 DATA OUTPUT REGISTER RE-SET
6 PRE-SET TIME DECODER OUTPUT

Figure 4. VISSR Pass II Program Sample Printout (continued)

For a more detailed explanation of the data flow and procedures used in the quality control of VISSR data, refer to the "Data Processing Plan for Synchronous Meteorological and Geostationary Operational Environmental Satellites (SMS/GOES)," P. L. McKowan, NASA/GSFC X-565-75-276, Section 8 "Video Data Processing System," October 1975.

TIME CORRECTION AND DECOMMUTATION

S. Sanders, Computer Sciences Corporation

The computer processing performed in the Telemetry Computation Branch at GSFC through the Synchronous Meteorological and Geostationary Operational Environmental Satellites (SMS/GOES) visual and infrared spin-scan radiometer (VISSR) data processing system results in tapes for hardcopy image generation, interactive analysis, and other uses.

A sample photographic image produced from a hardcopy tape is shown in Figure 1 and the annotation areas are explained in Table 1.

Experimenter history tapes (EHT's) are now being produced and are available on 7- or 9-track computer tapes. The general format of these tapes is as follows:

- Each record contains a full west-to-east image line of visible, or infrared (IR), data, plus documentation.

- IR data records are interleaved with visible data records.

- IR data records contain merged orbit, attitude, and telemetry data.

o The visible data records need not be present, thereby enabling a significant reduction in tape requirements.

A sample shipping letter is provided with each EHT (Figure 2).

To provide greater flexibility in the production of tapes for hardcopy generation and for the user community in general, a peripheral decommutation program is scheduled for implementation during the first half of 1976. A significant new product to be produced by this program is the sectorized experimenter tape (SET). The general format of this tape is as follows:

- Visible data, IR image data, and IR overlay grid data are present in separate files.

- Orbit and attitude data are present in the file label; telemetry data are present in the first eight data records.

ME01 010241.01 VA1 T/L:0090/1500 9SEP74 1500Z 0000
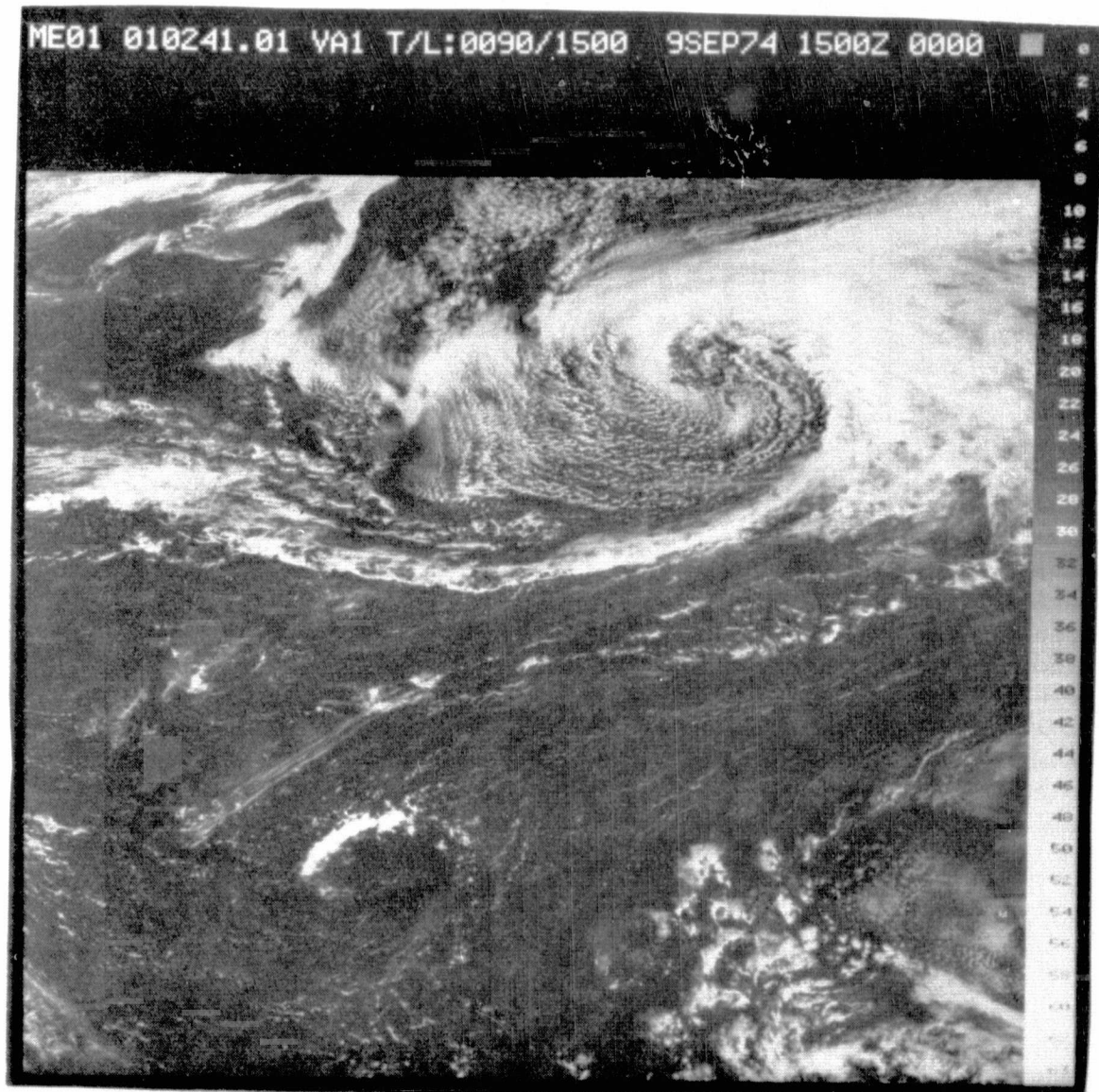
Figure 1. Photographic Image Produced from a Hardcopy Tape

29

```
09/15/75                          SMS VISSR SHIPPING LETTER - RUN NUMBER:  1085                        PAGE   20


                              AOIPS PICTURE TAPE NUMBER 01085102                              ASG ID. 085102

INTER- *********ANALOG TAPE*********     S *BUF* P2 *PET* *MDT* *********TIME*********  M   REQUESTED ***DECOM****  %  O G CREAT
 NATL   DATE  STA I TAPE F STRT STOP DIGTZD E R F S LN R F S R F S   START    STOP  ELAP O I IMAG-LINE   RUN  R F S DAT T M  DATE I
 CODE  YYMMDD COD D -NO.-L TIME TIME YYMMDD C L L F ID L L F L L F DDDHHMMSS HHMMSS MMSS D R FRST LAST   NMBR  L L F REC M T YMMDD D

7403301 740912 WSP B 010851       750212 1 1 1 1 X1 1 1 1 2 1 2 255133849 134335 0500 A N 0200 0699 01085 02 1 1  99 Y D 50915 A

7403301 740912 WSP B 010851       750212 1 1 1 1 X1 1 1 1 2 1 2 255133849 134335 0500 I Y 0200 0699 01085 02 2 2 100 Y D 50915 A

7403301 740912 WSP B 010851       750212 1 1 1 1 X1 1 1 1 2 1 2 255133849 134335 0500 G Y 0200 0699 01085 02 3 3 100 N D 50915 A

7403301 740912 WSP B 010851       750212 0 4 1 1 X1 4 1 1 1 1 1 255133637 133639 0002 K Y 0000 1821 01085 02 4 4 100 N D 50915 A


   --LINE CONVERSION TABLE--          %  --SCALING--
   ...SCAN.. ..IMAGE.. SCAN- IR-PIXEL SEC  TOT   TABLE   ...FILL SENSORS..                                              PE
FL STRT STOP STRT STOP IMAGE STRT STOP SIZ 1MAG  ID   DATE  TOP WITHIN BOTTM ....TM START.... .....TM STOP.... ........O/A...... CNT

 1  222  721  200  699   22  1000 1975  P   7% 0000       0     5      0 255 13:58:45.604 255 14:01:58.637 255 13:59:00.000   0
                                                        0.0%  0.1%  0.0% 255 14:02:01.702 255 14:05:14.735 255 14:03:00.000

 2  222  721  200  699   22  1000 1975  P   7% 0000             0      0 255 13:58:45.604 255 14:01:58.637 255 13:59:00.000   0
                                                        0.0%  0.0%  0.0% 255 14:02:01.702 255 14:05:14.735 255 14:03:00.000

 3  222  721  200  699   22  1000 1975  P   7% 0000       0     0      0 00:00:00.000   0 00:00:00.000   0 00:00:00.000   0
                                                        0.0%  0.0%  0.0% 0 00:00:00.000   0 00:00:00.000   0 00:00:00.000

 4    3    5    3    3   22     1 3822  U   0%                  0      0 00:00:00.000   0 00:00:00.000   0 00:00:00.000   0
                                                        0.0%  0.0%  0.0% 0 00:00:00.000   0 00:00:00.000   0 00:00:00.000


TAPE: 9-TRACK, 1600BPI
```

Figure 2.   VISSR Shipping Letter Report

Table 1

VISSR Picture Title Information

Column	Description	Example
1-4	Satellite identification	ME01
5	Blank	010241.01
6-14	Picture number, reel number	
15	Blank	
16-18	Picture type (IR, VA = mode A VIS; VB = mode B VIS) followed by picture section number	VA1
19	Blank	
20-32	Coordinate numbers of the top left pixel relative to the IR sensor (line/pixel)	T/L: 0090/1500
33	Blank	
34-40	Date	9 Sept 74
41	Blank	
42-46	Start time of sectorized image to nearest minute	1500Z
47	Blank	
48-50	Pixel scaling table identification	0000
51	Blank	
52	Sector size code	P

- A variety of subimage sizes will be available at varying resolutions. Subimages may be selected starting at any line and pixel. The size (geographic coverage) of a subimage will be determined by a one-letter code.

Additional information is available in the "Data Processing Plan for Synchronous Meteorological and Geostationary Operational Environmental Satellites (SMS/GOES)," P. L. McKowan, NASA/GSFC X-565-75-276 Section 8, and Appendix C, October 1975.

ORBIT AND ATTITUDE INTEGRATION

G. Repass, GSFC

Definitive orbit/attitude tapes are generated at the Goddard Space Flight Center (GSFC) for the Synchronous Meteorological and Geostationary Operational Environmental Satellites as shown in Tables 1 and 2. The definitive orbit data computed by GSFC are merged with the National Oceanic and Atmospheric Administration (NOAA) definitive attitude information and delivered to P. McKowan (GSFC) for merging with the experiment data.

It is planned that, in the future, the orbit and attitude information will be added to the NOAA grid tapes, transmitted to the spacecraft, and retransmitted to the ground with the spacecraft telemetry data.

The SMS orbit/attitude tapes are written in binary (odd) parity 7-track, with the integer words right-adjusted, and the floating-point words in the IBM 7094 floating-point format. The words identified as "BCD" are binary-coded decimal for the 6-digit times. The header record is a separate physical record. The data records are blocked ten logical records (frames) per physical record.

Table 1
Orbit Attitude Data Record

Word Number	Item	Format	Example
1	Day (9 bits), GMT in milliseconds (27 bits)	Integer	340, 57600000

2	Attitude identifier
	  1. GSFC attitude based on Sun and Earth data
	  2. GSFC picture attitude
	  3. NOAA attitude based on Sun and Earth data
	  4. NOAA picture attitude
		Integer	4

3	Geodetic latitude (deg to 0.001) + north	Floating Pt.	0.110
4	Longitude (deg to 0.001) + east	Floating Pt.	0.100
5	Height above oblate Earth (km)	Floating Pt.	35000.0
6	Right ascension of spin axis (deg to 0.001) 0 –360	Floating Pt.	230.3
7	Declination of spin axis (deg to 0.001) -90 to +90	Floating Pt.	-88.3
8	Spin period of spacecraft (microseconds)	Floating Pt.	600660.7
9	Right ascension of position vector with respect to 1st point of axis (deg to 0.001)	Floating Pt.	10.001
10	X (Cartesian components of position vector in km, in true of date	Floating Pt.	39907.81
11	Y geocentric equatorial	Floating Pt.	13644.710
12	Z coordinate system)	Floating Pt.	1058.823
13	X (Corresponding Cartesian	Floating Pt.	3578.646
14	Y components of velocity	Floating Pt.	10465.997
15	Z vector in km/hr)	Floating Pt.	162.737
16-150			

Table 2
Orbit Attitude Tape Header

Word Number	Item	Format	Example
1	Orbit attitude tape identifier (international flight code)	Integer	7403301
2	Epoch time of orbital elements (YYMMDD)	BCD	741206
3	Epoch time of orbital elements (HHMMSS)	BCD	160000
4	a = Semimajor axis (km)	Floating Pt.	42163.838
5	e = Eccentricity (dimensionless)	Floating Pt.	0.0032
6	i = Inclination (deg to 0.001)	Floating Pt.	0.700
7	m = Mean anomaly (deg to 0.001)	Floating Pt.	10.140
8	ω = Argument of perigee (deg to 0.001)	Floating Pt.	220.117
9	Ω = Right ascension of ascending mode (deg to 0.001)	Floating Pt.	180.210
10	Start time of data (YYMMDD)	BCD	741206
11	Start time of data (HHMMSS)	BCD	160000
12	Stop time of data (YYMMDD)	BCD	741206
13	Stop time of data (HHMMSS)	BCD	190000
14	1st point Aries at 0 hr GMT on epoch day (hrs)	Floating Pt.	17.0
15	Tape number (24 bits), file number (12 bits)	Integer	123, 1

IMAGE PROCESSING FACILITY SUPPORT FOR SMS

W. Webb, GSFC

The Image Processing Facility (IPF) provides data processing support for
Goddard Space Flight Center (GSFC) satellites with imaging sensors such as
the visible infrared spin-scan radiometer (VISSR). The Facility converts user-
selected VISSR imagery from digital tape to black-and-white 70-mm film nega-
tives, 9-1/2-inch paper positives, or 9-1/2-inch film positives. It also enlarges
1/4 or 1/16 portions of the image data by 2X or 4X, respectively, to a standard-
size image on 70-mm film negatives, 9-1/2-inch paper positives, or 9-1/2-inch
film positives.

Figure 1 is a flow diagram of the processing that takes place within the IPF in
support of the VISSR. As indicated, GSFC Code 565 is responsible for gene-
rating digital tape containing VISSR imagery in a format compatible with the
IPF along with tape release forms and shipping letters. Code 565 forwards
the VISSR tapes to NASA Tape Staging and Storage (NTSS) and the tape release
forms and shipping letter to the IPF production control element. Production
Control is responsible for preparing work orders identifying the enlargement
factor (IX, 2X or 4X) to use, product type to produce (70 mm (9-1/2-inch)
black-and-white paper or 9-1/2-inch black-and-white transparency), and quan-
tities of each to satisfy user requirements specified on the shipping letter.
VISSR tapes identified on the work order are retrieved from NTSS and forwarded,
along with the work order, to the black-and-white film recorder for conversion
to film.

VISSR tapes contain one image each in a 4096- by 4096-element data array of
8 bits each. The standard 1X method of converting this tape data array to film
imagery is a one-to-one transfer of tape elements to corresponding picture
elements of a 4096- by 4096-picture array on film. Options are available to
enlarge 1/4 or 1/16 portions of the tape data array by 2X and 4X, respectively,
to produce a full 4096- by 4096-element picture array. Figure 2 illustrates IX,
2X, and 4X techniques for mapping tape data to film images. Only full 4096- by
4096-picture-element size imagery is produced. Starting point constraints for
2X and 4X enlargements, shown in Figures 3 and 4, respectively, ensure that
the image area selected by the user for enlargement does not extend into the
annotation or annotation gray scale.

Image format and size of the VISSR film imagery produced on the black-and-white
film recorder for both 1X and 2X/4X enlargements are shown in Figures 5 and
6, respectively. In Figure 6, note that the 33-step annotation gray scale does
not appear in the image. This is to be expected if the starting point constraints

37
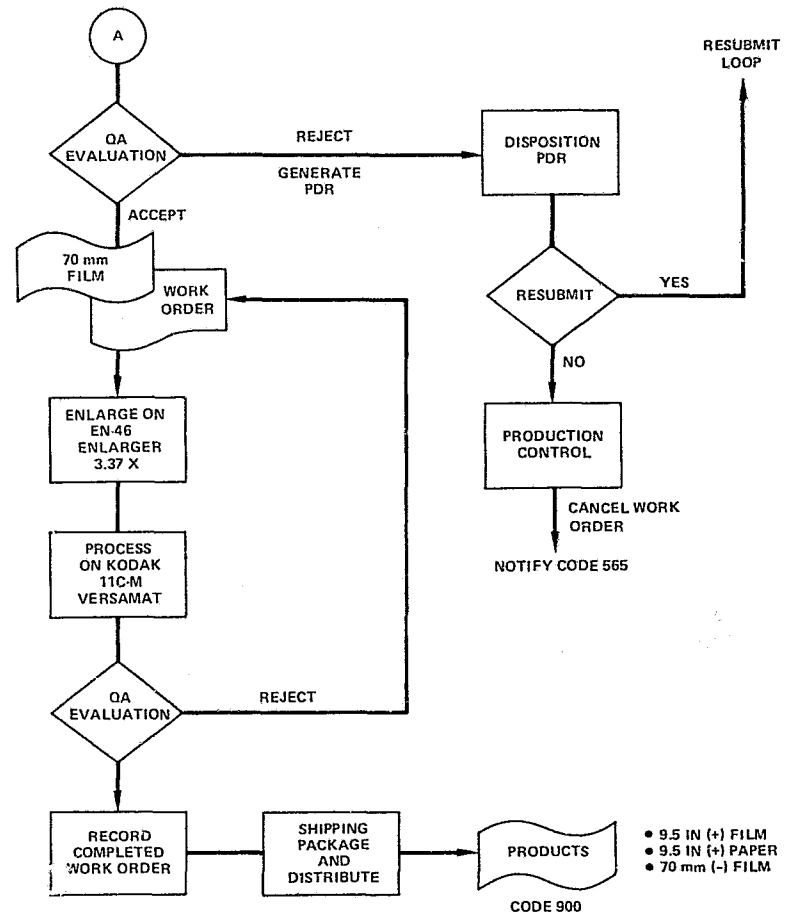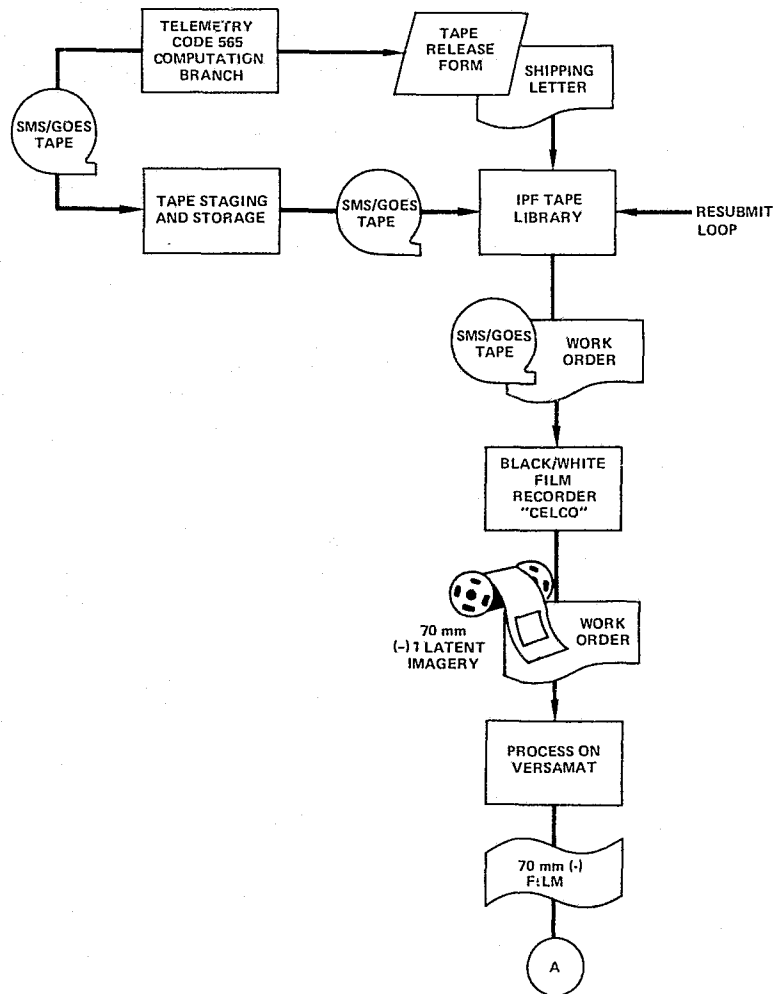
Figure 1.   Image Processing Facility Processing Flow Diagram

DIGITAL TAPE DATA ARRAY

SMS FILM IMAGE

PIXELS

1   4096

1   4096

1 X

2 X

4 X

1/4

1/16

FULL-SIZE IMAGE ONLY

LINES

4096   4096

ENLARGEMENT TECHNIQUE

•   2 X

•   4 X
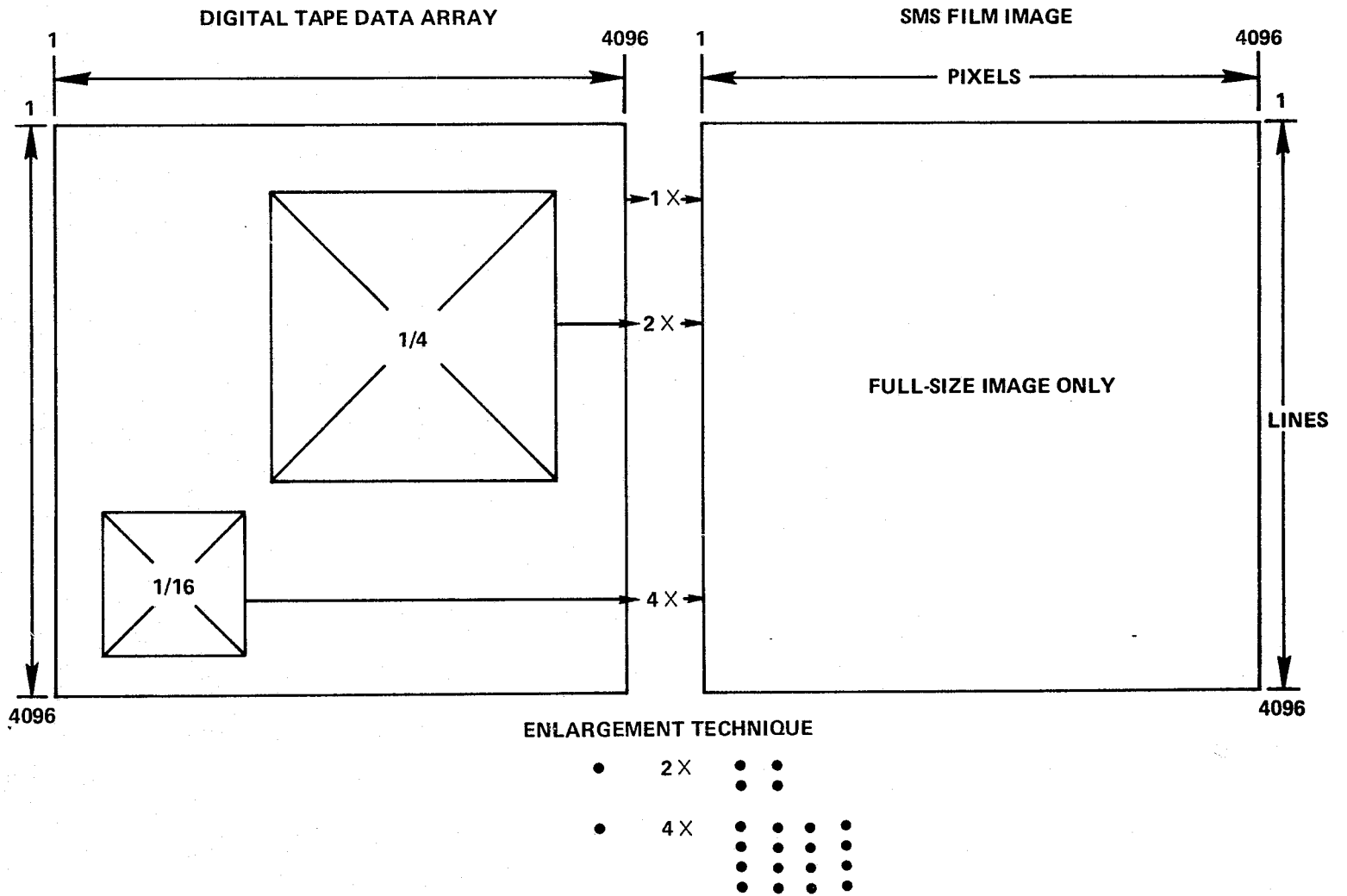
Figure 2.   SMS Digital Tape-to-Film Conversion

