Proceedings of the WEFAX Users' Conference for National and International Users' of GOES WEFAX Services

Lanham, Maryland
April 28-29, 1981

Washington, D.C.
June 1982

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Earth Satellite Service

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Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
John V. Byrne, Administrator

National Earth Satellite Service
John H. McElroy, Assistant Administrator for Satellites

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ACRONYMS AND ABBREVIATIONS

AFOS	- Automation Field Operations and Services
AM	- Amplitude Modulation
ANMET	- Antilles Meteorological Telecommunications Network
APT	- Automatic Picture Transmission
ATS	- Applications Technology Satellite
AVHRR	- Advanced Very High Resolution Radiometer; on TIROS-N series satellites
CDA	- Command and Data Acquisition Station at Wallops Station Virginia and Gilmore Creek, Alaska
CEMET	- Central America Meteorological Telecommunications Network
CGMS	- Coordination on Geostationary Meteorological Satellites
DACS	- Data Acquisition and Control Subsystem
dB	- Decibel
DBm	- Decibels above (or below) one milliwatt
DCS	- Data Collection System - The system that relays messages from in situ platfroms to the Wallops CDA for further dissemination through the WWB to the user community
DIR	- Day Infrared
DMD	- Digital Muirhead Display, an electronic recorder which copies imagery on photographic film.
DPSS	- Data Processing Services Subsystem - large, high-speed computer system in FB-4 that processes polar orbiting data.
DSB	- Direct Sounder Broadcasts
EIRP	- Effective Isotropic Radiative Power
ESA	- European Space Agency
FGGE	- First GARP Global Experiment
FM	- Frequency Modulation

ACRONYMS AND ABBREVIATIONS (CON.)

FB-4 - Federal Building # 4 at Suitland, Maryland

FET - Facsimile Encoder Transmitter; dual tape drive, mini-computer which generates WEFAX products.

GARP - Global Atmospheric Research Project

GMS - Geostationary Meteorological Satellite (Japan)

GOES - Geostationary Operational Environmental Satellite

G/T - Gain-to-temperature Ratio

GTS - Global Telecommunications System

HRD - Hurricane Research Day - GOES-East scans every 15 minutes.

HRD(10) - Hurricane Research Day - GOES-East scans every 10 minutes at selected times.

HRPT - High Resolution Picture Transmission

HRSD(S) - Hurricane Rapid Scan Day (Stereo) - GOES-East and West scans every 7 1/2 minutes at selected times.

Hz - Hertz

ITOS - Improved TIROS Operational Satellite

KWBZ - Call letters for National Weather Service Communications Center, Washington, D. C.

MHz - Megahertz

NASA - National Aeronautics and Space Administration

NESS - National Earth Satellite Service

NF - Noise Figure

NMC - National Meteorological Center

NIR - Night Infrared

NMC - National Meteorological Center

NOAA - National Oceanic and Atmospheric Administration

ACRONYMS AND ABBREVIATIONS (CON.)

NWS	- National Weather Service
PSK	- Phase Shift Key
RISOP	- Rapid Internal Scan Operations - GOES-East scans every 15 minutes instead of every 30 minutes.
RRSD	- Research Rapid Scan Day
S/DB	- Synchronizer/Data Buffer
SEM	- Space Environment Monitor; satellite-borne instrument that monitors the magnetic field and the energetic particle flux in the vicinity of the spacecraft.
SMS	- Synchronous Meteorological Satellite - Prototype GOES
SOCC	- Satellite Operation Control Center - NESS unit located in FB-4
SVISSR	- Stretched Visible Infrared Spin Scan Radiometer
TBUS	- 4-letter indentifier for Ephemeris data message (APT-Predict)
VAS	- VISSR Atmospheric Sounder - More sophisticated version of the VISSR
VDM	- VISSR Digital Multiplexer; converts VISSR analog data to digital data for transmission to the CDA
VHF	- Very High Frequency
VHRR	- Very High Resolution Radiometer
VISSR	- Visible Infrared Spin Scan Radiometer - on GOES satellites
WEFAX	- Weather Facsimile
WMO	- World Meteorological Organization
WWB	- World Weather Building - NOAA/NESS/NMC offices at Camp Springs, Maryland

ACKNOWLEDGMENTS

Many of the people attending the WEFAX User's Conference travelled many miles to learn more about the WEFAX services offered by NOAA/NESS, or to report how they utilize these services, to ask questions, and in some instances to offer constructive criticism regarding the program. Some people came halfway around the world, often at great personal expense.

Others came from much closer, offering both time and expertise, to help our visitors understand and appreciate the complex technologies which must merge to produce a useful WEFAX service, and to learn from the users how much importance they attach to this service.

The contributions that all of the attendees, both visitors and local experts, made to this Conference cannot and should not go without recognition.

Recording, transcribing, typing, and editing the extemporaneous remarks and, in some cases, the prepared texts, also should be acknowledged. Here, the nimble fingers of our Branch secretarial staff -- Laura Wydick, Rosemary Fike, and Angela Surratt, helped this report come together. The steady hand of Paige Bridges helped draft many of the figures. We are deeply indebted to these four people for the long and tedious hours spent helping prepare these proceedings for publication.

Robert W. Popham
Chairman
WEFAX User's Conference

1. Welcome Address

Mr. David S. Johnson

Assistant Administrator for Satellites
NOAA

I certainly am pleased to be here today to welcome the many people who have come to attend this Conference, especially those visiting from other countries. We are very pleased to have you here, and we hope you will find this meeting as beneficial to you as we expect to find it beneficial to us.

Historically speaking, the geostationary satellite meteorological application program began with very little in the way of resources, and mostly through imagination and perseverance. For example, the first geostationary satellite, the Applications Technology Satellite (ATS)-1 was conceived by the National Aeronautics and Space Administration as a test of a possible means of communicating from satellites in geostationary orbit. Two years before its launch, when the design of ATS-1 was essentially "frozen", Dr. Vernon Soumi, a professor at the University of Wisconsin, came to Washington as Chief Space Scientist for the U.S. Weather Bureau's Meteorological Satellite Laboratory and, with the help of Dr. Homer Newell of NASA, argued for the inclusion of a spin scan camera on ATS-1, basically a "pin-hole" camera which would point out the side of the spinning satellite, and having a rotating mirror that would pass in front of the camera, and thereby providing scan images of the Earth. Another member of our staff at that time, Mr. Dave Holmes, suggested that the transponder on this satellite would permit retransmission of pictures acquired with this camera to ground stations equipped to receive low resolution Automatic Picture Transmission (APT) services from polar orbiting satellite.

Their arguments were successful, and ATS-1 was modified to acquire meteorological imagery and retransmit to APT stations, thus introducing the Weather Facsimile, or WEFAX, service.

Mr. Jack Purner, also on our staff, had the idea of using these geostationary satellites to collect data from automatic platforms, and thus the concept of the Data Collection Service emerged, with a few additional changes in the design of later geostationary satellites.

With this information as background, I now return to the purpose of this Conference. We are gathered here, for the first time since the inauguration of the WEFAX service in 1966, to discuss the WEFAX service as it affects the user. We have had informal communications with many members of the user community, but we do not often "take stock" to inform this community of where we are and where we are going, or to discuss the ideas our customers or users of the WEFAX service have concerning provisions of this service. The primary purpose of this Conference, therefore, is to have an information exchange between those of us responsible for operating WEFAX and those of you who are present or potential users of this service.

I have been asked to especially address the issue of WEFAX policy. Well, what is WEFAX policy? You won't find it written down. I know even my colleagues are waiting with baited breath to hear me say something about what constitutes WEFAX policy.

First, why are we providing WEFAX services? We are doing it primarily to serve agencies of the U.S. Government. The service is supported by U.S. tax revenues. The question may be asked that, since it is supported by such tax revenues, is it a function which the U.S. Government should be performing, or is it a function that should be handled by the private sector, i.e., commercial enterprise? If the private sector were handling it, then the users should expect to pay the private sector for this service.

As I indicated earlier, however, the U.S. Government is the primary user of this service; this is the basic underlying reason for providing WEFAX broadcasts. Despite this fact, we do not attempt to ignore those users who are not a part of the U.S. Government. We have introduced a three-GOES WEFAX operation, using as the third GOES a satellite on which the imaging system has failed but the WEFAX relay transponder is still functioning. We are now able to transmit more continuous WEFAX broadcasts using this additional spacecraft. The format and scheduling are determined primarily by U.S. Government needs, but clearly these data are of value to many forecasting organizations in the United States as well as overseas. We have been able to accomplish this additional broadcasting with very limited resources, and without any capital investment in ground equipment.

The scope of WEFAX services is expected to expand as we work more closely with the National Weather Service in scheduling the transmission not only of processed satellite pictures, as we have been doing, but also by adding weather analyses and prognostic charts. We are very pleased that we can work together in providing a WEFAX service that is of greater service to a wide range of people.

WEFAX History and Purpose

Dr. C. A. Spohn*

The WEFAX services in existence today have evolved through more than a decade of experiments with geostationary satellites, beginning with the launch of the first Applications Technology Spacecraft (ATS)-1 in December 1966. The ATS series was designed primarily to develop communications satellite technologies. The WEFAX experiment, one of several communications experiments on this series of spacecraft, was designed to demonstrate the feasibility of transmitting processed meteorological data from a central source up to an Earth synchronous satellite and back down to remote, widely scattered weather stations or receiving units.

In order to facilitate ground reception, the WEFAX communications subsystem was designed to be compatible with Automatic Picture Transmission (APT) subsystems developed for polar orbiting satellites and flight-tested on TIROS-VIII 3 years earlier. The transmissions were on VHF (136.5 MHz); line speed was 240 RPM, same as APT. The same type antenna could be used to acquire both APT transmissions from polar orbitors and WEFAX broadcasts from ATS, the major difference being that a tracking antenna was required for polar orbitor data acquisition, while the antenna would be stationary for geostationary satellite data acquisition.

Products from ATS-1, and later from ATS-3, consisted of satellite images acquired with an Image Dissector Camera onboard the satellite, transmitted to a central processing facility, and retransmitted back through the satellite to properly equipped ground receiving stations. Broadcasts from ATS-1 were made twice daily, in two block times, each broadcast consisting of 10 images.

The success of these early WEFAX experiments, both in terms of demonstrated imaging and communications technologies and the value of such broadcasts from the users' standpoint, led NASA to begin development of an operational satellite designed specifically to provide such services. This development became even more urgent as WEFAX data users were forced to compete more and more with other experiments on ATS. WEFAX broadcast schedules had to be changed frequently, not only because of these other experiments, but also due to an increase in the north-south oscillation (inclination) of ATS. Eventually, the inclination of ATS-1, at 145°W, increased to the point where the satellite would be below the Earth's horizon, as viewed from the CDA station at Wallops, several hours each day, making it impossible to command the satellite or to send WEFAX products through it. Users also had difficulty keeping their antennas aimed properly to receive clear images.

In the late 1960s and early 1970s, the National Weather Service (then known as the U.S. Weather Bureau) established 12 APT stations at weather forecast offices around the country. Several were modified for WEFAX reception from ATS-3. But plans to modify other APT stations for ATS WEFAX reception were terminated as the design and operating characteristics of the new SMS/GOES

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* Dr. Spohn was Deputy Director, National Earth Satellite Service, until his retirement from Federal service in January 1982.

series of geostationary satellites became more firm. In early 1972, two Satellite Field Service Stations were established at Miami, Florida, and Redwood City, California. Originally, it was intended that these stations, and others like them to follow, be equipped with S-band antennas and high resolution display devices to copy WEFAX directly, but the display devices were not delivered to the stations on schedule. Budget and manpower resource limitations further dictated that this was not the best way to proceed; instead, a Central Data Distribution Facility was established at the World Weather Building near Washington, D.C., and computers were installed to sectorize the SMS/GOES images and transmit them by landline to the field service stations. (This method of data dissemination is still used today to relay high resolution, enhanced, sectorized images to all six Satellite Field Service Stations in the United States.)

In May 1974, NASA's first Synchronous Meteorological Satellite (SMS)-1, prototype of the future GOES, was launched and placed in orbit over the Equator near 75°W. Instead of the Image Dissector Camera used on ATS, a Visible Infrared Spin Scan Radiometer (VISSR) was used as the primary imaging instrument. The WEFAX communications frequency was changed from 135.60 MHz to 1690.1 MHz (S-band) to remove it from the aeronautical communications band. Some early experimental WEFAX broadcasts were made through SMS-1.

The SMS-2 satellite was launched in February 1975, followed by GOES-1 in October of the same year. In early 1976, GOES-1 replaced SMS-1 at 75°W and became the primary operational geostationary satellite for VISSR data collection and WEFAX broadcasts. SMS-2, positioned at 135°W, routinely acquired VISSR data, but was not used to broadcast WEFAX data until late 1976, and then only on an experimental basis.

Even at this stage, however, there were only eight WEFAX broadcasts each day from GOES-1, each consisting of two "chips", or sectors, of processed VISSR images. In October 1976, all this changed, with the introduction of an expanded WEFAX operation on GOES-1, when the number of broadcasts was increased from 10 to 34 per day.

Determining which products were to be broadcast, and arranging a suitable broadcast schedule, was not an easy task. The first step was to determine how much time could be allocated for WEFAX. Out of a 24-hour day, 20 minutes of each half hour, or 16 hours per day, would be used for VISSR data acquisition. Additional time was required for satellite position checks (trilateration) and preventive maintenance (CDA station equipment repair or replacement). Schedules also would have to take into account the eclipse periods when the satellites, which depend primarily on solar power, would be partially eclipsed by the Earth's shadow for a 6 week period during both the vernal and autumnal equinoxes.

Taking all of these into account, 3 hours, or 180 minutes, remained each day for WEFAX broadcasts. Since each image sector required 4 minutes to broadcast, it was decided to send two products in the 10-minute period following VISSR data acquisition except when PM or TRILAT was required. And schedules had to be arranged for minimum interruption during eclipse periods.

The primary products in the expanded GOES-1 schedule consisted of VISSR visible and infrared images acquired at 3-hourly intervals. These were processed and sectorized into quadrants; two quadrants, or related data pairs, were sent in 10-minute time slots. Each pair consisted of a NW/SW or NE/SE quadrant. A tropical pair derived from the VISSR image, and showing the Tropical Convergence Zone, also was included. Processed data gathered from polar orbiting satellites, the APT Predict (TBUS) bulletin, and a daily operational WEFAX message also was included in this early schedule, but no weather charts.

After determining which time slots would be available for WEFAX broadcasts, the next step was to determine the sequence and timing of individual products. Meteorological observations are time-perishable elements, and must reach the forecaster as soon as possible. The broadcast schedule for WEFAX products was developed to permit relay of image products to field users as soon as possible after each 3-hourly full Earth disc image acquisition. The sequencing of the products, i.e. NE/SE or NW/SW pairs, was dictated by software programs which of necessity had to be developed to facilitate data formatting in a fully automatic mode. Human intervention in any part of the data processing activities had to be minimized to ensure a rapid flow of data with very few transfers of tapes or other mechanical functions. Implementation of an expanded GOES-1 WEFAX service was therefore the result of long and careful considerations of user needs, data timeliness, and ground equipment hardware and software functions, limitations, and capabilities.

In August 1977, GOES-2 replaced GOES-1 at 75°W. Now, with ATS-1 and -3, SMS-1 and -2, and GOES-1 and -2 in space, there was growing confusion among users regarding which satellites were operational and which were not. It appeared necessary to adopt some convention for distinguishing these satellites by some means other than by the name of the actual satellite. Two locations, 75°W and 135°W, were identified as operating positions of geostationary satellites, since satellites located at these positions would meet user needs while still keeping them within command range. It was decided at this time to identify any environmental satellite at 75°W as GOES-East (GE) and any at 135°W as GOES-West (GW). This nomenclature became standard U.S. practice in 1977.

In 1978, the National Meteorological Service decided to experiment with weather chart broadcasts via WEFAX through GOES-East. Since all broadcast slots were being used, the only way this could be accomplished was by sending the charts during VISSR data acquisition periods. It was important, however, not to degrade the quality of the VISSR data. Tests showed that by decreasing the uplink power from the standard 500 watts to 125 watts, WEFAX products could successfully be transmitted simultaneously during VISSR operations, with some slight degradation in the WEFAX product. In November 1978, four weather charts were included in the operational GOES-East WEFAX broadcasts, a major milestone in the development of current WEFAX services.

In December 1978, all ATS WEFAX broadcasts were terminated. The Wallops CDA station had neither the staff nor equipment to maintain both VHF WEFAX operations supporting the ATS and operations supporting S-band broadcasts through SMS and GOES series spacecraft. Also, most first-order meteorological stations in the Western Hemisphere had completed the transition from the earlier ATS to the newer SMS/GOES series, and preferred the expanded product line available from the newer series.

In early 1979, the GOES-2 VISSR instrument failed. Although this failure made it difficult to provide much needed imaging and digital data collection, the failure was greeted with mixed emotions by operators of the WEFAX service. It did, in fact, establish another milestone in WEFAX history. Although the VISSR was lost, perhaps it could be used for WEFAX, at full power. The opportunities seemed limitless - expanded schedules, more products, full uplink power broadcasts and elimination of the interference patterns common to simultaneous VISSR/WEFAX broadcasts, etc. On October 11, 1979, GOES-2 was reactivated for WEFAX broadcasts and began operations as GOES-Central, at 105°W. (The position was later changed to 107° to minimize the possibility of an in-space collision with other spacecraft and space debris, and to permit reception of WEFAX data at certain locations in the western Pacific).

Although GOES-Central is being used operationally for WEFAX broadcasts, it still is not considered a full "partner" in the scheme of things. If the WEFAX transponder fails, a new satellite would not be launched to replace it. If ground equipment supporting GOES-East or GOES-West should fail, GOES-Central support equipment could be used until repairs were completed.

On the brighter side (at least from the WEFAX point-of-view), any GOES spacecraft already in space, and having a VISSR instrument which is not functioning, conceivably could be moved to the GOES-Central position as a replacement. Also, efforts are being made by the National Meteorological Center, working in close cooperation with the National Earth Satellite Service, to ensure that the necessary ground equipment at Wallops is available to support GOES-Central WEFAX services and to have this spacecraft designated as an operational platform.

This report of the history and development of WEFAX services would not be complete without mentioning that another by-product of the earlier ATS experiments and SMS/GOES developments was the decision by other nations to operate their own geostationary environmental satellites. In 1972, a Coordination on Geostationary Meteorological Satellites (CGMS) group had been formed in hopes of achieving a commonality among geostationary satellites that would, among other things, enable mobile users of the WEFAX services to travel from one part of the globe to another and still be able to receive WEFAX broadcasts without major ground equipment changes. Also, standardization of data formats and transmission frequencies would enable existing APT station operators around the world to make the same basic modifications to their receiving equipment in order to receive WEFAX broadcasts from whichever geostationary satellite might be within range. Largely as a result of the coordination and cooperation of members of this group, both Japan's Geostationary Meteorological Satellite, launched in July 1977, and the European Space Agency's METEOSAT, placed in orbit in November of the same year, are compatible with the United States' GOES, providing WEFAX services on a frequency of * 1691.0 MHz and operating at a 240 line rate.

In conclusion, it should be obvious to the users, as it is to us, that the development and refinement of WEFAX services is not a static exercise. It has been marked by technological breakthroughs and man's inovative instincts. The early ATS experiments were a result not only of our ability to put an Earth sat-

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*METEOSAT also provides WEFAX services on a frequency of 1694.5 MHz.

ellite into a geosynchronous orbit, but also to use it for communicating WEFAX data to existing APT stations. In the SMS/GOES series development, we saw improvements in spacecraft stabilization and communications techniques, and substantial increases in the quantity, quality, and timeliness of WEFAX broadcasts, including use of a spare GOES for simultaneous VISSR/WEFAX transmissions, and the addition of weather charts and other products.

This history is further evidence that we can expect more change in the future -- in sensor improvements as well as in methods of communicating products to the field. It is important to us at this conference -- the operators of the service as well as the users -- to have a mutual and meaningful dialog, for it is only through such a dialog that you can learn what we do to provide this service, and we can learn about your requirements, concerns, and problems.

3. Evolution of Basic Ground Receiving Stations

Mr. C. H. Vermillion
Program Manager
Satellite Direct Readout Applications
Goddard Space Flight Center
NASA

I would like to begin by talking about the satellite which (spawned) user ground stations -- TIROS-VIII, launched in December 1963. This satellite carried the first user experiment in the United States space program, the Automatic Picture Transmission (APT) experiment. This experiment was first designed for the NIMBUS satellite, but we wanted to get it up earlier, so it was modified to fit on TIROS. At first, there were only three countries - - the United States, Canada, and France - - capable of receiving these APT broadcasts. Today, there are over 123 countries capable of receiving transmissions, with thousands of users all over the world. The variety of ground stations employed to receive these pictures has changed, and so have the sources of data -- from the old vidicons carried by the early TIROS and NIMBUS satellites to today's scanning radiometers. On the present satellites, we use an Advanced Very High Resolution Radiometer (AVHRR) system, and derive our APT data from this system.

After the TIROS satellites came NIMBUS, which carried the test instrumentation for the next generation of weather satellites, the TIROS Operational Satellite (TOS) and the Improved TIROS Operational Satellite (ITOS) series.

The first ITOS was TIROS-M, renamed ITOS-1 after launch. It was the first satellite with infrared capabilities in the emissive (10.5 -12.5) band. This opened new horizons for users of satellite data, including oceanographers, and allowed meteorologists to obtain cloud-top temperatures roughly indicative of cloud heights. The present series, a modified version of the Air Force satellites and called TIROS-N, is our operational meteorological satellite.

The GOES satellites -- GOES-East and -West -- measure the infrared and reflected energy and transmit it to the Earth as a high resolution picture, whereupon on the ground, it is converted to WEFAX. It is then retransmitted back to the satellite to stations within range. For instance, GOES-West can be received from the east coast of the United States, west to Guam. With GOES-East, we can see all the way to Western Europe. These two satellites cover nearly one-third of the earth.