38
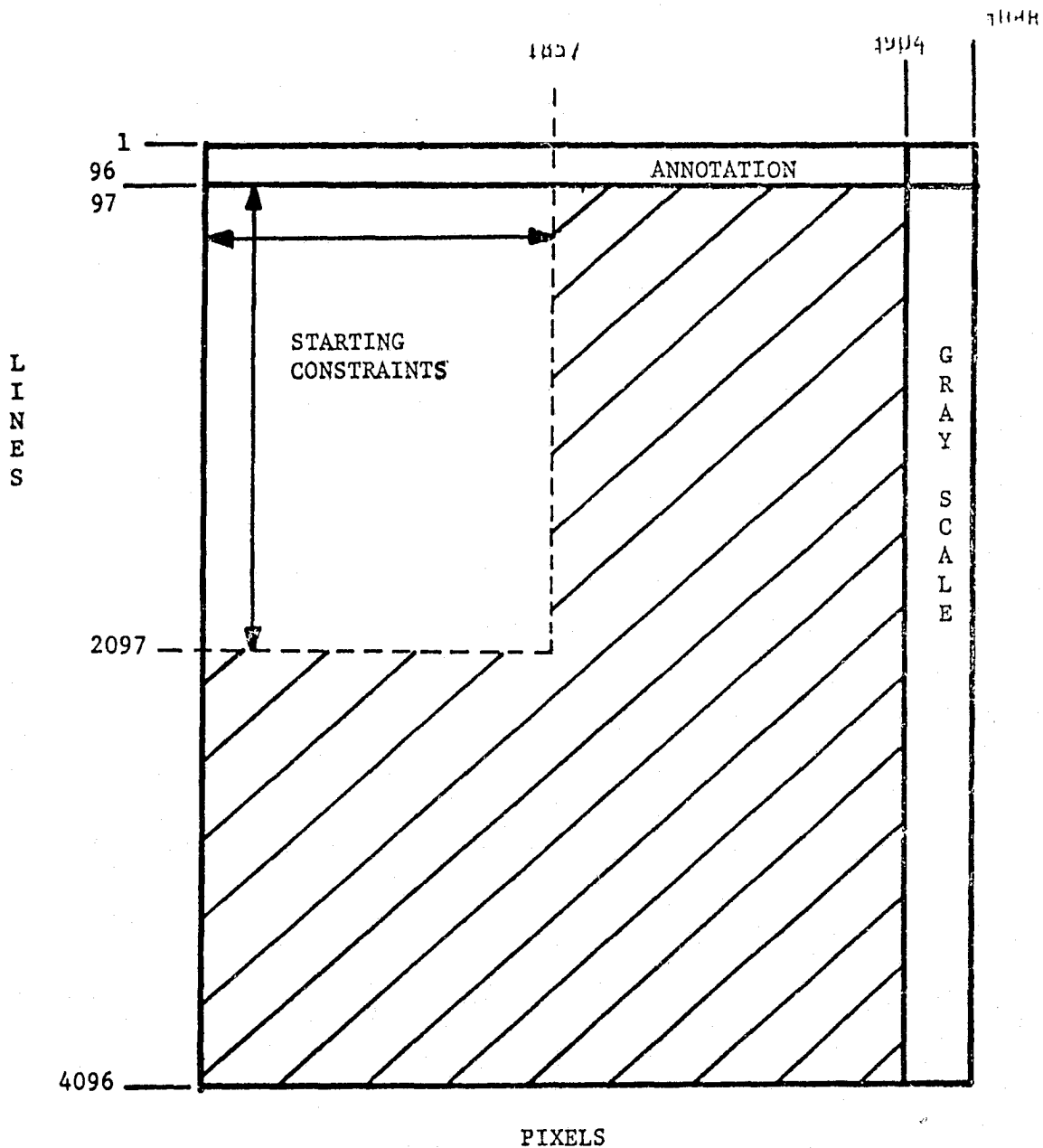
Figure 3. 2X Mapping of SMS Imagery
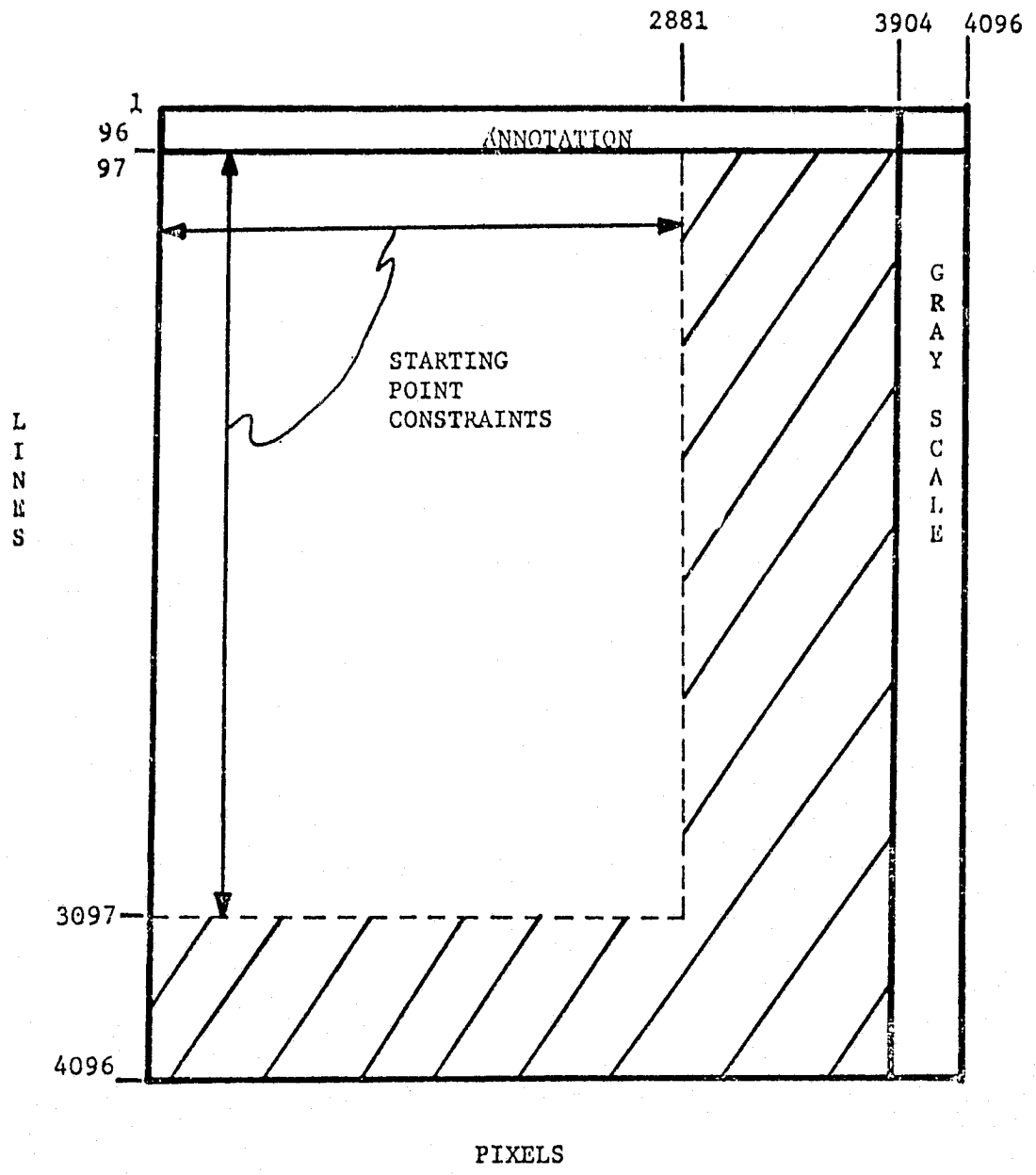
Figure 4. 4X Mapping of SMS Imagery

40

Figure 5. IX-SMS Image Dimensions (Nominal Measurements in mm, 14-Percent Aspect Ratio Correction Applied)

```
                    ┌─────────────────────────────────────┐
1.15  ─┬─      ┌────────────────────────────────────┐
(3.87) ─┴─     │         ANNOTATION                  │
               │                                     │
               │                                     │
               │                                     │
               │                                     │
               │           IMAGE AREA                │   51.7
               │        X = 45.25, Y = 51.7          │  (174.2)
               │      (X = 152.49, Y = 170.35)       │
               │                                     │
               │                                     │
               │                                     │
               │                                     │
               └────────────────────────────────────┘
               │←────── 45.25 ( 152.49 ) ──────→│
        │←──────────── 70 ( 241.3 ) ─────────────────→│
```
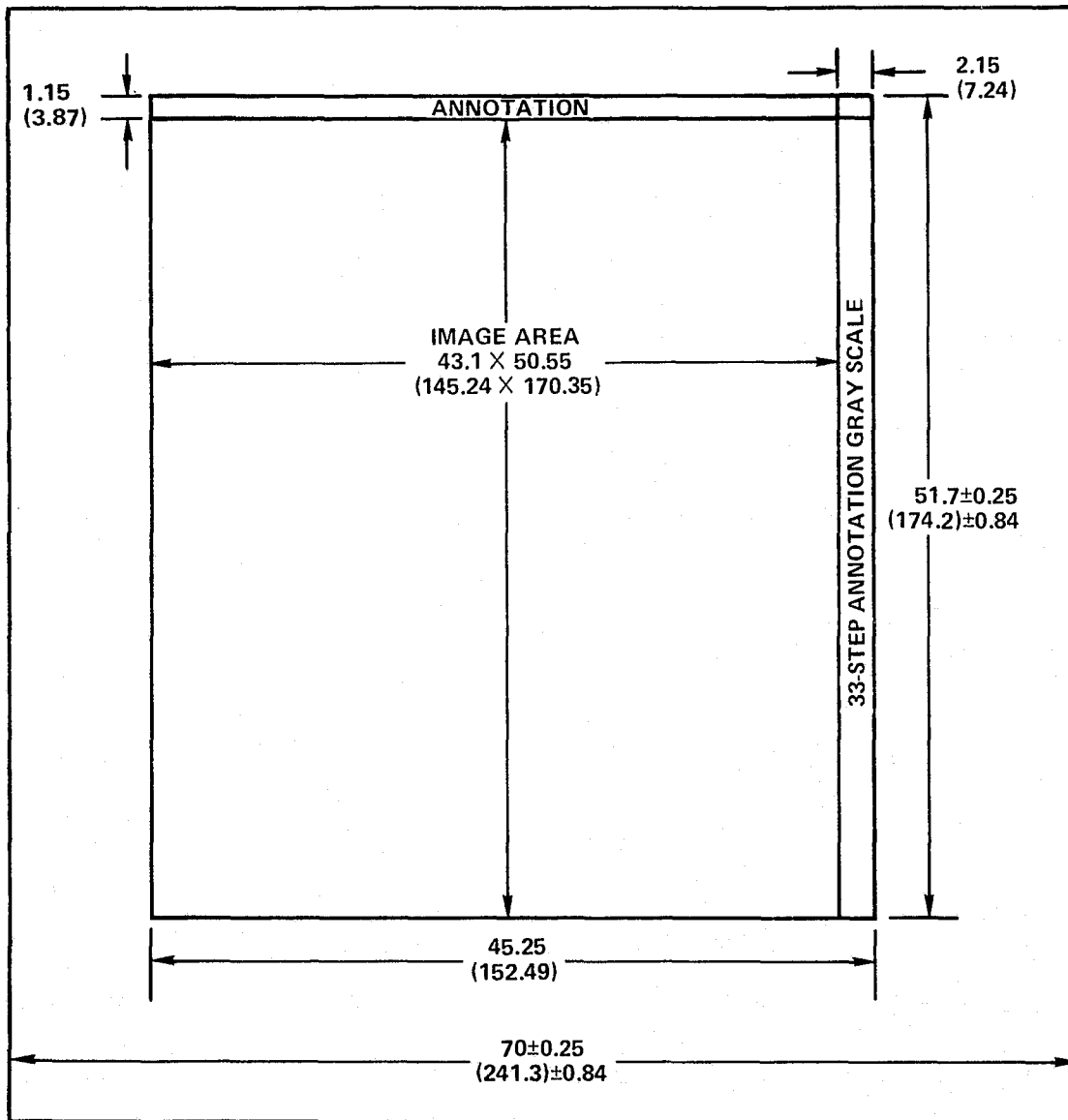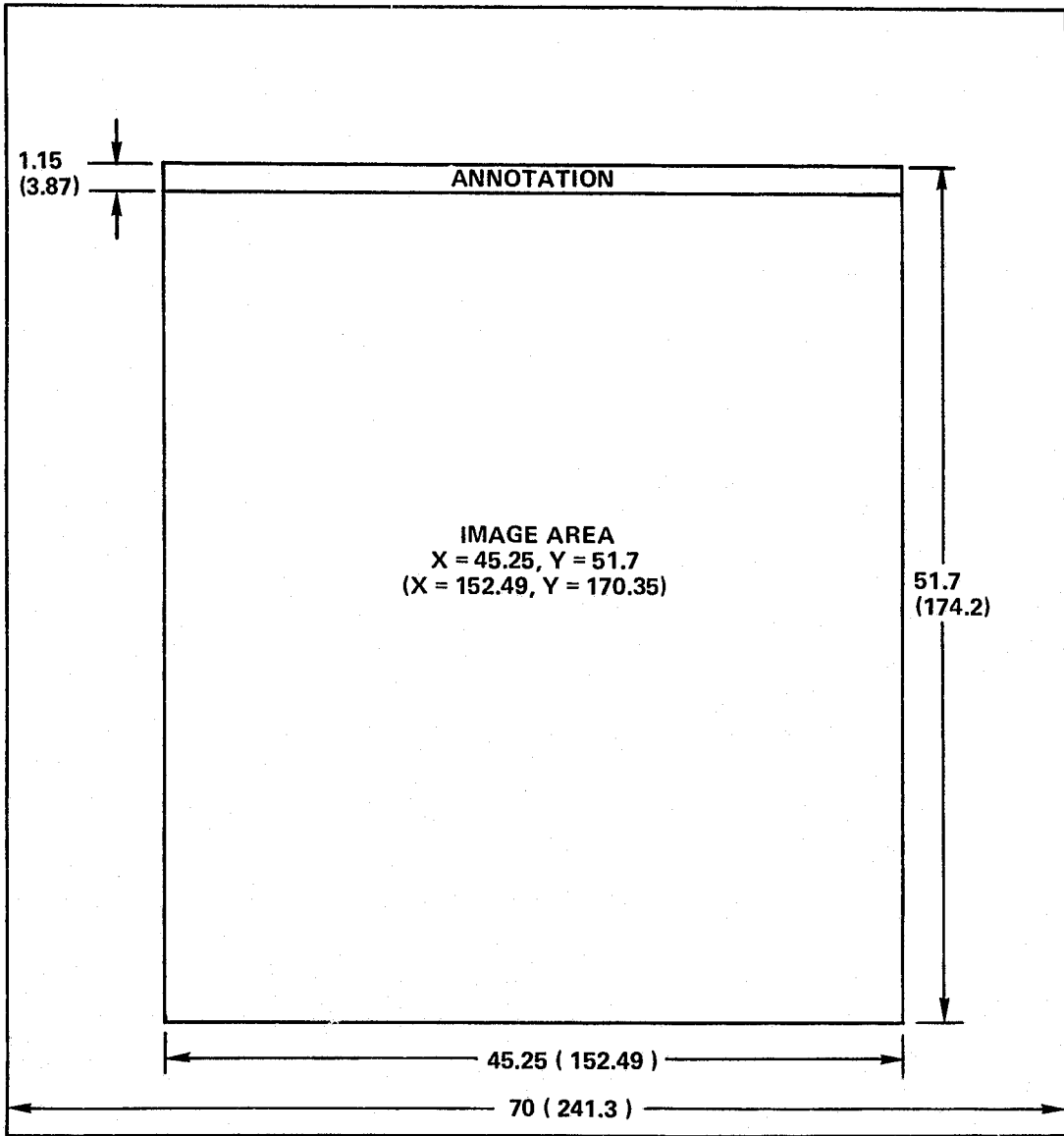
70MM FILM NEGATIVE SIZE IN MILLIMETERS
9.5" FILM/PAPER POSITIVE SIZE IN MILLIMETERS ( )

Figure 6. 2X– and 4X–SMS Image Dimensions (Nominal Measurements in mm,
14–Percent Aspect Ratio Correction Applied)

42

are observed. An aspect ratio correction is also applied during the tape-to-film conversion process in the form of a 14-percent increase in Y dimension.

VISSR frames are exposed as latent negative images on 70-mm roll film. The exposed film is forwarded to the photo lab where it is developed and inspected against quality standards established for VISSR imagery. If the imagery is rejected, the processing problems are identified, and the imagery is remade. If the imagery passes quality standards, it is enlarged by 3.37X to produce 9-1/2-inch second-generation positive transparencies and/or 9-1/2-inch second-generation positive paper prints. The 70-mm negative film, along with any 9-1/2-inch products produced for the user, are packaged and made available for pickup by GSFC Code 900—the point of delivery for all VISSR products produced by IPF.

Characteristics of the processing system are:

- Picture size—4096 pixels per line and 4096 lines per image.

- Resolution—21 cycles per millimeter as determined at the 50-percent modulation transfer function point.

- Density—For a 0-to 255-input-exposure range, the following product density ranges are obtained: 70-mm negative—0.2 to 1.8; 9-1/2-inch positive transparency—0.35 to 2.15; and 9-1/2-inch paper positive—0.1 to 1.5.

- Geometry—Nominal size: 70 mm—(45.25 x 51.7 mm) ±0.25 mm, and 9-1/2-inch—(152.49 x 174.2 mm) ±0.84 mm. Aspect ratio correction—Y size increased by 14 percent.

Quality control is performed by individual product inspection and by system calibration/certification. Individual photographic products are inspected for:

- Excessive cosmetic defects (e.g., scratches, dirt, pin holes, Newton Rings, etc.)

- Excessive electronic defects (e.g., line drops, data breaks, salt-and-pepper defect caused from byte dropout, etc.)

- Complete and legible annotation and annotation gray scale

The black-and-white film recorder and photo-lab enlarger are certified at the beginning of each shift through use of a line test. Geometry is determined to

be within specifications through use of line tests conducted on the black-and-white film recorder and the photo-lab enlarger. This equipment is recalibrated if it found to be out of specification.

Radiometry is certified by routine line tests in addition to evaluation of standard end-of-roll test targets processed along with each production roll of film. The black-and-white film recorder, photo-lab enlarger, and film processors used in support of VISSR processing are also certified in this manner. Adjustments are made when required to maintain the equipment within established specifications.

Two methods are available to VISSR users for ordering photographic products from the IPF: standing orders and data requests. Standing orders can be placed for 1X-size photographic products in 70-mm negative film and 9-1/2-inch positive paper print formats only. One 1X size 70-mm negative and two 9-1/2-inch positive 1X-size paper prints will be produced and supplied to the user as a standard practice. Because this is the most efficient operation for the IPF, 90 percent of VISSR user requests will be processed in this manner.

Data requests can be placed for 1X, 2X, and 4X products in 70-mm negative film, 9-1/2-inch positive paper, and 9-1/2-inch positive transparency black-and-white formats in addition to the option of specifying the number of 9-1/2-inch products to be delivered. A maximum of 10 percent of VISSR user requests and/or product volume are expected to be in the form of data requests.

Standing orders for IX-size 70-mm film negatives can be processed at the rate of 240 per week and for 9-1/2-inch paper positive, at 480 per week. Individual data requests fro IX-size or enlargement of portions to full size can be processed at about one-tenth this rate. These rates apply through February 1976, after which processing rates will be doubled. All orders are completed in about 10 days.

DATA STORAGE AND DISSEMINATION

J. Lease, GSFC

The Meteorology Branch of the Atmospheric and Hydrospheric Applications Division at the Goddard Space Flight Center (GSFC) has been involved in research using geosynchronous meteorological satellite data since Applications Technology Satellite-1 (ATS-1) was launched in December 1966. Archiving of analog data began with the launch of Synchronous Meteorological Satellite (SMS-1) and ATS-6 and has continued through SMS-2 to the present. The data were originally archived for use in research programs conducted at GSFC. However, because of the unique nature of the data, it is being made available to secondary users by the Meteorology Branch through the National Space Science Data Center (NSSDC). This Center collects data records before any reduction has been performed which might alter the fundamental information content. These records are usually prepared by a compaction, editing, and merging operation performed by the investigators. Included are the instrument responses measured as functions of time, along with appropriate position, altitude, and equipment-performance information necessary for others to analyze the data. The Center also collects final analyzed data which the investigators designate as the most useful and the best illustration of the scientific results of their experiments. Machine-sensible data are stored on tapes; other data are stored in their original form or reproduced on microfilm.

Because of the large amount of data involved, procedures have been established for responsibility to both internal and secondary requests. The experimenters' data flow for internal requests is shown in Figure 1. All request received are sent to William Shenk, GSFC, for approval. Upon approval, the Information Processing Division performs the analog-to-digital conversion and makes the data available in computer tapes and photographs. The tape data consists of full-resolution visible light and infrared digital data on 9-track, 1600 bpi tapes. The photographs, which are archived in 70-mm negative format, are a visual presentation of the digital data contained on the tapes. To facilitate use by secondary experimenters, the National Space Science Data Center receives one copy of the data in both tape and photographic formats.

Because of the large quantity of data available, only a portion of the data will be processed into digital format. The data that are processed will be that requested by Meteorology Branch personnel. It is anticipated, however, that requests will be received for data that has not been processed. To respond to such requests, the experimenter and NSSDC have set up procedures by which data not archived at NSSDC can be obtained (Figure 2). In this case, NSSDC will act as an internal requestor and, if the request is approved, will provide

the data to the secondary user. NSSDC will also archive a copy of the data requested.

SMS digital data are presently available on tape at NSSDC. To request data or information on data availability, contact the National Space Science Data Center, Goddard Space Flight Center, Code 601, Greenbelt, Maryland 20771. (Telephone: 301-982-6695).
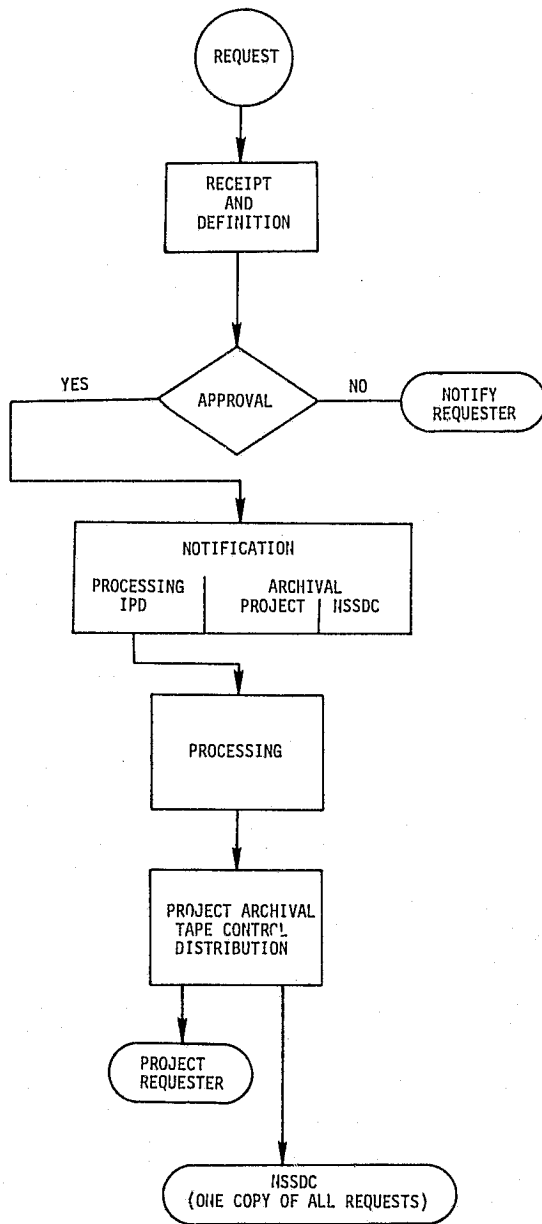
Figure 1. Experimenters' Data Flow
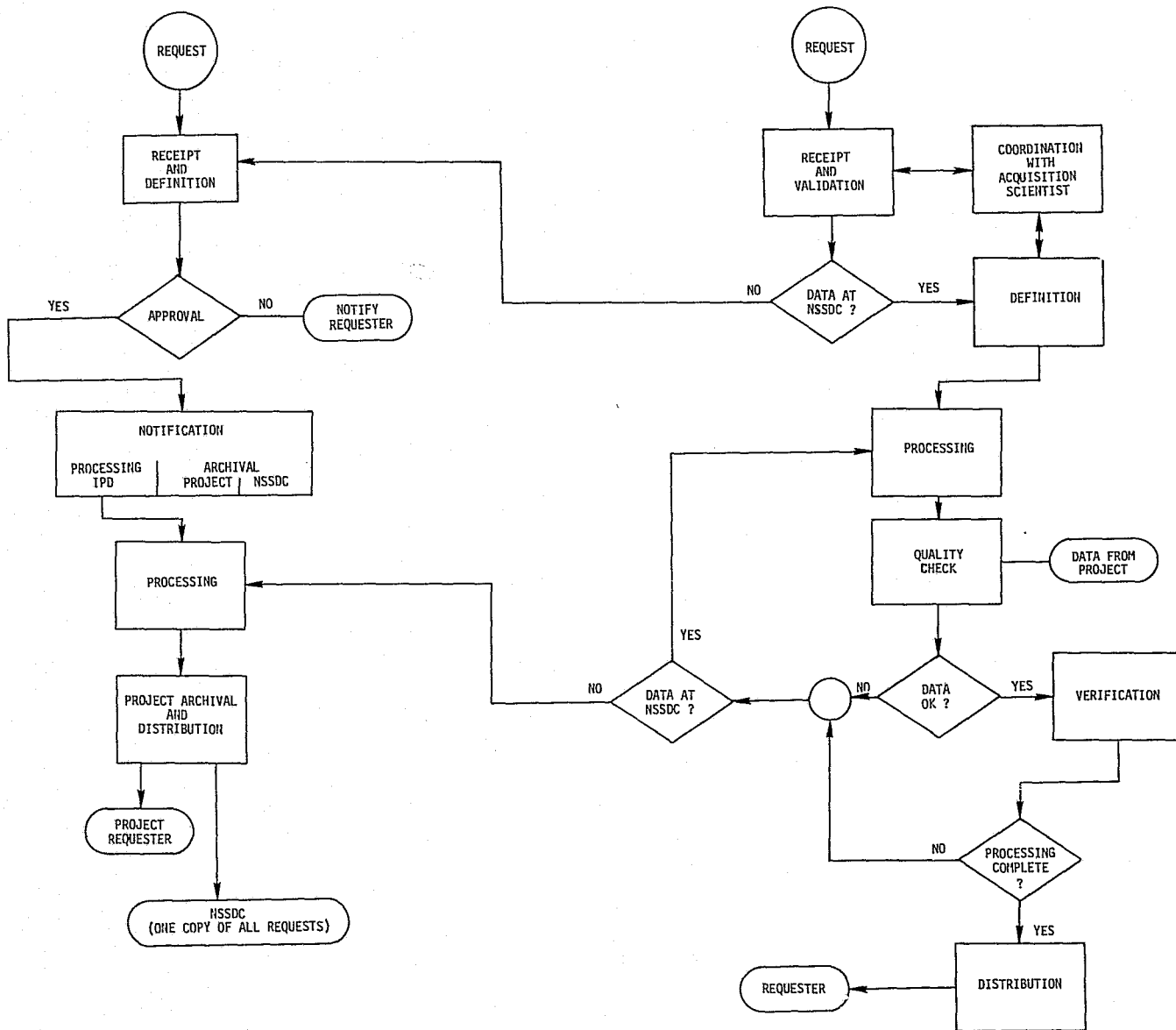
Figure 2.　Experimenter/NSSDC Interface

SESSION B

CURRENT GSFC DATA ANALYSIS CAPABILITIES

CLOUD-MOTION/WIND RELATIONSHIPS

W. Shenk, GSFC

Three cloud-motion/wind relationship expeditions have been conducted over tropical oceans where aircraft-measured winds at 150 m and at the base, middle, and top of clouds have been compared with the cloud movements derived from satellite and aircraft sources. The expeditions were based at Puerto Rico, Panama, and near Houston, Texas, and the measurements were made over the water within 700 km of the airports where the flights originated.