A good example of WEFAX coverage is shown by this picture obtained from a station (fig. 3-1) we put into Bangladesh. I wanted to show you that something that we have started here has been carried around the world through the GMS, the European satellites METEOSAT, and the Indian satellite, INSAT.

WEFAX and APT are quite similar, as Dr. Spohn has pointed out. The ground systems are almost identical, the primary difference being in the receiving frequency. We have kept them that way on purpose to keep the cost down. APT is received on VHF; the L-Band frequencies -- 1691.0 Mhz and thereabouts -- are used for WEFAX and requires the use of a different antenna.

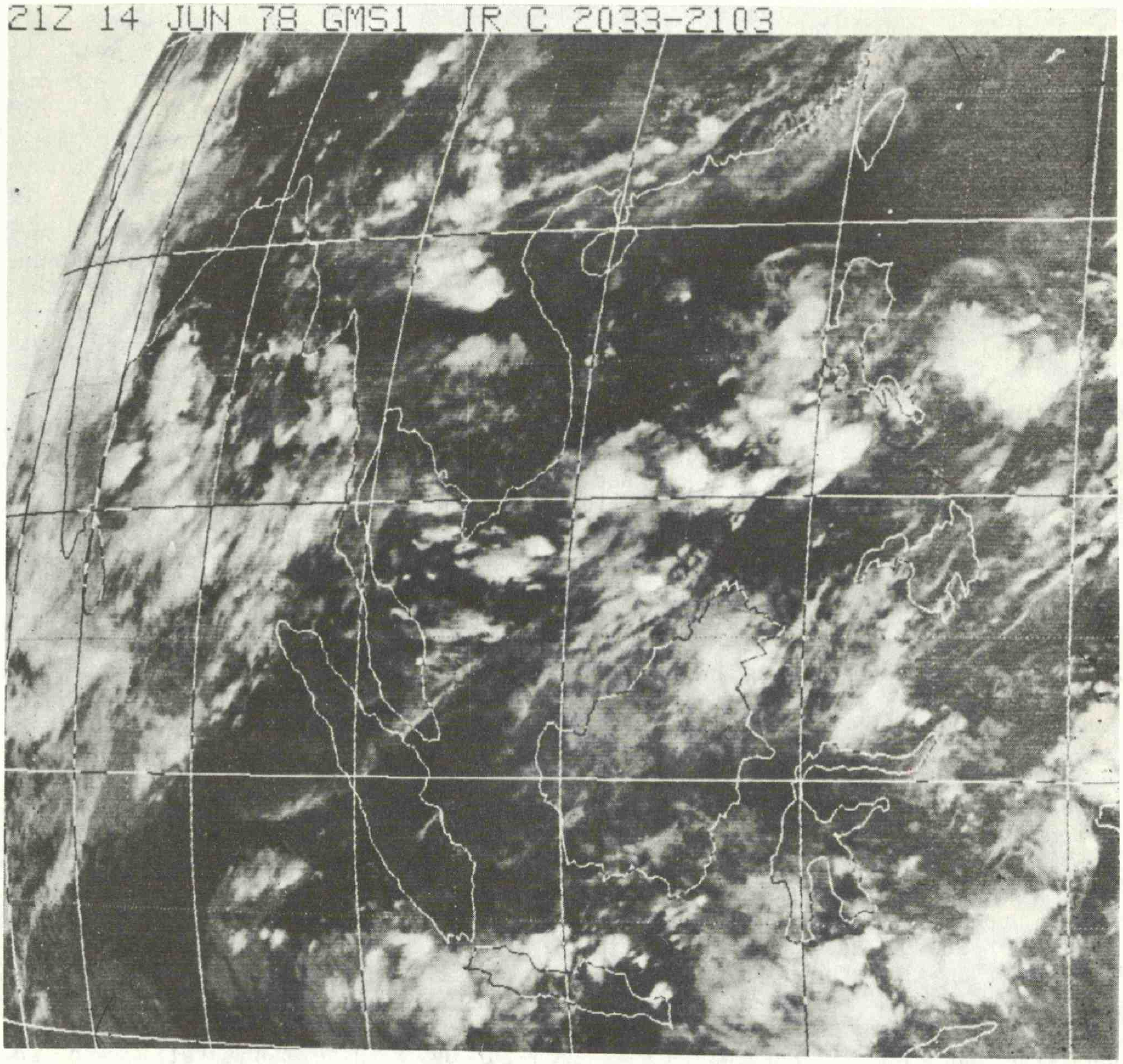


Figure 3-1.--WEFAX Picture
Received in Bangladesh

Figure 3-2 shows the first system the Government developed for APT. We later modified this for use with the ATS WEFAX. In the upper left-hand corner is the antenna control system, a Scientific Atlanta antenna, a helix with 10 db gain and very wide beam width. It was very prone to noise; ignition noise, aircraft noise, etc. Pictured is a NEMS-Clark receiver, which I understand the United States Navy is still using 20 years later. On the right is storage space underneath the facsimile. This facsimile, after many studies, was found to be the best we had for those days.

Our primary efforts in this field have been to develop a ground station for APT and WEFAX that could be used by forecasters aboard ship or in remote areas. If we could supply the needs of shipboard users, we certainly could supply the needs of other users on land, so we concentrated on the shipboard developments. We had to have a unit which could perform aboard ship without chemicals. We knew that photographic processes were superior in quality, but we could not find a system which could be aboard ship without corrosive chemicals and fumes. So we settled on an electrolytic process. The paper is impregnated with an electrolyte; as the satellite passes overhead, it sends a satellite signal down. An iron bar behind the paper moves in a helix fashion, causing a straight line with current passing through the paper. The more current, the darker the paper, corresponding to the oceans; the less current the lighter the paper, corresponding to land and clouds. This reconstitutes an image.

We have improved upon the system in later years. Figure 3-3 shows a Heli-fax, which uses a crater tube as an exposure or modulator source. The signal is modulated in proportion to the video, and is scanned through drum motion on a Kodabromide paper, a stabilized process. After completion, the paper is pulled off and processed through a chemical bath.

Again, the same problem exists - - it cannot be shipboard mounted. In fact, in attempting to do so, it caused several problems aboard the vessels used in these experiments. In an attempt to improve on ground systems - - and I want to bring out that in the early days these ground stations cost about $40,000 each -- we developed within our American industry the unit shown in figure 3-4, a laserfax, which uses a dry silver halide film. After the picture is exposed, the film is heated for a few seconds to produce a finished product; there are no wet products involved.

We also managed to develop some very early processing techniques to digitize the incoming signal. Figure 3-5 shows one of the first digitizers. When we attempted to operate this equipment in another country, away from routine maintenance and supply contractors, we found problems, especially in the laser display. We couldn't keep the equipment running without considerable maintenance. Later, we replaced the equipment with an Alden facsimile.

I would also like to mention that a lot of technology development was created through newer, higher resolution systems which helped to benefit both APT and WEFAX as a spinoff. In the early 1970's we developed a local user terminal for meteorology to receive the higher frequency transmissions from the new ITOS, specifically ITOS-D, launched in October 1972. This satellite carried a high resolution, two channel radiometer. The visible channel was sensitive to the .5 to .7 micron range, and the IR channel was sensitive to the .10 to .12

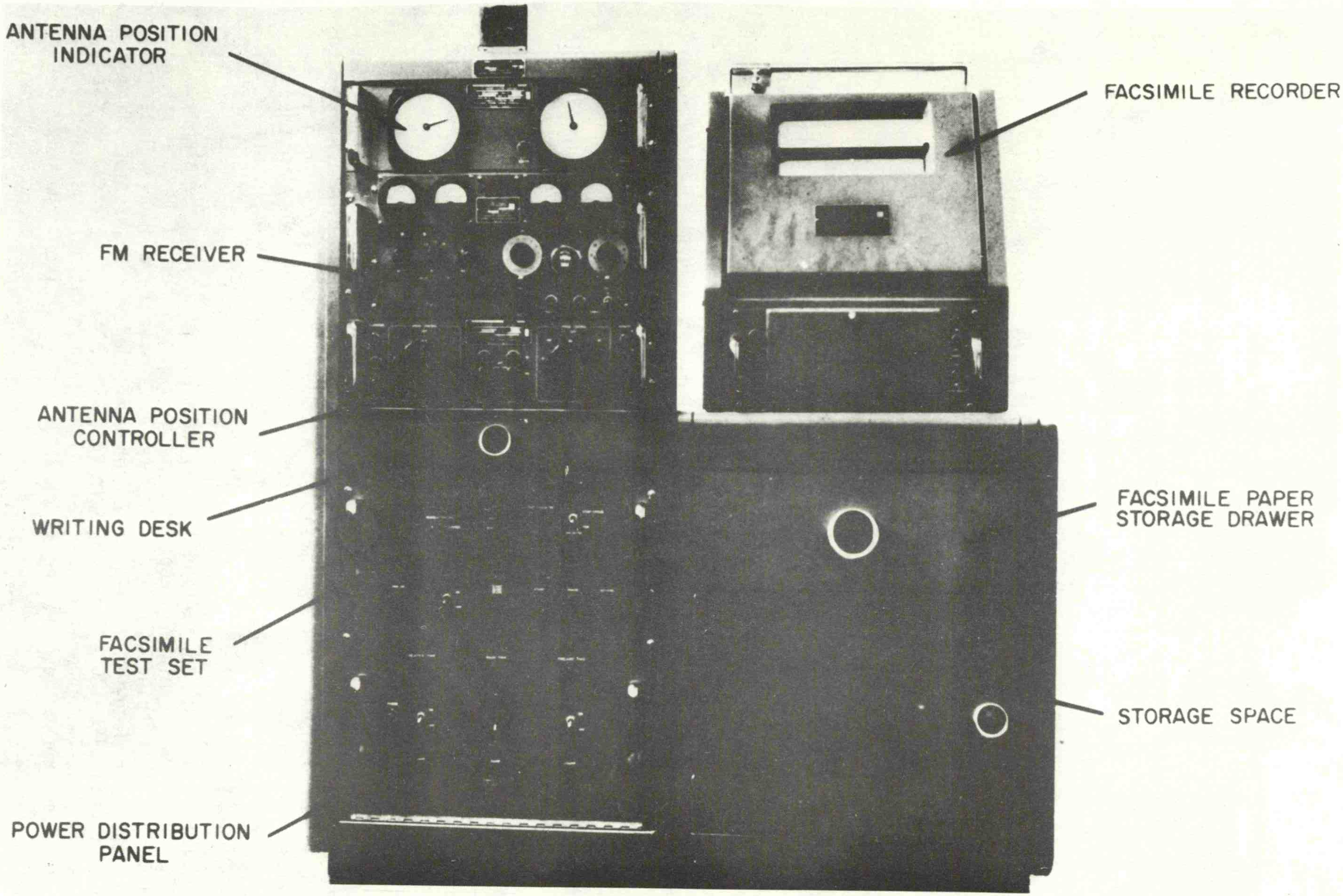


Figure 3-2.--First System Developed for APT.

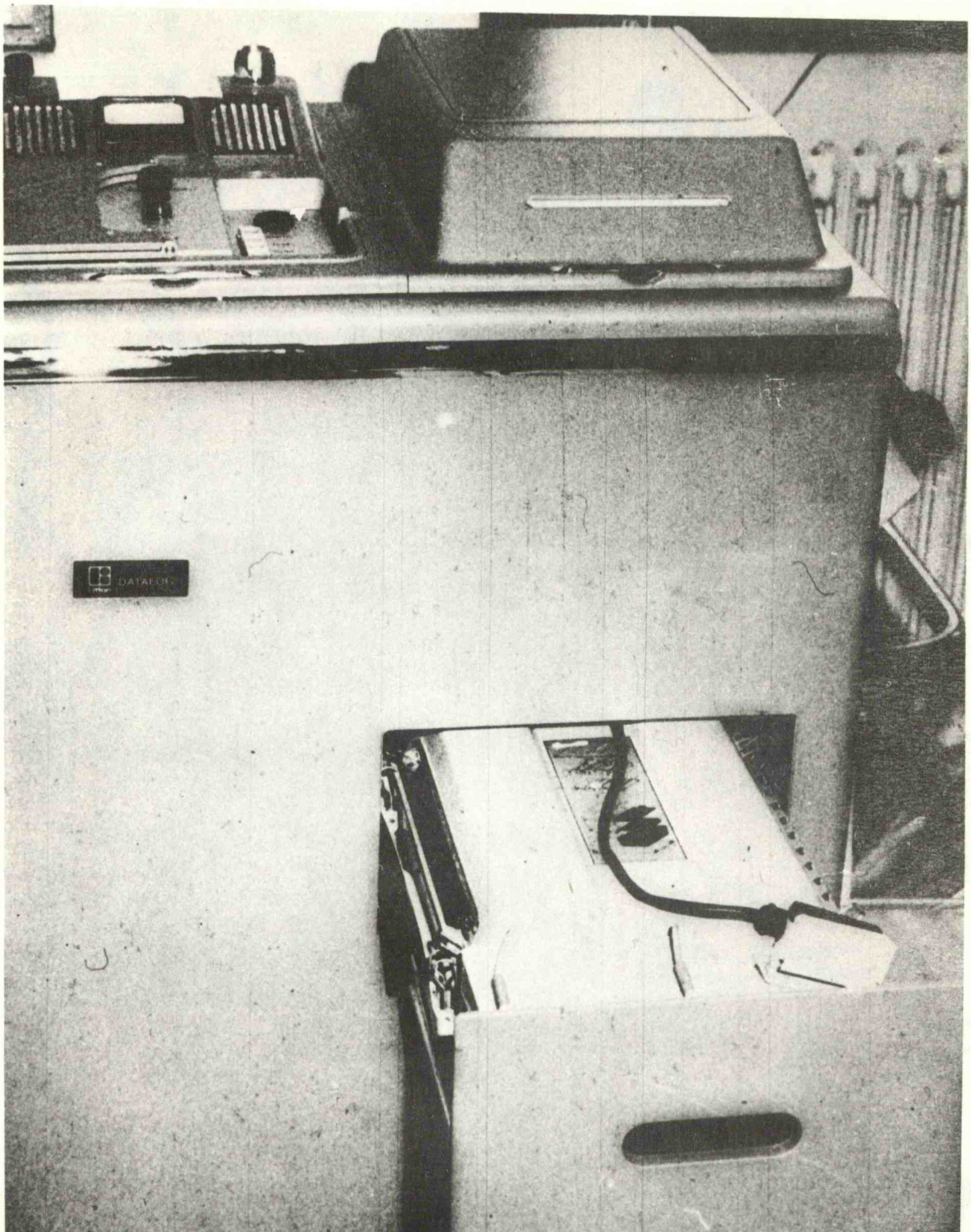


Figure 3-3.--Heli-fax System

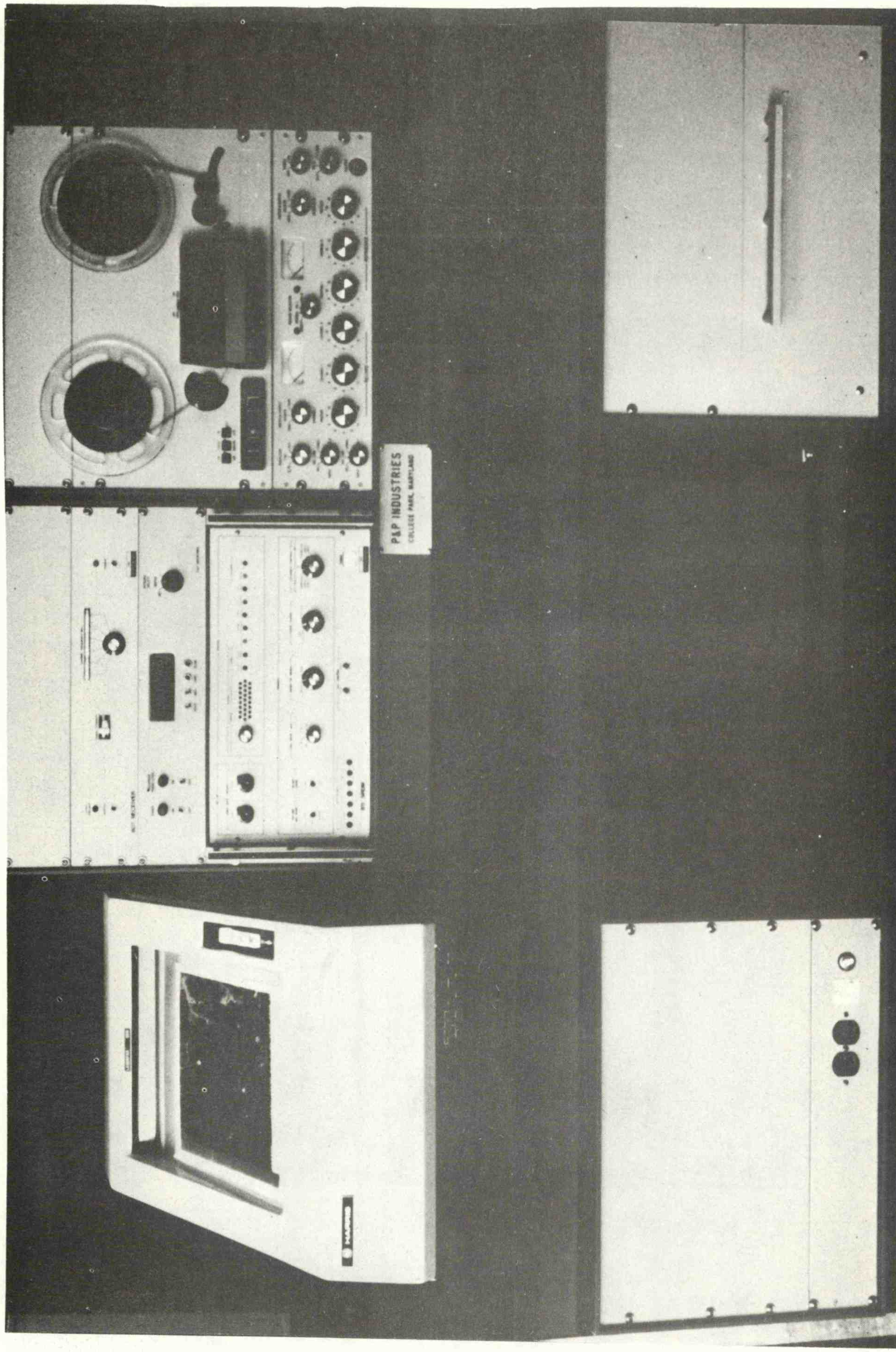


Figure 3-4.--Laserfax System

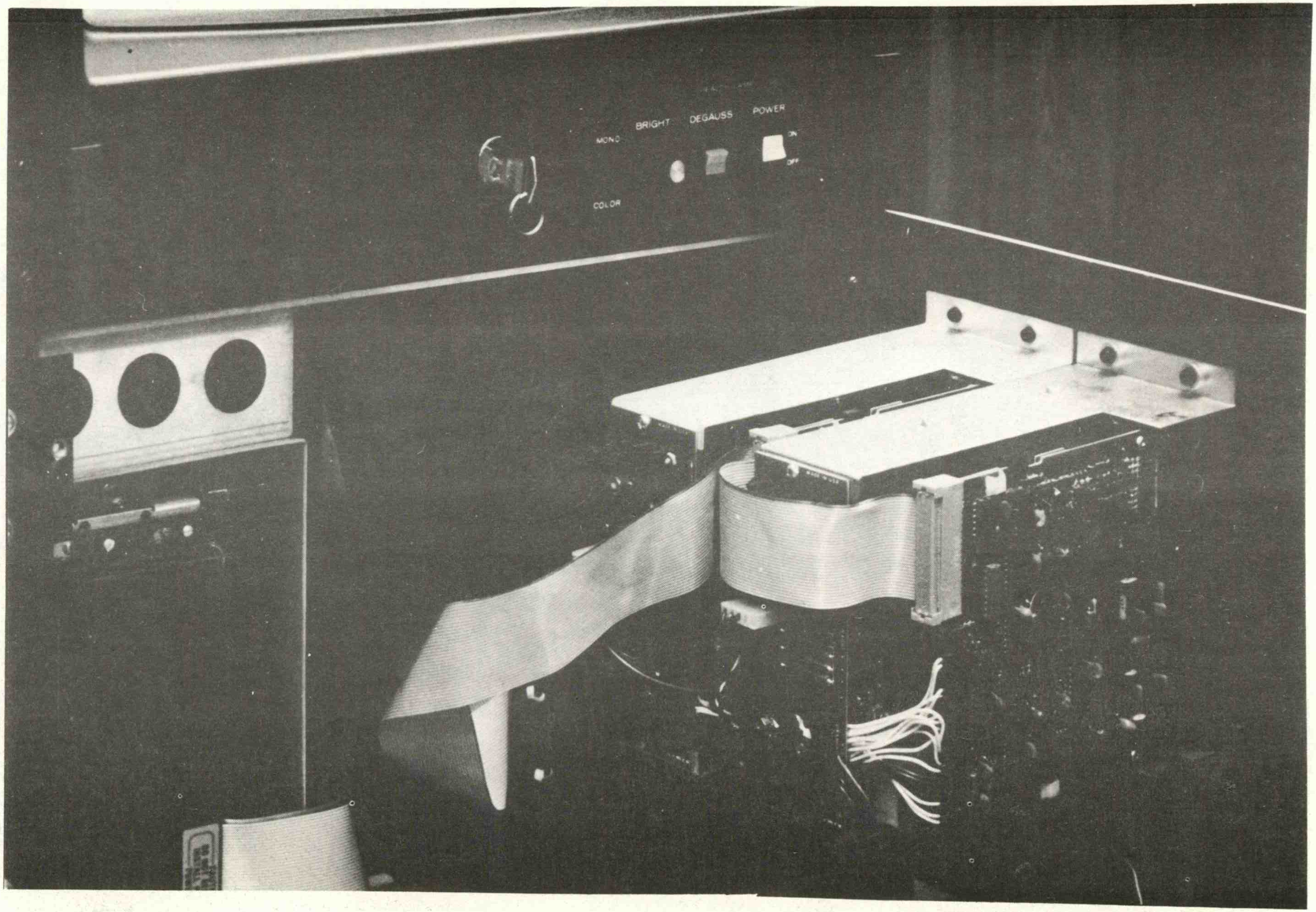


Figure 3-5.--First Digitizing System

micron range. Figure 3-6 shows a dish antenna developed for this system. The WEFAX dish looks similar to this antenna. The antenna system automatically tracks the satellite.

Figure 3-7 shows another laser display. At the top is the Microdyne receiver, one of the best in its day. Also shown are our tape recorders and digital handling packages. We found that we had to digitize the image to perform data enhancement the meteorologists and oceanographers wanted, that is, to enhance it to bring out the subtleties of the ocean surfaces, to see upwelling, ocean currents, cloud tops, and flood inundation. We found a "new world" with one-kilometer data. We found we could do far more than what we could do with APT; not as much as what we could do with Landsat, certainly, but at least we had the opportunity for synoptic viewing.

Figure 3-8 is a good example of an infrared (10.5-12 micron) picture from the old VHRR, predecessor to the AVHRR. The east coast of the United States is easily seen, as is the Gulf Stream, with lighter areas indicating the slope waters.

On the left, in figure 3-8, we can see Long Island and nearby, a warm eddy (called warm core rings). These eddies break away from the Gulf Stream and mix with the slope waters, practically destroying the fishing.

By assigning colors to temperatures (note the calibration at the top) an oceanographer can immediately tell the temperature of the scene he is viewing. Figure 3-9, made from the earlier VHRR picture and taken over the coast of Maryland, shows another warm intrusion into the cooler slope waters. The loop of the Gulf current is where the Gulf Stream begins, crosses the Atlantic and keeps Europe cool.

For users of APT, and obviously when used aboard ship, this system is not too expensive nor too large. Use of the auto track antenna would be beyond reach of research vessels and other institutions.

In the early 1970's, we initiated a research program with the state of Texas utilizing the Texas Clipper (fig. 3-10), a Texas A&M training vessel. We began putting APT equipment on board this ship each time she made a cruise, generally down to South America. We were able to put on new equipment and try out different types of displays, such as electrolytic, semidry UNIFAX, and a laserfax, all of which worked extremely well. However, we were unable to quantitatively analyze the data to determine sea surface temperatures. Many experiments with computers led to the development of microprocessors. We recognized the value of microprocessors, and concurrently with the development of these devices, were able to develop a system which is currently in use at the U.S. Navy's Post Graduate School, in Monterey, California -- a complete APT station with tape recorder, receiver, and an interactive graphics display, a microprocessor containing a hard disc for the image, two operating floppy discs interacting with the computer through the graphics display, and a keyboard for data entry to enter instructions, all in one package.

The tape recorder, especially designed for WEFAX, had to be developed to record and play at exactly the recorder rates; otherwise the picture would skew. The receiver had to be oblivious to bursts of noise, radar, or other forms of electronic interference. The device shown here is the Alden, with a UNIFAX

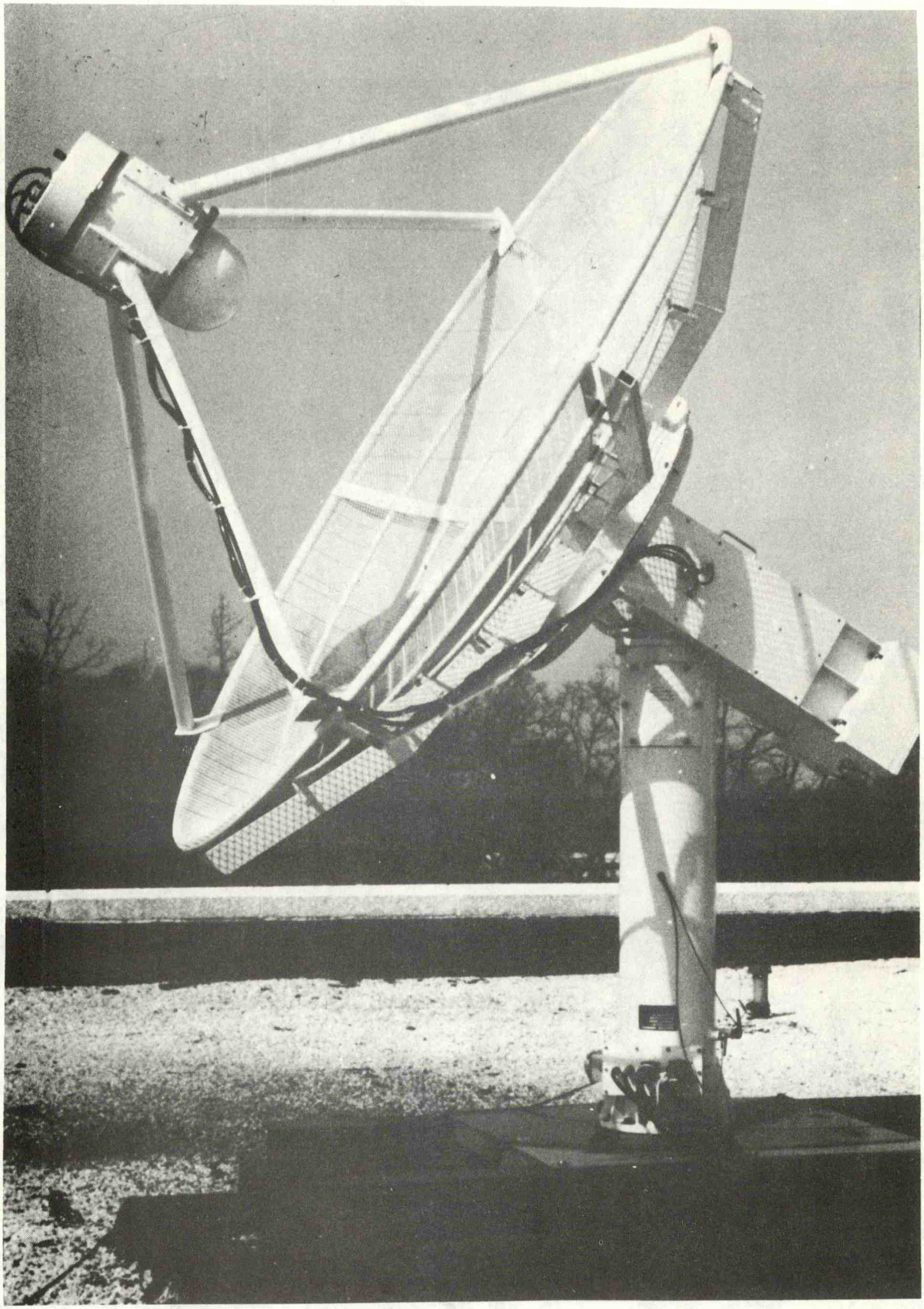


Figure 3-6.--Dish Antenna

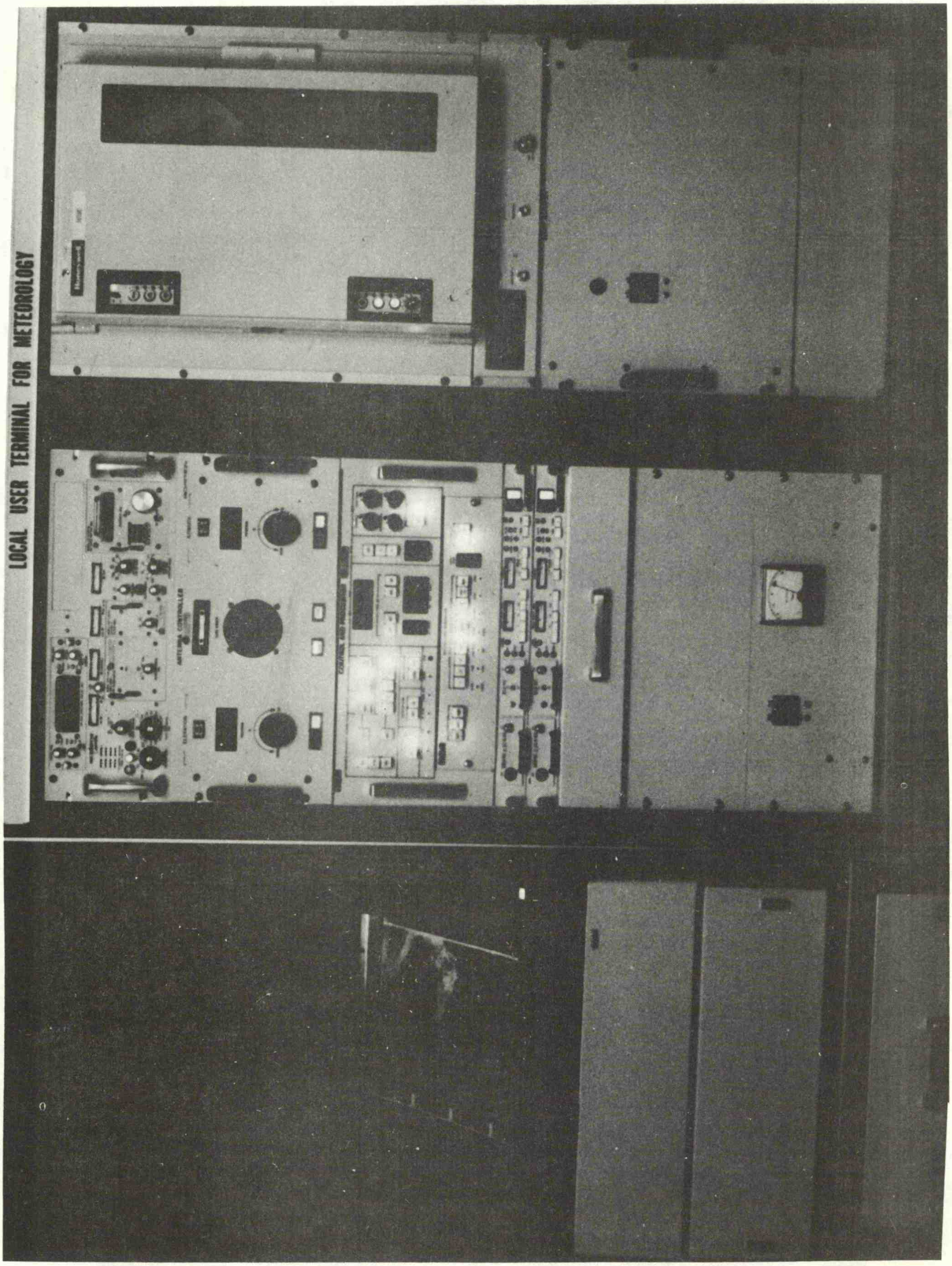


Figure 3-7--Laser Display

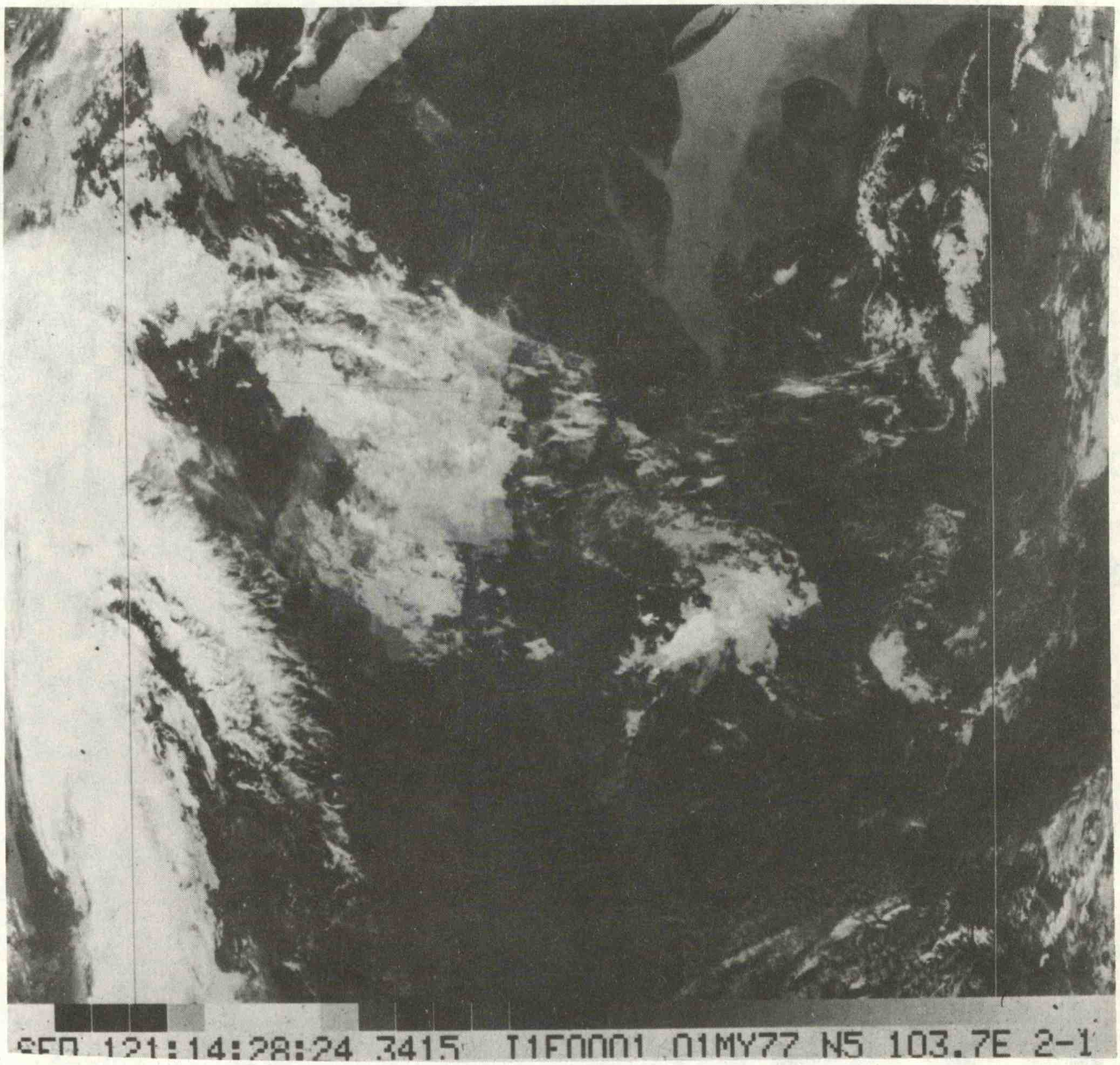


Figure 3-8.--IR VHRR Picture

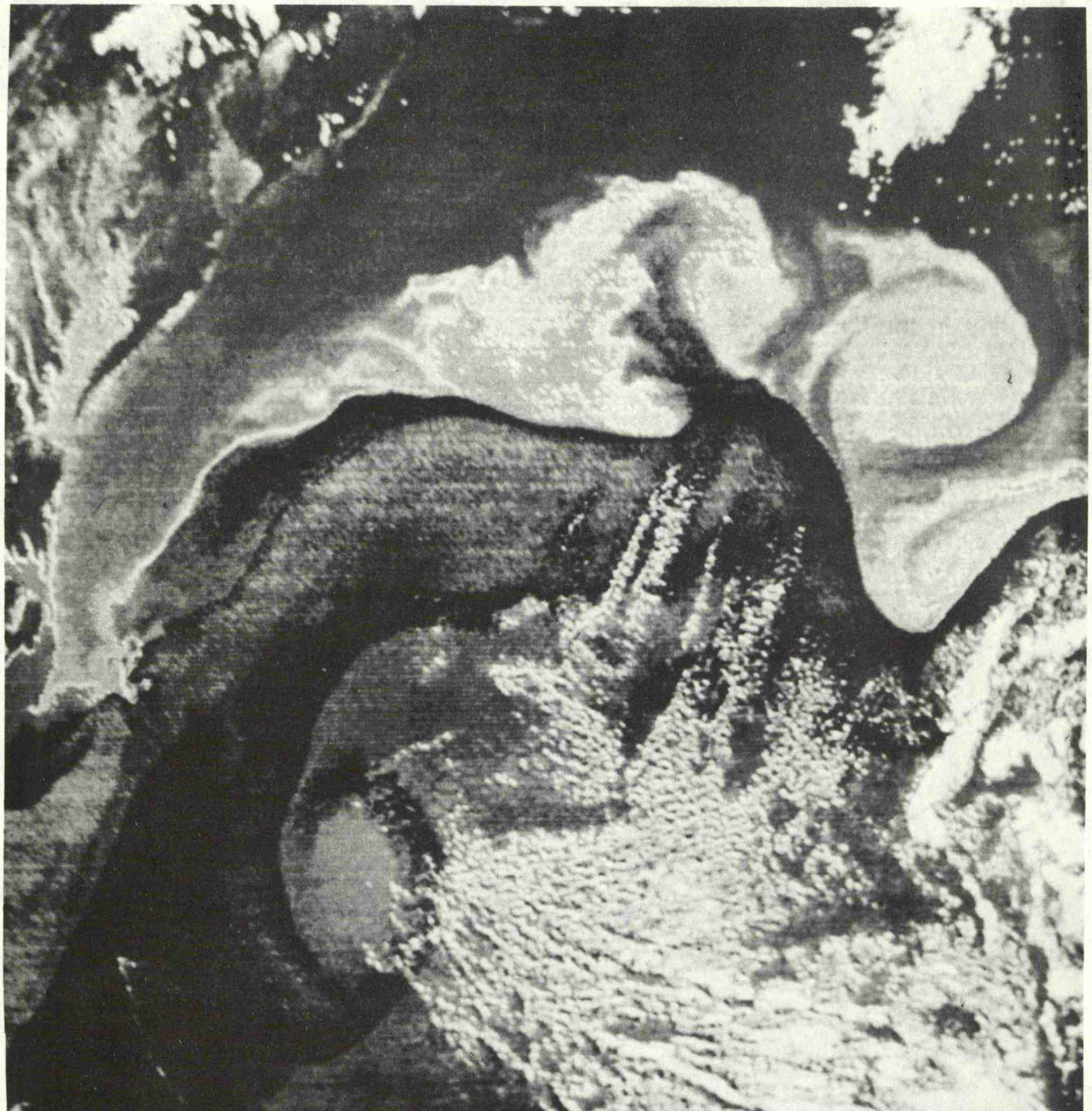


Figure 3-9.--VHRR Picture of Coast of Maryland

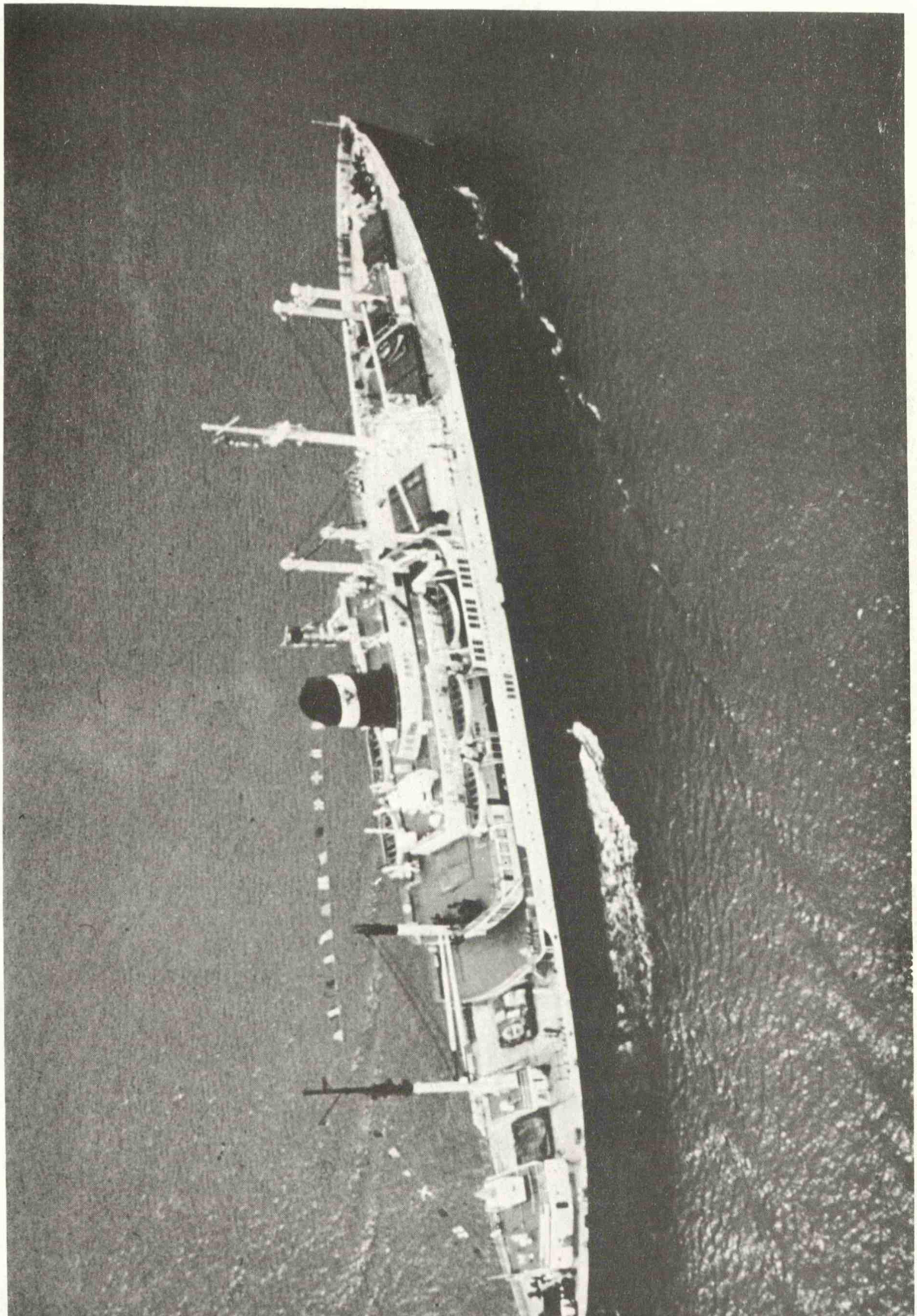


Figure 3-10.--Texas Clipper
(Texas A&M Training Vessel)

copy which we inserted into the Alden. When we open the door to the computer, we see the floppies and the hard copy disc. This is a Winchester drive, with an 11 megabyte capacity.