The experiments were usually conducted with at least two aircraft. A plane passed repeatedly over the same cloud field, and the inertial navigation system (INS) provided the cloud positions as a function of time. The movement of clouds other than the principal one being tracked could also be calculated. Therefore, the variability of cloud velocities over a 25- by 50-km area could be studied. The winds below and at cloud level were determined from the average of reciprocal flight paths from measurements obtained by an INS. An independent method of measuring the cloud motion of the principal cloud being followed was from frequent penetrations by low-flying aircraft.

Forty convective cloud areas were tracked using aircraft positions, and their movements were compared with the wind at 150 m and cloud base, middle, and top (usually 500, 2000, and 4000 m, respectively). A 1σ vector difference of 1.5 m/sec was found between the cloud-base wind and the cloud motion, and about the same difference occurred at 500 m. However, the differences at the middle of the cloud and at the top of the cloud were 3 m/sec and 7 m/sec, respectively. Table 1 gives the details of the results.

The same type of experiment has also been performed for cirrus clouds where the same aircraft made the cloud-motion and wind measurements. Table 2 summarizes the results for five cirrus clouds.

A cloud-tracking experiment was also performed in 1 day for small cumulus clouds over Springfield, Missouri. The principal result was that the 1- to 2-km clouds which have 5- to 10-minute lifetimes must be viewed at approximately 1-minute intervals to ensure that scene continuity is maintained.

Table 1
Wind Estimates from Cloud Motions:
Phases I, II, and III of an In Situ Aircraft Verification Experiment
(Results: Tropical Oceanic Cumulus Clouds)

						SYSTEMATIC BIAS		$\overline{V}$ Cloud $-$ $\overline{V}$ Wind			
Date	Location	Aircraft	Number of Cloud Tracks	Avg. Cloud Speed (m sec 1)	Avg. Wind Speed At Cloud Base (m sec 1)	Speed (m sec 1)	Direction Cloud- CB Wind (degree)	\
Speed (m sec $-$ 1) 150 m	Cloud Base	Mid-Cloud	Cloud Top
Dec. 72	N.W. Caribbean	NCAR Sabreliner	6	12.5	12.9	−0.4	1.0		1.2	3.4	5.5
April 74	S. W. Caribbean	NCAR Sabreliner	10	10.7	10.4	0.3	−2.1	1.9	1.5	2.7	7.0
April 74	S. W. Caribbean	NASA C130	9	10.0	9.2	0.8	3.4	1.6	1.8	2.8	6.8
July 74	Gulf Of Mexico	NASA P3	15	5.1	5.1	0.0	−3.1	1.6	1.4	3.1	5.4
		Total	40								
		Total Sample Mean	8.7		8.5	0.2	−0.8	1.6	1.5	3.0	6.2
		Standard Deviation	3.6		3.6			0.8	0.8	1.2	2.5
		Number of cases with track length of 1 hour or longer 13						13	21	16	17
		Mean						1.3	1.2	3.1	6.1
		Standard deviation						0.6	0.6	1.4	2.5
		61 percent of cases with this difference or less						1.5	1.3	3.6	7.0

Table 2
Wind Estimates from Cloud Motions:
Phase II of an In Situ Aircraft Verification Experiment, Puerto Rico and Panama Canal Zone
(Results: Cirrus Clouds)

| | | Wind Velocity For | | | | | | | | | | | | $\overline{V}$ Cloud – $\overline{V}$ Cloud | | | |
| | Track Length (Hrs.) | Cloud Velocity | | Cloud Layer Mean | | Cloud Base | | Mio Cloud | | Cloud Top | | Estimated Cloud Top | Speed (m sec 1) | | | |
		DIR (deg)	SPD (m sec 1)	DIR (deg)	SPD (m sec 1)	DIR (deg)	SPD (m sec 1)	DIR (deg)	SPD (m sec 1)	DIR (deg)	SPD (m sec 1)	(10^3 m)	Mean	CB	MC	CT
DEC. 5, 1972	0.5	265	20.5	261	20.6	262	20.6	261	20.6	261	20.6	8.5	1.4	1.1	1.4	1.4
APR. 15, 1974	1.7	242	8.9	234	10.4	247	10.4	235	11.6	217	9.7	12.1	2.0	1.7	3.0	4.1
APR. 16, 1974	1.6	218	10.0	217	10.2	218	9.8	213	8.5	220	12.2	12.8	0.2	0.2	1.8	2.2
APR. 18, 1974	2.2	253	8.1	238	8.2	234	9.9	232	8.7	251	6.8	11.3	2.2	3.5	3.1	1.3
APR. 18, 1974	1.0	175	7.5	190	8.8	211	6.8	181	7.6	185	12.5	12.1	2.4	4.5	0.0	5.2
Total Sample Mean			11.0		11.6								1.6	2.2	2.0	2.8
Standard Devation			5.4		5.1								0.9	1.8	1.0	1.1

$\triangle$ Speed = 0.6 m sec $^{-1}$ $\triangle$ Lirection = 2.6 $^\circ$

CURRENT SCIENTIFIC DATA ANALYSIS

R. Adler, C. Peslen, and E. Rodgers, GSFC

Current in-house research with Synchronous Meteorological Satellite (SMS) digital data concerns studies of severe local storms, tropical and extratropical cyclones, and tropical cloud clusters. Wind information is being determined by tracking clouds with SMS visible and infrared (IR) data on the image-display and manipulation system (IDAMS) using the meteorology package (METPAK) software. Cloud structure information is also being obtained from the digital data. Analysis of the wind fields are made using the software objective-analysis package (SOAP).

TROPICAL CLOUD CLUSTER

The first example of in-house research is a case study of a tropical cloud cluster over the GARP Atlantic tropical experiment (GATE) area in the eastern Atlantic Ocean. The upper tropospheric flow field (200 mb) is determined by tracking clouds with a sequence of IR images. Visible images are used to determine the low-level (900 mb) flow. Results from three sequences of three images each are combined to obtain the flow fields for the period 1100 to 1400 GMT on September 12, 1974. A few additional conventional surface observations are added to the low-level analysis. The low-level flow indicates a sharp east-west oriented trough with strong convergence. The upper-level flow is generally easterly, with divergence associated with the low-level convergence.

Attention centered on a 5-degree latitude by 5-degree longitude area bounded by 3 to 8° N and 24 to 29° W, which contains a cloud cluster. The wind field around the periphery of this area is well defined at high levels and fairly well defined at low levels. Because area-mean divergence and vorticity is only a function of the wind around the area boundary, these area-mean parameters over this particular area should be good estimates. The resulting area-mean divergence is -19.3 by $10^{-6} \, s^{-1}$ at low levels and $+29.3$ by $10^{-6} \, s^{-1}$ at high levels.

With low-level convergence and high-level divergence, air in the middle troposphere is obviously ascending. The magnitude of the vertical velocity can be determined by fitting the known divergence values at 900 mb and 200 mb to an assumed divergence profile and integrating the continuity equation. The shape of the divergence profile assumed here is based on previous studies of conventional data. An additional restraint on the profile is that the vertically integrated divergence is forced to zero. With these assumptions, the vertical motion $\omega = dp/dt$ is determined by integrating the continuity equation. The strongest ascent is $6.5 \, \mu b \, s^{-1}$ ($\sim 10 \, cm \, s^{-1}$) at 550 mb.

The cloud structure over the same area has been examined using both visible and IR data. Frequency distributions of digital brightness have been constructed. By selecting cloud/no-cloud boundaries (both visible and IR) and a low-cloud/high-cloud boundary (IR), areal-cloud and high-cloud coverage can be determined. In the present example 80% total cloudcover and 59% high cloudcover is calculated. These cloudcover estimates, along with the calculated vertical motion, are important characteristics of tropical cloud clusters.

SEVERE LOCAL STORM

Cloud tracking is being done on the IDAMS with 5-minute SMS-2 limited scan images for a severe local storm which occurred south of Omaha, Nebraska, on May 6, 1975. The low-level (850 mb) and upper-level (200 mb) winds with their associated divergence and vorticity fields have been derived for a 10-minute period during the cell's mature stage.

Preliminary results show areas of inflow and outflow for the cell. The magnitude of the divergence and convergence is 10^{-4} sec^{-1} for the more intense areas of the cell. Low level convergence (divergence) is overlaid by high level divergence (convergence). Large positive and negative values of relative vorticity (10^{-4} sec^{-1}) are also observed in the results for this 10-minute period.

These preliminary results and others suggest that satellite digital image data can assist conventional data methods in gaining a qualitative and quantitative understanding of the dynamic interactions between the severe local storm and its environment. Cloud tracking will be done at half-hour intervals for 10-minute periods during the storm's lifetime to study time sequences of the storm's dynamics. Satellite infrared digital data is also being tested to determine vertical development of severe local storms.

TROPICAL CYCLONE CARMEN

The third example of current in-house research is a study of tropical cyclone Carmen. Carmen was first examined qualitatively through the use of films that show the IR image of Carmen at approximately half-hour intervals during its life cycle from 1300 GMT August 27 to 1200 GMT September 10, 1974. Carmen was then examined more quantitatively during the time of her explosive growth on August 31 and September 1, 1974, by examining the wind field and cloud structure obtained from the IDAMS.

Study of the films reveals the following:

- During the intensification of Carmen:

  a. An increase in areal extent and organization of deep convection.

  b. The formation of a dense cirrus canopy.

  c. The outward expansion of the cirrus canopy.

- During the weakening of Carmen:

  a. The dissipation of the dense cirrus canopy.

  b. The disorganization and decrease of the deep convection.

- When Carmen interacted with her environment:

  a. The cirrus outflow was enhanced.

  b. An area circular clearing within the cirrus canopy was observed.

Dynamic parameters obtained from the wind analysis and information on the cloud structure can be related to the changing intensity and movement of Carmen. The following dynamic parameters will be examined from 3 degrees to 6 degrees latitude from the center (outside cirrus canopy) at 1-degree intervals at different quadrants:

- Mass transport

- Absolute angular momentum transport

- Vorticity

- Horizontal divergence

- Dynamic instability of the outflow layer

The following information about the cloud structure will be examined:

- Areal change

- Vertical change

As an example of this quantitative evaluation, it was found from the wind field analysis that during the period from 1300 to 1400 GMT on August 31 to 1300 to 1400 GMT on September 1, 1974, when the maximum winds of Carmen increased from 32 m/sec to 50 m/sec that:

1. The areal mean relative vorticity for a circular area 3-degree, latitude radius from the center increased cyclonically by 2 percent at the low levels and increased anticyclonically 420 percent at the upper levels.

2. The areal mean horizontal divergence for the same area became 60 percent less convergent at low levels but became 310 percent divergent at the upper levels.

The change in the cloud structure of the cirrus canopy showed a 46 percent increase as determined from the increase in the number of pixels with gray scales > 49 within an approximate 4 by 4-degree latitudinal area surrounding the cirrus canopy.

CALIBRATION AND SCALING

R. Lo, Computer Sciences Corporation

The accuracy and scientific usefulness of Synchronous Meteorological Satellite (SMS) visual and infrared spin-scan radiometer (VISSR) observations depend to an important degree on the performance of calibration. Calibration is also important in the evaluation of sensor stability. Calibration procedures for visible and infrared sensors differ in that the visible radiation observed is direction-dependent but the infrared observations are not.

Regular infrared calibration involves a regression analysis which relates discrepency between observation and ground truth to temperatures of sensor elements, shutter signals, and other parameters. The calibration is performed at National Ocenaic and Atmospheric Administration (NOAA) on a regular basis. Results are incorportated into the line-stretch process. Accuracy of calibration is believed to be ±1,0 K.

Diurnal characteristics have not been calibrated regularly by NOAA. The diurnal irregularity is the result of the physical phenomenon of the satellite coming back into solar radiation after being cooled by the shadow of the Earth. This phenomenon takes place during about 130 days of the year, centering around the two equinoxes, and can produce a maximum error of 4.0 K. A set of data has been prepared which represents days when the satellite is in the shadow for different periods of time and at different hours of the day. Results of calibration based on these data enable safe elimination of the diurnal effect from observations.

The calibration of visible observations has been difficult because:

1. They are direction-dependent, and the direction dependency varies significantly among different targets.

2. The direction characteristics are not well measured.

3. Ground stations with adequate instruments observing the necessary quantities are very few.

4. Measurements of important parameters, such as aerosol and ozone content over chosen targets, have not been readily available.

5. Accurate navigation techniques must be available when observations and ground-truth information are to be matched.

In a study of calibration for NOAA satellites, a model was proposed and tested on a number of cases at White Sands, New Mexico. Although further develop-ment of the model is necessary, the results show that the scheme is reasonable and will be tested on SMS instruments at White Sands, New Mexico. Results will be useful to studies in which the brightness of cloud and other atmospheric and terrestrial features are important.

A scaling tape program has been implemented on the image display and manip-ulation system to conveniently incorporate calibration results into data and to provide a way for scientists to control the enhancement of a satellite or other image. The gray levels of the original data are scaled according to a look-up table provided for the irpose of producing images of desired characteristics. A look-up table will be produced from a calibration algorithm and stored in the scaling tape.

INTERACTIVE METEOROLOGICAL DATA ANALYSIS

J. Billingsley and A. F. Hasler, GSFC
T. Mottershead and J. Chen, Computer Sciences Corporation

INTRODUCTION

Meteorological image data processing program objectives at Goddard Space Flight Center are centered on the analysis of geostationary satellite data to obtain a qualitative understanding of, and derive quantitative parameters for, the detection and prediction of severe storms, the improvement of short-term and long-term global atmospheric numerical prediction models, and the development of improved satellite systems. Qualitative understanding is sought through multispectral display of a series of time-lapsed, enhanced images of a rapidly developing severe local storm. The principal requirement of the quantitative parameter derivation is the measurement of cloud motions for the determination of wind velocity.

In January 1971, an image-processing system was completed at Goddard Space Flight Center. This system was developed in-house and was designated IDAMS (image display and manipulation system). IDAMS was developed to interactively perform geometric and radiometric modification to digital image data and to display the results on color and black-and-white television monitors. Operator interaction with the computer software and display hardware is achieved through a computer graphics terminal, a joystick, and function-control switches. Early in 1974, the potential of using IDAMS for meteorological image data processing was explored, and the decision was made to implement meteorological data processing functions on IDAMS.

Two approaches to wind-velocity (speed and direction) determination using television and computer systems have been developed under NASA meteorology study contracts, one by Stanford Research Institute (SRI) and the other by the University of Wisconsin. Both methods are based on the premise that wind vectors relate directly to change in cloud position over a period of time. Satellite image data received at known intervals provide a data base from which cloud sets are selected for tracking.

The Stanford Research Institute system (SRI/NASA cloud-study console) records photographic hardcopy imagery on an analog television "instant replay" disk recorder. Time-lapse viewing of the recorded image series, using conventional television monitors, enables the operator to select cloud sets which can be tracked to generate the cloud-motion/wind estimates. A cursor is manually

positioned on each cloud to be tracked, and the cursor position is transferred to punched paper tape for input to the computer. This process is repeated on each successive image to establish cloud motion. Landmark data are similarly assembled and transferred to the computer to be used as a geometric standard for image-data registration and geographic location. Cloud and landmark positions are computer-processed to produce an output tabulation and vector plot of the wind vectors.

The University of Wisconsin system, designated McIDAS (Man/Computer Interactive Data Access System), is similar to the SRI wind-vector generation; however, the processing computer is an integral part of the system. This system approach offers greatly improved operator interaction, system accuracy, and flexibility. The McIDAS input data base is from direct recorded satellite digital data. Digital data from approximately 30 Synchronous Meteorological Satellite (SMS) visible spectrum images (15 288 6-bit picture elements per line by 14 568 lines on each image) and 30 infrared images (3822 8-bit picture elements per line by 1821 lines per image) are stored on a single 14-inch reel of magnetic tape. Image data are merged with orbit, landmark, and sensor-related measurements in a preprocessing mode to establish the geographic location of picture elements.

When geographic locations of the picture elements are known, precise positions of clouds selected to establish wind vectors are also known. Interactive cloud selection is followed by vector generation, which yields an image display on the television monitors of the original image data overlaid with arrows which represent the wind vectors.

A cloud-height preprocessing algorithm is being tested at the University of Wisconsin to determine the altitude of clouds used for wind-vector generation, thus providing wind-vector data for several altitudes. The construction of three-dimensional wind-vector sets will be possible using this approach.

DEVELOPMENT OF FACILITIES

Design of the IDAMS was initiated in early 1970 to provide an image-data manipulation capability primarily for earth-resources satellite data processing. Basic system guidelines required the use of an existing computer manufactured by Control Data Corporation (CDC-3200) and the development of an interactive television terminal to be connected to the computer.

The IDAMS interactive terminal was designed around a digital disk recording system which refreshes the television monitor screen 30 times per second. Approximately 6 million bits or three television images (500 × 700 × 5 bits)

are stored in digital form on the disk. Figure 1 is a simple block diagram of the IDAMS display terminal and computer system.

Image data is transferred from computer tape or disk through the computer interface and a buffer memory to the IDAMS television refresh disk. Transfer time is 13 seconds per image. The three stored images may be displayed in true color, false color, pseudo color, or black-and-white as the operator chooses. Digital-inversion capabilities permit a mixture of positive and negative image data for false-color presentation and image subtraction. A fade control is used to view two images simultaneously. Image alternation for time-lapse viewing and split-screen presentations are included in the terminal hardware. Selection of image-alternation rates and the sequence which the stored images are to be shown in time lapse are under either computer or manual control. A video disk recorder is available as the image-storage media for time-lapse viewing of up to 600 images. The video recorder is an analog system, and therefore modification of image data must be performed prior to recording. An IDAMS hardware digital level-slice function is used to divide the image gray scale into three-color display boundaries. The lower gray-scale values are displayed in shades of red, the middle values in shades of green, and the upper levels in shades of blue. Two thumbwheel switches are used to select the dividing points between colors at any point on the 32-level gray scale.

Graphic overlay hardware functions include a crosshair or cursor and a variable-sized rectangle. The position of the cursor and the rectangle's position, size, and shape are under direct computer control. The operator can position or modify rectangle size by either typing his input requirements or by using the joystick and switches on the terminal console. The joystick and switches are linked back to the computer so that their functions may be determined by software assignment. The IDAMS software package is very broad and encompasses most image data manipulation operations being performed at image processing facilities around the country. Image-display software is based on image reduction or zoom of input image data to television-sized images. Image data sets which are larger than approximately 500 × 700 picture elements are reduced for television-monitor display by linear interpolation between adjacent elements. Smaller data sets are either displayed one-to-one, or the zoom function is performed by repeating picture elements to fill the 500 × 700 dimension.

The special-purpose software package developed for performing meteorology operations on IDAMS is METPAK, an enhanced combination of modified McIDAS cloud-tracking and wind-vector generation functions and IDAMS special-purpose image processing functions. The METPAK design is predicated on grouping of image manipulation functions and the elimination or minimization of housekeeping requirements, such as tape assignments, file numbering, and other non-meteorology functions.

63
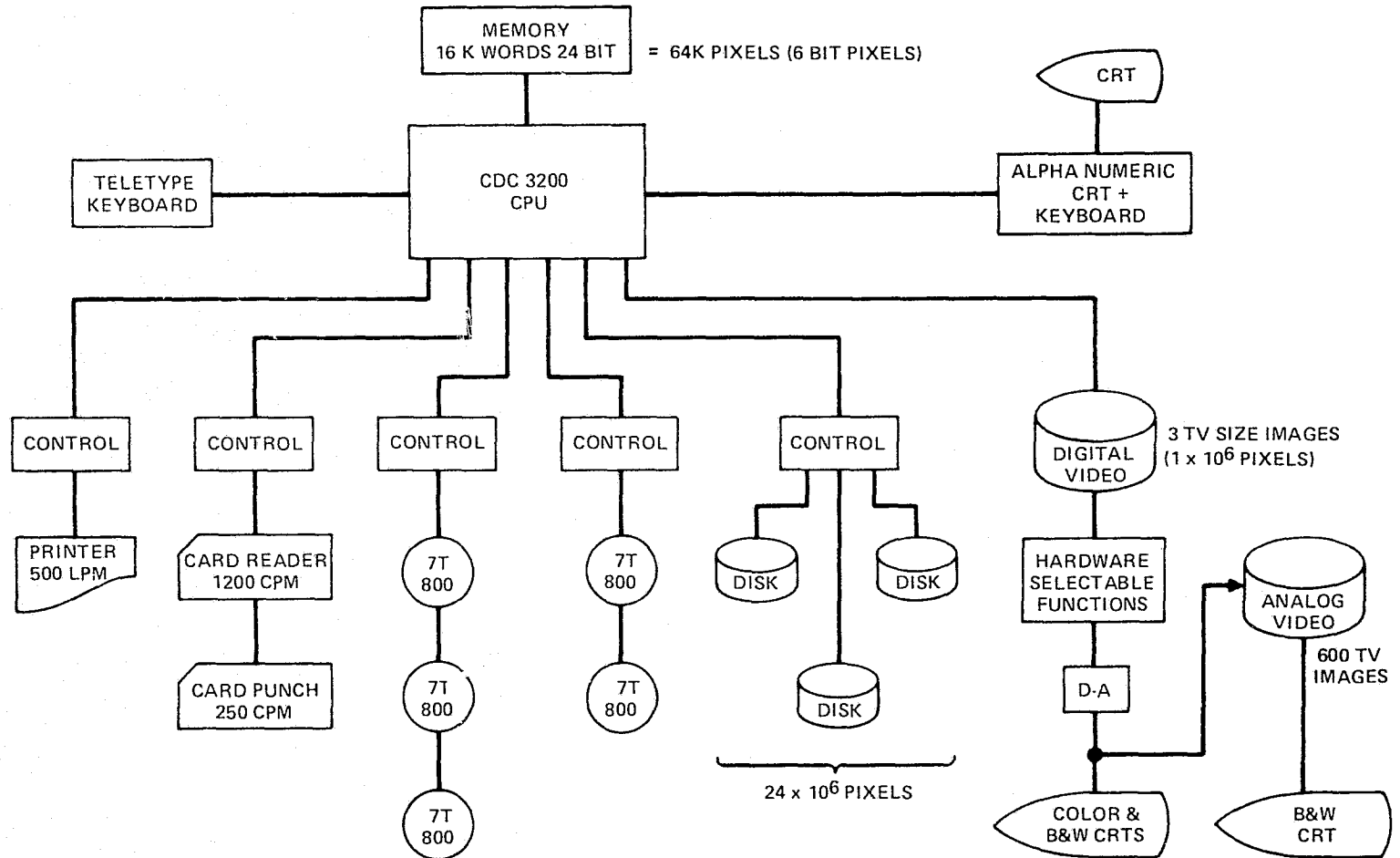
Figure 1. Image Display and Manipulation System (IDAMS)

The METPAK serves to establish latitude and longitude of selected clouds to accurately measure cloud position change from one image to another, to compute wind vectors from the displacement of the selected clouds, to display the wind vector field for evaluation and interactive modification, and to provide printer output for direct analysis and magnetic tapes of wind vectors for plotters and hardcopy image generation systems.

The meteorologist selects a working image data set by indicating data-acquisition date and time and the acquiring satellite. Data tapes are selected from the tape archives and sent to the IDAMS facility for processing.

The first instruction is to have the computer operator mount the master data tape on a specific tape drive. The second instruction requests the operator to name the reduced image. During each operation, informative statements are displayed to indicate to the user what is in process and where data are being stored. The reduced image data are automatically transferred to the IDAMS television refresh disk for display.

The reduce function is repeated for three image data sets which were acquired from the satellite at selected intervals. More data sets may be used for wind-vector generation; however, the first image reductions are performed to allow the user to select landmarks and areas of meteorological interest. The three images are viewed by the operator in a time-lapse moving-picture display to note position of viewable land, storms, and weather-feature motion. The IDAMS graphic rectangle is used as a locator to outline the areas of interest for enlarge or zoom functions.

The zoom function is first performed on areas that the operator selects to establish geographic earth reference. The operator selects the landmark register function and responds to inquiries such as zoom ratio, number of images to increase, and name of each image, and the processes are performed based on operator responses. Zoom ratios of either 1:1 or 4:1 are typical for locating landmarks.

After landmark zoom, the operator positions the cursor over a known landmark on each zoomed image and assigns latitude and longitude coordinates to the selected point or points. An accurate map facility must be maintained for this purpose. A landmark data file is accumulated in the computer as the operator locates landmarks on an image series. When landmark selection is complete, the navigation program is used to perform the computations necessary for precisely locating Earth coordinates of any clouds which will be selected for wind-vector generation. Inputs to the navigation programs are satellite orbit parameters and landmark coordinates from the landmark data

file. The quality of navigation is tested, and a navigation quality report is presented on the alphanumeric display. Poor navigation quality indicates improper landmark selection or incorrect orbit parameters. If corrections are required, the operator makes them before proceeding to the cloud-tracking function.

Two modes of cloud selection are possible using IDAMS METPAK. One mode is single-point tracking in which the operator selects the center or an identifiable feature on a cloud with the cursor on three successive images. Point-selection accuracy is enhanced by alternately switching between images to display the point selected on the previous image and allowing the operator to modify the position of selected points on any of the images. Viewing the three images in time-lapse motion with the selected points on each cloud displayed ensures good single-point selection. The second mode of cloud selection is similar to single-point tracking, except that a rectangle is used to outline selected cloud areas on each of the three images. Cloud displacements are computed by best-fit cross-correlation between the three cloud-image data sets. This method requires less effort by the operator and is more precise than single-point tracking, but it requires more computer time.

As cloud selection progresses in either mode, the operator is kept aware of selected clouds by the cursor momentarily flashing at each point previously selected. This function is necessary for eliminating duplicate selection and for ensuring complete cloud-selection coverage over the displayed area. Upon completion of cloud selection, wind-vector programs are initiated.

Wind vectors are calculated by applying the previously determined navigation coordinate transform to the picture coordinates of a selected cloud set and establishing true-Earth displacement (distance and direction) of the clouds. Cloud displacement is divided by the time interval between images to calculate cloud velocity. Arrows are generated to present wind-vector information to the user with arrow length proportional to wind speed. Arrow position and pointing direction relate wind direction as established from a particular cloud set.

Wind vectors are the output product of the IDAMS METPAK and are presented in several forms for use by the meteorologist. The display mode is used to observe wind flow and to edit out any obvious erroneous vectors. Display options include vector-field display or vector display overlaid on selected images. Time-lapse motion viewing of the vector overlaid image sets may be used for dynamic analysis of atmospheric motion. Another wind-vector output product is a computer printout of the wind-vector information. The printout lists date, time, latitude, and longitude of each cloud selected and the wind

speed and direction from each cloud set. Magnetic tapes of the vector and image overlaid vector data are another output product. These tapes are used to produce hardcopy products, such as ink-plot vectors for map overlay and photographic outputs of the vector sets overlaid on the original image series.

FUTURE PROGRAM

An operational system, the atmospheric and oceanographic information processing system (AOIPS), is currently under development. AOIPS will perform meteorology and earth-resources data processing, as well as new technique development on a much larger scale than the current IDAMS effort.

Central processing and control are performed by two Digital Equipment Corporation PDP-11 computers interconnected as multiprocessors. Either computer may use any of the peripheral equipment in both foreground and background modes of operation. System management software is used to assign equipment priorities for optimum data throughput. The system block diagram shown in Figure 2 illustrates interconnection of the AOIPS terminals, computers, and related equipment. Items shown in the block diagram are under development with anticipated delivery in late 1975 and 1976. In the present configuration, a modified General Electric Image-100 serves as the interactive terminal.

The Image-100 system has been modified to allow sequence-viewing of an image series and to incorporate computer-control of all hardware functions necessary for image manipulation. Digital image data is stored in the Image-100 terminal for television-screen refreshing and hardware manipulation. Five solid-state memories provide storage for five television-sized images. Each memory can store one 8-bit image with dimensions of 512 picture elements per line and 512 lines per image. The Image-100 terminal is directly connected to one of the PDP-11 computers. Data linkage between computers is accomplished by interconnecting the computer data buses and certain control functions.

The AOIPS high-density digital tape recorder will be used for image-data input. A large data-compression ratio is achieved by using high-density tapes rather than standard 9-track computer tapes. Image data from 250 9-track tapes may be stored on one high-density tape. Savings of tape, storage space, and data-acquisition time are considerable.

Television-sized images generated during an operating session are stored for rapid recall on the two large computer disk systems. Accumulation of over 600 digital television-sized images is possible. Data-management software allocates storage area to each user for later recall of his image data. Larger
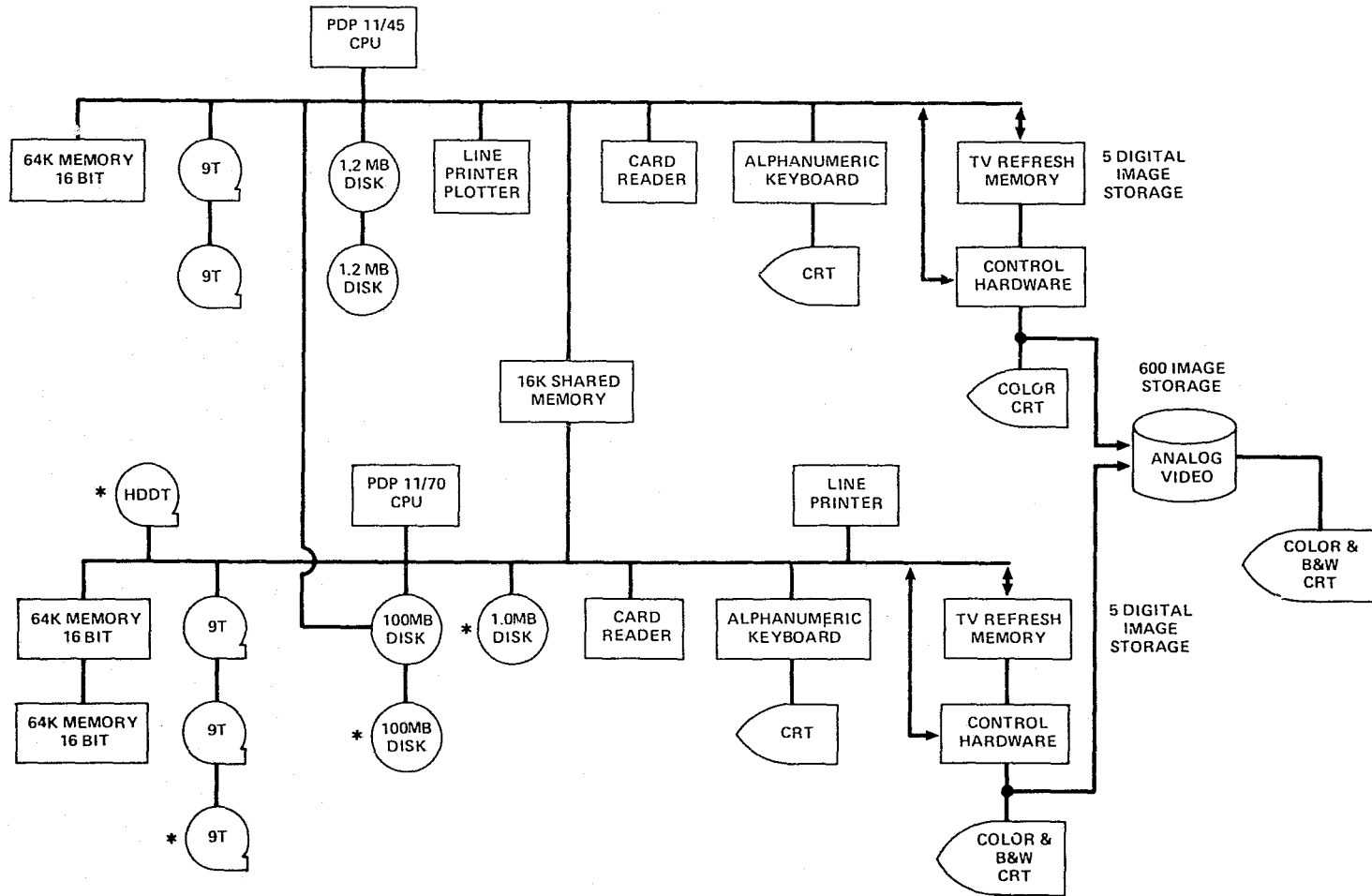
*ITEMS BEING PURCHASED AS OF JULY 1, 1975

Figure 2.   Atmospheric and Oceanographic Information Processing System (AOIPS) Block Diagram

image data sets may be stored if a user should want to manipulate more than the viewed image area.

The development of a real-time facility for severe-storm forecasting research is now underway.

SOFTWARE OBJECTIVE ANALYSIS PACKAGE

D. Berman, Computer Sciences Corporation

The purpose of the Software Objective Analysis Package (SOAP) is to aid meteorologists in the analysis of wind data. It is particularly useful in the analysis of wind fields covering small areas of the earth, such as small storms and hurricanes. It is now being used by GSFC to analyze data obtained by the tracking of clouds from Synchronous Meteorological Satellite (SMS) or Applications Technology Satellite (ATS) imagery on the image display and manipulation system (IDAMS).

SOAP has two basic features: an objective analysis of randomly located wind measurements to obtain a uniformly gridded field of various scalar quantities such as divergence and vorticity and the graphic display of the data and results.

The objective analysis is based on a scheme developed by Dr. F. Hasler (GSFC) and R. Lackman (NCAR) at the National Center for Atmospheric Research and modified for use at GSFC. The u- and v-components are treated separately, as is each different height (or pressure level) at which data are available. Up to 20 passes are made through the grid. On each pass, the raw data and grid points calculated on all previous passes within a given distance of each grid point are examined to calculate a value at that grid point. A calculation is made if three or more data points are available and their center of mass is less than a given value which is relaxed on each pass. The calculation is made by weighting each data point by its distance from the grid point and by a shadowing factor to take into account the vector nature of the data.

The scalar quantities calculated by SOAP include wind speed, divergence, vorticity, stream function (height), and radial and tangential wind speeds relative to a given storm center. The graphic display features include the display of the raw data and analyzed field using standard meteorological wind barbs and contour plots of the scalar fields. These plots may be generated on the CalComp pen plotter, the SD4060 microfilm plotter, and the Dicomed or Optronics recorders. On the latter devices, each of the plots may be overlayed on a gray level image of the cloudcover data.

SOAP is now operational on the IBM 360/91 computer at GSFC. An interactive version is now being implemented on the atmospheric and oceanographic information processing system (AOIPS).

GLOBAL ATMOSPHERIC RESEARCH PROGRAM
UTILIZATION OF CLOUD-TRACKED WINDS

J. P. Gary, GSFC

Cloud-tracked winds have been routinely generated by different computerized techniques at the National Environmental Satellite Service (NESS) and at the University of Wisconsin for inclusion into special data bases for use by global weather modelers at the Goddard Institute for Space Studies and at the National Meteorological Center. This work was supported by the Global Atmospheric Research Program (GARP).

Within the total GARP program, NASA (GSFC, in particular) has a charter to implement an end-to-end Data Systems Test (DST) as a precursor to the international First Garp Global Experiment (FGGE). There have been four DST periods of increasing length and complexity in which cloud-tracked winds were utilized:

- October 1974—5-day subsystem test

- January 1975—15 day-data-collection period

- August 1975—30-day real-time demonstration

- January 1976—60-day real-time demonstration

These DST periods have been conducted as a broad operational test of many of the proposed concepts, elements, and interfaces involved in the observation, data-management, and data-utilization systems planned for FGGE (Figure 1). The data flow implemented for these tests (Figure 2) parallels the operational procedures of the National Weather Service. In this data flow, two systems are used for determining winds from Synchronous Meteorological Satellite (SMS) images. Both measure cloud displacements from satellite cloud images and assume that these displacements are produced by the wind.

The NESS system (Figure 3) uses two methods for determining winds. Most low-level vectors are determined in a completely automated fashion by cross-correlation techniques using pairs of either visual or infrared photos. Winds are calculated only over ocean areas from 35N to 35S at preassigned points on a 2.5-degree grid. Vectors are manually edited to eliminate middle- and high-cloud motions. The remaining "low-level" winds are assigned pressures of 900 mb. Figure 4 is a sample product produced by this method.

DATA SYSTEMS TEST

END–TO–END OPERATIONAL TEST OF PROPOSED FGGE SYSTEM

```
┌──────────────┐      ┌──────────────┐      ┌──────────────┐
│  GLOBAL      │      │  DATA        │      │  DATA        │
│  OBSERVING   │ ──►  │  PROCESSING  │ ──►  │  UTILIZATION │ ──►  FORECASTS
│  SYSTEM      │      │  SYSTEM      │      │              │
└──────┬───────┘      └──────┬───────┘      └──────┬───────┘
       │                     │                     │
       ▲                     ▲                     ▲
       └─────────────────────┴─────────────────────┘
```

FEEDBACK FROM USERS
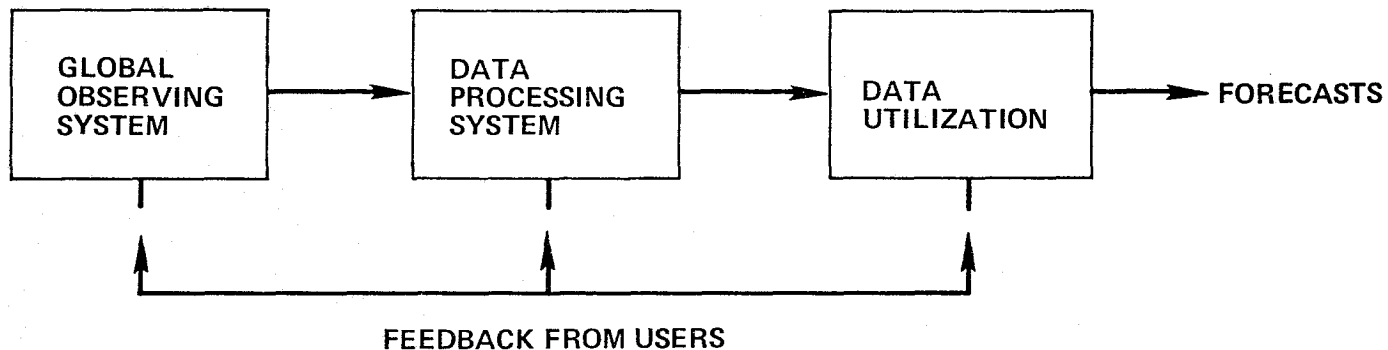
OBJECTIVES FOR CLOUD-TRACKED WIND FIELDS

- REAL-TIME

- COVERAGE

- QUALITY

Figure 1.   Global Atmospheric Research Program
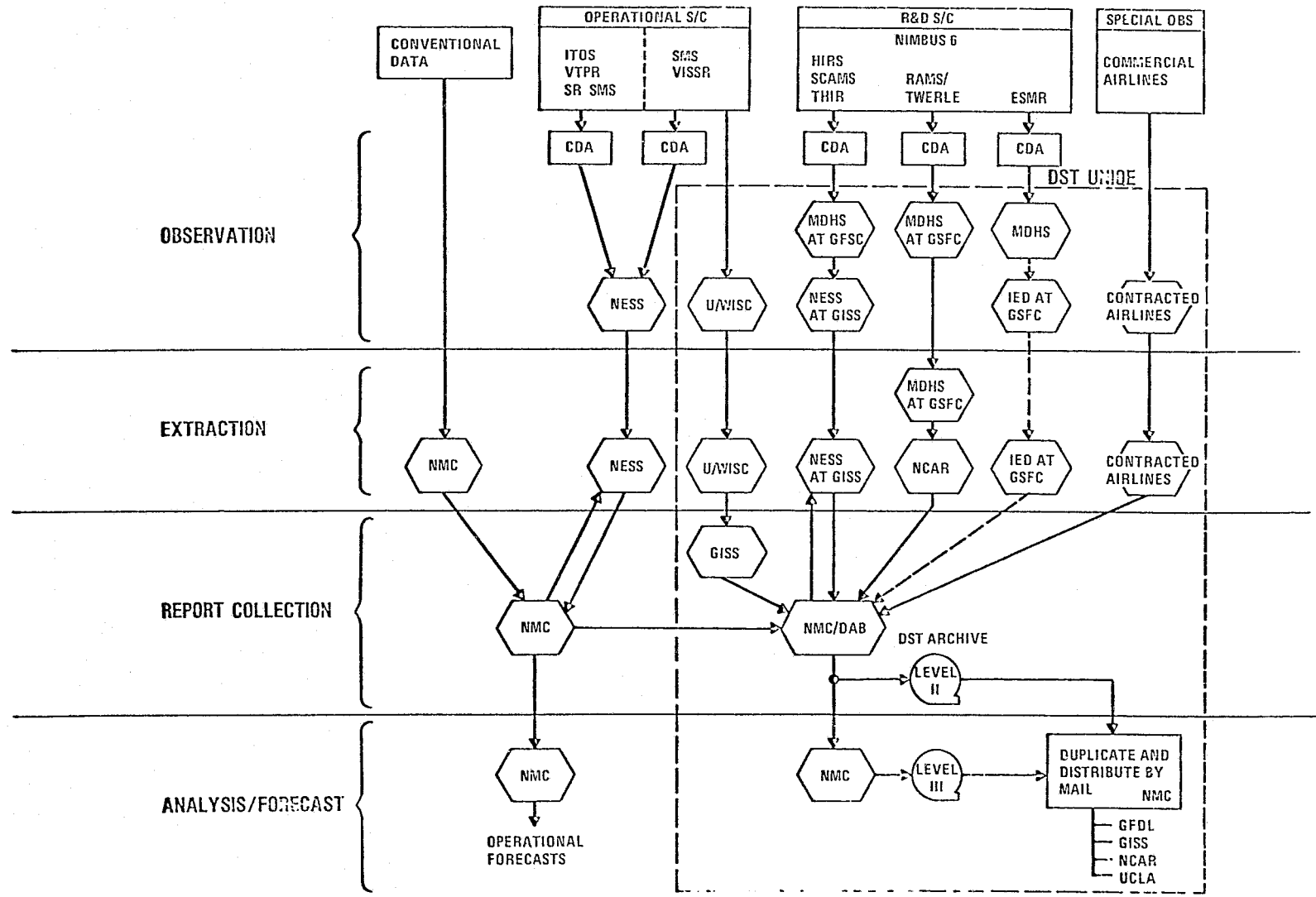
Figure 2.　DST Data Flow
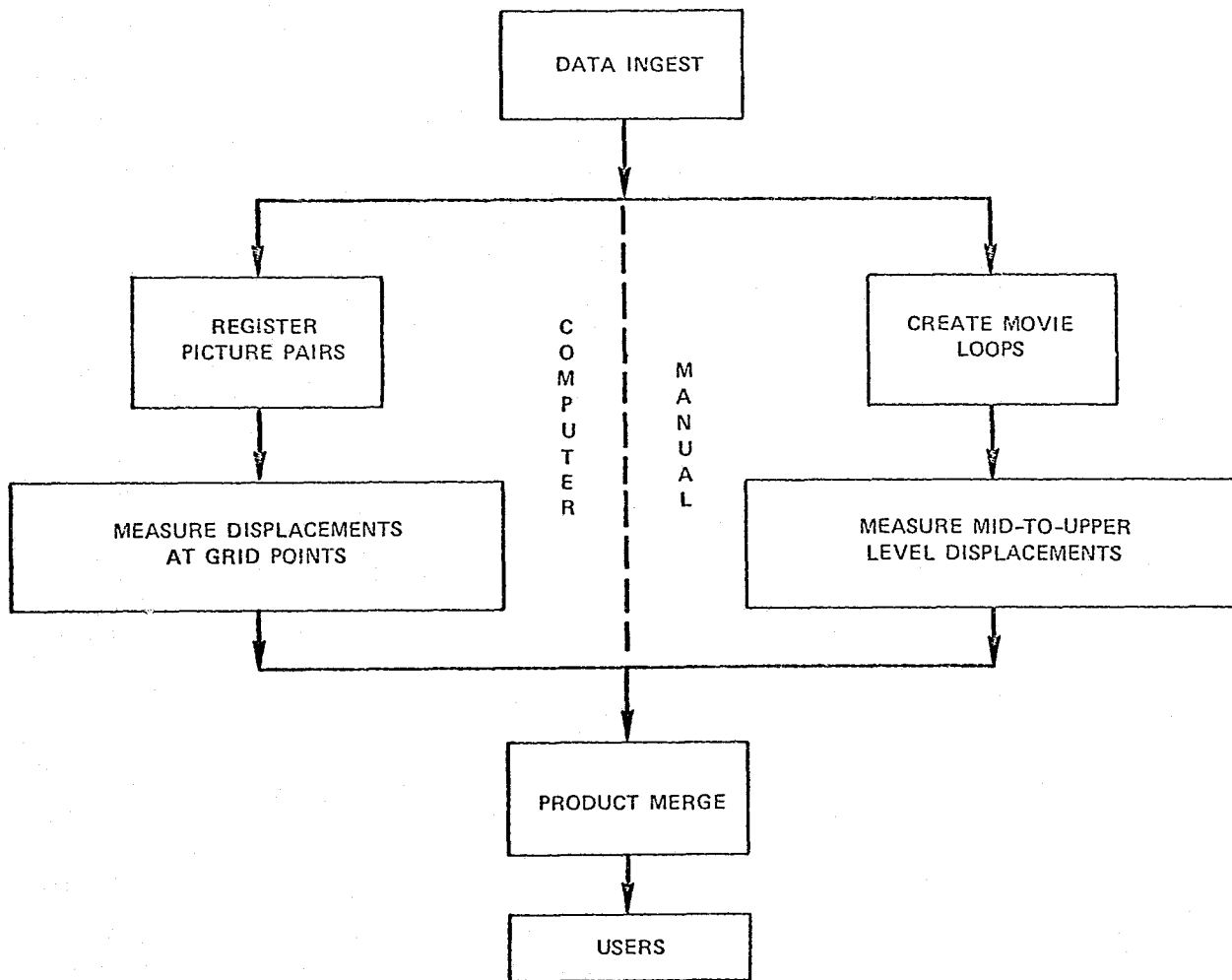
Figure 3.   Current NOAA Operational Winds System

74
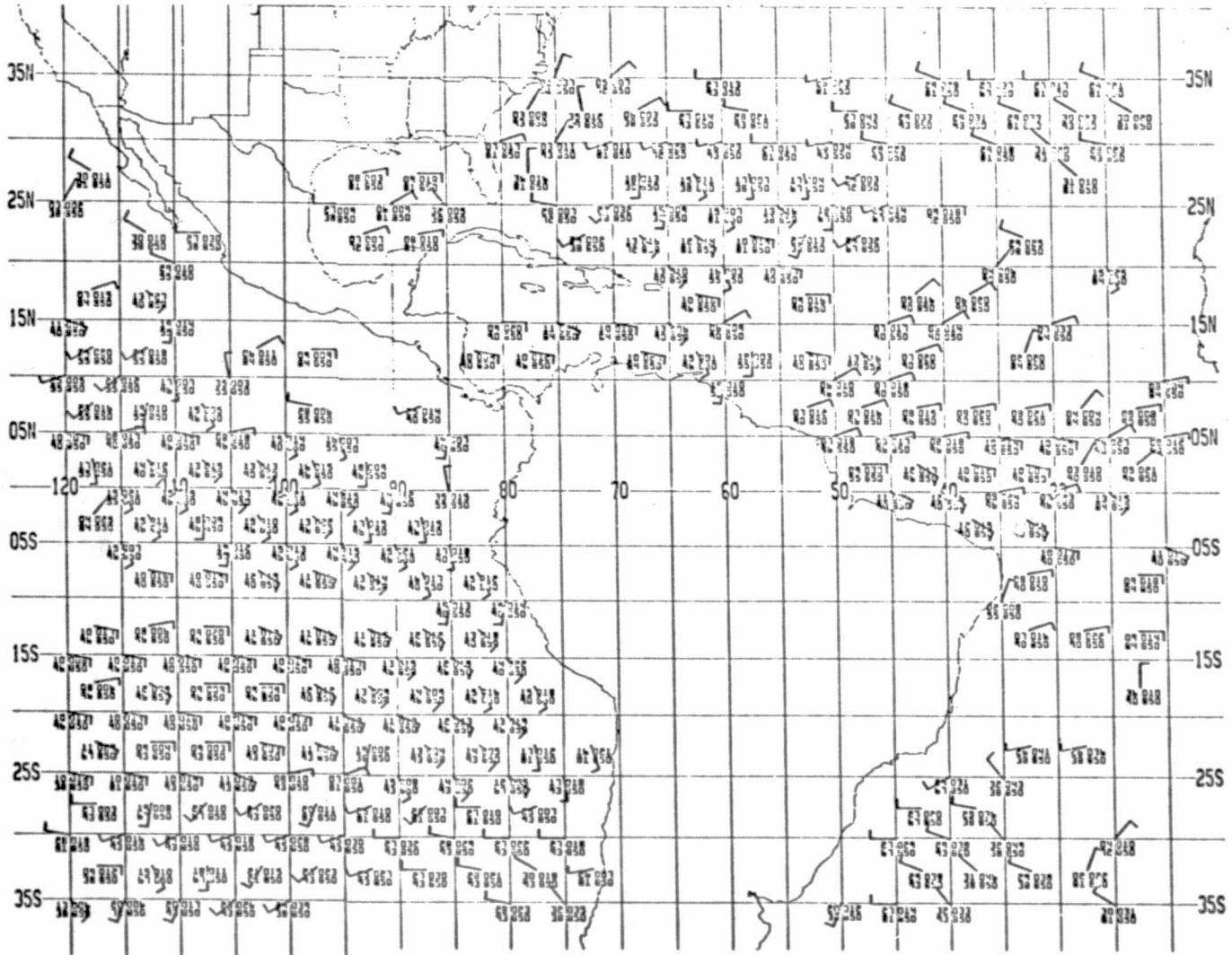
Figure 4.   Sample Cloud/Wind Product

High-level winds are determined from manual tracking of selected cloud elements appearing in projected film loops made from sequences of visible or infrared (IR) images. Winds from SMS film loops are assigned pressure altitudes inferred from equivalent blackbody temperatures. Temperatures are converted to pressures by using 12-hour-old National Meteorological Center (NMC) temperature analyses.

The McIDAS (Man/Computer Interactive Data Access System) cloud-tracking system (Figure 5) developed at the University of Wisconsin generates winds from pairs or triplets of pictures. In this system, an operator uses a video display unit to select targets which may be either individual clouds or features of clouds. Displacements may be determined by a variety of techniques, including both manual tracking and cross-correlations. The temperature of the target is determined from its blackbody temperature and from its emissivity as estimated from visible and IR data. Temperature is related to pressure by use of climatological profiles stratified by season and latitude. Figures 6 and 7 are example wind sets produced by McIDAS under operational constraints during the summer DST of 1975. Table 1 is a comparison of yield from different sounding retrieval systems and wind deriving systems, all of which contribute to the total DST data set. Figure 8 shows an example of Northern Hemisphere wind coverage generated by McIDAS. Table 2 compares results obtained from the University of Wisconsin cloud-tracking system.

Several sources of error have been identified and estimated. Navigation errors as large as a full visible pixel are inherently possible, although the largest measured is 0.38 m/sec determined in the January 1975 DST. Operator errors of reproducibility may be as high as 1.3 m/sec for cumulus clouds and up to 2.0 m/sec for cirrus clouds. Resolution errors match the temporal and spatial resolution of the sounder. A trained meteorologist is needed to determine when clouds are not moving with the speed of the wind. However, the largest source of error probably is in the computation of cloud height.