We now have the ability not only to process the data using a microcomputer, but also to display it on a CRT and zoom in to an area of interest. This picture (fig. 3-11) was taken aboard the research vessel ACANIA off the Coast of California. Although very seasick, this observer was able to record the data onboard the ship. We have stopped the recorder to screen in the area around San Francisco Bay, then use the cursor to enlarge and process the area.

Figure 3-12 is a close-up of the CRT showing the San Francisco Bay area in the center. Differences in temperature are reproduced as variations of colors. We can enlarge this even more. Remember this is done aboard ship in real-time. You can see down to the instantaneous field of view (IFOV) of 4 kilometers; every block of data is one picture element from the satellite. In the 1960's, the systems which we developed cost about $40,000. Both systems have led to this system, which does about all we want in terms of analyzing APT data. This system sells for $60,000.

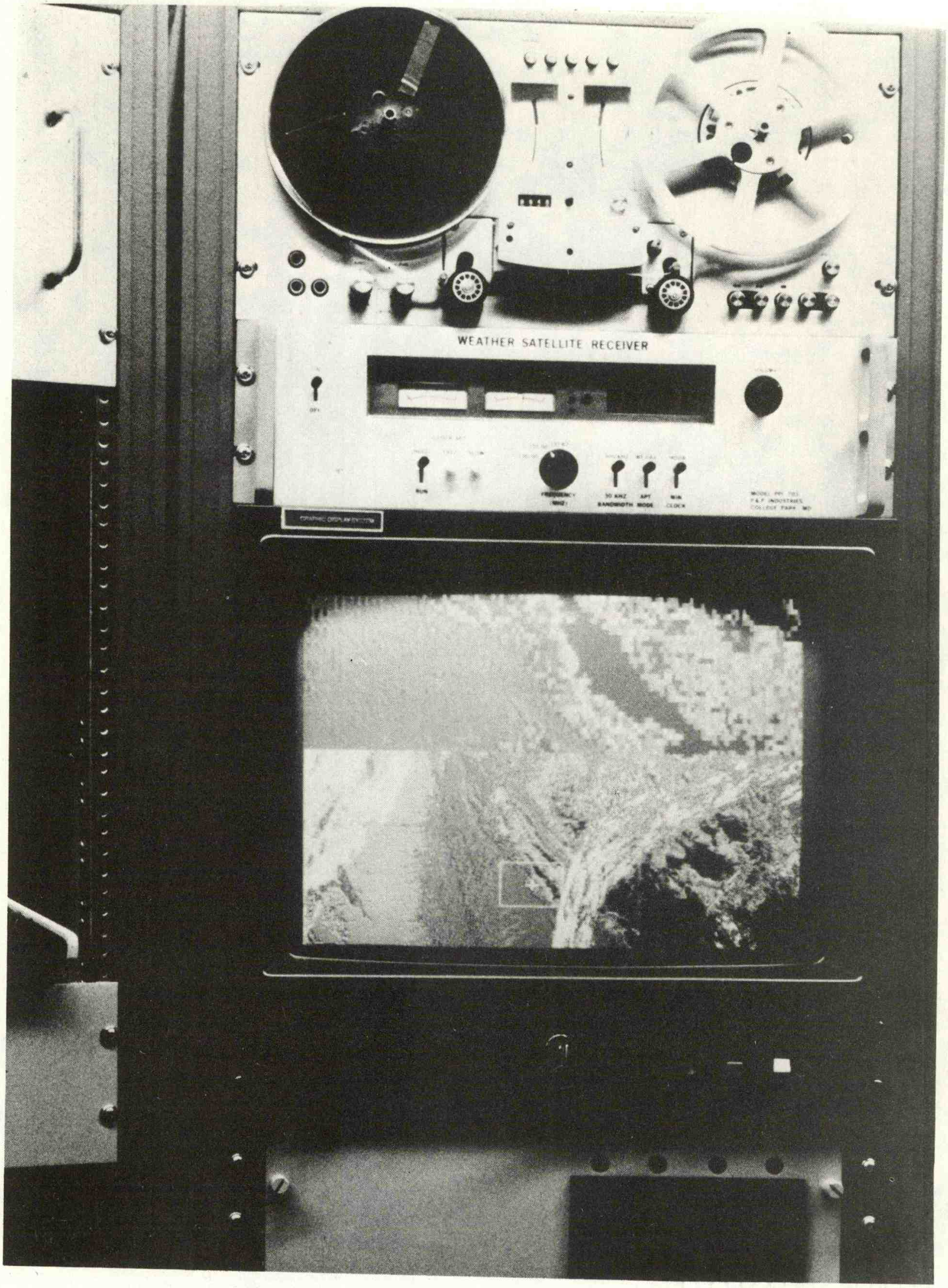


Figure 3-11.--Picture Taken Off Coast of California

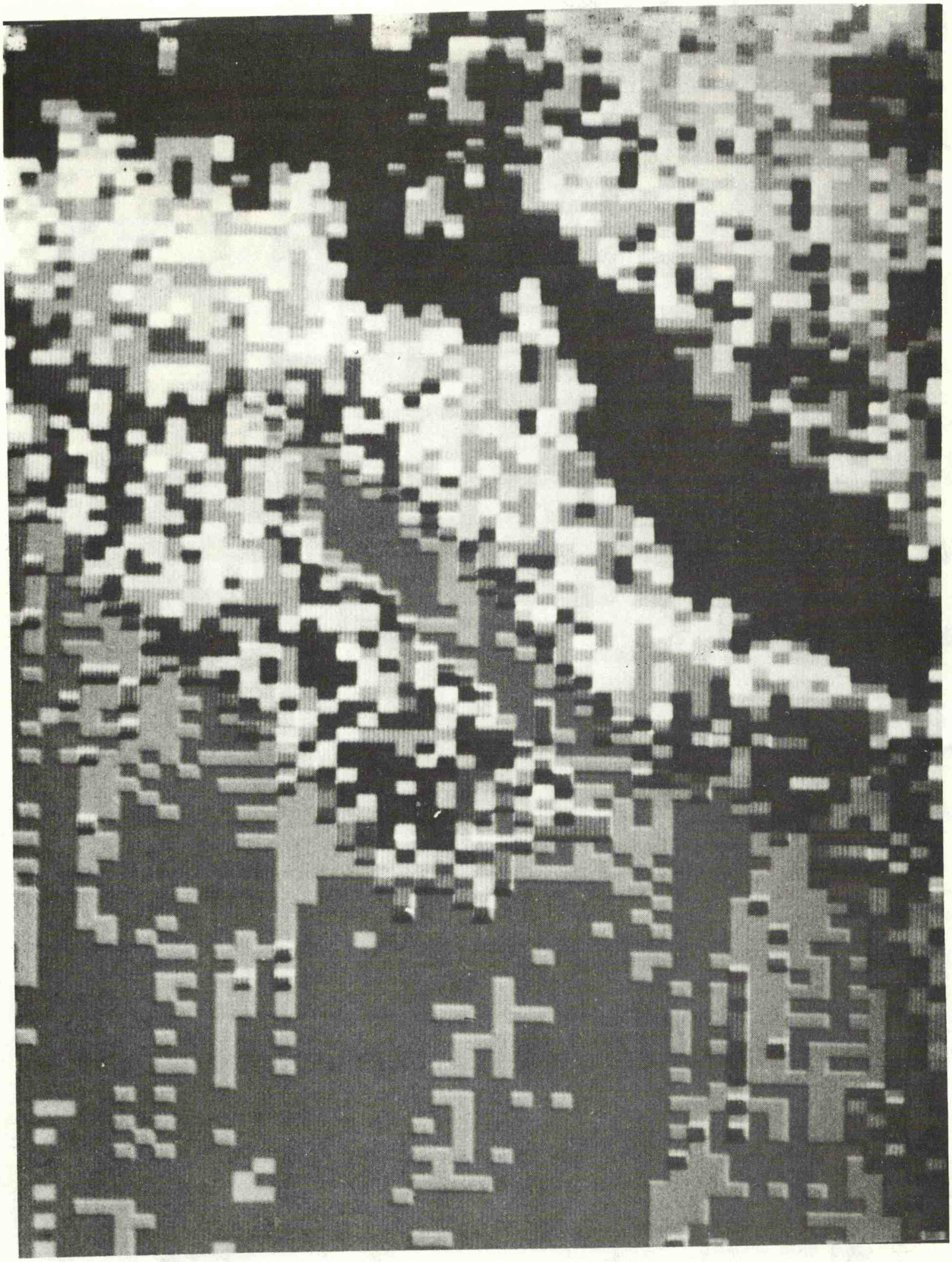


Figure 3-12.--Close-up Picture of
CRT Showing SF Bay

4. WEFAX Operational Program

Mr. Donald Winner
Chief, Satellite Services Division
National Earth Satellite Service
NOAA

Basic Commitment

The National Earth Satellite Service (NESS) of the National Oceanic and Atmospheric Administration is fully committed to a Weather Facsimile (WEFAX) image schedule on both the East (75°W longitude) and West (135°W longitude) Geostationary Operational Environmental Satellites (GOES). Data are transmitted in approximate 10-minute periods between normal VISSR imaging. Daily exceptions, when no WEFAX image is transmitted on this half-hourly schedule, include the 10-minute periods for the six TRILATERATIONS (spacecraft ranging) and two APT Predict (TBUS) bulletins, as well as a 3-hour and 30-minute block of time (centered on spacecraft midnight) during the twice yearly spacecraft eclipse periods when operations are suspended.

Both polar orbiter mapped and geostationary unprocessed Visible Infra-red Spin Scan Radiometer (VISSR) imagery will be broadcast. The priorities for image products during these normal WEFAX image transmissions are as follows:

1. Full disc VISSR IR coverage each 3 hours.
2. Full disc VISSR IR coverage each 6 hours.
3. Mapped polar orbiter mosaics for Southern Hemisphere coverage twice daily.
4. VISSR visible sections at 3-hourly intervals during daylight hours.
5. Mapped polar orbiter IR coverage for Northern Hemisphere coverage once daily.

NESS will interrupt its normal WEFAX operations to conduct rapid interval scanning during periods of severe storm conditions that require near-continuous VISSR imaging. Simultaneous VISSR/WEFAX operations are necessary during these periods in order to make WEFAX transmissions. There is no change in the WEFAX broadcast schedule but there is a reduction in power by (6 dBm) on the WEFAX up-link signal. This, in turn, reduces the power of the WEFAX down-link signal emanating from the spacecraft to Earth by 12 dBm, resulting in degraded signal reception for WEFAX receivers. During these rapid interval scanning operations, NESS ingests a full disc VISSR image each 3 hours to support the WEFAX schedule.

Other WEFAX services that are provided on the East and West GOES include the relay of National Meteorological Center charts and additional satellite imagery. The satellite imagery is in addition to the normal WEFAX broadcasts. These broadcasts occur during normal VISSR operations and must be made at reduced WEFAX up-link power similar to that required by the rapid interval scanning operations.

In the event of WEFAX failure on either the East or West GOES, NESS will attempt to maintain the WEFAX service with partially disabled spacecraft that still have a WEFAX capability. However, we will not launch a new spacecraft solely to restore WEFAX services.

Added WEFAX Services

NESS has established a dedicated WEFAX service from a satellite located at 107°W $\pm$ 0.5° longitude. This service (GOES-Central) uses an earlier GOES no longer suitable for imagery. Selected National Meteorological Center charts, the entire East GOES imagery schedule, two TBUS bulletins, the majority of the GOES-West VISSR imagery schedule, a daily operational message and a test pattern are broadcast. Since there is no VISSR operation on the GOES-Central, these broadcasts can be made at anytime during the hour, always at normal signal power, and are often made in 30-minute or longer blocks of time. Daily exceptions to this schedule occur during the 3-hour and 30-minute block of time reserved for ground station periodic maintenance (1500-1830 GMT) and the twice yearly spacecraft eclipse periods (centered on spacecraft midnight) when operations are suspended. The likelihood of there being no spacecraft to support the GOES-Central WEFAX service is considered small, but that possibility does exist. With that one caveat, it is NESS's intent to provide the GOES-Central WEFAX service on a full operational basis.

QUESTION AND ANSWER PERIOD

Mr. Oliver: You mentioned that none of the transponders have worn out. How many of the old satellites do we have now?

Mr. Winner: We have one which we kicked out of orbit, SMS-1. We don't have that for WEFAX anymore.

Mr. Oliver: If you put one old one in the East, and one old one in the West, you would have 24 hours of WEFAX. What would be wrong with that?

Mr. Winner: If I understand your question, we would have two antennas, one for each.

Mr. Oliver: You already have the antennas pointing at those two satellites.

Mr. Winner: It wouldn't work.

Question: How much fuel do you have left on board?

Mr. Winner: Fuel for positioning.

Question: How long until the satellite is out of fuel?

Mr. Winner: Fuel for positioning?. Gary can you answer that?

Mr. Holt: SMS-1, as you know, has been pushed out of orbit. On SMS-2, we are limited to minor corrections.

Statement: I just want to get an idea whether it would be a thousand years, a hundred years, or what.

Mr. Winner: It is limited; it depends on which spacecraft has more fuel, and previous history of the spacecraft.

Dr. Dutton: You and Dr. Spohn have emphasized this notion that you will not launch a new satellite to restore the GOES Central service. This leads me to ask which satellites you will launch in order to restore the service.

Mr. Winner: I do not believe it will ever be necessary to launch a satellite to replace the GOES WEFAX service, as the communication system on a satellite generally has a longer life span than the VISSR system.

Question: Would you launch one to restore GOES East?

Mr. Winner: No.

Question: Are there any satellites you would launch immediately to restore a service?

Mr. Winner: Are you saying the WEFAX service, or services in general?

Statement: The services in general, not just WEFAX.

Mr. Winner: We will launch a satellite to restore service on GOES-East or West. We are going to launch a satellite May 14 - GOES-5. What its disposition will be, I don't know. It may be used temporarily for research, or it may be assigned to the GOES-East position.

Question: In case of failure, you would restore GOES-East or GOES-West?

Mr. Winner: We have contingency plans with all satellites now in orbit. All satellites now in orbit have some capability; we will move them back and forth as required to provide certain services.

Mr. Vanoni: I read in the last Bulletin that you expect to place GOES E more west than the present GOES-East. That will give us some problems in Europe.

Mr. Winner: I'm not aware of this. Is anyone from NESS aware of this? Mr. Vanoni says he has heard that when we launch GOES E, it will be further west than the present GOES-East.

Statement: It will be placed at 85° during check-out, 10°W of the current GOES-East position.

Mr. Schloeman: GOES-4, which has been put on line as the Western GOES satellite after extensive VAS experiments, has exhibited a failure in the number one S-band transmitter. We had a failure on GOES-1 or GOES-3. The S-band transmitter, which I believe was then subsequently or mysteriously fixed, hasn't had a characteristic failure on the VAS instrument on the Hughes satellite. Have they been able to document whether or not they would expect to recover that S-band transmitter, since you are now down to one? Could this happen on GOES-Central as well?

Mr. Winner: Gary, have they conducted any satellite tests on the West satellite?

Mr. Holt: Yes. Hughes does not hold any hope of recovering that S-band and transmitter. Some of these failures have to do with the VAS VHF receivers.

Question: Are there any plans to change the frequencies? For example, go up to some much higher frequency? Do you plan to stay right in the S-band for the WEFAX?

Mr. Winner: I am sure there are no plans to change the frequency.

Dr. Taggart: I would like to address the anomalies we have been getting on GOES-East and GOES-Central. Transmissions were well below 4 percent (the carrier level) as the black parts are very black and the white parts very white.

Mr. Feigel: I can't answer your question directly, because I am not aware of that happening. The percentage modulation that we use is 86 percent.

Statement: Well, for the past couple of months on all GOES-East VISSR-derived products, the whole gray scale range appears to have disappeared. Essentially what happens is that the subcarrier actually disappears. We have been talking back and forth with Bob Popham, to sort out this problem.

Mr. Feigel: I know that questions of this nature have come up in the past and on every occasion, when we look at the signal at either of our facilities, the modulation is correct. I fail to see how it is getting into your system and not being observed throughout the entire system. I'm not aware of it and we have not been able to see it.

Question: Bob, is that a system wide problem?

Mr. Popham: Yes.

Dr. Taggart: Have you verified it with your system, Mr. Feigel?

Mr. Feigel: Tom, have you noticed it with your system at Wallops?

Mr. Vilov: No.

Mr. Popham: There are several different people we consult when we get this type of problem. A single problem relayed to us by one individual may or may not be acted upon. In some instances, however, we are able to verify single anomalies.

Mr. Feigel: Have we been able to verify that it is over-modulating in our system?

Mr. Popham: Larue Amacher, could you comment on this?

Mr. Amacher: There is a difference in the modulation, but I don't know whether it is generated by the FET's in FB-4.

Mr. Feigel: It certainly sounds like something that should be looked into more closely. All I can say is that when I have observed the signal, I have never seen it over-modulated. I don't know what else to say.

Question: You haven't noticed it recently, have you?

Dr. Taggart: Oh yes, last night, and it could do it again today. What happens is that it happens abruptly and usually stays on until shutdown; the whole gray gets skewed downward. What should be a moderate contrast IR picture becomes cold black, with very white clouds. It usually happens intermittently, but has been happening several times. We have rather voluminous reports on it.

Question: Do you have samples?

Dr. Taggart: Oh, yes, from last night.

Mr. Anderson: If you give me some examples from last night we will try to track it down.

Dr. Taggart: It happened a couple of times last night. Then I can't remember whether it dropped out before the last couple of transmissions before shutdown. It never affects GOES-West products sent through the Central satellite, and it never affects charts or the TBUS messages. It does affect all GOES-East derived products and all Polar and GOES mosaics sent through the Central satellite. When I first noticed it, it was affecting the mosaics sent during the period just before the shutdown. Then it started cropping up earlier and earlier in the day. It may come in earlier in the day or late in the day, but when it does come in, it is a fairly persistent phenomenon.

Statement: It may actually be some form of a line problem?

Dr. Taggart: I suspect that it may be more than that, because the charts are not affected.

Mr. Anderson: The charts from the East satellite are not going out in a simultaneous situation, whereas on the West satellite we may be using the west line.

Dr. Taggart: When it does happen, do you wait for GOES-West transmission?

Mr. Feigel: They say that it happens only when you have just GOES-East and Central in operation.

Dr. Taggart: When I see it happening on Central, I very definitely switch over to GOES-East to see if it's happening there, too. It is only the GOES-East Polar and Mercator products that are affected.

5. Description of WEFAX Services - Part 1

Mr. Richard Clark
Data Collection and Direct Broadcast Branch
National Earth Satellite Service
NOAA

With my presentation this morning I would like to describe how the raw products which go into making up the WEFAX broadcasts are acquired, formatted, broadcast and received by the user in their final form. Hopefully, as we go along, we will answer some of the questions we know you have about the operation of the WEFAX system and, maybe more importantly, what happens when it's not operating.

In my presentation I will be speaking in broad generalities about the WEFAX system. Mr. Earl Feigel, the speaker who follows me, is an engineer; and he will get into the technicalities concerning the electronics of the WEFAX ground equipment.

WEFAX broadcasts consist of five products:

GOES IMAGERY
POLAR ORBITER IMAGERY
NATIONAL METEOROLOGICAL CENTER CHARTS
TBUS BULLETINS
OPERATIONAL MESSAGES

As users, you are concerned with the receipt of these products - probably in this order of priority - based upon your individual requirements. I'll touch briefly on each of these products during the next few minutes.

Before you can appreciate the complexity of the WEFAX system, you have to understand the data flow. In the case of GOES imagery which you receive, the raw high resolution (1 km) VISSR data are transmitted to the Command and Data Acquisition (CDA) Station at Wallops Station, Virginia. Wallops sends stretched gridded infrared VISSR data and ungridded visible VISSR data back to the satellite, as indicated by the dashed line in figure 5-1. It is then retransmitted to NESS' computer complex at Suitland, Maryland, where it is acquired by two ingest computers (GOES-E and W). Ingest tapes are manually loaded on to a Facsimile Encoder Transmitter (FET), which transforms the full disc imagery into a low resolution 8 km image format. From Suitland, the imagery is sent over one of three telephone lines to Wallops, and broadcast back up to the spacecraft, then down to the user.

The FET formats the full disc into 4 quadrants as shown in figure 5-2. In this figure, the horizontal (longitude) and vertical (latitude) lines cross at the sub-satellite position of GOES-E at 0° (the Equator) and 75°W. With GOES-W, this point would be 0° and 135°W.