No way has been found to directly measure the accuracy of satellite-derived winds. Methods in current use can be appraised only on the basis of their mutual consistency, their contribution to reasonable, smooth synoptic scale wind analysis, and the extent to which they make a beneficial impact on global weather forecasting. The DST effort is developing analysis and techniques rapidly, and their continuous refinement is certain to improve results.
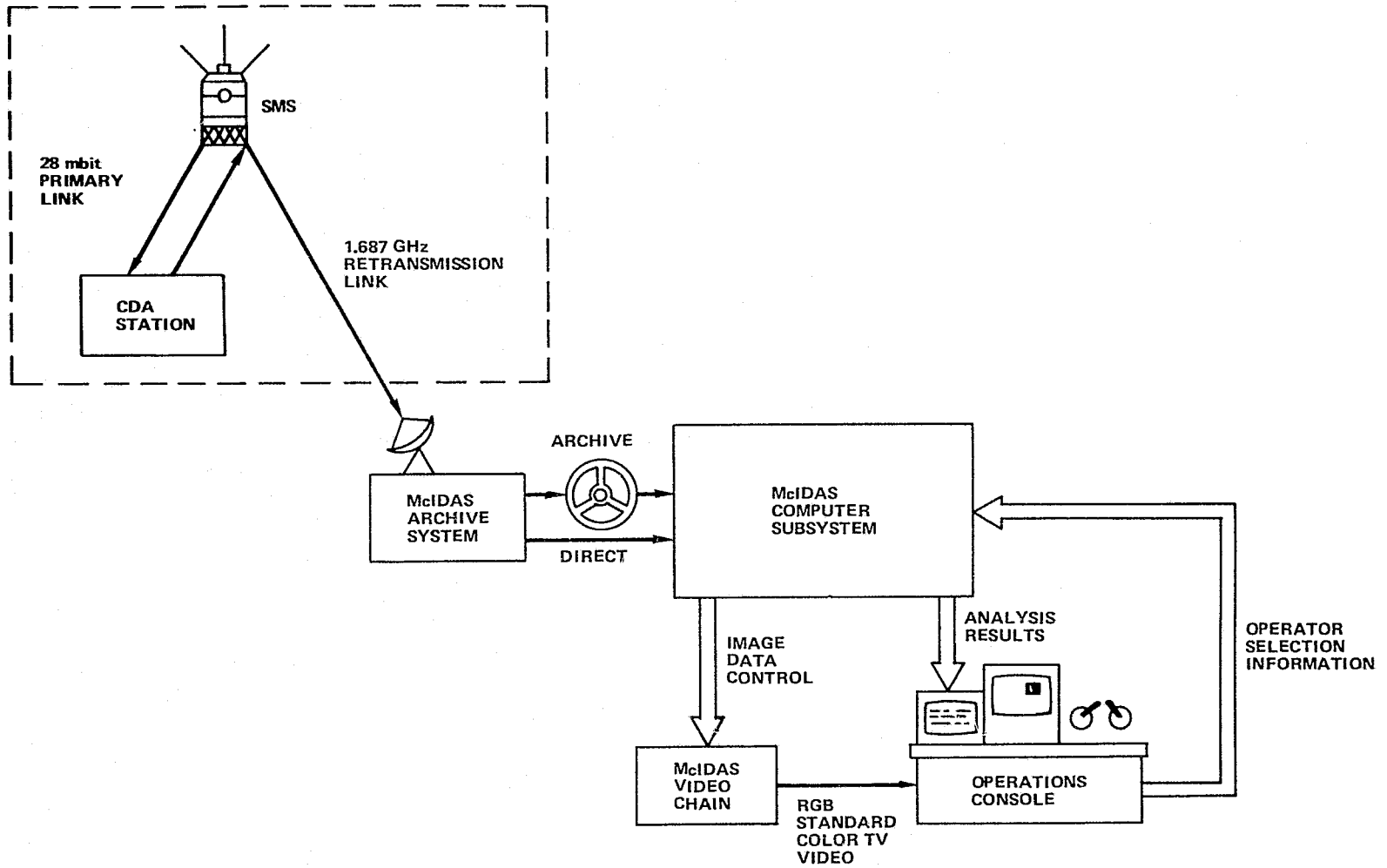
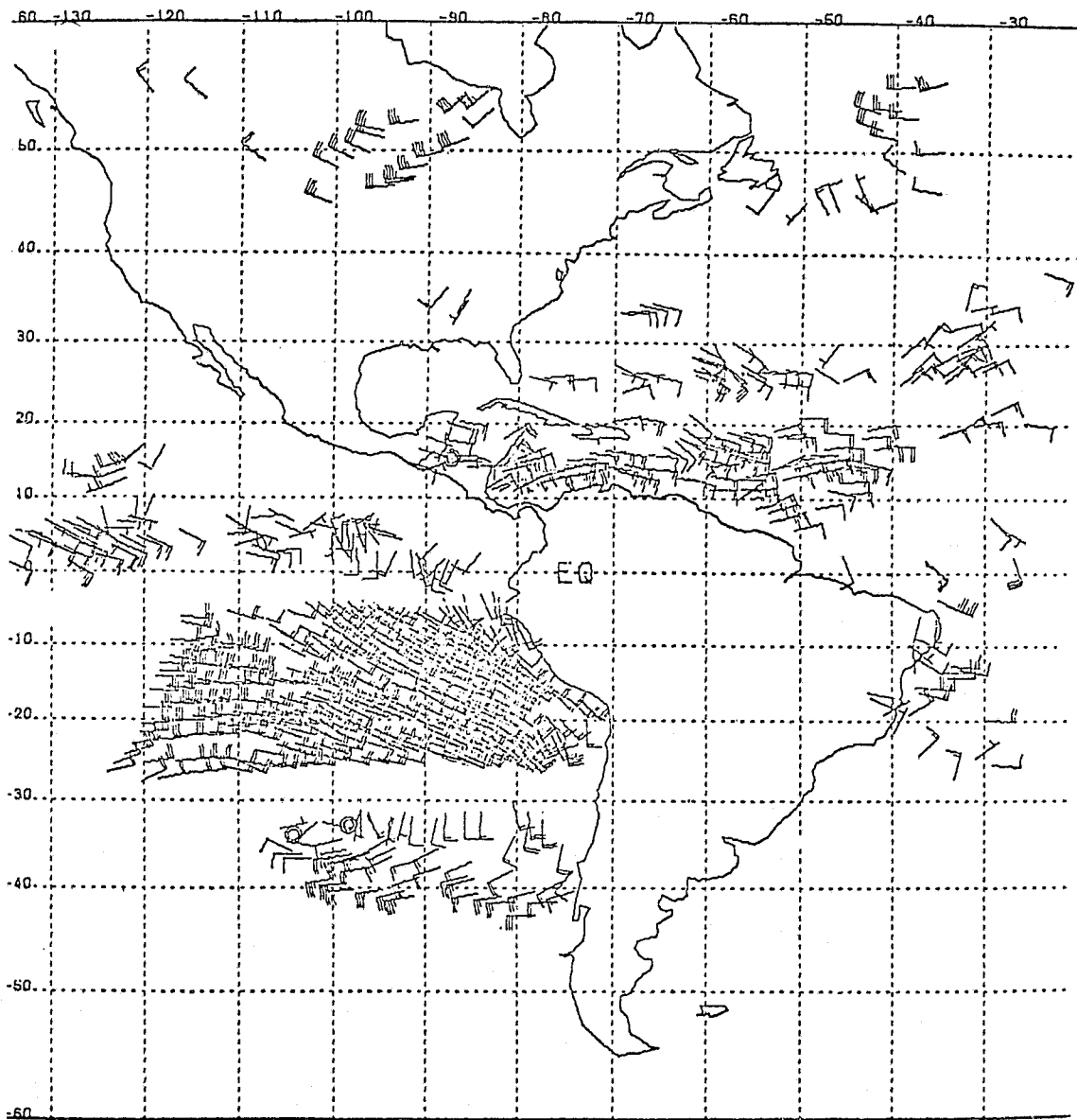Figure 5. McIDAS System Functional Block Diagram

Figure 6. Low-Level Winds (900 to 700 mb) for August 25, 1975, at 20 Z
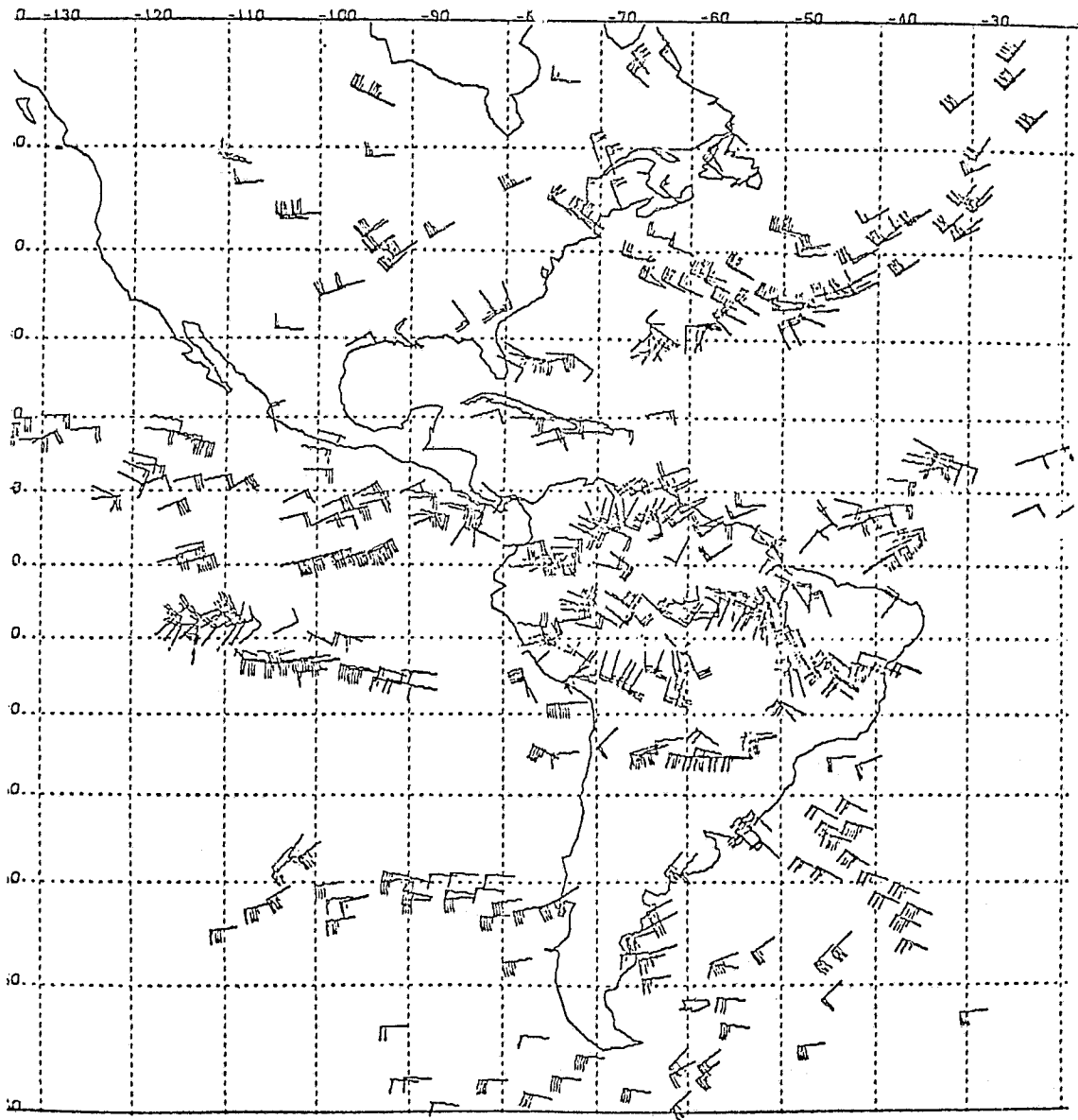
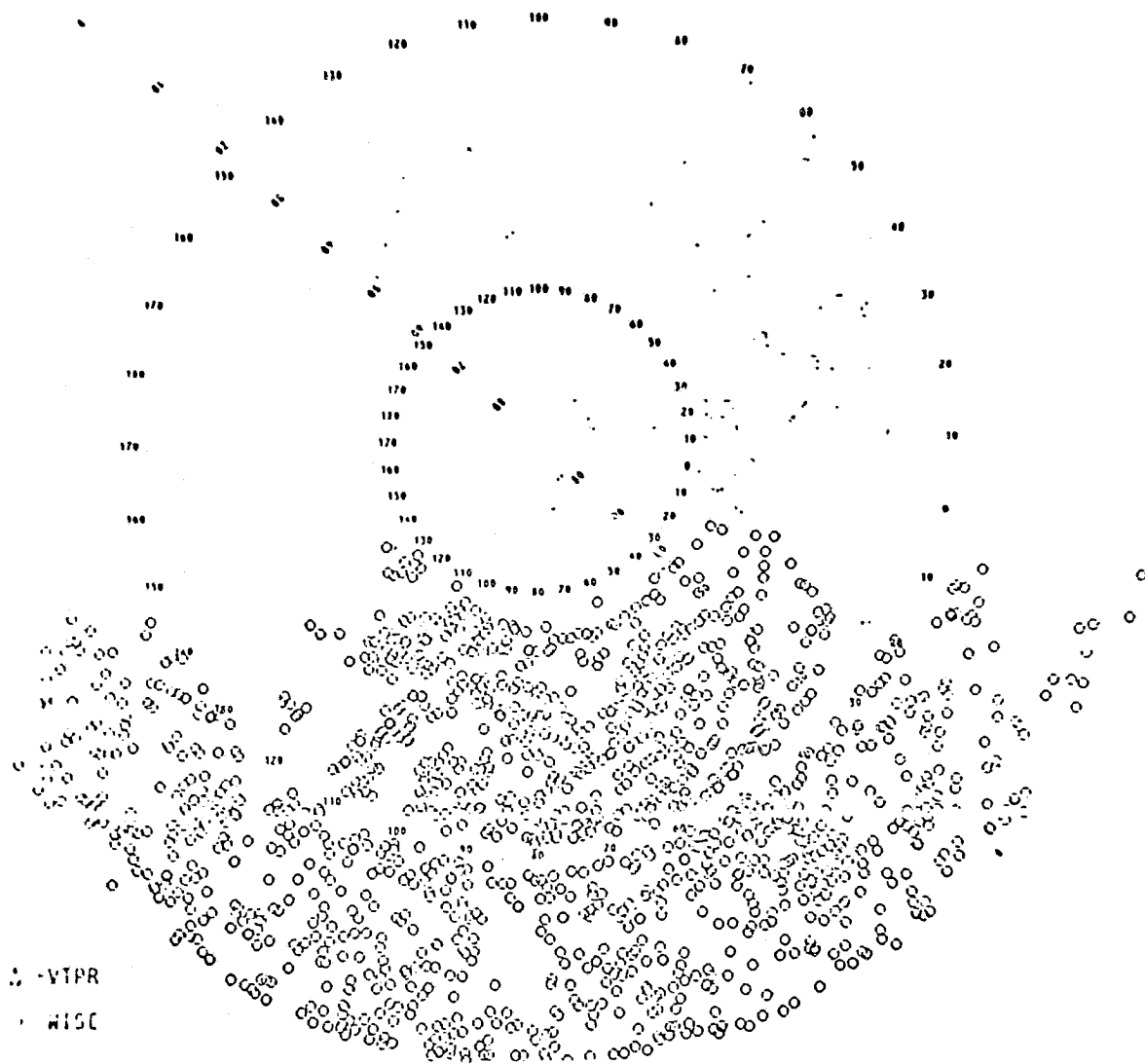Figure 7. High-Level Winds (300 to 200 mb) for August 25, 1975, at 20 Z

78

Figure 8.   Northern Hemisphere Wind Coverage

Table 1.   Data Counts

	NESS		DST	
	VTPR	SMS–A	NIMBUS	MCIDAS
August 18	1168	1630	4245	2986
August 19	1130	1322	5103	4436
August 20	1087	1380	6339	3248
August 21	1155	1312	4035	3595
August 22	1196	941	2024	2916
August 23	1120	910	5917	3666
August 24	1148	1405	6634	2759
Avg/day	1113	1326	5008	3652
s.d.	91	238	1106	678
Best day	1196	1645	6339	4685

Table 2. Cumulative Results of Comparisons

	Cloud Versus Rawinsonde	Rawinsonde Versus Rawinsonde
Mean distance to nearest rawinsonde station	316 km	278 km
Number of comparisons	3387	28007
Mean u difference	5. 49 m/sec	5. 13 m/sec
Mean v difference	4. 56 m/sec	4. 33 m/sec

Differences in Measured Winds for Simultaneously Launched Balloons

Distance between launch sites (km)	0.5	5	90	110	180	480	600	720	920
Differences (m/sec)	0.5	0.8	2.2	3.0	3.8	6.9	7.1	7.9	8.9

SOURCES

1. Lemar, P. and W. Bonner, "Comparisons Between Ness and Wisconsin Cloud Tracked Winds," 1975. Report available from authors at Data Assimilation Branch, Development Division, NMC.

2. Suchman, D., D. Martin, F. Mosher, B. Sawyer, and K. Baner, "Preliminary Assessment of the Cloud Tracking Systems Developed at the University of Wisconsin," 1975. Report available from authors at Space Science and Engineering Center, University of Wisconsin.

SECTION C

FUTURE CAPABILITIES/POSSIBILITIES

SEVERE-STORM RESEARCH PROGRAM

W. Shenk, GSFC

OBJECTIVE

The major objective of the NASA Severe-Storm Research Program is to develop and improve techniques for detection and prediction of severe storms through the use of space-related systems and remotely-sensed observations.

OBSERVATIONS

Geosynchronous satellite information is the most important satellite element because these data are taken with time and space scales that are commensurate with those of the phenomena. However, measurements from the low-orbiting satellites are useful for occasional surveillance with instruments that can provide high enough spatial resolutions for determining some important parameters (e.g., sea state in a tropical cyclone environment) that are currently impractical to obtain from geosynchronous satellites.

Aircraft measurements are necessary for improved interpretation of satellite information and for obtaining better descriptions of storm dynamics.

Radar, radiosonde, and surface reports are routinely supplied by the National Weather Service (NWS) and are the remaining part of the observing system. Some special observations of this type are taken by the National Severe Storms Laboratory in Norman, Oklahoma, and others.

The second element of the program is use of the data collected to improve the techniques for detection and prediction of severe storms, primarily through modeling, case studies, and applications demonstrations. The main thrust of the program is the implementation of field projects with a strong emphasis on aircraft measurements, development of diagnostic and prediction techniques with the focus on satellite information augmented by conventional data, and development of a Zero-G Cloud Physics Laboratory.

GEOSYNCHRONOUS SATELLITES

The measurements from geosynchronous satellites comprise the cornerstone of the program. Figure 1 shows the evolution of the NASA-sponsored meteorological instrumentation on geosynchronous satellites, including missions that now are being studied (Stormsat and Synchronous Earth Observatory Satellite (SEOS)). The Synchronous Meteorological Satellite (SMS) series now provides day and night coverage with temporal and spatial resolutions that are useful for
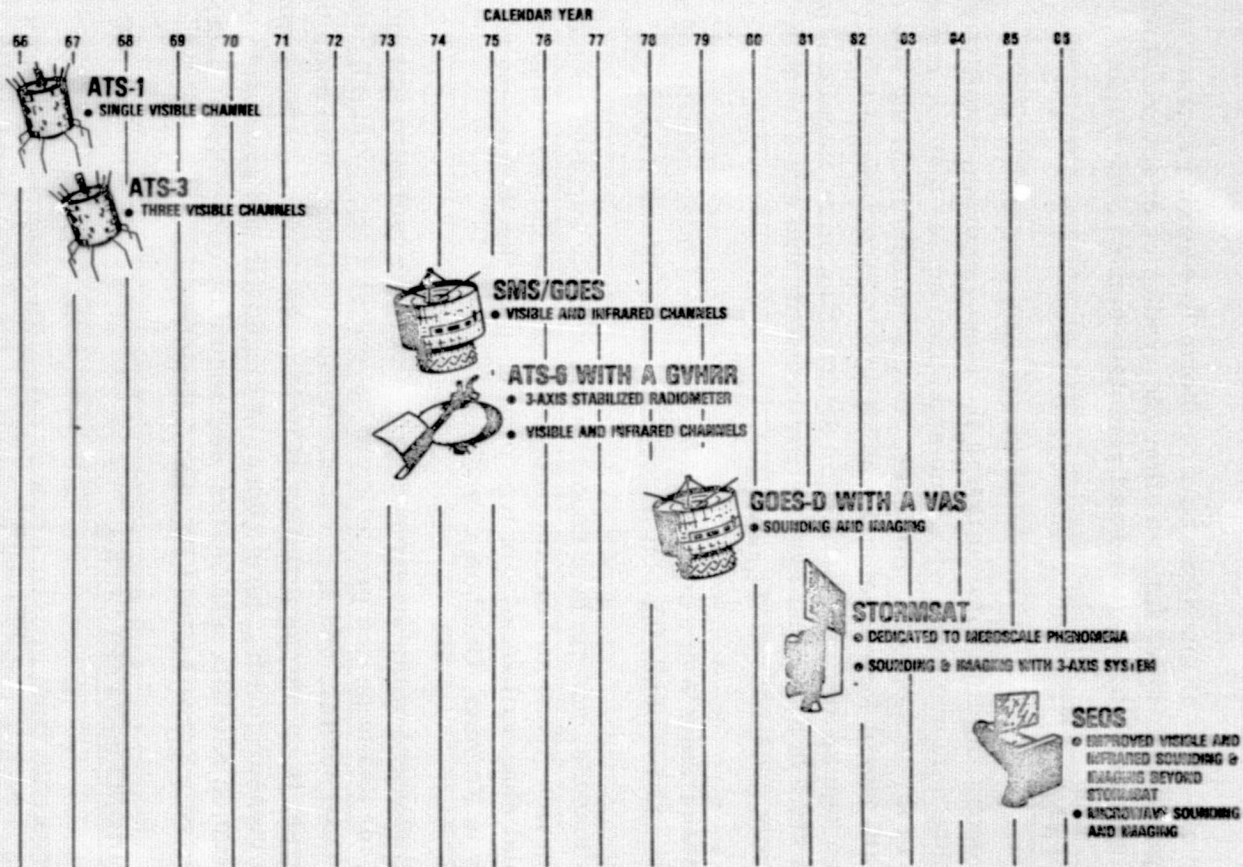
Figure 1. Evolution of the NASA, or NASA–Sponsored Meteorological
Geosynchronous Satellite Program.

severe-storm research. Future missions will add temperature and moisture profile retreival capability (infrared and microwave techniques) and substantially improve spatial and temporal resolutions and radiometric sensitivities. The Stromsat and SEOS missions will concentrate on severe storms and mesoscale phenomena, with a large percentage of time devoted to scanning small areas where the phenomena are located. The SEOS mission will be shared with Earth-resources observing requirements. The performance of the temperature profiling capability over $(750 \text{ km})^2$ areas of the VISSR Atmospheric Sounder (VAS), the Stormsat Advanced Atmospheric Sounding and Imaging Radiometer (AASIR), and the large radiometer on SEOS are superimposed in Figure 2 on the observation period and horizontal resolution requirements for the three major types of storms. The coverage of the VAS is 750 km by the width of the Earth because it is mounted on a spinning spacecraft. The thunderstorm requirements are the most difficult to meet, but the AASIR and the SEOS radiometers are designed to meet all of them. Figure 3 is for $(250\text{-km})^2$ areas and shows the requirements for other parameters and the capability of the 11-μm channel on each mission (in some instances used with others in multi-spectral techniques) to satisfy them. Thunderstorm cloud structures have the most severe requirements, particularly the measurement of the time history of cloud domes that penetrate above the cirrostratus anvil. Observation of the domes is an important measurement that will be developed to detect hail- and tornado-producing storms, as well as to isolate the parts of the storms that produce the heaviest rainfall. The AASIR 11-μm spatial resoultion will be slightly better than the VAS and will have much improved radiometric sensitivity. The larger SEOS optics will be used solely to improve spatial resolution.

FIELD PROGRAMS

There are four field programs for the study of (1) severe local storms, (2) the relationship between the mesoscale and synoptic scale, (3) tropical cyclones, and (4) the relationship between cloud motion and the wind.

SEVERE LOCAL STORMS

Predominantly an aircraft program, the severe local storm field program will steadily increase its capability during the next few years to determine the dynamical processes involved in the formation and maintenance of strong thunderstorm cells. In previous years, photographs taken at frequent intervals from aircraft have been correlated with severe weather reports. These flights have determined the size range of penetrating cloud domes above the cirrostratus and permitted an estimate of their lifetimes, indicated that the higher and larger persistent domes are probably associated with hailstorms, and established that
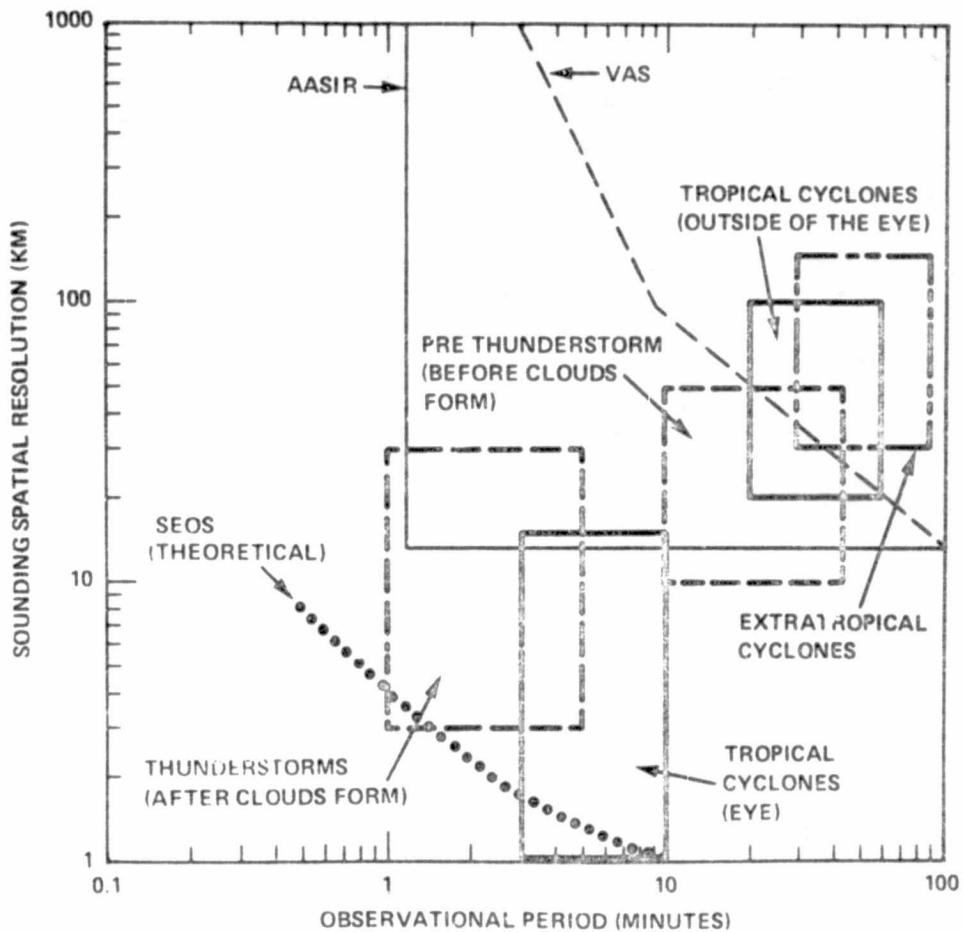
Figure 2. Comparison of Requirements and System Capabilities for Atmospheric Sounding from Geosynchronous Altitude (The area covered in this comparison is (750 km)^2 for the AASIR and SEOS and 750 km by the width of the Earth for the VAS.)
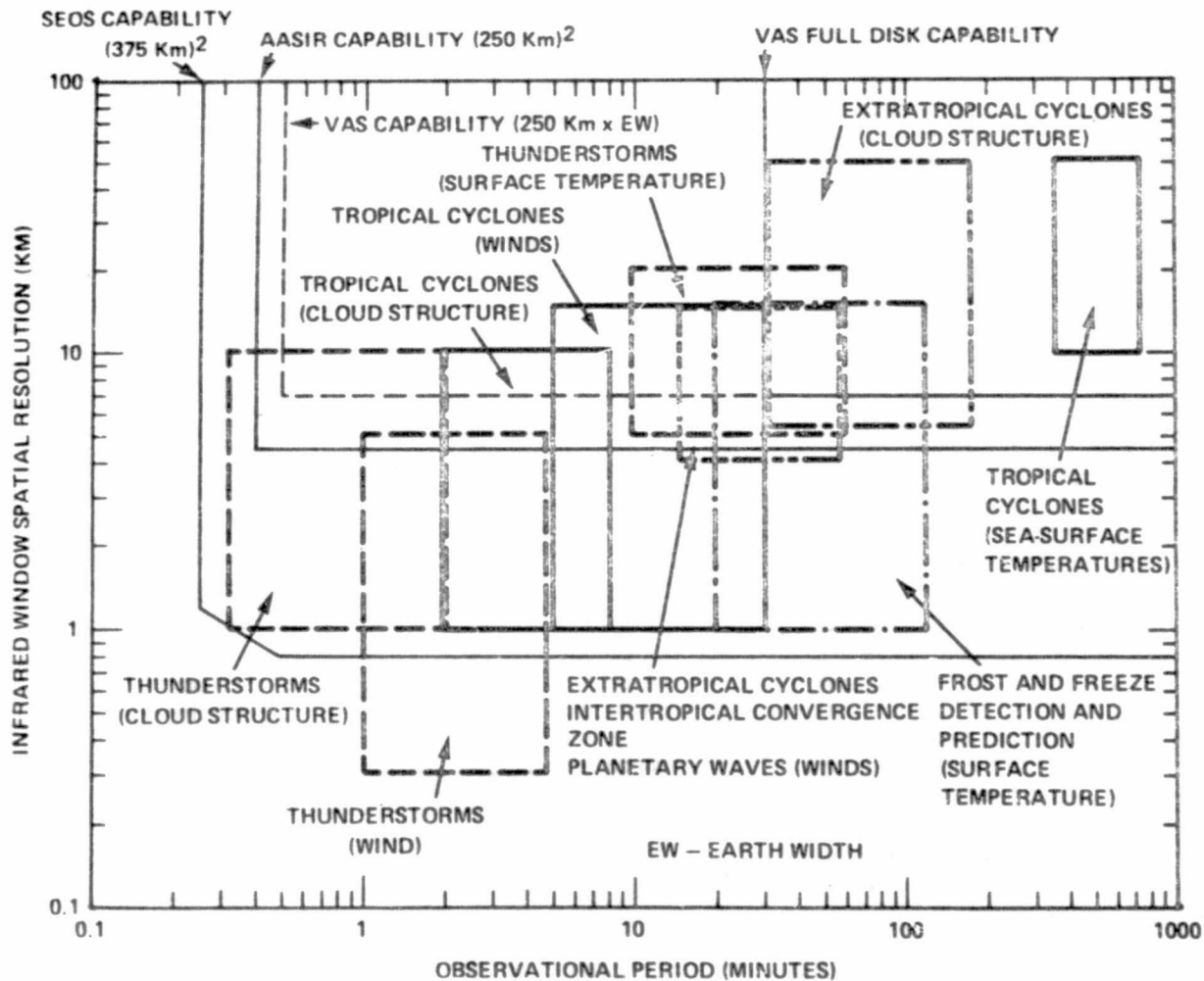
Figure 3. Comparison of Requirements and System Capabilities for Imaging Measurements from Geosynchronous Altitude (System capabilities are shown for the 11-μm channel. The area covered in this comparison is (250 km)^2 for AASIR, (375 km)^2 for SEOS, and 250 km by the width of the Earth for the VAS.)

tornadoes (four cases) have developed only during the collapse portion of the life cycles of major domes. This year the program added the capability for measuring the circulation surrounding, and to a limited degree, within the storm cells. These measurements will be combined with photographs of the changes in the cloud structure at the top of a storm as related to storm severity. After 1976, the program plans to add sensing capability to measure vertical temperature and moisture profiles, cloud-top temperatures and heights, and the three-dimensional motion field within the clouds and in the clear air surrounding the clouds.

MESOSCALE AND SYNOPTIC SCALE PHENOMENA

Special radiosonde measurements taken every 3 hours at NSW sites are used to investigate the relationships between mesoscale and synoptic scale phenomena. The measurements are usually taken for a 24-hour period over a large fraction of the Eastern and Central United States. After special processing to retain the detail, the measurements are used in the development of diagnostic and predictive models.

TROPICAL CYCLONES

The tropical cyclone field program will investigate the capability of remote sensors to measure wind, rainfall distribution and rate, cloud-top heights, cloud physics parameters, temperature, and moisture. The initial tropical cyclone flights are expected to be in the western Pacific in conjunction with National Oceanic and Atmospheric Administration (NOAA) Project Stormfury. Stormfury offers the opportunity for comparing remote measurements with the extensive in-situ information to be collected by the NOAA aircraft. Later flights are anticipated for the Atlantic.

CLOUD-MOTION/WIND RELATIONSHIPS

Winds are one of the most important parameters obtained from geosynchronous satellite measurements and are determined from cloud motions. The cloud-motion/wind relationship program, initiated in December 1972, has compared cloud movement with aircraft-measured in-situ winds from near the surface to cloud top. Forty tropical cumulus cloud areas have been tracked and a 1 to 1.5 m/sec vector difference between the cloud motion and the wind at the cloud base was found. Larger vector differences were measured at other levels. In 1976, a mission in the middle latitudes has been conducted where convective coupling to the cloud base was weaker than in the tropics and the windspeeds were higher. High-wind comparisons in a tropical cyclone environment are anticipated as part of the Stormfury flights.

DETECTION AND PREDICTION TECHNIQUES

An evolutionary set of interactive man-machine computer systems is being established and will be supported by existing large computers for batch processing. The interactive systems are the Image Display and Manipulation System (IDAMS), the Atmospheric and Oceanic Information-Processing System (AOIPS), and the Applications Information-Processing System (AIPS). The IDAMS is now operational, the AOIPS will be operational by April 1976, and the AIPS will be available in time for Stormsat (1980).

The IDAMS is used for extracting winds from cloud motions and for determining cloud-top height. The AOIPS will expand the parameter extraction capability by determining: (1) temperature and moisture profiles over limited areas, (2) precipitation parameters, and (3) cloud parameters. Conventional data will be supplied to AOIPS via the NOAA Automation of Field Operations and Services (AFOS) system. The batch processors will determine sea-surface temperature, calculate temperature and moisture profiles over areas larger than AOIPS can handle, and run atmospheric models available to GSFC. The multidiscipline AIPS will fulfill the real-time demonstrations of Stormsat and also extract parameters in a research mode.

Case studies will be performed to gain a better physical description of the storms and to specify what storm features and meteorological parameters should be emphasized in the modeling activities. Although case studies will be done throughout the program, the emphasis will be on the development of objective techniques as the program progresses.

Some mesoscale modeling activity exists either with NASA models or with models made available by others. These include models for severe-local-storm prediction and for general tropical diagnostics. Other modeling activities that will be pursued within the next 2 years are tropical-prediction models, tropical-cyclone models, middle-latitude finemesh models for extratropical cyclones, and others for mesoscale diagnostics and prediction. In addition to numerical models, an empirical orthogonal functions statistical model has been used for improving tropical-cyclone prediction.

ZERO-G CLOUD-PHYSICS LABORATORY

The physical processes which govern the formation of water droplets, the freezing of these droplets, and the effect of electrical fields and droplet charge on these processes cannot be adequately studied in a conventional laboratory because of the constant influence of the Earth's gravitational field on droplet motion. A Zero-G Cloud Physics Laboratory (CPL) will be placed on a space

shuttle and will thereby remove the normal contamination of the Earth's gravitational field. Research efforts in this program will focus on the development of theoretical models of cloud processes that can be tested on the Zero-G CPL and on the definition of the experiments to be conducted.

SEVERE-STORM FUTURE DATA SYSTEM

R. Jones, GSFC

All processing of visible infrared spin-scan radiometer (VISSR) output within the Telemetry Computation Branch is now performed by one program: the Synchronous Meteorological Satellite (SMS) VISSR data-processing program (DPP). This program performs editing time and data smoothing and merging of orbit/attitude/telemetry (O/A/TM) data, and produces master data tapes (MDT) for archive, as well as required experimenter tapes. However, the demand for processed VISSR data grows continuously as additional instruments are placed in orbit, and the quantity and variety of tapes requested is taxing the fixed capacities of SMS VISSR DPP.

Expansion of the present system is not practical. The need has been established for a new program to supplement the capabilities of SMS VISSR DPP and to provide flexibility for future expansion. A severe-storm future data system task group has studied the requirements, assumptions, and functions necessary for fulfilling the future preprocessing tasks and proposed the solution set forth herewith.

The foremost requirement of a new system is substantial increase in speed and therefore, capacity. The current system has a maximum throughput of six partial frames per day and a normal turnaround time of 14 days. This rate must be advanced to near real time by 1978, which may be as high as 40 visible images per day (48 full-Earth infrared (IR) images) for 24 hours per day, 7 days per week operations. Real-time preprocessed images should be available in about one-half hour and a 5-minute scanning should be available in 5 minutes.

The availability of high-density tape (HDT) offers a cornerstone for the new system, and all data will be recorded on this new medium for transmission to the atmospheric and oceanic information-processing system and to the archives. Computer-compatible tape will be used for hardcopy machine image processing and for data viewing by Applications Directorate (Code 900) meteorologists. This will permit real-time preparation of quick-look hardcopy images— although of comparatively poor quality—for rapid review by the Atmospheric and Hydrospheric Application Division. In contrast, high-resolution images will be available at the rate of about 10 visible or 20 IR per day. A request should be fillable with one week, and a special request, suitably documented as to urgency, should be fillable in a single day.

The new system is based on these assumptions: O/A/TM will be included in the documentation; capture tapes need be retained only until HDT tapes are

verified; no redundancy is required; and faced with a choice, the system will always record capture data in case of system failure rather than receive new data.

Elements of the planned new system are shown in Figure 1. The Direct-Read-out Ground Station (DRGS) is contained in two mobile trailers now located at the Westinghouse facility near Baltimore, Maryland. This complete satellite ground terminal is equipped to receive, record, process, and display stretched VISSR data relayed by SMS. These data enter the system directly into the digital interface equipment (DIE), although analog capture tapes are generated simultaneously as backup. Bit and frame synchronization are provided; a quality check is performed for line number, time, and deepspace value; and a calibration is extracted for the radiometric corrections. The data may be compressed if necessary. The VISSR data processor decommutates the orbit, attitude, and pulse-code modulation (PCM) data, documents the time, and provides the line number. Quick-look hardcopy of either the visible or infrared imagery can be produced.

The processed data are sent either directly or through HDT to the atmospheric and oceanic information-processing system (AOIPS). The HDT is then used for preparing low-resolution film and computer-compatible tape for distribution to film users. Required quality control, accounting, and trouble message reports are generated, and the archive data base is established. The new system will be capable of selecting a specific 4000-line by 4000-pixel area requested by user, eliminating empty sky or distorted Earth-edge areas. It will read back analog capture, O/A/PCM, and HDT tapes on user request.
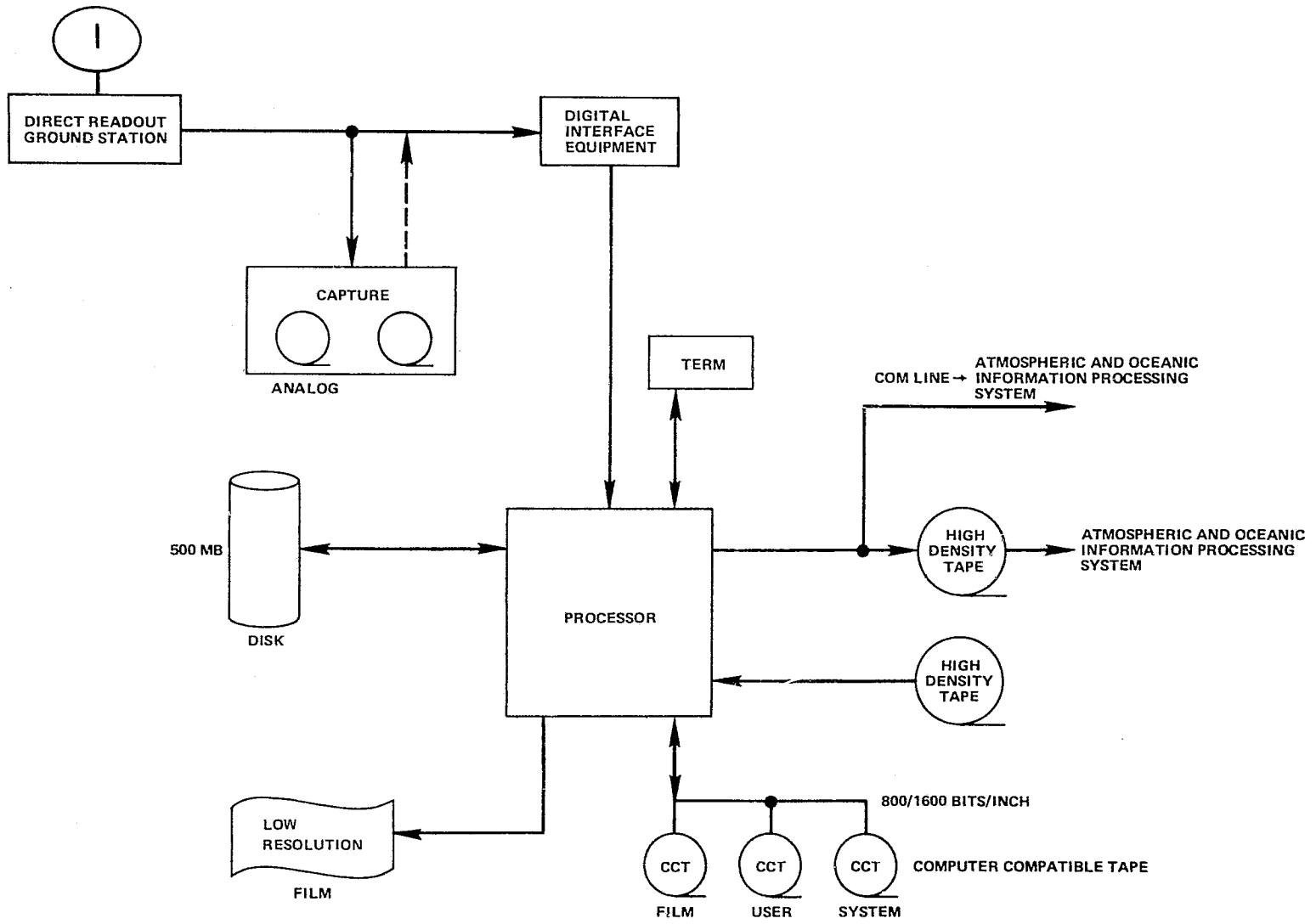
Figure 1. Severe-Storm Future Data System

ORBIT AND ATTITUDE STATE RECOVERIES FROM LANDMARK DATA

C. Velez, GSFC

The navigation of Earth-referenced satellites with imaging data rather than, or in addition to, conventional radio tracking and attitude-sensor telemetry is gaining increased popularity. Driving forces include a trend towards spacecraft autonomy, a need for timely and highly accurate gridding information, and a growing awareness of the presence of high quality navigation information contained in such data.

An experiment has been performed to determine the orbit and attitude state of the geosynchronous Synchronous Meteorological Satellite-1 (SMS-1) spacecraft from landmark observations extracted from Earth images generated by the onboard visible and infrared spin-scan radiometer (VISSR). Experimental results from two data-collection periods (August 1974 and May 1975) on the SMS-1 have demonstrated that:

- High quality landmark observations may be determined, using existing landmark extraction and identification techniques;

- Highly accurate gridding of all images may be accomplished with landmark data, using a subset of images taken over a 2- or 3-day interval;

- Navigation information contained in landmark data is comparable to that obtained from conventional radio-tracking devices. The accuracy of the landmark solution can also be improved through a better resolution of the semimajor axis of the orbit by increasing the observation time span of the data.

Details of the procedure are available in "Orbit and Attitude State Recoveries from Landmark Data" by C. E. Velez in the Proceedings of A.A.S. Astrodynamics Specialists Conference, Nassau, Bahamas, July 28-30, 1975. Paper No. AAS 75-058.

VAS INSTRUMENTATION FOR FUTURE GOES MISSIONS

H. Montgomery, GSFC

The Visible Infrared Spin-Scan Radiometer Atmospheric Sounder (VAS) will operate as an integral part of the Geostationary Operational Environmental Satellite (GOES) system. The GOES will be placed in an orbit at synchronous altitude (35.8 by 10^3 km) in a plane orthogonal with the Earth's spin axis. The VAS will provide both day and night two-dimensional cloud-mapping capability with a satellite subpoint resolution of approximately 900 meters (0.5 nmi) in daylight and approximately 6.9 km (3.7 nmi) at night. The VAS will also obtain radiometric data on the water vapor of Earth's atmosphere and CO_2 absorption band, providing the capability to determine the three-dimensional structure of the atmospheric temperature and humidity.

The VAS is an advanced version of the visible infrared spin-scan radiometer (VISSR) developed for worldwide geostationary meteorological satellite systems.

Figure 1 shows the VISSR and points out the aft optics as the area of modification. Figure 2 is a drawing of the aft optics which shows a 12-position spectral filter wheel and an oscillating calibration shutter added to the VISSR.

The VAS arrangement as used in the spin-stabilized geostationary satellite is shown in Figure 3. The mapping raster is formed by the combination of the satellite spin motion (spin-scan) and the step action of the scanning optics. One raster line, corresponding to the Earth's west-east (W-E) axis (longitude), is formed for each revolution of the spinning satellite, and the VAS scanner positions each successive line in the north-south (N-S) (latitude) direction. Each 0.192 milliradian (mr) N-S axis scan step corresponds to the total field of view of the eight visible-channel detectors. The 900-meter resolution in the visible spectrum (0.55 to 0.72 μm) is obtained by using a linear array of eight detectors aligned so that they sweep out the complete scan line path. The instantaneous geometric field of view (IGFOV) of each of the visible channels is 0.025 mr (W-E) by 0.021 mr (N-S), allowing 20-percent underlap between field stops for fabrication considerations. The Earth is covered in the N-S direction with 1821 successive latitude steps until 20-degree coverage is obtained.

The VAS has six infrared detectors. Two have a subpoint resolution of 6.9 km (IGFOV of 0.192 by 0.192 mr) used primarily for imaging, and four have a resolution of 13.8 km (IGFOV of 0.384 by 0.384 mr) used for sounding information. The two small infrared channel detectors are mercury-cadmium-
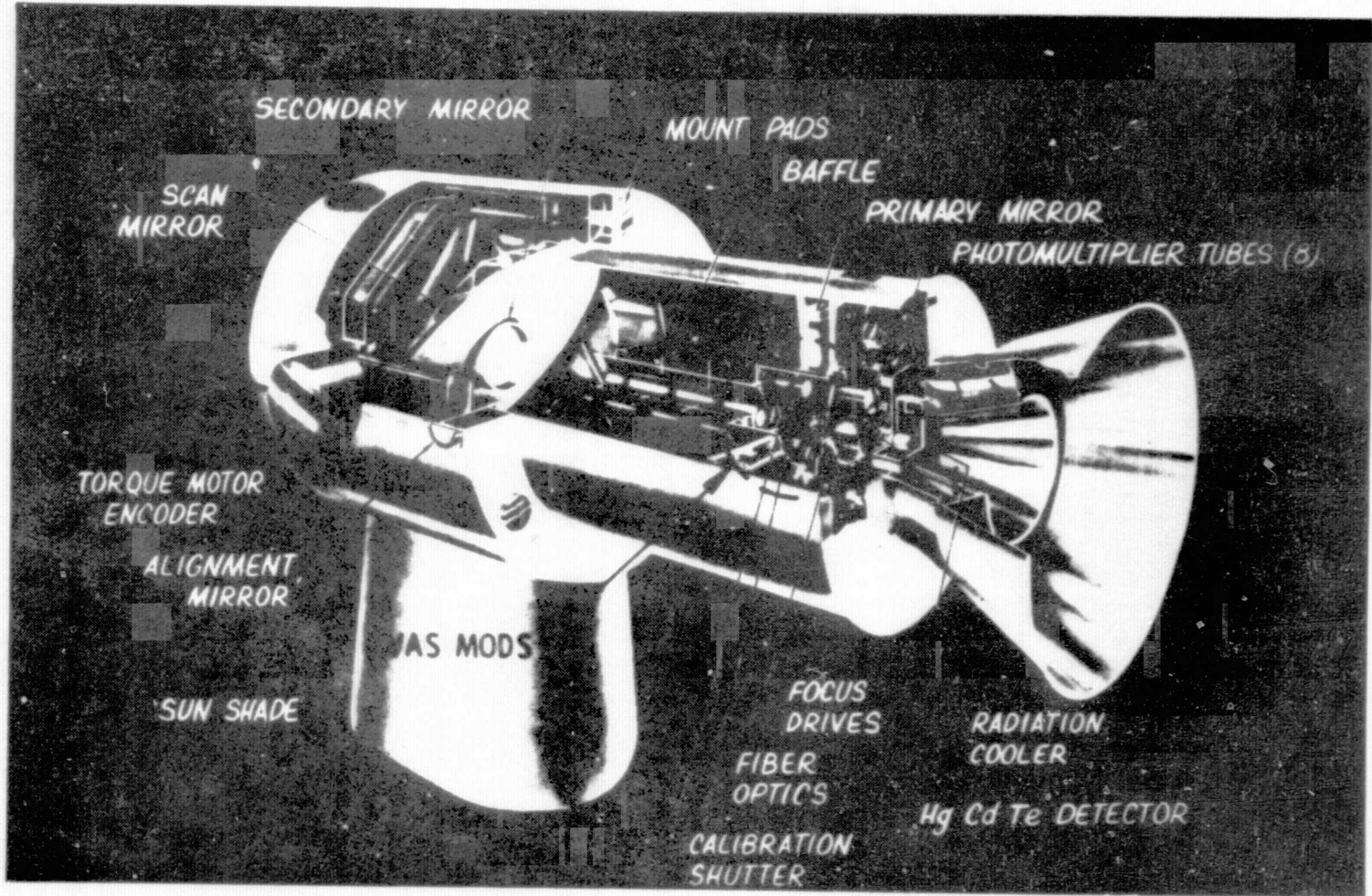
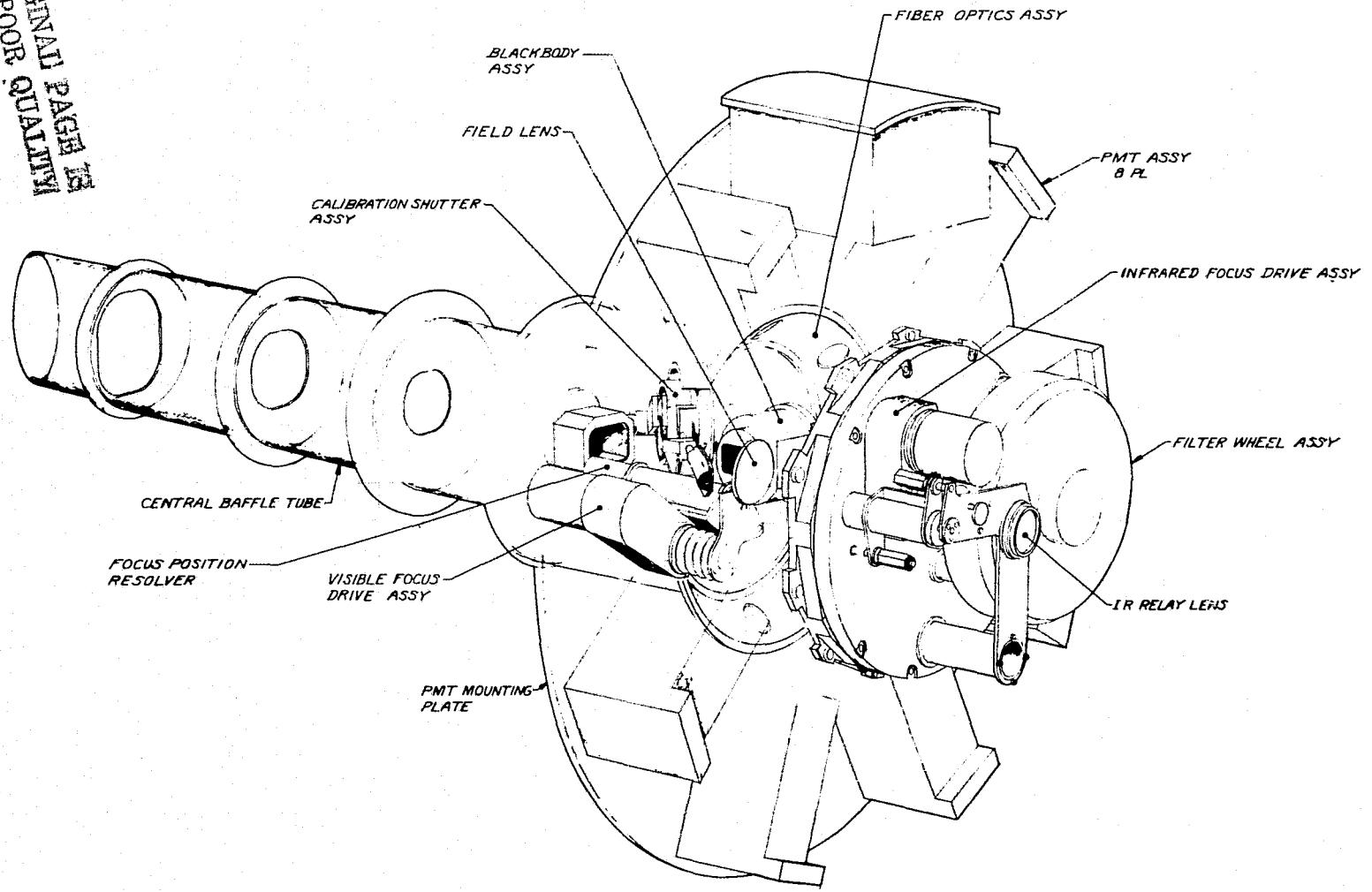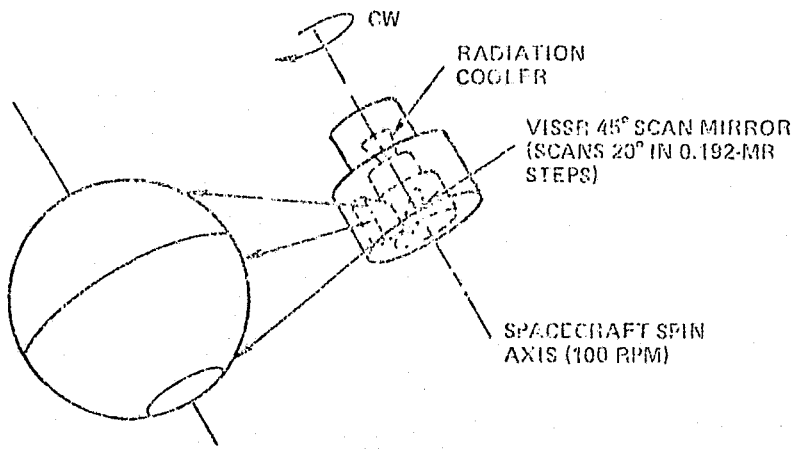Figure 1-2.   VISSR Telescope/Scanner Assembly