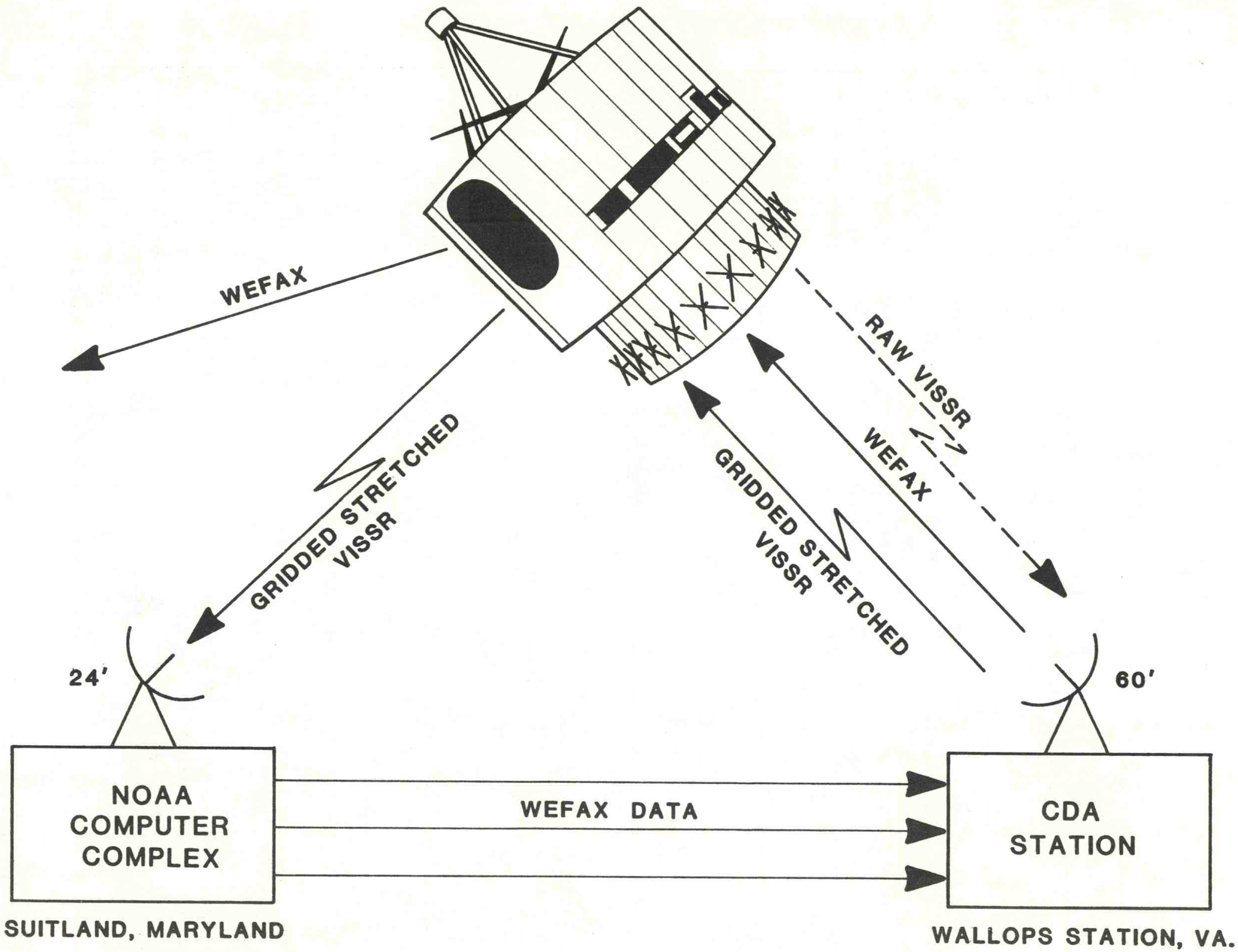


Figure 5-1.--GOES Data Flow

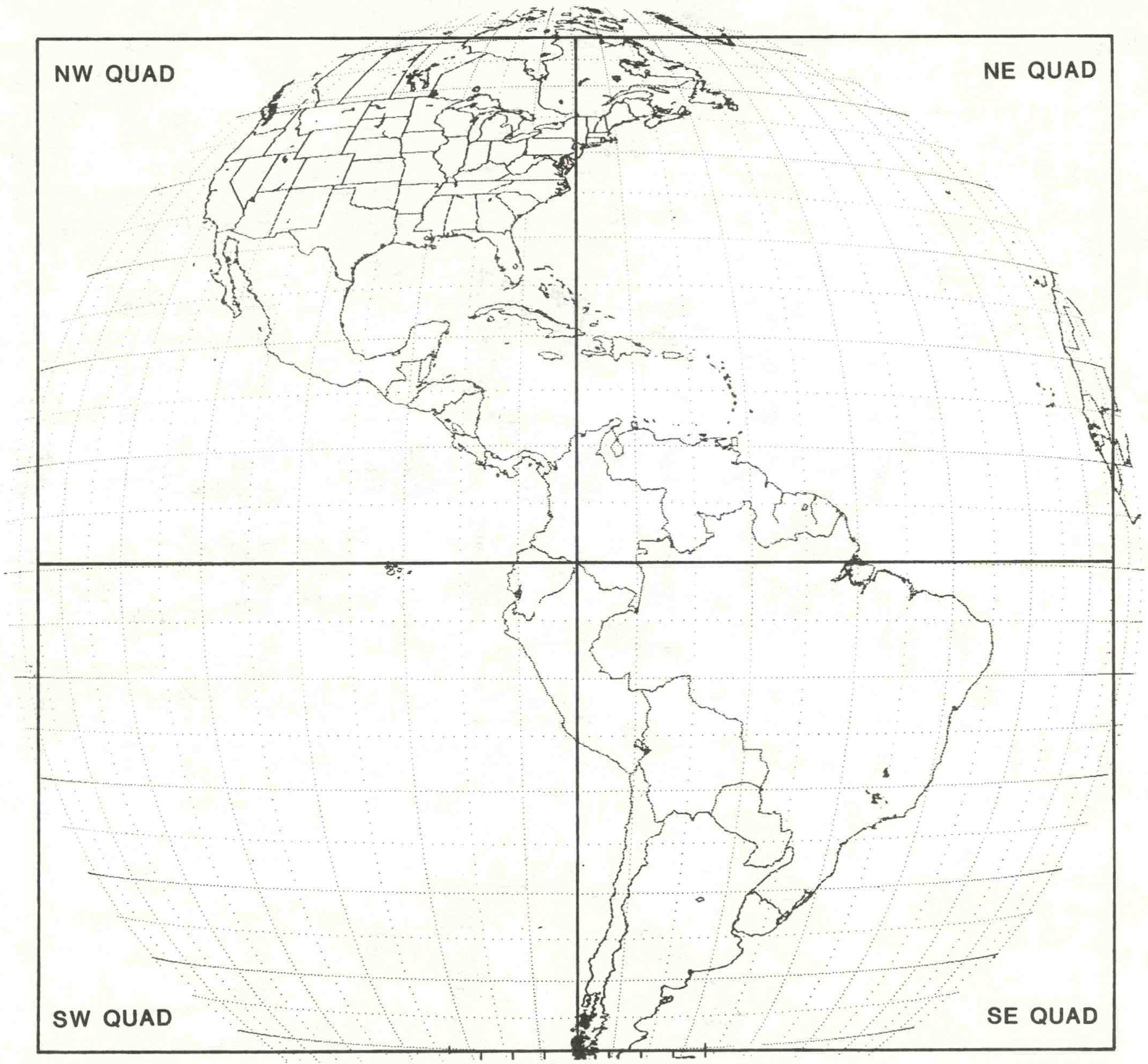


Figure 5-2.-- GOES Quadrant Pairs

Two quadrants are broadcast in each 10 minute time block. The data extends about 60° north and south and about 60° east and west of the sub-satellite point. In addition to the quadrant pairs, sectors covering tropical areas also are broadcast in pairs, as shown in figure 5-3. These are referred to as Tropical East (T/E) and Tropical West (T/W) sectors, and cover the area between 20°N and 20°S, again approximately 60° East and West of the sub-satellite point.

One of the questions frequently asked by the users is: Why are IR images gridded and the visible are not? The answer is that the grid information is contained in the 9th bit of a 16 bit word in the stretched VISSR IR data relayed from Wallops, but not in the visible data. The FET's, in addition to formatting WEFAX products for broadcast, also format facsimile products for landline transmission and make photographic negatives for imagery picture products. As a result, the limiting factor in the operation of the FETs is computer memory. This also is the reason we are presently unable to provide look-up tables or to enchance imagery for broadcast on WEFAX. This subject will be addressed in more depth by a later speaker.

From a GOES-E user's standpoint I would suspect that your biggest complaint is when WEFAX broadcasts are made at reduced power and contain the VISSR Digital Multiplex pattern (VDM) -- horizontal, evenly-spaced white lines on the imagery. I'll explain why this happens.

The National Weather Service office in Kansas City, Missouri, has the responsibility for forecasting tornadoes and severe thunderstorms. When they suspect the atmosphere is ripe for these storms to occur, that office will call NESS for a Rapid Interval Scan Operation (RISOP). During RISOP, the GOES-E VISSR is commanded to scan every 15 minutes. On the hour and 15, 30, and 45 minutes after the hour, only part of a full disc image (1200 lines) is generated. Since we broadcast the WEFAX at 20 and 50 minutes after the hour, the VDM signal from the 0015 and 0045 minute imagery will appear on the WEFAX broadcasts.

However, there are two problems when this occurs. First, to protect the VISSR (considered the primary operation) the WEFAX uplink signal is reduced from its normal 500W to 125W. This reduces the signal received from the spacecraft by 12 dB, resulting in a degraded product.

Secondly, RISOP calls for 1200 scan lines, as shown in figure 5-4. This results in a loss of coverage of the area south of 15°S.

We also have Hurricane Research Days (HRD), which may be called by our researchers to help them in their studies of tropical storm development. An HRD requires that a partial disc of 1200 lines be obtained every 15 minutes for three periods of the day beginning at 1300Z, 1600Z and 1900Z.

NESS also supports an "HRD (10)" for any storm west of 50°W. An HRD (10) requires a partial disc every 10 minutes, for three periods of the day, also beginning at 1300Z, 1600Z and 1900Z. An HRD (10) calls for 850 lines - or terminating the disc coverage at about 12°N. There also is an HRD (7-1/2) which is used only for situations when storms threaten the United States. As the name implies, a partial scan is programmed every 7-1/2 minutes in this instance.
A 7-1/2 minute scan is 600 lines, which terminates the image at about 25°N. In the past, when either the HRD (10) or (7-1/2) are required, the tropical

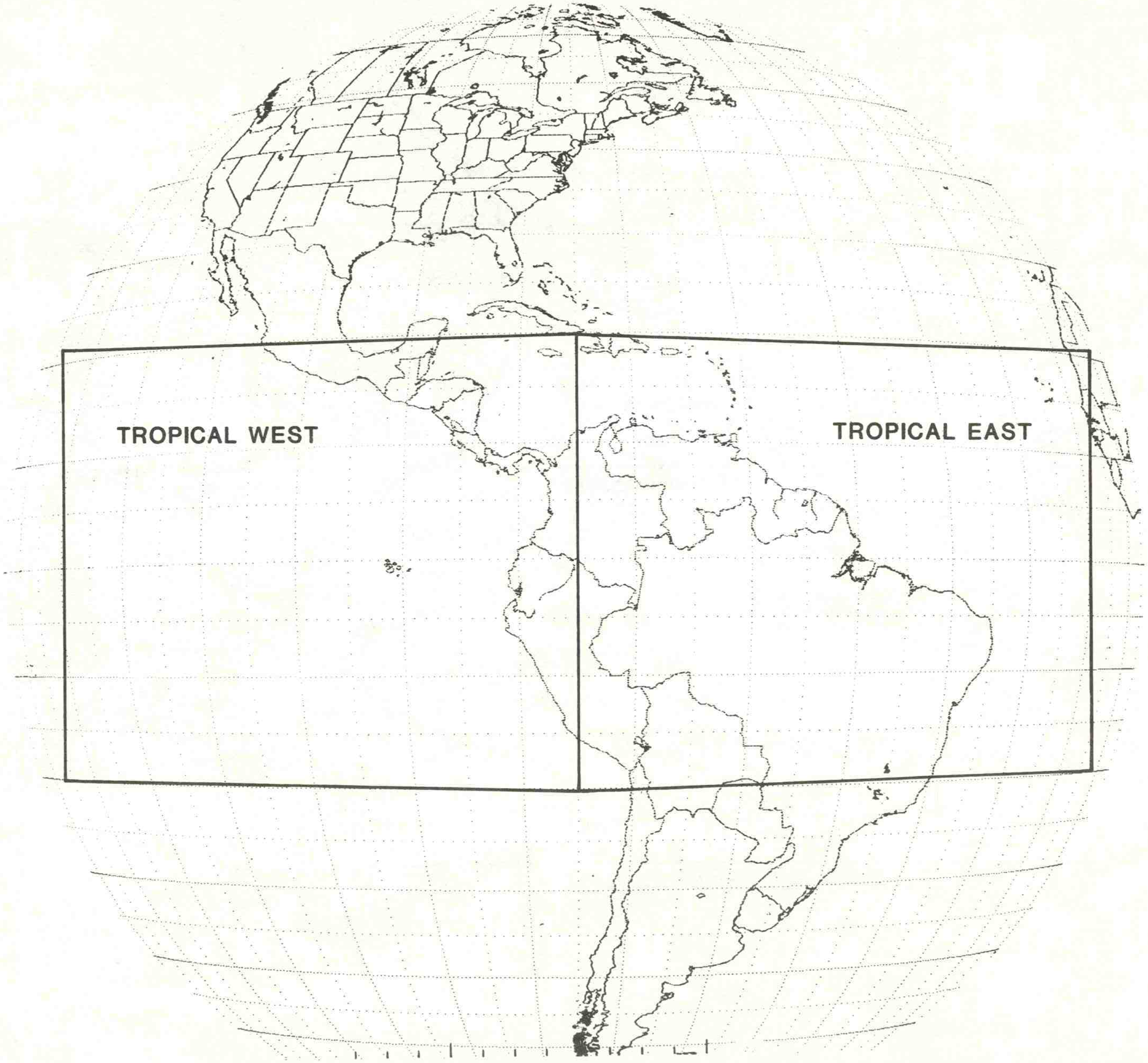


Figure 5-3.--GOES Tropical Sectors

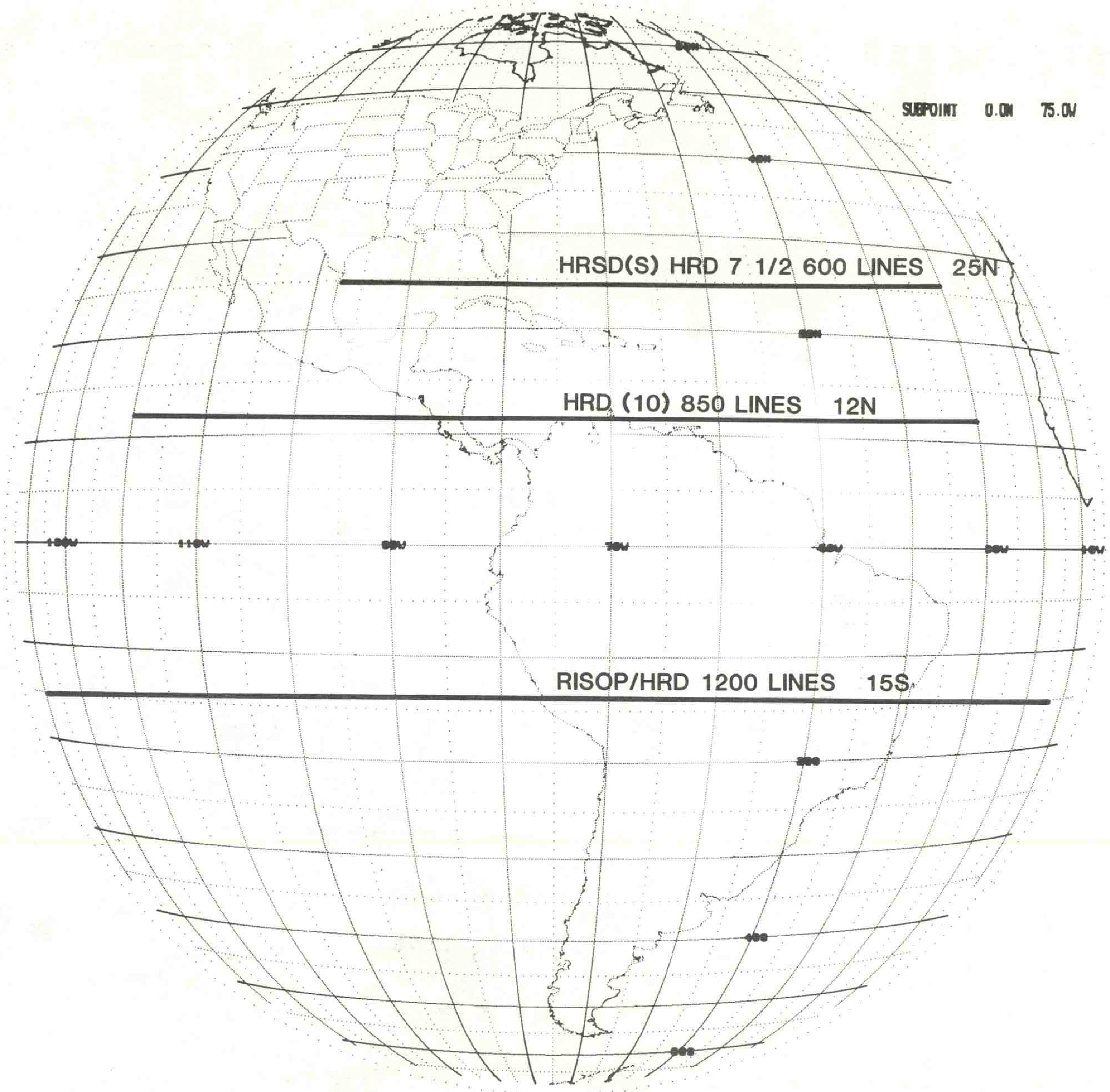


Figure 5-4.--Coverages for HRSD(S) HRD(10), and RISOP/HRD

imagery charts are lost. Now, we will still be able to acquire these data, but the broadcasts will be degraded.

Thus far, the RISOP and HRD plans have only affected WEFAX users that copy the GOES East broadcasts. However, there also is an operation that affects both the users of the GOES-West as well as GOES-East. We have what is known as Hurricane Rapid Scan Day (Stereo) HRSD(S), which is restricted to storms between 120°W and 80°W, and favors the Gulf of Mexico area. Again this calls for 7-1/2 minute imagery, or 600 lines, terminating at about 25°N. In order to use stereographic techniques for viewing the imagery, the GOES-West VISSR is commanded to function on the same time schedule as GOES-E. Therefore, when HRSD(S) is implemented, both the GOES-W and GOES-E will scan for 7 1/2 minutes at the same time. GOES-W will remain on the GOES-E schedule from 1300Z through 2000Z.

The above explanation is offered to help the user understand why the full disc imagery is cut off at various latitudes and the VDM effect.

NESS has recently adopted a program whereby we will copy the entire GOES-E full disc each 3 hours, i.e., 00Z, 03, 06, 09, etc., whenever RISOP or research days are required. This will allow a normal WEFAX ingest schedule on the GOES-E and eliminate the absence of data at various latitudes. However, you will still see the VDM effect on the broadcasts when the VISSR is operating. During 1980, there were 67 call-ups for RISOP totaling 654 hours. One other bright spot on the horizon worth mentioning: as you know, our GOES-C at 107°W does not operate the VISSR, so we don't have a VDM problem, and we can operate the WEFAX at full uplink power. We would like to make this an operational system and have all of the GOES-E schedule plus additional meteorological charts from the GOES-W broadcast. This would be a big improvement over the present system.

So much for the GOES-imagery; let's now consider the polar-orbiter data flow.

We have two CDA stations in the U.S.; one at Wallops Station, Virginia and the other at Gilmore Creek, Alaska, that copy the polar orbiter data. Stored global data are recorded at the two CDA stations and played back at a high-speed data rate via commercial satellite links to Suitland. Large, high speed Data Processing Service Subsystem (DPSS) computers are used for processing each day's satellite imagery and formatting them into the polar-stereographic and mercator mapped products which you receive as a WEFAX product. Magnetic tapes have to be physically transported from the large DPSS computer to the FET prior to broadcast time.

Four polar-stereographic quadrants (or mosaics), divided as shown in figure 5-5, are then formatted for both the Northern and Southern Hemispheres. It takes about three consecutive orbits to acquire the data necessary for the computer to construct a quadrant.

Since these products are derived from the large DPSS computers, there is sufficent memory to employ look-up tables. Therefore, the contrast in these products is superior to the GOES data generated in the smaller FETs.

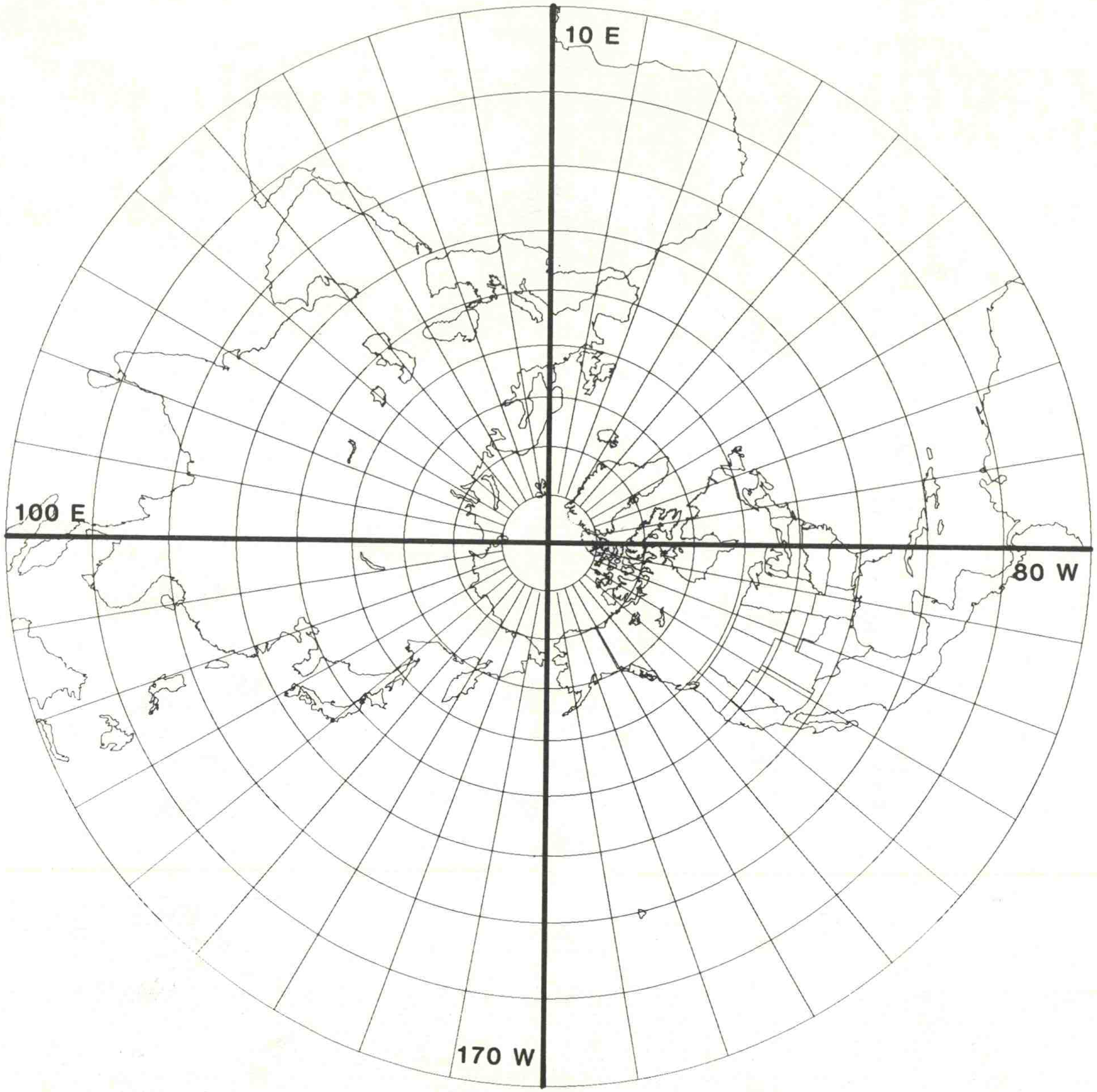


Figure 5-5.--Polar Stereographic Quadrants

National Meteorological Center (NMC) charts broadcast over GOES-C are computer generated upper-air charts. There are 14 basic 24-hour prognostic charts which are updated each 12 hours by the NOAA 360/195 computer.[1] These charts were introduced into the GOES-Central schedule as a test program and have proven quite satisfactory. Mr. James Neilon, Chief, NWS Communications Division, will have more to say about this program during his presentation.