Figure 1. VISSR Aft Optics
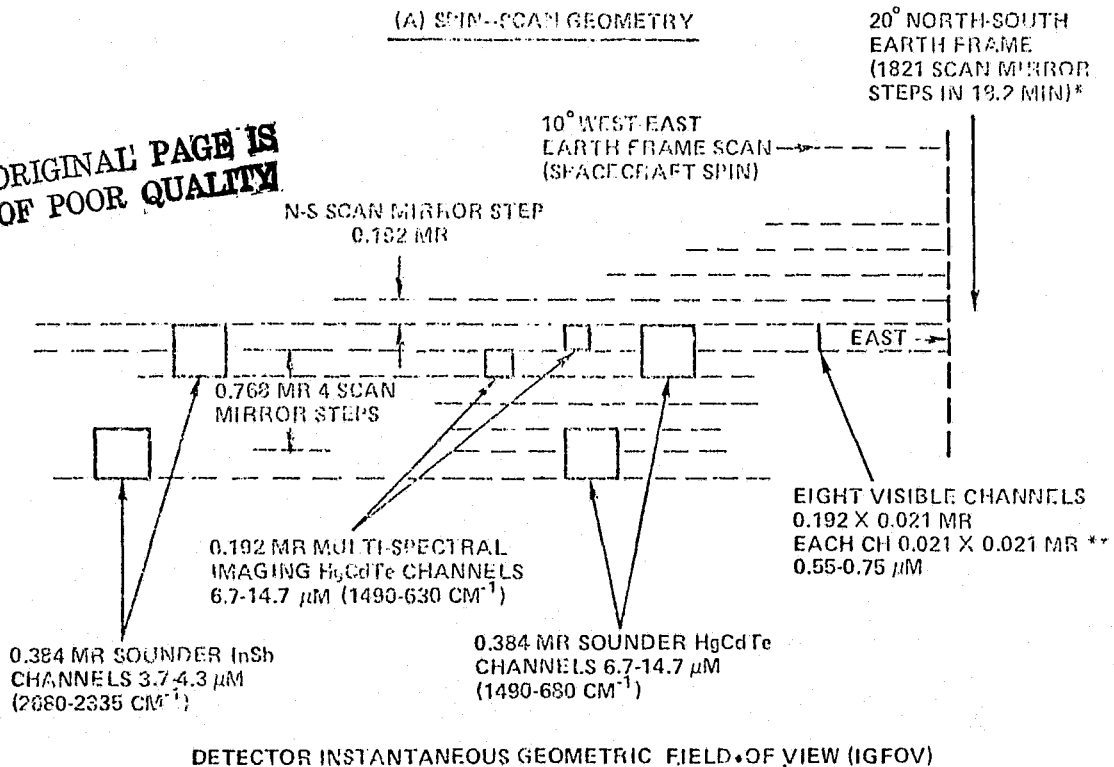
CW

RADIATION
COOLER

VISSR 45° SCAN MIRROR
(SCANS 20° IN 0.192-MR
STEPS)

SPACECRAFT SPIN
AXIS (100 RPM)

(A) SPIN-SCAN GEOMETRY

20° NORTH-SOUTH
EARTH FRAME
(1821 SCAN MIRROR
STEPS IN 18.2 MIN)*

10° WEST-EAST
EARTH FRAME SCAN
(SPACECRAFT SPIN)

N-S SCAN MIRROR STEP
0.192 MR

EAST

0.768 MR 4 SCAN
MIRROR STEPS

0.192 MR MULTI-SPECTRAL
IMAGING HgCdTe CHANNELS
6.7-14.7 μM (1490-680 CM⁻¹)

EIGHT VISIBLE CHANNELS
0.192 X 0.021 MR
EACH CH 0.021 X 0.021 MR **
0.55-0.75 μM

0.384 MR SOUNDER InSb
CHANNELS 3.7-4.3 μM
(2680-2335 CM⁻¹)

0.384 MR SOUNDER HgCdTe
CHANNELS 6.7-14.7 μM
(1490-680 CM⁻¹)

DETECTOR INSTANTANEOUS GEOMETRIC FIELD-OF VIEW (IGFOV)

(B) PICTURE DATA FORMAT (NOT TO SCALE)

NOTE: ONE INFRARED DETECTOR PAIR USED DURING EACH SCAN LINE
(PERMITS USE OF UNMODIFIED SPACECRAFT MULTIPLEXER)

* NORMAL VISSR AND MULTISPECTRAL IMAGING MODE
** 0.021 X 0.021 MR GOES D, 0.020 X 0.025 MR GOES E, F

Figure 3. VAS Arrangement as Used in GOES Satellites

100

telluride (HgCdTe) long-wavelength detectors. Two of the large infrared channel detectors are HgCdTe, and the other two are indium antimonide (InSb).

Of six VAS infrared detectors, only two will be used during any satellite spin period. Pairs of channels—the small HgCdTe channels, the large HgCdTe channels, or the InSb channels—will be automatically switched into the satellite video digital multiplexer by the VAS processor, depending on the selected mode of operation. In the manual mode (called the VISSR mode), the detector size and type are determined by the position of the filter wheel.

Table 1 presents the VAS detector and spectral band configuration. Figure 4 shows the two data configurations: the stretched VISSR mode and the VAS mode. The stretched VISSR mode yields 0.9-km visible and 6.9-km infrared (11.17 micrometer) at the Data Utilization Station (DUS). The VAS mode yields 3.6-km visible and any or all infrared spectral bands shown in Table 1. The VISSR mode is the only mode available through GOES-C. In addition to the VISSR mode, GOES-D, -E, and -F will have the multispectral-imaging (MSI) mode and the dwell-sounding (DS) mode. Both the MSI mode and the DS modes are programmer-controlled.

The large number of selectable parameters associated with spectral filters, detector size, dwell spins, and scan selection requirements are selected and preset in the VAS electronics memory before a particular operating mode is initiated. Programming is accomplished with a dedicated command line where a bit stream of 171 bits sets the processor memory to the desired program. The bit stream is transmitted by a satellite command line and requires approximately 11 seconds for loading.

By satellite command and parameter selection, the VAS may be a two-channel output radiometer. When certain submodes are selected, the VAS will output two channels of infrared imaging data for one satellite spin, followed by two channels (on the same output channels) of visible imaging data for one satellite spin. The frame size of interwoven infrared and visible-channel imaging is selectable by updatable parameter. The visible-channel imaging is reduced in resolution and is accomplished by summing four adjacent channel outputs to form one output.

The multispectral-imaging mode in which the scan mirror steps each spin, and the field-of-view, band, and frame are programmable; a resolution of 3.6 km is obtainable in the visible band, 6.9 km in the 11-μm window (band 8), and 13.8 km for any two other bands. Imaging rates may be computed by the following equations:

101

Table 1
VAS Infrared Spectral Bands

SPECTRAL BAND	ATMOS. PRESS. (mb)	γ (cm^{-1})	λ (μm)	$\Delta\gamma$ (cm^{-1})	SINGLE SAMPLE S/N FOR 320 K SCENE TEMPERATURE		REMARKS	
					0.192 mr IGFOV	0.384 mr IGFOV	BAND	DETECTOR TYPE
1	80	680	14.71	10	N/A	28.5	CO_2	
2	100	692	14.45	16	N/A	65.2	CO_2	
3	200	703	14.22	16	35.6	71.3	CO_2	
4	500	715	13.99	20	46.5	92.9	CO_2	
5	600	745	13.42	20	41.5	82.9	CO_2	HgCdTe
6	900	760	13.15	20	41.8	83.8	CO_2	
7	1000	790	12.66	20	42.9	85.8	H_2O	
8	SURFACE	895	11.17	140	430.2 *	875.8	WINDOW	
9	750	1380	7.25	40	17.0	34.1	H_2O	
10	300	1490	6.71	150	51.7	103.4	H_2O	
11	20	2335	4.28	50	N/A	83.6	CO_2	InSb
12	SURFACE	2680	3.73	440	N/A	223.3	WINDOW	

* FOR 340 K SCENE TEMPERATURE

STRETCHED VISSR MODE

VAS MODE

(LOW DATA RATE)

28 M BITS/SEC   CDA DOWN LINK

1.75 M BITS/SEC   STRETCHED

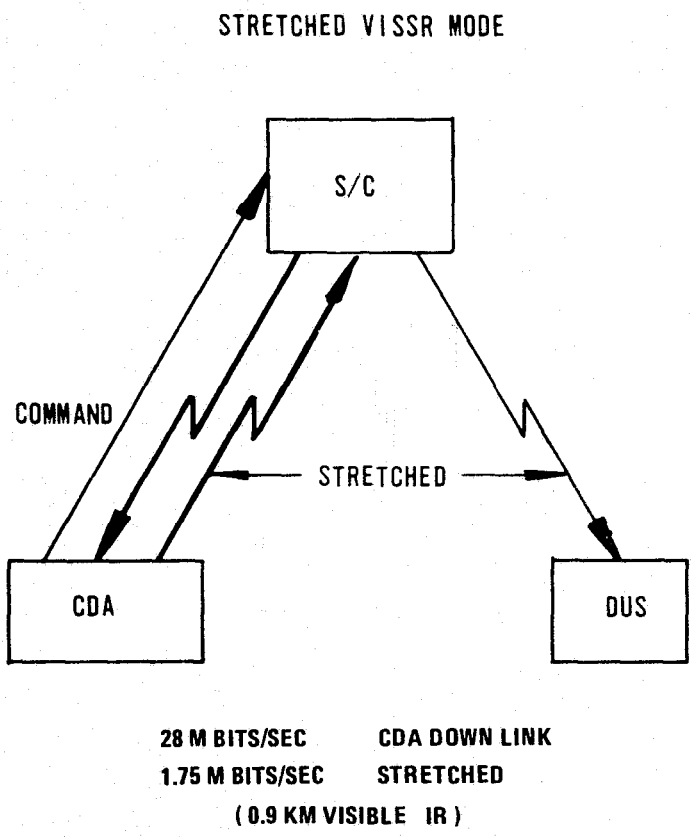(0.9 KM VISIBLE IR)

2.5 M BITS/SEC
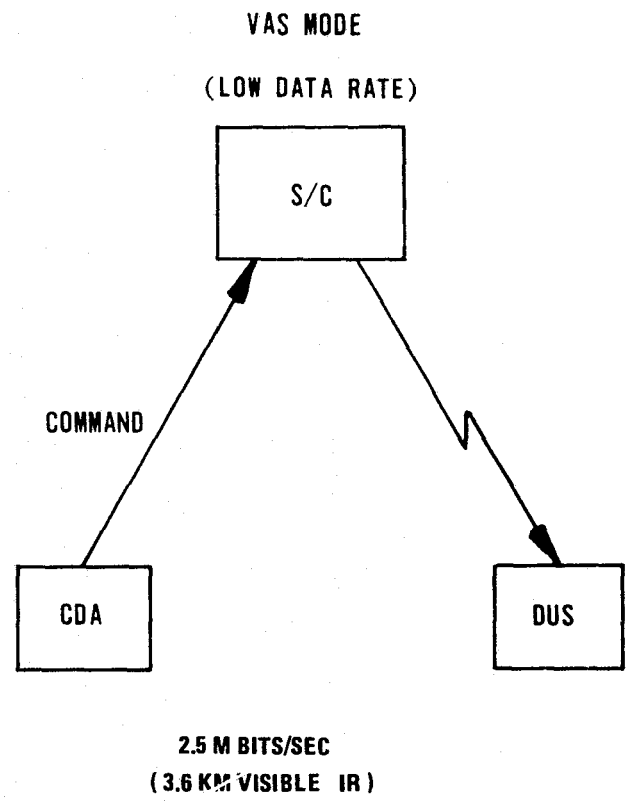
(3.6 KM VISIBLE IR)

Figure 4.   Data Configurations

No visible

11.2 μm at 6.9 km + m (bands at 13.8 km)

Imaging rate = 8/(8 + 2n) 691.2 km/min

where n = 1 to 12

With 3.45-km Visible

11.2 μm at 6.9 km + n (bands at 13.8 km)

Imaging rate = 16/(16 + 2n) 345.6 km/min

where n = 1 to 12

A summary of the dwell-sounding mode follows:

- S/N enhanced by repeated spins

- Spectral-band sequencing

- Programmable parameters: FOV, band, frame, and spins per band

  } Scan mirror not stepping

- Provides imaging mode (spins per band = 1)

Up to twelve spectral filters, covering the range from 680 cm^{-1} (14.7 μm) to 2680 cm^{-1} (3.7 μm), can be positioned into the optical train while the scanner is dwelling on a single N-S scan line. The filter wheel can be programmed so that each spectral band (filter) can dwell on a single scan line for 0 to 255 space-craft spins. Either the 6.9-km or 13.8-km resolution detectors can be selected for the eight filter positions operating in the spectral region 703 cm^{-1} (14.2 μm) through 1490 cm^{-1} (6.7 μm). The 13.8-km resolution detectors are used for the four remaining spectral bands. Selectable frame-sector size, position, and scan direction are the same as those in the multispectral-imaging (MSI) mode of operation.

Multiple-line data are required in some of the spectral regions to enhance the signal-to-noise ratio. The multiple filters and the dwells associated with each filter total approximately 170 satellite spins at the same N-S scan-line position to obtain the desired sounding data. This "spin budget" is defined by data required to obtain soundings having a 30- by 30-km resolution element.

Sounding accuracy requirements are:

680–895 cm^{-1}	0.25 mw/etc*
1380 cm^{-1}	0.15 mw/etc
1490 cm^{-1}	0.10 mw/etc
2335–2680 cm^{-1}	0.002 mw/etc

Relative accuracy of 0.5 K

Absolute accuracy of 1.5 K

Sounding rates may be calculated by the following method:

- Sounding resolution of 30 by 30 km**

- Measurement uncertainty of 0.5 K

- Sounding rate is given by

$$\text{Rate} = 8/(8 + 2n) \; 691.2 \; \text{km/min}$$

Detector	N Spins	Sounding Rate km/min
Engineering model	400	6.84
Specification	170	15.89
Best measured	50	51.2

The instrument is calibrated by dc restore on space between each line (zero radiance). The internal calibration must be corrected for telescope temperature gradients. The calibration equation is defined in Figure 5. 5.

---

* etc = m^2 ster cm^{-1}

** Bands 1 and 11 are averaged over 150 by 150 km.
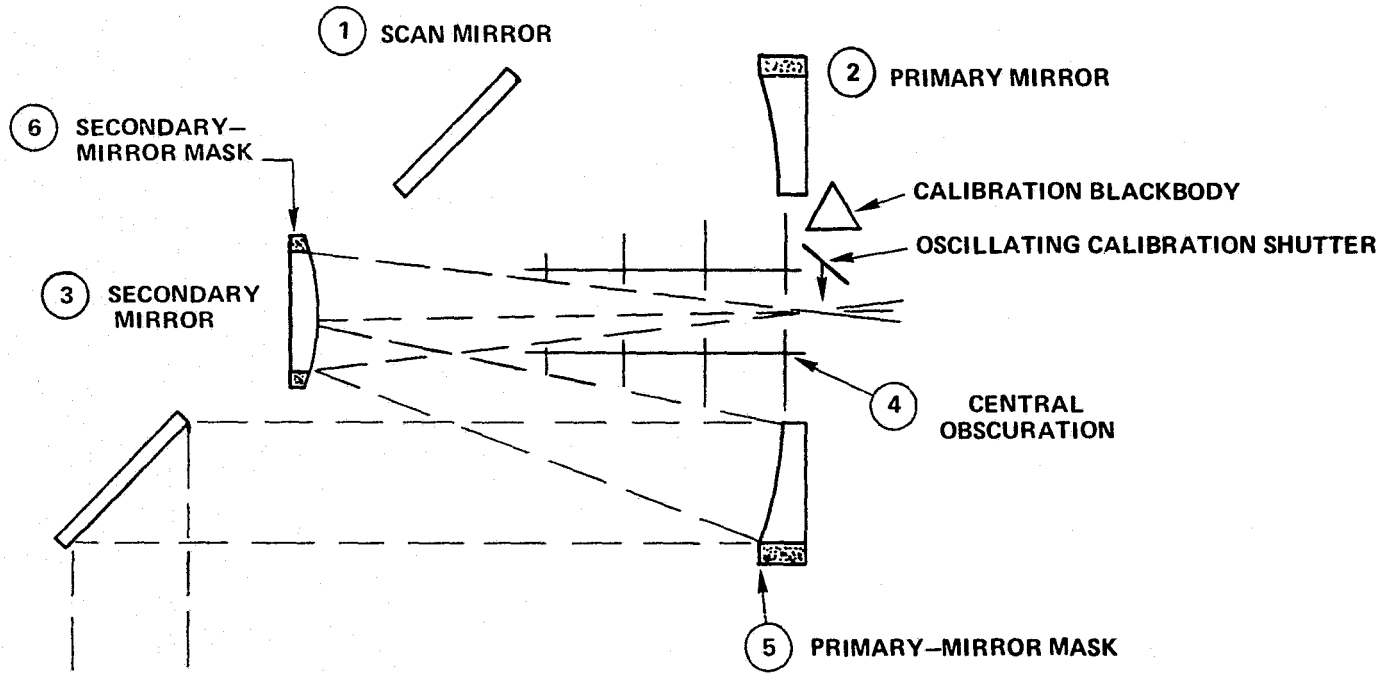
$$N_T = \frac{S_T}{S_{S\tau}} \left[\tau N_S + \sum_{i\,1}^{6} a_i \left(N_S - B(T_i)\right) \right]$$

Figure 5.   Calibration Algorithm

A precision voltage-ramp waveform is used as a method of electronic calibration of both the infrared and visible channels for gain and linearity. The ramp is inserted at the channel preamplifier input and is designed to have an input linearity of better than 0.1 percent.

A conventional temperature-monitored infrared blackbody, along with a reflective shutter, is used for an inflight radiometric calibration of the infrared channels. The calibration shutter is inserted into the optical path of the infrared detectors during the satellite/VAS backscan (non-Earth view). The resultant signal voltage is sampled (through a reduced bandwidth for noise improvement) and held as a channel output voltage until 100 μsec after a satellite-supplied timing signal. When commanded on, the infrared channel inflight calibration is accomplished for each scan line in a data frame. Temperature sensors, with an inherent accuracy of 0.1°C rms, are located on optical and telescope components that influence radiometric response to allow a more accurate data-correction algorithm to be used in ground data processing. The calibration blackbody contains a commandable heater to allow multipoint calibration.

In summary, the VAS is capable of imaging in any or all of 13 spectral bands. It has the flexibility for sounding, and its programming flexibility provides for spatial and temporal averaging to achieve the required accuracy.

VAS DIRECT-READOUT GROUND STATION

H. Ausfresser, Westinghouse

The Geostationary Operational Environment Satellite-D (GOES-D) spacecraft will be launched in about four years. It will contain the VISSR atmospheric sounder (VAS) instrument capable of providing current visual and infrared spin-scan radiometer (VISSR) functions, as well as multispectral scanning and dwell sounding.

In addition to the current high data rate modes (28 Mbps or 14 Mbps or 14 Mbps), a low data rate mode at 2.5 Mbps will be provided which will be capable of transmitting full resolution thermal- or 2-mile visible data. Furthermore, sufficient data for synchronization of this signal will be contained within the format. As a result of these improvements, it will be possible for small ground stations such as the VAS Direct Readout Ground Station (VDRGS) to directly receive these data from GOES-D.

The primary function of the VDRGS is to support the VAS experiment by providing data to be used to evaluate the VAS instrument performance and to demonstrate the sounding capabilities of the VAS prototype system. The VDRGS functions of data acquisition, preprocessing, and product generation will require extensive modification of the DRGS. Added equipment will include synchronization units, a computer subsystem with digital disk and tape storage, high-density tape recorders, and low rate communications units.

The key output products will be high-density tapes, computer-compatibility tapes, laser-beam recorder images, a pulse-code modulation (PCM) telemetry signal, and real-time VAS data signals to users.

STORMSAT/SEOS MISSION PLANS

W. Shenk, GSFC

Stormsat and Synchronous Earth Observatory Satellite (SEOS) missions are now being planned. The latter will include both Earth-resources and meteorological objectives.

Over the past few years, a set of severe-storm requirements has been developed for geosynchronous satellites. The most demanding requirements are the measurement of wind from cloud motions, the determination of the rapidly changing structure of thunderstorm cloud tops, and acquisition of vertical temperature and moisture profiles. Sensor spatial resolutions as small as 200 meters are required for accurate cloud tracking, and observation frequencies as often as every 20 sec are needed to follow the thunderstorm cloud height changes associated with domes that penetrate above the cirrostratus anvil. Temperature and moisture profile measurements should be made about every half-hour before thunderstorms form and every few minutes once the cells develop and begin to interact with the enviroment. These and other severe-storm requirements are currently under review by the NASA/NOAA Stormsat working group.

The Stormsat mission, to be launched in 1981, will be three-axis stabilized which will permit a much greater scanning efficiency than spinning systems for surveying only those areas on the Earth where important mesoscale events are occurring. The area viewed is presently designed to vary from the full disk, scanned in 20 minutes, down to a $(250\text{-km})^2$ area scanned in 0.4 minutes. Temperature and moisture soundings with 15-μm CO_2 channels can be made with 13.5-km resolution concurrent with high-resolution imaging over a $(750\text{-km})^2$ area in 1.2 minutes. The time to cover the same area increases to 20 minutes when 4.3-μm CO_2 band channels are added to the temperature profiling complement. The currently-designed imaging spatial resolutions are 4.5 km for the 11-μm channel (which is at the pratical diffraction limit) and 0.75 km for the reflectance channel. Real-time forecast demonstrations are planned with a combination of Stormsat and conventional measurements. Microwave sounding is being considered with a 2- to 3-meter antenna that could provide 30- to 40-km spatial resolution at 183 GHz which is a frequency where water vapor measurements are possible.

The SEOS mission, to be launched in 1986, will improve spatial resolutions for the imaging channels in the infrared and visible portions of the spectrum over what is anticipated on Stormsat because the optic of the large telescope is about four times the diameter of that proposed for Stormsat. One mode is to

have higher spatial resolution than that of Stormsat with the same channels that are selected for Stormsat. The other mode is to add more channels and improve the signal-to-noise level while degrading the spatial resolution to 36 km.

FURTHER DEVELOPMENT OF INTERACTIVE COMPUTER SYSTEMS

J. Quann, GSFC

Goddard Space Flight Center has developed an interactive minicomputer-based processing and display system, which will be used primarily for image information extraction. This system, known as the atmospheric and oceanographic information-processing system (AOIPS), has been installed and accepted and is now operational.

Figure 1 is a functional diagram of this system. The heart of the system is a PDP 11/70 computer. Two interactive terminal systems are connected to the 11/70. The first is a General Electric Image-100 system which is connected to the 11/70 through a digital-disk interface. The second is a terminal designed by Hazeltine Corporation that is driven directly by the 11/70. Both systems will be used as a general facility for image analysis and will support the severe-storm research program (SSRP), the heat-capacity mapping radiometer (HCMR), the coastal-zone color scanner (CZCS), and Landsat. Note that this is a minicomputer system with limited computational capability. It cannot support the sophisticated atmospheric models that will be required by the later phases of the severe-storm research program.

By 1980, a large-scale computer system will be necessary for meeting the computational and data-management needs of Goddard Space Flight Center with respect to the water-resources application system verification tests (ASVT), the severe-storm research program, the Agromet program, and the earth and ocean physics program, as well as supporting research and technology. In addition to providing the computational support required, this system will also provide an integrated data base which will interrelate information from a variety of sensors as indicated in Figure 2. This applications information processing system (AIPS) is shown in Figure 3. It will consist of a central processor interfaced with a number of peripheral processors such as AOIPS. By the early 1980's, the severe-storm research program will require a dedicated processor of its own to support real-time applications demonstrations. This processor will also be a minicomputer and will be interfaced with AIPS. Figure 4 is a functional diagram of the system architecture and operation; the actual system implementation may differ.