After these charts are generated in the computer, they are stored on a disc.[2] When scheduled for transmission, they are routed through the NMC's 360/40 communications computer over to the NESS side of Federal Building 4 in Suitland, Maryland, where both NESS and this part of the NMC are located. These charts do not have to go through the FET but are manually patched through distribution, or "patch", panels direct to Wallops.

The TBUS messages for the polar orbitors are generated and distributed in the same manner as these meteorological charts.

And finally, we come to the Operational Messages. These are generated on magnetic tapes by NESS personnel and must be manually placed on the FET for formatting and transmission to each of the three spacecraft. If we know in advance of any test on the spacecraft or other anomolies in the WEFAX schedule, the operational message will contain this information. Otherwise, only the current WEFAX broadcast schedule is transmitted.

In addition to the operational message, we also have a system for alerting users to such things as storm days, equipment outages, cancellations, etc. This is in the form of WEFAX coded messages. These messages are introduced into the software through teletype keyboard by the computer operator monitoring the WEFAX broadcasts, and are appended to the legends which precede the imagery.

In summary, let me say that the dissemination process of the WEFAX is not an automated process, and certainly not simple. Of the five products broadcast through the GOES WEFAX system, three - the GOES imagery, the polar orbiter imagery, and the operations messages - involve manually tape-loading the FET, an operation which is cumbersome and prone to human errors. And, while the NMC charts and TBUS bulletins are computer generated, they must be manually patched through a distribution panel which can be easily misconfigured.

I hope this presentation has enlightened you somewhat as to how the system operates.

---

1 Now an operational program
2 Now using IBM 4341 computers

6. Description of WEFAX Services--Part II

Mr. Earl Feigel
Office of Systems Development
National Earth Satellite Service
NOAA

GOES VISSR Imagery

The majority of the products transmitted on WEFAX are derived from the VAS instruments on board the GOES-East and West spacecraft operating in the VISSR imaging mode. The VISSR provides the satellite imaging capability in both the visible and IR spectra. The satellite is spin stabilized and rotates at approximately 100 RPM. The spinning motion provides line scan in the west-to-east direction while north-to-south step tracing is accomplished within the VISSR instrument. A full-disc view of the Earth requires approximately 1820 steps or scan lines. With the spacecraft spinning at 100 RPM, frame time is therefore about 18.2 minutes. Retrace time of the VISSR from line 1820 (southerly position) back to line 1 (northerly position) takes about 1.7 minutes, for a total of approximately 20 minutes.

The raw VISSR data are transmitted to the Command and Data Acquisition (CDA) station at Wallops Station, Virginia. The data are received on one of two receiving systems utilizing 60-foot diameter paraboloidal antennas. Prior to retransmission of the data back to the satellite the data are processed at the CDA for increased usefulness and retransmitted in the form of gridded and time-stretched VISSR. A synchronizer/data buffer (S/DB) performs the key actions by separating the digital bit stream into visible, IR, and format identification channels. Gridding data are merged with the IR data. The S/DB then reassembles the visible, IR gridding, and identification data for transmission to the satellite at a lower, or stretched, bit rate.

The uplink signal from Wallops is a Phase Shift Key (PSK) modulated signal at 2029.1 MHz (figure 6-1). The nominal transmitter output power is 500 watts (+57 dBm). A 60-foot transmitting antenna (gain 46.8 dB) is used, allowing approximately 1.1 dB transmission line-loss. This combination of power and gain results in an uplink Effective Isotropic Radiated Power (EIRP) of + 102.4 dBm. The uplink signal is received by the satellite with a receiving system gain-to-noise temperature ratio (G/T) of -25.6 db. The stretched VISSR signal is amplified and translated to 1687.1 MHz and retransmitted at a signal level, or EIRP, of 54.4 dBm (specified value). This retransmitted signal is linearly polarized. (The RF communication link budget between Wallops and the spacecraft is summarized in table 6-1). As seen in figure 6-2, the stretched VISSR signal is received at Suitland, Maryland, on one of two systems, each composed of a 24-foot diameter antenna, a preamplifier (gain 48 dB, noise figure (NF) 2 dB), a PSK demodulator, the Digital Interface Electronics (DIE), consisting of bit and frame synchronizer, and finally the GOES Data Ingestor, or ingest computers, where the data are recorded on tape.

WEFAX signal routing at Suitland is shown in figure 6-3. Ingest tapes from both GOES-East and West are manually loaded onto a Facsimile Encoder Transmitter, or FET. The FET performs a digital-to-analog conversion, filters

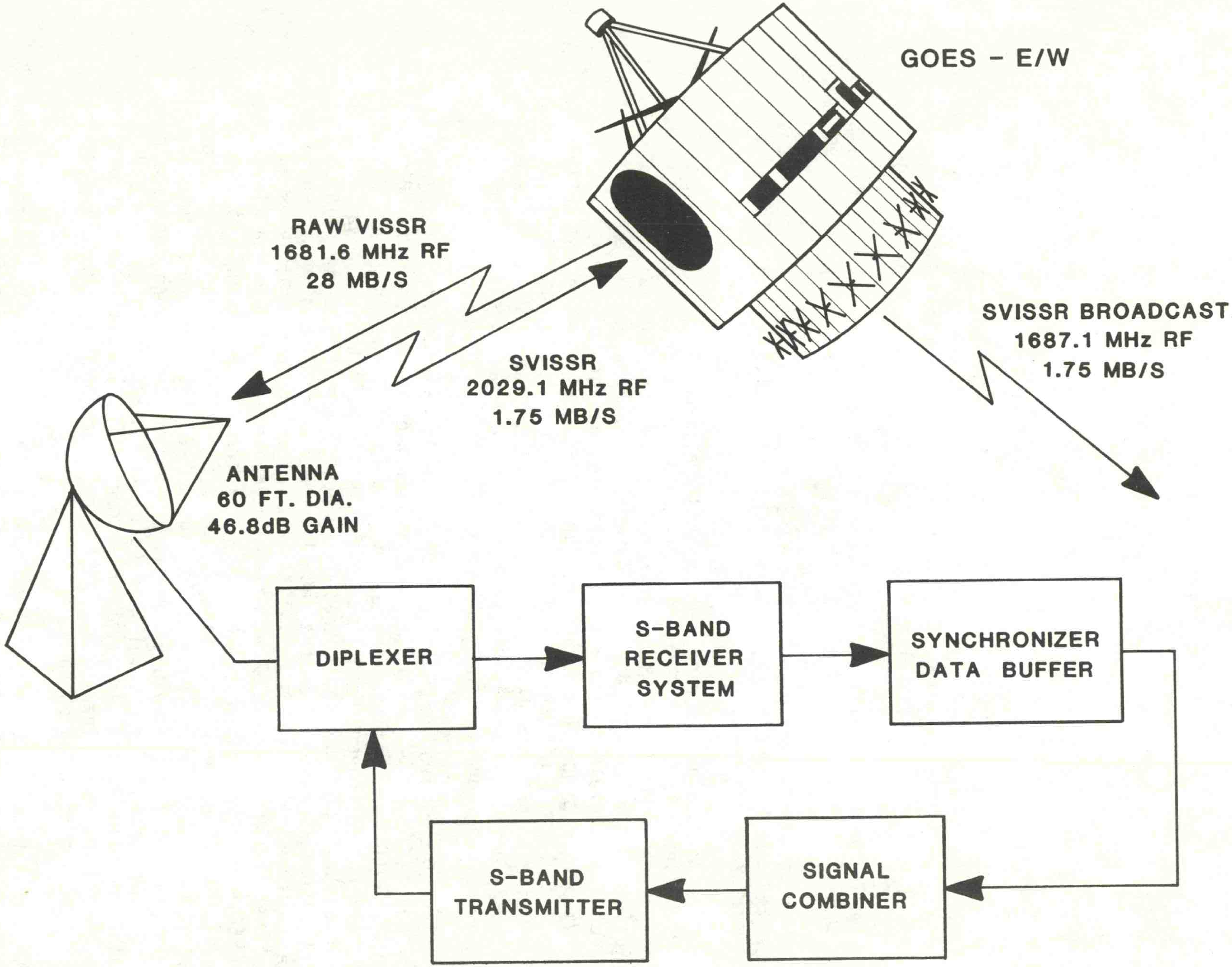


Figure 6-1.--GOES SVISSR
Broadcast System

RF COMMUNICATIONS LINK BUDGET

WALLOPS CDA TO SPACECRAFT

CDA TRANSMITTER POWER	+57 dBm
LINE LOSS	- 1.1 dB
TRANSMIT ANTENNA GAIN	+46.8 dB
EIRP	+102.7 dBm
FREE SPACE LOSS	-190.5 dB
POLARIZATION LOSS	-0.2 dB
SPACECRAFT (S/C) RECEIVER G/T	-25.6 dB
RECEIVED C/No = EIRP - LOSSES + G/T-K	+85 dB
S/C TRANSMITTER OUTPUT C/No	+85 dB

Table 6-1--RF Communication Link Budget Wallops CDA to Spacecraft

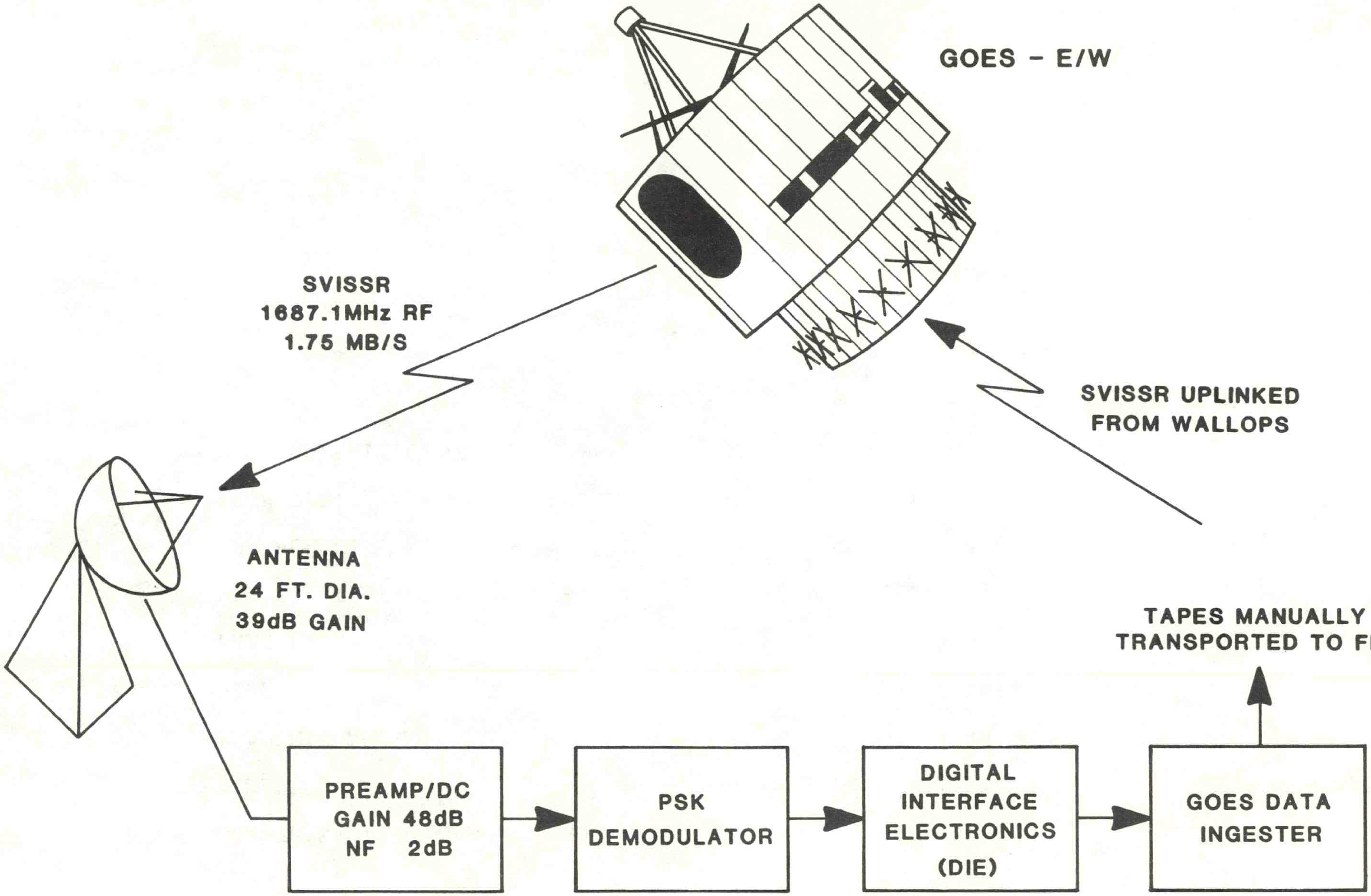


Figure 6-2.--Reception of GOES Data at Suitland

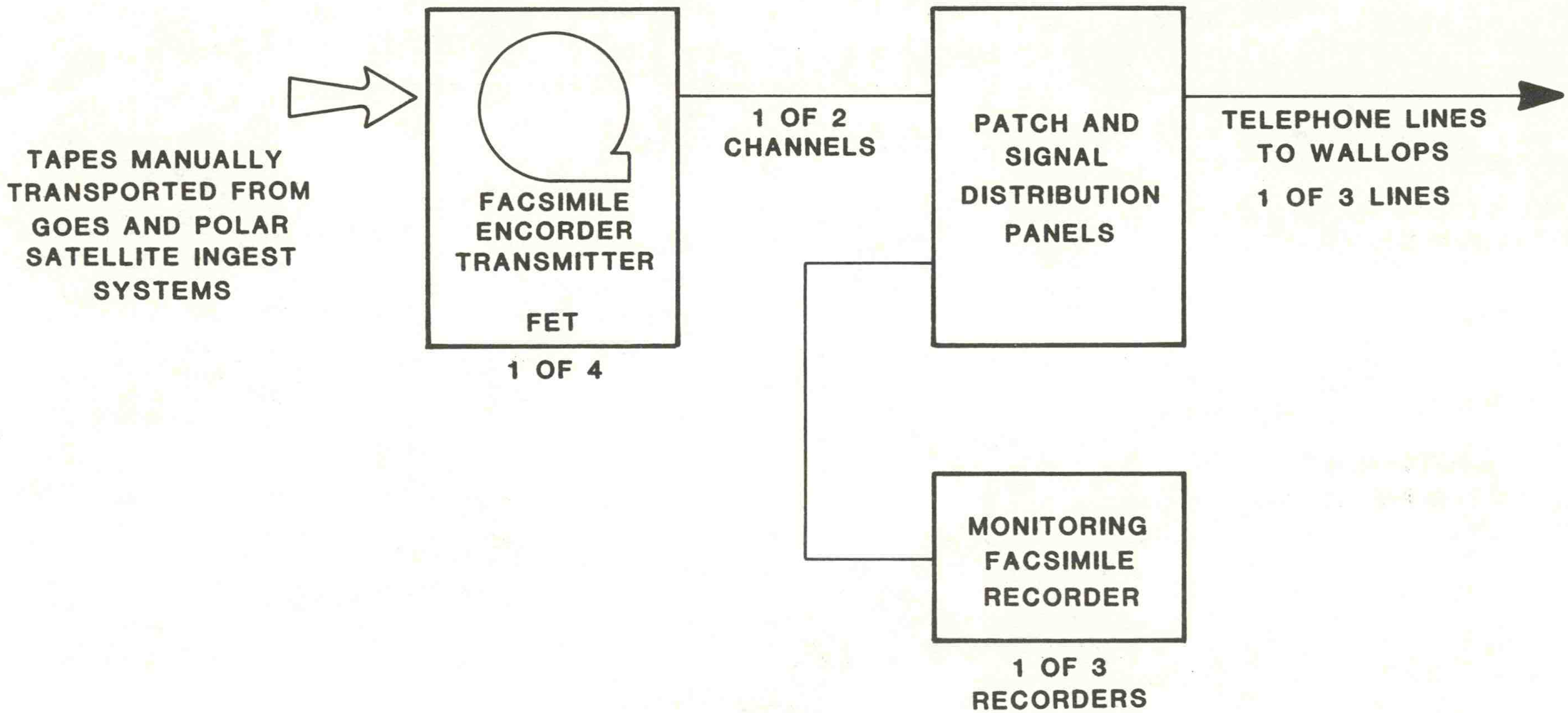


Figure 6-3.--The WEFAX Signal Routing at Suitland

the video signal, and amplitude modulates a 2400 Hz subcarrier. The subcarrier is further filtered by a vestigial filter, thus creating the vestigial side band modulated subcarrier.

The WEFAX image format is such that a complete single image transmission consists of four parts: the starting tone, the phasing signal, the data portion, and the stopping tone. The complete transmission consists of 920 lines each of 250 milliseconds duration. The starting tone is 5 seconds or 20 lines in duration and consists of the 2400-Hz subcarrier being modulated by a 300-Hz square wave. The phasing signal is 20 seconds or 80 lines in duration. The modulation of the subcarrier during this portion of the transmission is such that the first 12.5 milliseconds of each line is fully modulated. This is minimum subcarrier level (equivalent to black level). The remainder of each line, 237.5 milliseconds, the subcarrier is unmodulated, and the 2400-Hz level is maximum or white. During the data portion of the transmission, 200 seconds or 800 lines in duration, the first 12.5 milliseconds of each line is modulated by a rectangular signal such that it is two-thirds black and one-third white. The remainder of each line is modulated by the analog data signal. The stopping signal is 5 seconds or 20 lines in duration and consists of the 2400-Hz subcarrier being modulated by a 450-Hz square wave signal. There will be a 30-second pause between the end of one image transmission and the start of the next transmission. Figure 6-4 depicts the image format (not to scale) as it will appear at the receiver/recorder. Figure 6-5 depicts the modualated 2400-Hz subcarrier during the four parts of the transmission. Modulation characteristics are summarized in table 6-2.

The FET also transforms the GOES low-resolution, 8-km, full-disc imagery into the formats in which the users receive it. There are a total of four FETs, each with a dual tape transport capability. Therefore two images may be transmitted simultaneously, each by a separate tape or channel. Further, each of the two channels has two separate outputs. All the output signals from the FETs are routed to a small patch panel. By configuring the patch panel, the subcarrier can be routed to a number of monitoring facsimile recorders or to other land-line facsimile circuits.

As seen in figure 6-6, the first device encountered by the signal at Wallops is the auto-level-set amplifier, commonly referred to as the AGC (Auto Gain Control) amplifier. This amplifier, upon detecting the WEFAX signal start-tone, automatically adjusts the amplifier gain so as to ensure the proper deviation of radio frequency (RF) during the frequency modulation (FM) process. The RF signal, approximately 70 Mhz, is generated in the WEFAX modulator where the modulation takes place.

Following the FM process, the signal is passed to the signal combiner where the WEFAX signal is combined with any other signals which are to be uplinked simultaneously. The combined signal is then routed to the S-Band transmitter where it is translated in frequency to S-Band (2032 MHz) and amplified by a power amplifier. Normally if the WEFAX is to be broadcast by either GOES-East or West, the uplink to the spacecraft will be via a 60-foot antenna (gain 47 dB) at 500 watts (57 dBm) transmitter power. When the WEFAX is broadcast by GOES-Central, the uplink will be transmitted by a 24-foot antenna (gain 39 dB) with the transmitter power at 1000 watts (60 dBm). However, no adjustments to ground receiver are required by users.

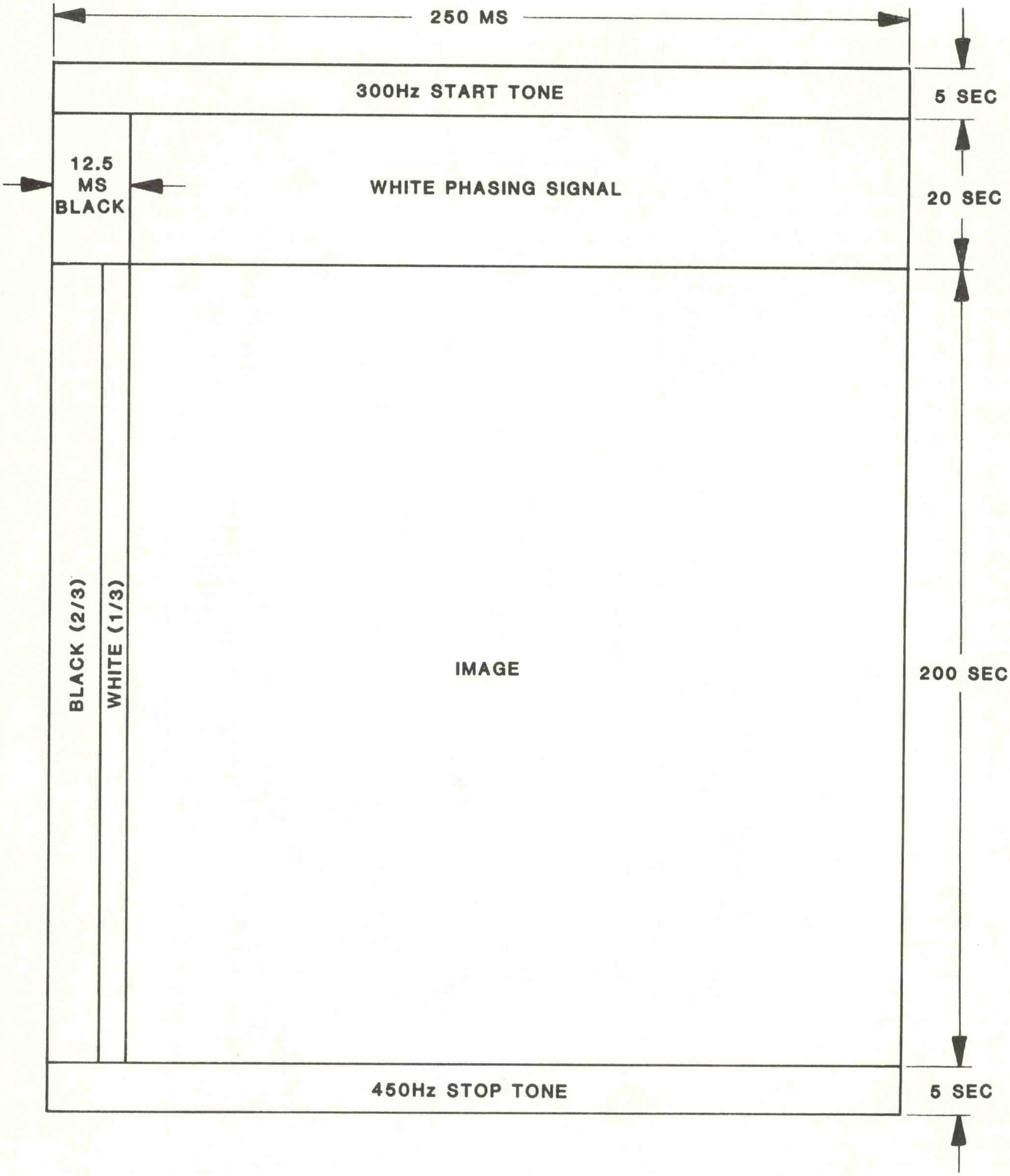
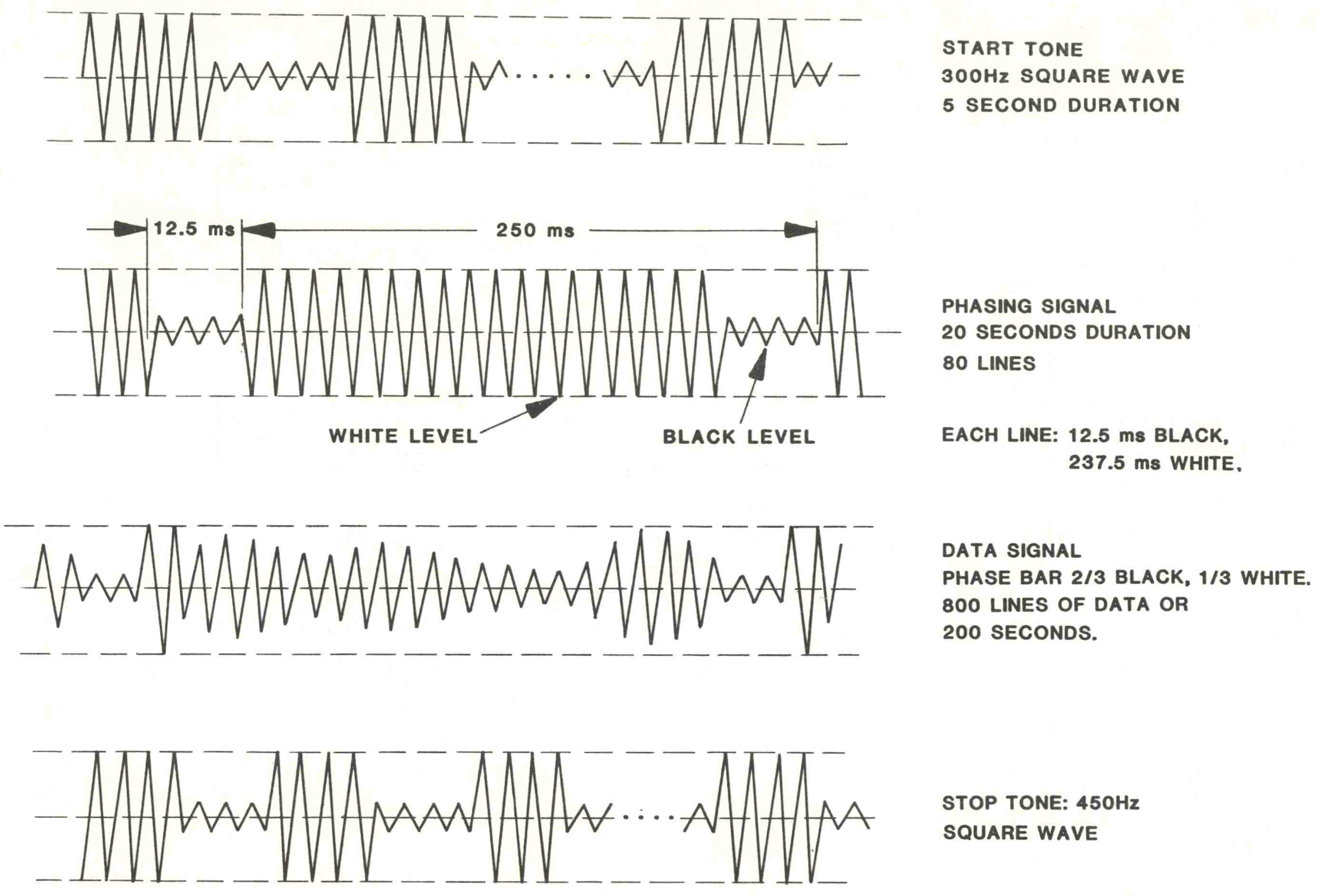


Figure 6-4.--WEFAX Image Format



$$20 \text{ LOG } \frac{\text{VMAX}}{\text{VMIN}} = 17\text{Db}$$

Figure 6-5.--Modulated 2400 Hz Subcarrier

MODULATION CHARACTERISTICS

TYPE OF MODULATION	-	AM VESTIGIAL SIDEBAND/FM
PEAK FREQUENCY DEVIATION	-	9 KHz
SUBCARRIER FREQUENCY	-	2400 Hz
SUBCARRIER MODULATION	-	AM VESTIGIAL SIDEBAND 86% DOWNWARD OR NEGATIVE
BASEBAND FREQUENCY	-	0 TO 1600 Hz
RF BANDWIDTH (BY CARSONS RULE)	-	22.8 KHz

Table 6-2--Modulation Characteristics

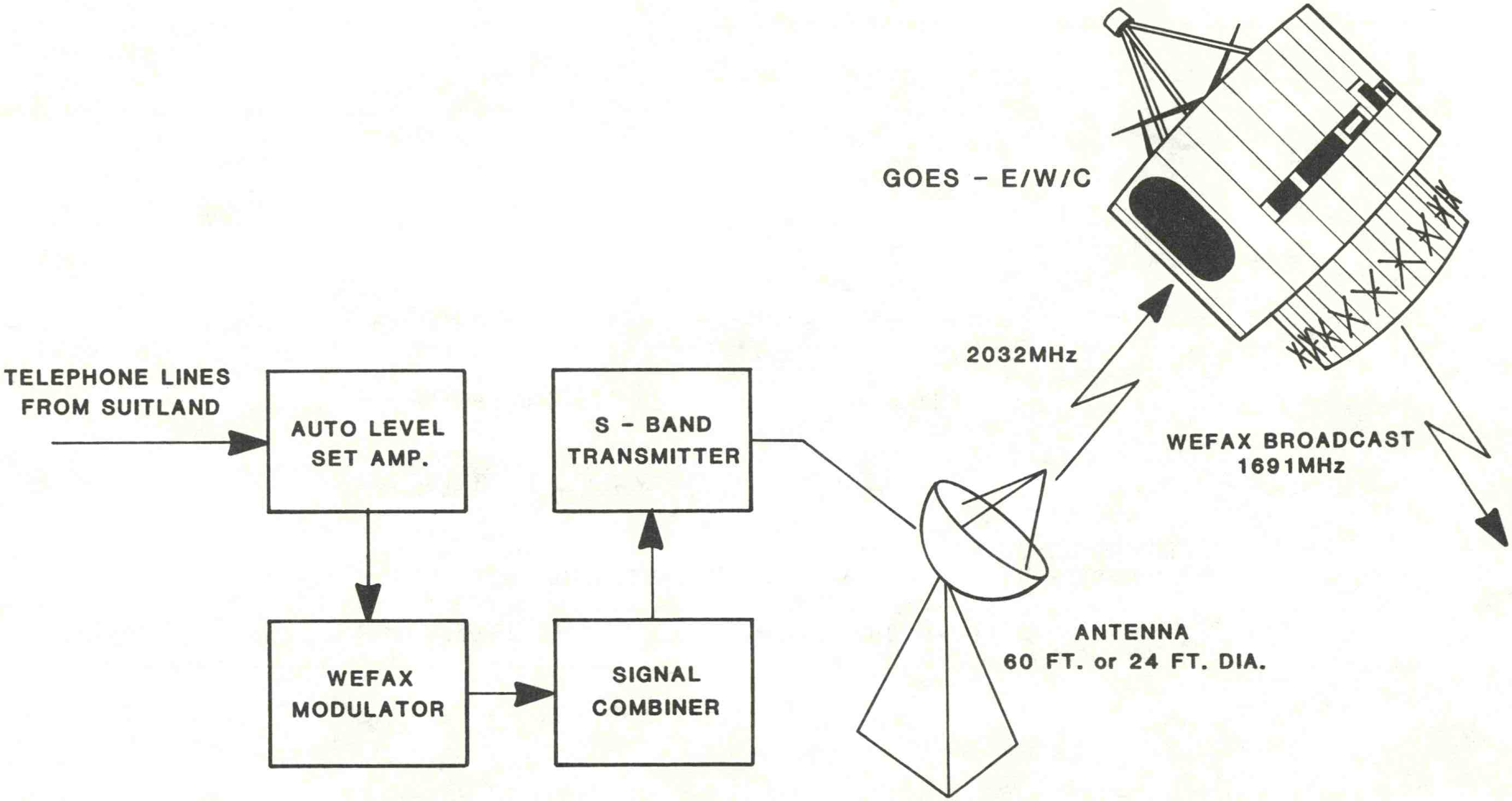


Figure 6-6.--WEFAX Signal Routing at Wallops CDA

The signal is received by the spacecraft with a receiver gain-to-temperature ratio (G/T) of -25dB. This signal, like the stretched VISSR signal, is first translated to a downlink frequency of 1691 MHz and then is amplified and broadcast with a radiated signal strength, or EIRP, of 54.4 dBm. The RF Communications link budget from the spacecraft to a WEFAX terminal is summarized in table 6-3.

Figure 6-7 depicts one of the three WEFAX monitoring systems operated by NESS at Suitland. There is one system for each of the three spacecraft broadcasting WEFAX. A WEFAX signal uplinked from Wallops is broadcast by one of three GOES satellites at 1691 MHz. At Suitland a WEFAX signal is received on a system using a 6-foot-diameter antenna and a 2.5-dB noise figure (NF) preamplifier and down converter combination. The down converter converts the received S-Band signal to 136 MHz to reduce the loss due to the long cable run from the antenna to the receiver. The receiver contains the FM demodulator and recovers the amplitude modulated (AM) subcarrier. This subcarrier is the input signal to the facsimile recorders. The recorders perform the AM demodulation function and recover the start signal, the phasing signal, the line synchronizing signal, the video data, and the stop signal.

In addition, the FM receiver contains both an amplitude modulation meter and a frequency deviation meter. These meters are for monitoring purposes and normally would not be included on a typical user's receiver set.

The three WEFAX monitoring systems were purchased and installed in Federal Building Number 4 (FB-4), Suitland, Maryland, in late 1980. Previously the WEFAX downlink signals were acquired on the 24-foot antennas normally used to acquire the stretched VISSR data from Wallops via the spacecraft. Since the receipt of the WEFAX broadcasts on these large antennas was considered to be nonrepresentative of broadcasts received by most users, the antennas were acquired for representative real-time monitoring of the WEFAX system.

FET Limitations

The Facsimile Encoder Transmitter, or FET, is a mini-computer, referred to as the TEMPO II, and has two tape drives. There are four FETs which, in addition to formatting WEFAX products for broadcast, also format landline facsimile products (at 120 lines per minute) and support Digital Muirhead Device (DMD) photographic production. The FETs have a computer core, or memory, of only 28,000 bits, and a limiting factor in their operational capability is a lack of computer memory. This is the reason why NESS has been unable to provide look-up tables for enhanced images on WEFAX.

One of the questions that has been frequently asked by the WEFAX users is: Why are the IR images gridded while the visibles are not? The answer is that the grid bit is only contained in the IR channel of the stretched-VISSR data relayed from the CDA at Wallops.

Polar Orbiter Imagery

NOAA has two CDA stations in the United States that copy the TIROS-N Series polar orbiter data (figure 6-8). One is at Wallops Station, Virginia, and the other is at Gilmore Creek, Alaska. Stored global data are transmitted from the satellites and are acquired on 85-foot tracking antennas. The data are recorded

RF COMMUNICATIONS LINK BUDGET

SPACECRAFT TO WEFAX TERMINAL

SPACECRAFT EIRP	+54.4	dBm
FREE SPACE LOSS	-189.3	dB
POLARIZATION LOSS	- 0.2	dB
RECEIVING ANTENNA GAIN (6 Ft.)	+27	dB
RECEIVING LINE LOSS	- 1.0	dB
RECEIVER INPUT POWER LEVEL	-109.1	dB
RECEIVER SYSTEM NOISE TEMPERATURE (3dB AMP + 100^{o}K ANT. = 400^{o}K)	26	dB
RECEIVER INPUT NOISE POWER DENSITY (No)	-172.6	dB-Hz
RECEIVER INPUT C/No	63.5	dB-Hz
OVERALL C/No	63.47	dB-Hz
REQUIRED C/No for C/N = 10dB IN 30 KHz BANDWIDTH	55	dB
MARGIN	8.47	dB

Table 6-3--RF Communication Link Budget Spacecraft to WEFAX Terminal

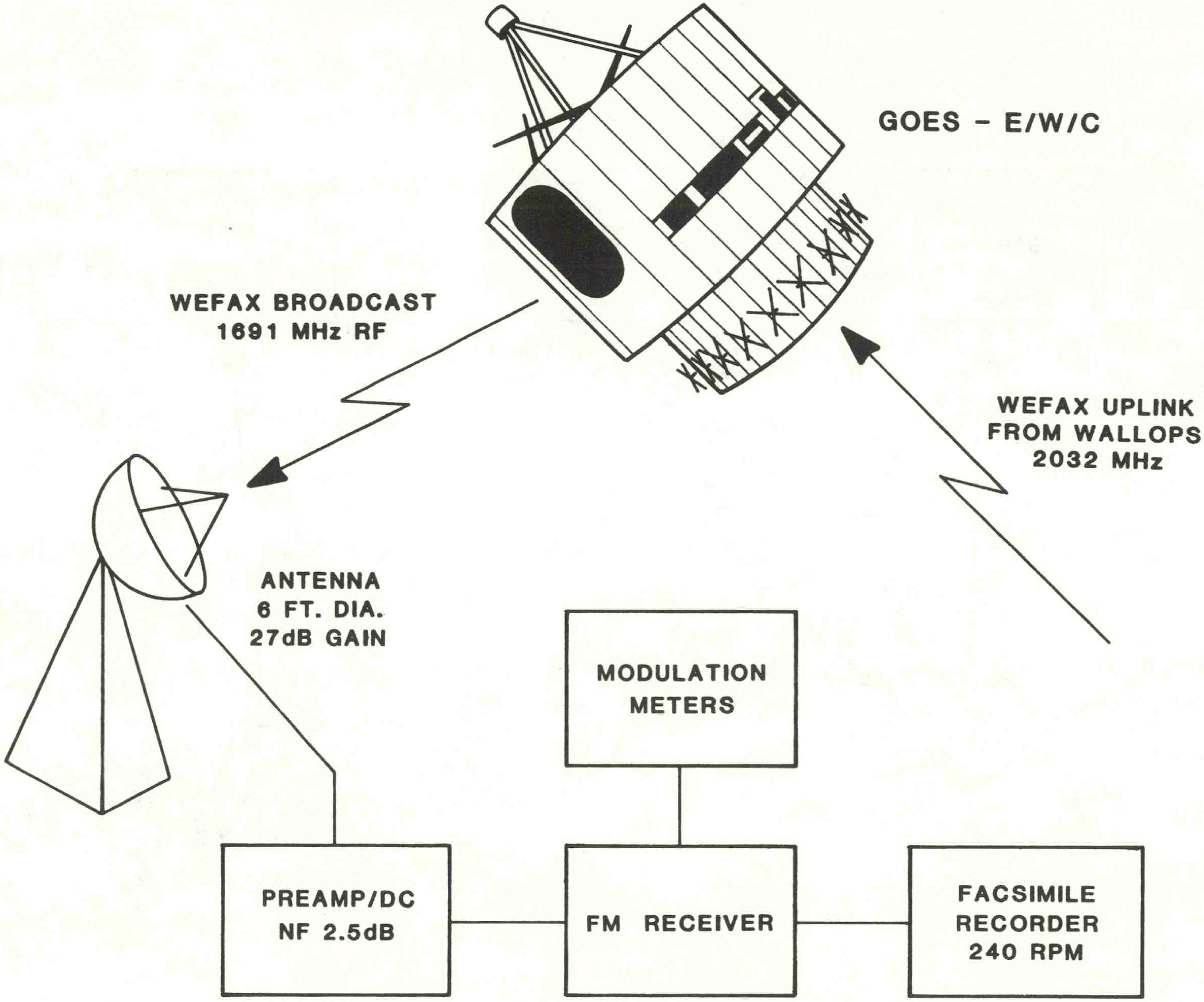


Figure 6-7.--WEFAX Broadcast Monitor System

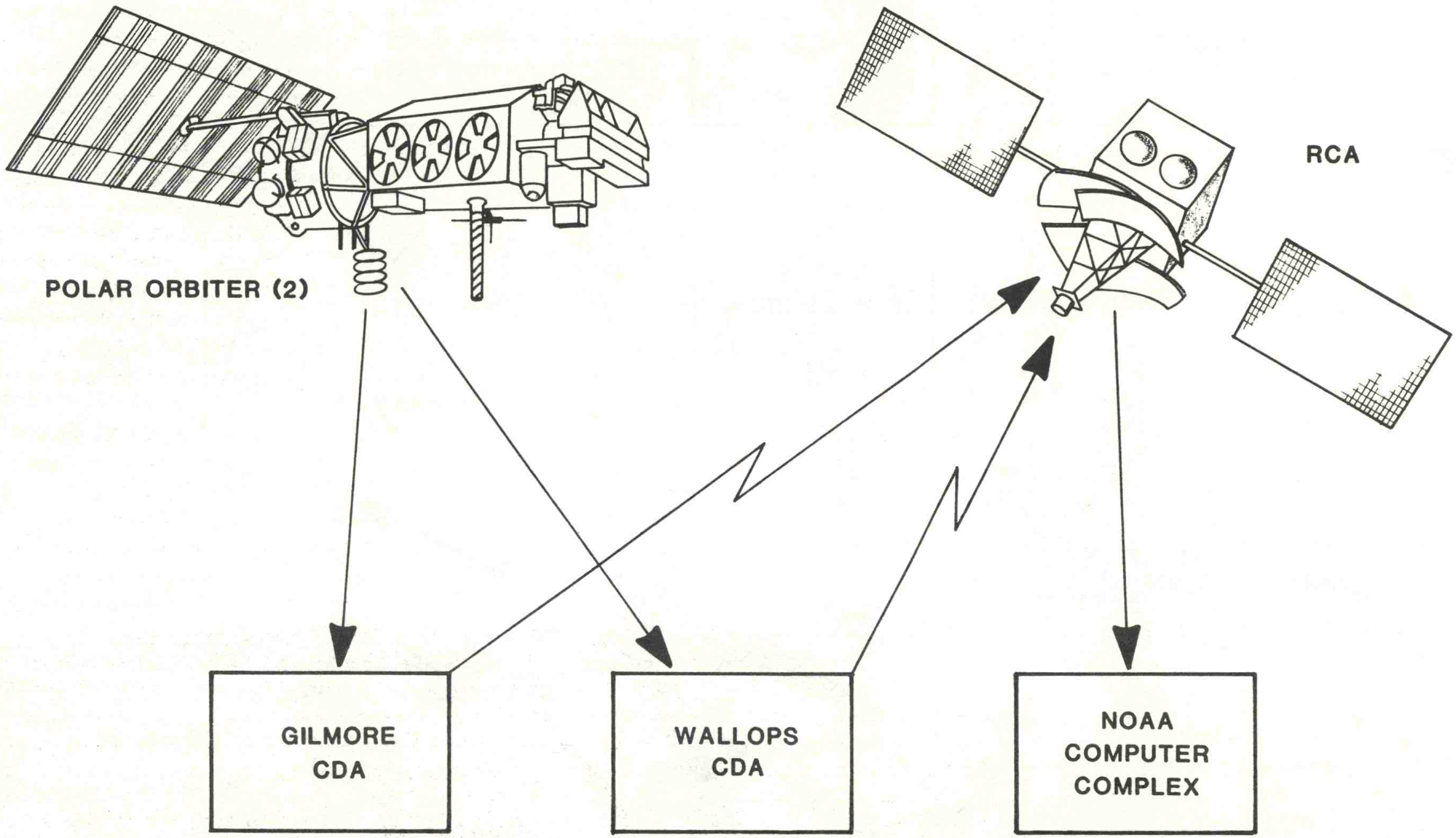


Figure 6-8.--NOAA Polar Orbiter Data Flow

at the two CDA stations, then played back at a high data rate, via commercial geostationary satellite links. The data are received at the NOAA Computer Facility at Suitland, Maryland, on a commercial receiving system utilizing a 30-foot antenna (figure 6-9). After reception at Suitland, the data are passed to the Data Acquisition and Control System (DACS) where they are reconstructed and decomutated. From the DACS the data are passed to the Data Processing Services Subsystem (DPSS). Here, the imagery is formatted into polar-stereographic and mercator mapped products. Four polar-stereographic quadrants, divided at 10°E, 80°W, 170°W, and 100°E longitudes, are formatted for both the Northern and Southern Hemispheres (see figure 5-5, page 38). It takes about three consecutive orbits to acquire the data necessary for the computer to construct a quadrant mosaic. The processed imagery is written to digital tape. This tape is then manually transported and placed on a FET where the selected data are transmitted over the GOES WEFAX system at the scheduled times. Since these products are derived from the large DPSS computer, there is sufficient memory to employ look-up tables for the various gray shades. Therefore, the contrast for these products is superior to the GOES data generated for transmission in the smaller FETs.