The implementation schedule for AIPS (Table 1) calls for delivery of equipment in June 1979 and full-system operation in January 1980. The actual system, equipment, and configuration which will be procured is subject to a feasibility study and analysis that is now underway. NASA Headquarters has approved the construction of a facility to house this equipment. Initial construction will begin in 1977, with completion scheduled for 1979, prior to equipment delivery.
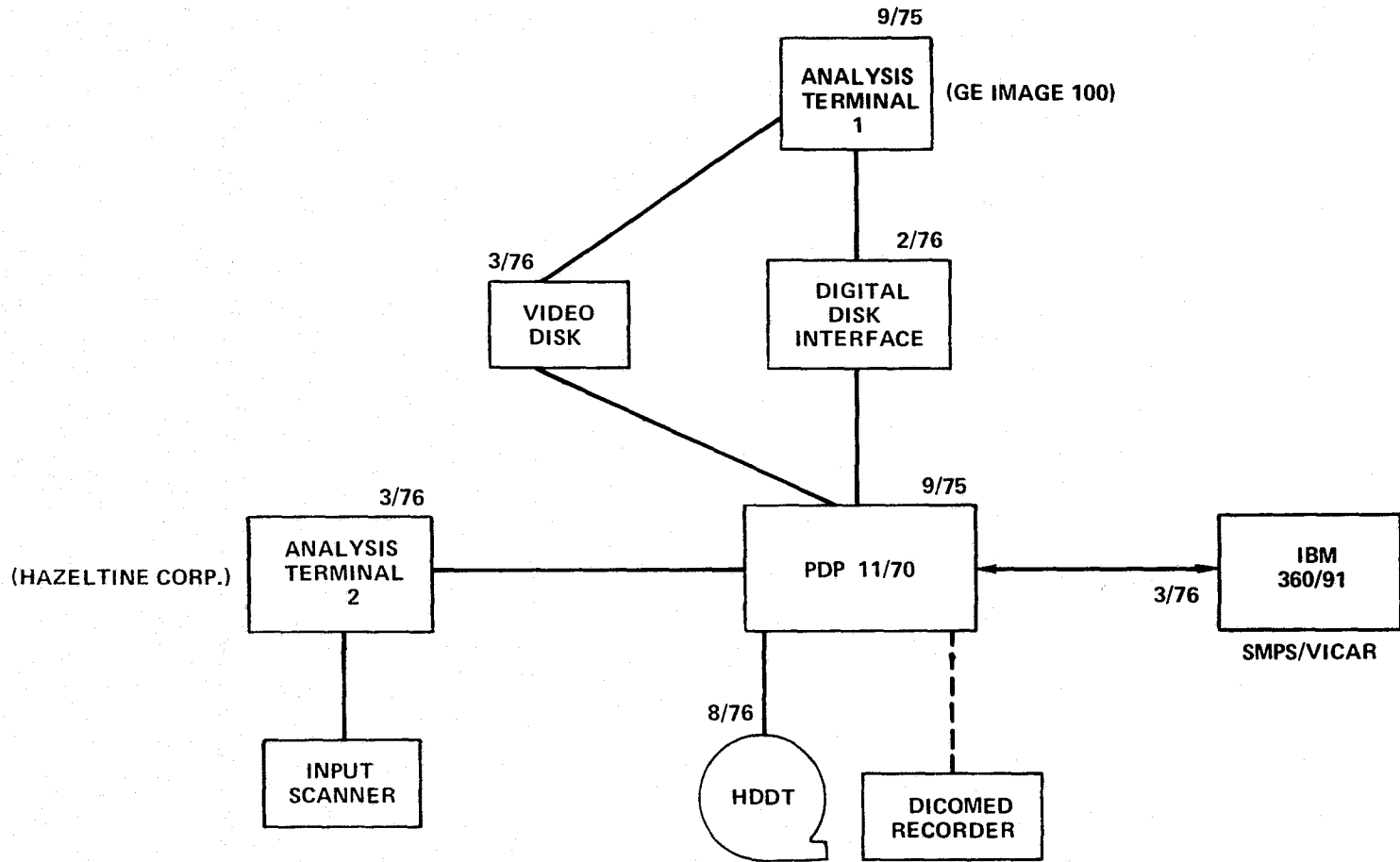
Figure 1. Atmospheric and Oceanographic Information-Processing System (AOIPS)

AIRCRAFT	EOS (MSS THEMATIC MAPPER)	GEOS (ALTIMETER)	HCMM	LANDSAT (DCP)	LANDSAT (MSS)	NIMBUS (BUV-TOMS LIMS SAM SAM II)	NIMBUS (ERB)	NIMBUS (THIR)	NIMBUS (ESMR)	NIMBUS (CZCS)	NIMBUS (SMMR)	SEASAT (RADIOMETER)	SEASAT (SCATTEROMETER)	SEASAT (ALTIMETER)	SEOS	SMS/GOES (VISSR-VAS)	SMS/GOES (DCP)	STORMSAT (AASIR)	TIROS N	PROGRAM AREA
	X			X	X				X		X				X		X			WATER RESOURCES ASVT
X																X		X		SEVERE-STORM RES. PROG.
X	X		X	X	X	X	X	X	X		X	X	X		X	X	X		X	CLIMATE
X	X				X				X		X				X	X		X		AGROMET
		X						X		X	X	X	X	X					X	EARTH AND OCEAN PHYSICS
X	X		X		X					X					X					INFORMATION TRANSFER PROGRAM (INTRALAB)
					X				X		X					X		X	X	SUPPORTING SRT

Figure 2. Project Sensors

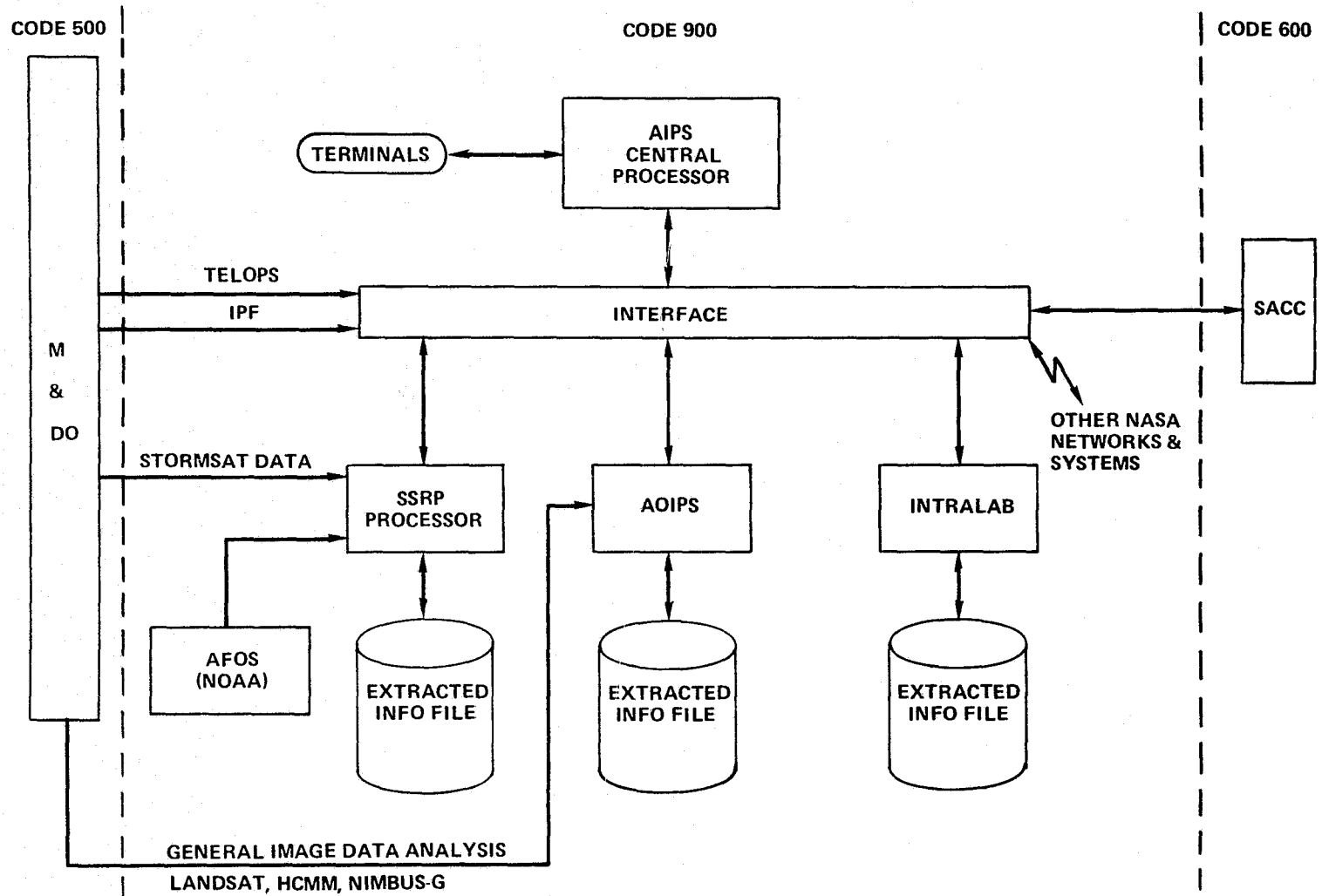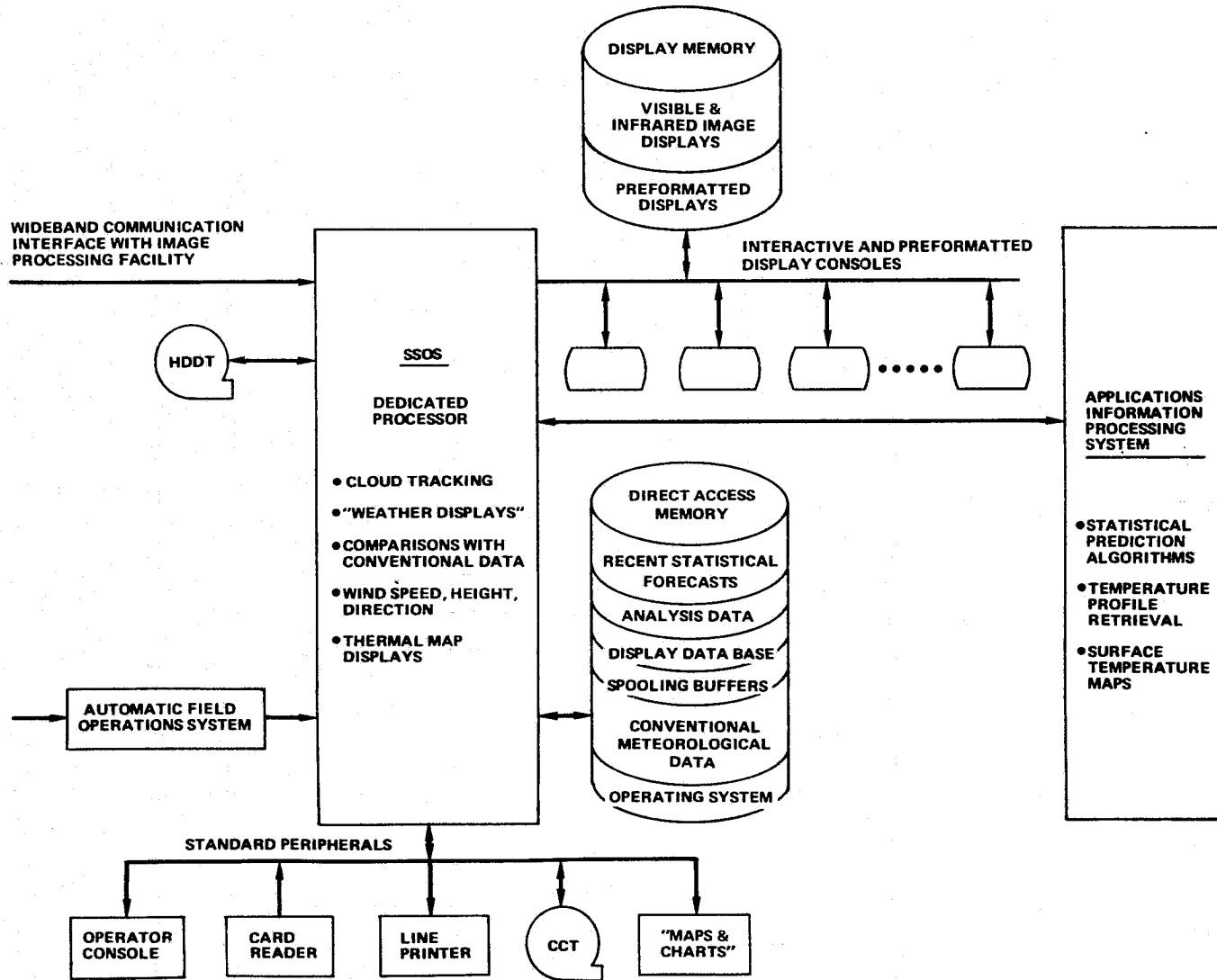Figure 3. Applications and Information-Processing System (AIPS)

Figure 4. System Architecture and Operation Functional Diagram

Table 1
AIPS Project Implementation Schedule

July 1975	FY 76	Begin project plan Begin feasibility study Prepare functional requirements documents
July 1976	FY 76 (Trans.)	Project plan completed Feasibility study and technical specifications completed
October 1976	FY 77	Project plan approved
November 1976	FY 77	ADP plan completed
March 1977	FY 77	ADP plan approved—concurrent GSA approval Begin RFP preparation
July 1977	FY 77	Issue AIPS RFP
May 1978	FY 78	AIPS contract signed
June 1979	FY 79	Installation of equipment
July 1979	FY 79	Begin acceptance testing
January 1980	FY 80	Begin full operation

GLOSSARY

AASIR	Advanced Atmospheric Sounding and Imaging Radiometer
A/D	Analog-to-digital data conversion
AFOS	Automation of Field Operations and Services
AIPS	Applications information processing system
AOIPS	Atmospheric and Oceanographic Information Processing System
ASVT	Application system verification tests
ATS	Applications Technology Satellite
BCD	Binary-coded decimal
CCT	Computer-compatible tape
CDA	Command and data acquisition
CPL	Claud Physics Laboratory
CSC	Computer Sciences Corporation
CZCS	Coastal-zone color scanner
DACU	Data-acquisition and control unit
DCP	Data-collection platform
DCPC	Data Communications Processing Center
DDRS	Digital data-recording system
DIE	Digital interface equipment
DODS	Digital orbit-determination system
DPCC	Data Processing Central Control
DPP	Data processing program
DRGS	Direct-readout ground station
DRL	Data Reduction Laboratory
DS	Dwell sounding
DST	Data Systems Test
DUS	Data Utilization Station
EHT	Experimenter history tape

FGGE	First GARP global experiment
GARP	Global atmospheric research program
GATE	GARP Atlantic tropical experiment
GOES	Geostationary Operational Environmental Satellite
GSFC	Goddard Space Flight Center
GVHRR	Geosynchronous very high resolution radiometer
HCMR	Heat-capacity mapping radiometer
HDT	High-density tape
IDAMS	Image display and manipulation system
IGFOV	Instantaneous geometric field of view
INS	Inertial navigation system
IPD	Information Processing Division
IPF	Image Processing Facility
IR	Infrared frequency spectrum
ITOS	Improved TOS Operation Satellite
MDT	Master data tape
McIDAS	Man/Computer Interactive Data Access System
METPAK	Meteorology package of software
MSI	Multispectral imaging
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NESS	National Environmental Satellite Service
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NRZ	Nonreturn to zero
NSSDC	National Space Science Data Center
NTSS	NASA Tape Staging and Storage
O/A/TM	Orbit/attitude/telemetry
PCM	Pulse-code modulation
PED	Pre-edit

SEOS	Synchronous Earth Observatory Satellite
SET	Sectorized experimenter tape
SMS	Synchronous Meteorological Satellite
SMS/GEOS	Synchronous Meteorological and Geostationary Operational Environmental Satellites
SOAP	Software Objective Analysis Package
SSRP	Severe-storm research program
VAS	VISSR atmospheric sounder
VDRGS	VAS Direct Readout Ground Station
VHRR	Very high resolution radiometer
VIS	Visible energy spectrum
VISSR	Visual and infrared spin-scan radiometer
VTPR	Vertical temperature-profile radiometer

ATTENDEES

G. Alvord
SUNYA Computing Center
State University of New York
    at Albany
1400 Washington Avenue
Albany, NY 12222

(518) 457-1893

Wm. R. Bandeen
GSFC
Code 910

982-4406

Joe Barksdale
GSFC
Code 931

982-4744

Brian Bauier
NESS/FOB-4
Suitland, MD

GSB 763-2506

Don Berman
Computer Sciences Corp.
8728 Colesville Road
Silver Spring, MD 20910

589-1545

Mr. Berry
Satellite Data Services Branch
Room 606
World Weather Building
Washington, DC 20233

763-8111

A. J. Bielawski
GSFC
Code 931

982-6034

Ed Bisone
NOAA
Code 490

982-4727

Peter A. Bracken
NASA/GSFC
Code 933

982-6989

Donald R. Carver
Naval Weather Service CMD
Navy Yard
Washington, DC 20374

(202) 433-2736

G. Thomas Cherrix
GSFC
Code 931

982-6642

Dennis Chesters
1814 Metzerott Road, #75
Adelphi, MD 20783

GSFC 982-5824
Code 9a

L. W. Cisney
GSFC

982-5079

Arthur C. Cote
Westinghouse
P.O. Box 1693 MS 973
Baltimore, MD 21203

(301) 765-6546

Dan Cotter
FOB-4, Room 3010
NOAA
Suitland Road
Washington, DC 20233

763-5390

Loren W. Crow
Certified Consulting Meteorologist
2422 South Downing Street
Denver, CO 80210

(303) 722-8665

Michael Crowe
NOAA-NESS S11/B
Washington, DC 20233

763-2507

Ernesto Cuesta
Computer Sciences Corporation
GSFC, Bldg. 23, Room E205

982-5517 or 5926

R. Davies
Aeronutronic Ford
3939 Fabian Way
Palo Alto, CA 94303

(415) 494-7400 Ext. 4962

Dr. Paul A. Davis
Code L2094
Stanford Research Institute
Menlo Park, CA 94025

(415) 326-6200 Ext. 3119

Michael S. Deutsch
Hughes Aircraft Co.
Bldg. 390 - Mail Station 2018
El Segundo, CA

(213) 648-4940

Lt. Col. Lee Dickinson
USAF Technical Applications Center/WE
Patrick AFB, FL 32925

494-4531

David L. Dietrich
General Electric Co.
GSFC, Glendale Bldg. 3
Code 902.6

982-6095

Richard A. Dirks
1800 G Street, NW
National Science Foundation
Washington, DC

632-4380

Hans Dolezalek
Code 462
Office of Naval Research
Arlington, VA 22217

(202) 692-4025

James Ellickson
NOAA-NESS S11/B
Washington, DC 20233

(301) 763-2516

James Ellis
Department of Atmospheric Sciences
Colorado State University
Ft. Collins, CO 80521

(303) 491-8527

David Escoe
Computer Sciences Corporation
8728 Colesville Road
Silver Spring, MD 20910

589-1545 Ext. 646

J. Farrell
Hughes Aircraft Corporation
Space & Communications Group
Bldg. 373, Mail Station 1190
P.O. Box 92426
Los Angeles, CA 90009

(213) 648-2838

Douglas Fenn
MATSCO

937-8848

James L. Foster
320 Vierling Drive
Silver Spring, MD 20904

982-2350

S. Fritz
University of Maryland
College Park, MD

454-2708

J. Patrick Gary
NASA/GSFC
Code 933

982-6079

Dr. L. E. Giddings
Lockheed Electronics Company
LEC/CO9
16811 El Camino Real
Houston, TX 77058

(713) 483-5529

James Giraytys
World Weather Program Office, NOAA
Rockville, MD 20852

(301) 496-8861

Brent Goddard
NESS/FOB-4
Suitland, MD 20233

GSB 763-2506

Ron Gird
NESS
World Weather Building
Room 510
Marlow Heights, MD

763-8414

Robert Green
NOAA-NESS S11/B
Washington, DC 20233

763-2700

Cecilia Griffith
NOAA-NHEML
P.O. Box 248265
Coral Gables, FL 33124

(305) 666-3329

Ronald Grosh
Illinois State Water Survey
Box 232
Urbana, IL 61801

(207) 333-4261

Tom Haig
Space Science Engineering Center
University of Wisconsin
1225 West Dayton Street
Madison, WI 53706

(608) 262-0544

Jack Herkert
NOAA-NESS S11/B
Washington, DC 20233

763-2506

LCDR William Hillyard, USN
OP-945G
Office of the Oceanographer
Hoffman Bldg II
200 Stovall Street
Alexandria, VA

325-8779

Arthur Hilsenrod
AID451
Transpoint Building DOT
2100 2nd Street, SW
Washington, DC 20590

426-8427

Dr. H. W. Hiser
REMOTR Sensing Lab
Box 248003
University of Miami
Coral Gables, FL 33124

(305) 284-3881

Mr. Hoppe
Satellite Data Services Branch
Room 606
World Weather Building
Washington, DC 20233

763-8111

Lester F. Hubert
Synoptic Meteorology Branch, NOAA
S311 Room 711
World Weather Bldg.
5200 Auth Road
Washington, DC 20233

763-8122

Capt. Ronald E. Hughes USN
Naval Air Systems Command
  (AIR-3706)
Washington, DC 20361

692-2515

Dr. Oscar Huh
Code 6110
U. S. Naval Oceanographic Office
Washington, DC 20373

767-2840

Ralph E. Huschke
Rank Corporation
1700 Main Street
Santa Monica, CA 90406

(213) 393-0411

Richard K. Jeck
Atmospheric Physics Branch
Code 8323-311
Naval Research Laboratory
Washington, DC 20575

767-2437

John S. Jensenius, Jr.
Penn State University
Dept. of Meteorology
University Park, PA 16802

(814) 865-2658

J. Jones
Office of Meteorological Operations
    WIIXI
National Weather Service, NOAA
Gramax Bldg.
8060 13th Street
Silver Spring, MD 20910

427-7867

Robert E. Jones
GSFC
Code 564.3

982-6413

Paul Llanso
NOAA/NESS
World Weather Bldg.
Auth Road - Room 501
Camp Springs, MD

773-8401

Robert C. Lo
Computer Sciences Corporation
8728 Colesville Road
Silver Spring, MD 20910

589-1545 Ext. 613

James E. Lovill
Atmospheric Sciences Division, L-142
Physics Department
University of California
Lawrence Livermore Laboratory
Livermore, CA 94550

(415) 447-1100 Ext. 8811

Jim Luers
University of Dayton Research Inst.
Dayton, Ohio

(513) 229-3921

Ronald A. Lusen
Geophysical Fluid Dynamics Laboratory
Princeton University
P.O. Box 308
Princeton, NJ 08540

(609) 452-6543

Elizabeth Mack
NOAA-NESS S1123, STOP E
Washington, DC 20233

763-2506, 2507

Matthew Jurotich
NOAA-NESS S11/B
Washington, DC 20233

763-2516

H. Lee Kyle
Code 931
GSFC

982-5940

CDR Wayne R. Lambertson
Naval Weather Service Command
Washington Navy Yard
Bldg. 200
Washington, DC 20374

433-3233

J. T. Lee
U. S. Dept. of Commerce, NOAA
National Severe Storms Laboratory
1313 Halley Circle
Norman, OK 73069

736-4916

Richard Legeckis
NESS FOB-4
S-33 Stop D
Washington, DC

(301) 763-1980

Eugene Legg
NESS
Satellite Winds Section
World Weather Building
5200 Auth Road - Room 510
Marlow Heights, MD

Paul McKowan
11801 Lusby Lane
Brandywine, MD

982-6017

Mr. Merritt
Earth Satellite Corporation
7222 47th Street
(Chevy Chase)
Washington, DC 20015

652-7130

Major Walter Meyer
Headquarters, Air Weather
    Service (MAC)
Scott AFB, IL 62225

(618) 256-4731

Dr. Donald Miller
NOAA-NESS Sll/B
Washington, DC 20233

763-7145

James R. Miller
Department of Meteorology
Cook College
Rutgers University
New Brunswick, NJ 08903

(210) 932-9551

Tom Mottershead
Computer Sciences Corp.
GSFC - Bldg. 16 W
Code 933

589-1545 (ext. 265)

Edward W. Mowle
NOAA/NESS
Suitland, MD

763-5098 (NESS)
982-4727 (GSFC)

Whitney V. Myers
Computer Sciences Corp.
8728 Colesville Road
Silver Spring, MD 20910

589-1545 Ext. 630

Myron L. Nack
Computer Sciences Corp.
8728 Colesville Road
Silver Spring, MD

589-1545

Robert Neff
GE/MATSCO
5030 Herzel Place
Beltsville, MD 20705

982-6351

Lt. Col. J. R. Norton
USAF AWS/NESS LIASON
World Weather Building, Room 706E
5200 Auth Road
Marlow Heights, MD 20233

(301) 763-8311

Charles Novak
NOAA-NESS Sll/B
Washington, DC 20233

763-2506

Dr. Richard E. Orville
Dept. of Atmospheric Sciences
State University of New York at
    Albany
1400 Washington Avenue
Albany, NY 12222

(518) 457-3985

Mr. Page
Satellite Data Services Branch
Room 606
World Weather Building
Washington, DC 20233

634-7236

Donald A. Parker
GSFC
Code 564

982-6074

Edward Pearl
The University of Chicago
Department of the Geophysical
    Sciences
5734 South Ellis Avenue
Chicago, IL 60637

(312) 753-8114

Philip B. Pease
GSFC
Code 933

982-6276

Cynthia Anne Peslen
GSFC
Code 911

982-6908

Karen Posey
GSFC
Code 933

982-4347

Harry Press
GSFC
Code 901

982-4353

Michael J. Prokopchak
GSFC
Code 513

982-6061

Lt. Cmdr. Peter Quinton
Commanding Officer
Fleet Weather Facility-Suitland
Washington, DC 20373

763-5973

Dr. D. V. Reames
Code 601
GSFC

982-6314

Benjamin Remondi
NOAA-NESS Sll/B
Washington, DC 20233

763-2507

Gerald D. Repass
GSFC
Code 581

982-4822

David W. Reynolds
Colorado State University
Atmos. Sci. Dept
Ft. Collins, CO

491-8636

Henry Robinson
Computer Sciences Corporation
8728 Colesville Road
Silver Spring, MD 20910

589-1545

Vincent W. Roper
Fleet Weather
Suitland, MD

763-5524

Alex Rosenberg
GSFC
Code 564

982-6335

Larry Rouse
Coastal Studies Institute
Louisiana State University
Baton Rouge, LA 70803

(504) 388-2395

Col. John Samotis
OJCS/DDOES Pentagon Room
    2B941
Washington, DC 20301

697-7117

Richard Schreitz
NOAA-NESS Sll/B
Washington, DC 20233

763-2507

Clark L. Smith
National Center for Atmospheric
    Research
P.O. Box 3000
Boulder, CO 80303

FTS 322-5493

Dr. Paul L. Smith, Jr.
Institute of Atmospheric Sciences
South Dakota School of Mines and Tech.
Rapid City, SD 57701

(605) 394-2203

Capt. John V. St. Onge
NOAA/NESS/MSL-LN
World Weather Bldg.
Washingtion, DC 20233

(301) 763-8331

Dr. Dan Tarpley
NOAA-NESS Sll/B
Washingtion, DC 20233

763-2700

M. P. Thekaekara
GSFC
Code 912

982-5034

Dr. A. H. Thompson
Department of Meteorology
Texas A&M University
College Station, TX 77843

(713) 845-3919, 845-6011

Edward V. Tiernan
World Weather Program Office, NOAA
Rockville, MD 20852

(301) 496-4185

Prof. Tom Vonderhaar, Head
Department of Atmospheric Sciences
Colorado State University
Ft. Collins, CO 80521

(303) 491-8566

Dr. Mark Waters
NOAA-NESS Sll/B
Washington, DC 20233

(301) 763-2700, 567-2739

Gerald F. Watson
Dept. of Geosciences
Box 5966
North Carolina State University
Raleigh, NC 27607

(919) 737-2212

Dr. Willis Webb
ASL-Meteorological Satellite Tech
     Area
White Sands Missile Range, NM 88002

(915) 678-4207

L. F. Whitney
Synoptic Meteorology Branch, NOAA
S311 Room 711
World Weather Bldg.
5200 Auth Road
Washington, DC 20233

763-8122

Francene T. Wright
Computer Sciences Corp.
8728 Colesville Road
Silver Spring, MD

589-1545 Ext. 252

Michael T. Young
NOAA - NESS
World Weather Bldg.
Camp Springs, MD

763-8414