Like the NMC charts, the TBUS bulletins are generated on the NOAA 360/195 computer and do not go through the FETs; they are manually patched through NESS distribution panels directly to Wallops.

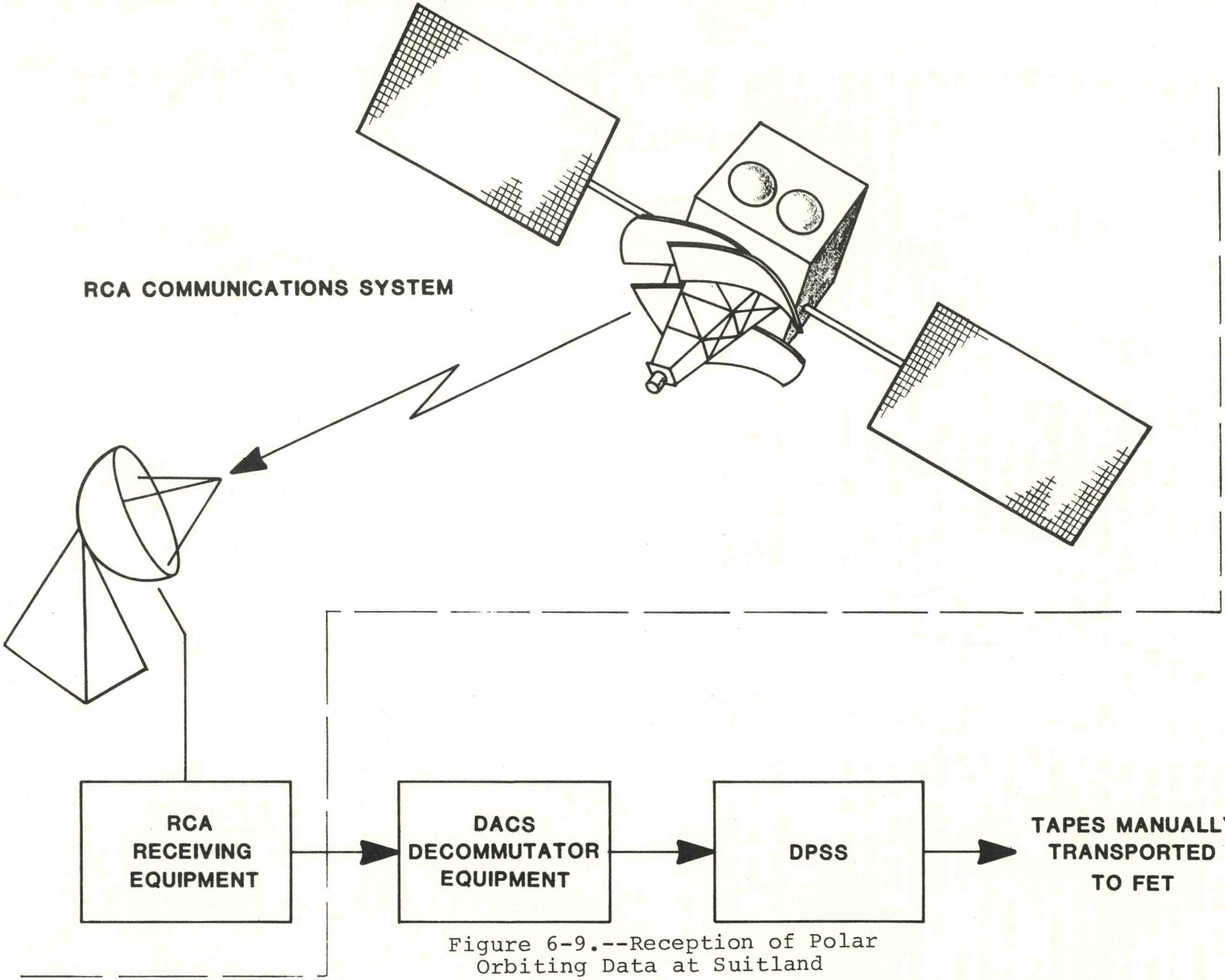


Figure 6-9.--Reception of Polar Orbiting Data at Suitland

7. Future WEFAX Plans

Mr. Douglas MacCallum
Chief, Data Collection and
Direct Broadcast Branch
National Earth Satellite Service
NOAA

Now that you have heard about the history and the current WEFAX service, it is time to talk about the future. In this presentation, I will review agreed-to changes that will occur in the immediate future, and available options for the more distant future. This latter area has been further subdivided into three categories based primarily on time and the currently planned spacecraft that will be available during these time periods. Naturally, budgetary considerations are paramount in exercising these options, but there also must be a genuine user community need before any serious consideration will be given to these options.

Assuming that the launch of GOES-E (GOES-5 after a successful launch) and subsequent checkout of the spacecraft are satisfactory, the probable spacecraft array for the summer of 1981 will be as depicted in Figure 7-1. Note that both the GOES-East and GOES-West WEFAX S-band signals have vertical linear polarization, while the GOES-Central S-band signal has horizontal linear polarization. This means that, whenever a change is made by the ground receiving station from either GOES-East or GOES-West to GOES-Central, an adjustment must be made to the ground receiver to accommodate the polarization.

Another anticipated change during the next few months will be in the VISSR IR data. Currently, the DMD/FET generates only a linear relationship between the voltage and temperature scale. This results in the loss of much data in the temperature range of particular interest to oceanographers and meteorologists. Therefore, NESS intends to replace the current linear relationship with a non-linear relationship that will expand the temperature ranges of interest. Prior to the implementation, NESS will notify the user community of the implementation date and the details of the nonlinear relationship.

The major effort in NESS during the past few months has been to improve the reliability of the WEFAX service. The recently installed small antenna system and modulation monitors in FB-4 have already improved our real-time monitoring capability. As you will note when you tour FB-4 tomorrow, the location of the monitor recorders is not convenient for the Digital Muirhead Device/Facsimile Encoder Transmitter (DMD/FET) operators for monitoring. With the pending removal of the low-volume telemetry computer, considerable realignment of the DMD/FET area will be possible. One of the first changes will be to relocate these monitor recorders so that the DMD/FET operator may conveniently monitor each transmission. In addition, periodic monitoring is performed at both Wallops and the World Weather Building, but not on a real-time basis.

PROBABLE

SPACECRAFT ARRAY SUMMER 1981

GOES-EAST 75°W	GOES-CENTRAL 107°W	GOES-WEST 135°W
GOES-5	GOES-2	GOES-4
WEFAX - VERTICAL LINEAR POLARIZATION	WEFAX - HORIZONTAL LINEAR POLARIZATION	WEFAX - VERTICAL LINEAR POLARIZATION

Figure 7-1.--Probable Spacecraft Array Summer 1981

Other areas that are being addressed include the use of dedicated DMD/FET's for each spacecraft's WEFAX operation. This will reduce the amount of line patches required to reconfigure the DMD/FET's between WEFAX and landline facsimile operations. Also, simplified patch panel procedures are being developed. However, before most of these procedural changes can be implemented, extensive tests must be conducted and, perhaps, adjustment in transmission schedules must be made to reduce computer operations during high density transmission periods.

Redundancy is always a key element in providing reliability to an operational system. There is a requirement for redundant DMD/FET's in FB-4 and antenna systems at Wallops. The Wallops problem develops as a result of a certain combination of events, and affects the GOES-Central operation. This problem becomes more critical during VAS operations and checkout of new spacecraft. These areas are under investigation and we hope to have plans made in the next few months to solve them.

Current expansion plans call for the addition of selected National Meteorological Center (NMC) meteorological charts to the GOES-West schedule. Since there are few open WEFAX periods available, these NMC charts will be broadcast in the simultaneous VISSR/WEFAX mode. Additional expansion will take place on the GOES-Central by including the remainder of the GOES-East imagery schedule and the NWS Caribbean Radio Facsimile Schedule. Also, there may be additional polar-orbiter mapped mosaics added to the GOES-East schedule. These mosaics will be broadcast in the simultaneous VISSR/WEFAX mode due to the lack of open WEFAX periods.

A need for special VISSR IR imagery has been expressed by some of the user community. Due to the lack of computer capacity, any special IR enhancements must await the hardware expansion in the DMD/FET's and, to a lesser degree, a corresponding increase in the number of WEFAX broadcasts. The same constraint is true for the broadcast of higher resolution data.

The more distant future offers additional possibilities, such as increasing the number of broadcasts during the open WEFAX periods by multiplexing two data streams. This change would require some hardware expansion in the NESS ground system and a demultiplexer for those users desiring to use the second data stream. With the distinct possibility that the user community will desire additional VAS channel imagery, such as the water vapor channel, additional WEFAX broadcasts will be a requirement in the future.

Another change that appears to be desirable is the elimination of the VISSR Digital Multiplexer (VDM) pattern. With the present series of satellites, this will have to be eliminated by changes in the NESS ground system and, perhaps, to some of the users' ground receiving equipment. However, by modifying the spacecraft hardware, i.e., providing a separate transponder for the WEFAX, this VDM problem can be eliminated at the source. NESS will examine these options and attempt to incorporate the most cost-effective method.

The more distant future (1986 and beyond) opens more degrees of freedom due to the improvements in technology and the experience that we have gained over a decade of WEFAX operation. The new satellites that are planned for the future are still in the developing stages and many changes are possible. GOES-G, -H, and -I will have some changes, but what will they be? There are possible changes in sensors, communication paths, etc. This series of satellites is planned to operate into the late 1980's. What will the "GOES-Next", or GOES in the 1990's be? Will it be a new block, or just a slightly modified continuation of the GOES-G, -H, and -I? Certainly there are possibilities of including digital WEFAX and a higher data rate WEFAX. These may be the next advancements in satellite data dissemination. On the other hand, what will happen to the user community with equipment that has been designed for the present system? It appears that these spacecraft of the future will have to operate in both modes, i.e., the current analog, 240-line-per-minute mode and the new higher data rate/digital WEFAX mode. In essence, NESS will operate two separate systems.

In conclusion, there are many options available to NESS, but budgetary limitations will be the major factor governing changes. There is even a possibility that future changes in the WEFAX service will depend upon funds provided by the user community. In other words, NESS may be charging the users to make changes in the system necessary to meet the users' requirements.

8. National Weather Service Products and Plans

Mr. James Neilon
Chief, Communications Division
National Weather Service
NOAA

The U.S. National Weather Service (NWS) is a user of WEFAX. It also is a user representative and it also functions as a producer of information which is transmitted via WEFAX. So we cover a very broad spectrum of activities. The NWS has been involved for a long time in the WEFAX service. Originally, when the WEFAX service began, some of our Weather Service Forecast Offices were supplied and equipped with receivers for the reception of WEFAX so that these offices could receive the imagery that was transmitted by that service. As it turned out, landline communications were fairly inexpensive at that time, and within a short period of time, landlines replaced the WEFAX service in our offices. Today, we have very few offices in the NWS equipped to directly receive WEFAX. I am saying WEFAX explicitly; we certainly do make use of the satellite information which is derived from both the geostationary and polar orbiting satellites.

There were meteorological charts broadcast from some of the earlier geostationary satellites -- the ATS series. The meteorological charts were intermixed in the schedules with the imagery. But the major interest of that time was clearly in the imagery, because we had conventional communication systems which could satisfy our requirements for the more conventional meteorological charts, contours, and things of that nature.

It was about 4 years ago now that there was a renaissance of interest in WEFAX for conventional meteorological charts, brought about by a number of reasons. Initially, we were confronted with the fact that the WEFAX schedule at that time was essentially filled with imagery. Later, there was some experimentation done with simultaneous WEFAX and VISSR transmissions in order to expand the schedule. You have seen some of the results of that. Earl Feigel showed some results with the VDM effect. At the time, we used to call it "the venetian blind effect" - it looks like there is a venetian blind across it, with the white lines. It was felt that meteorological charts would suffer less from that particular pattern than cloud imagery would. In fact, there were some experiments run at the time that showed no significant degradation, again depending on the quality of the receiver that was used.

One of the first public experiments for simultaneous WEFAX/VISSR broadcasts took place at the time of the WMO Regional Association IV meeting in 1977 in Mexico City. The simultaneous transmissions that took place were quite impressive. We were very optimistic at that time concerning what we could do with the service. A little later, on close examination, we found out that things weren't quite as rosy as we thought they were, and the interest waned for a while (for several months or a couple of years, as a matter of fact). It was not until the possibility of using a separate satellite that was not involved with the VISSR operation that the interest was really revived. The proposal from NESS to use what has come to be known as GOES-Central for WEFAX has caused another surge of interest on our part and on the part of the international community for the use of WEFAX for conventional meteorological charts. Since October of 1979 we have had an experimental operation on GOES-Central. That experiment is a result of a lot of work by many people, both in NESS and in the NWS. Within the NWS, I can mention Tony Veith, Art Bedient, and Dick Schnurr, who have contributed considerable effort to that experiment. The experiment is continuing; it is a limited experiment in that we have limited time for that broadcast and a limited number of charts. The charts we are transmitting are not particularly timely, but there are some constraints under which we are working, some of which Doug and others have mentioned, for example, the concern about ground equipment at Wallops. All the caveats we have heard about NESS's real commitment for two satellites, and not for the third, are important. It is not considered to be an operational satellite, although its continued operation is pretty well assured if one takes a probabilistic attitude toward these things.

The other reason we are not in more of an operational mode is because we have some higher priority projects within the NWS that have been consuming the time of many of us. I will mention AFOS as one of those projects which has been taking a considerable amount of time. We do hope to have an expanded schedule on GOES-Central within the next 2 to 3 months. We are negotiating with NESS now for that expansion; we hope to arrive at a satisfactory conclusion which will allow us, by early summer of 1981, to increase the number of charts we are transmitting. The charts we are transmitting at the moment, which number about 28 charts each day, are selected from the charts that are included now on the WMO high-frequency radio facsimile broadcasts we make out of Brentwood, Long Island, which is intended for reception primarily by the international community in the Caribbean, Central America, Mexico, and the northern part of South America. These charts include the 24-hour forecast at 850 MB, 500 MB, 300 MB, and 200 MB. We will be adding some surface analyses and significant weather charts which are used for aviation purposes, and some charts which are currently on the broadcasts which originate in Miami.

The current schedule includes only 24-hour forecasts. I mentioned before that the charts are not particularly timely in their broadcast. That is our fault, and not anyone elses. We feel relatively secure with the 24-hour forecast in that we don't have to be especially timely. It has plenty of time for validity after transmission, but we will be adding charts forecast of 12-, 18-, and perhaps 36-hour duration. We also plan to expand the area of coverage as required by the users. The polar stereographic sections which we will be able to transmit are shown in figure 8-1. We have two of them programmed into the current schedule, are designated APT1, and APT2. We will be adding essentially the back half APT8 and APT9 segments if they are required by the users.

In polar stereographic projection, we will be able to display all of the Northern Hemisphere north of 30° except for Africa and a small piece of Asia and the Middle East. These sections include all of the Northern Hemisphere land areas north of 20°.

I will ask you to use your imagination for a moment and picture the Southern Hemisphere. We will be able to produce essentially the same geographical areas in four sections in the Southern Hemisphere as we do in the Northern Hemisphere on polar stereographic projection. With the global forecast model which is now being run at the National Meteorological Center (NMC), we will be able to provide forecast information as well as analyses for the Southern Hemisphere as

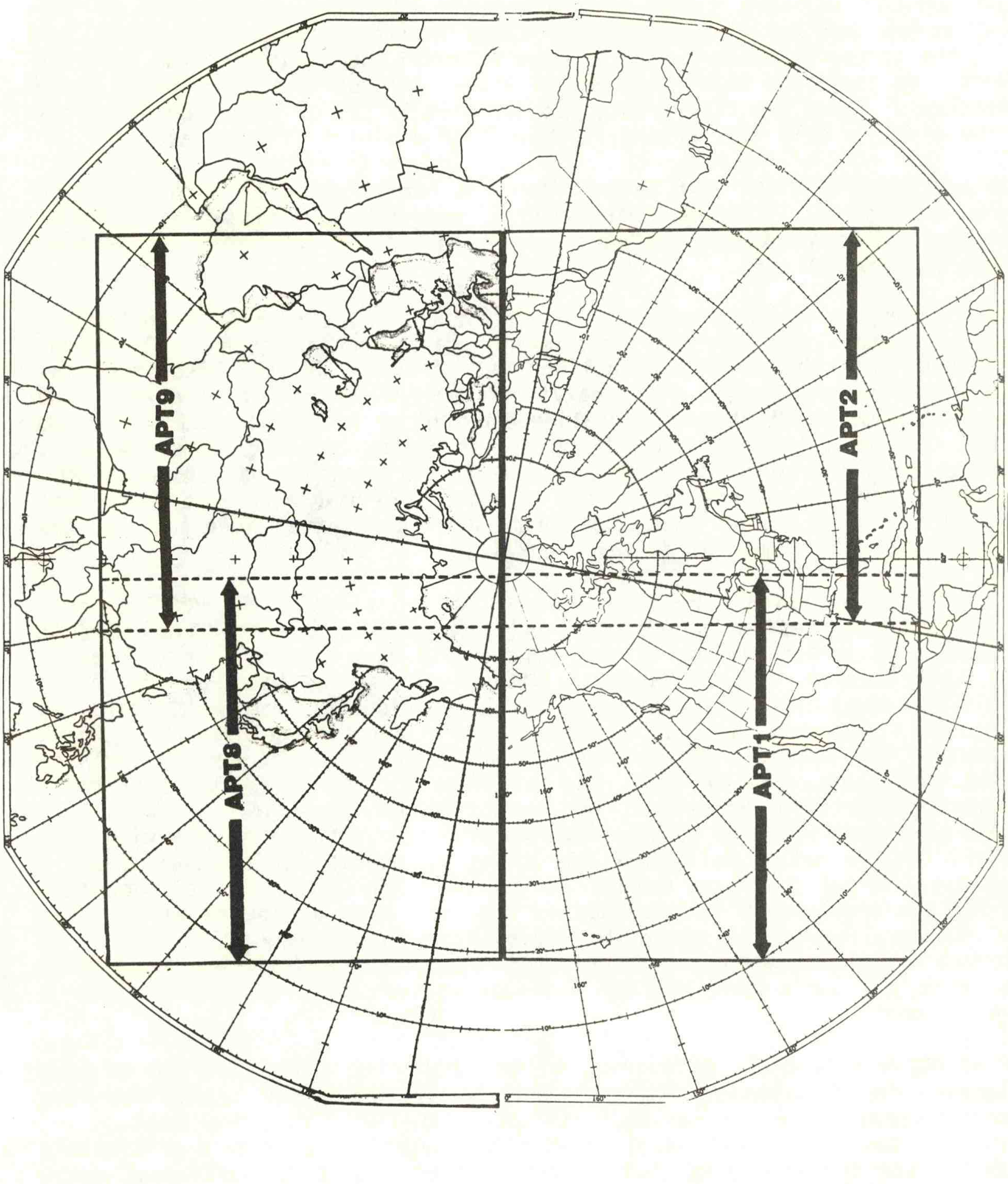


Figure 8-1.--Polar Stereographic
Forecast Areas

well as the Northern Hemisphere.

Figure 8-2 indicates the sections that we will be able to display of the tropical area. We have taken some liberties with the definitions of the tropics, as you can see. We are pretty close in the Northern Hemisphere; 26° North is the northern boundary, but we have extended the tropics in the south to 48° South. We cover the major continental areas in mercator projection in these five sections. There are five areas, each of them is 80° of longitude in width. Since the earth is only 360° around, we have four areas of 10° overlap.

The section APT7 (140° East to 140° West) is one in which our Pacific Region is very interested. In the near future, we will be initiating a WEFAX transmission of conventional meteorological charts on GOES-West in a simultaneous VISSR/WEFAX mode.

Washington, in the international scheme of things, serves as a World Meteorological Center and a Regional Telecommunications Hub. Regional Telecommunications Hubs have the ability to collect data from all of the associated National Meteorological Centers (the individual Member countries of the WMO), and meet the requirements of those National Meteorological Centers for both data and products. We are able to do that through appropriate communications channels. The strong recommendation, of course, is that these channels be dedicated communication meteorological communications circuits. We have been able to do that within WMO Region IV, which includes North America, Central America, and the Caribbean area, by a number of different ways.

For data transmissions, we have a number of circuits. The ANMET Circuit serves Member countries in the Windward and Leeward Islands. The CEMET Circuit serves countries in Central America and Panama. We have direct links to Canada, Mexico, Cuba, Jamaica, and the Bahamas. With respect to graphics, we are trying to supply the needs of these countries with output products from the Center. We have special links with Canada. We have drops on our National Circuitry which serve Mexico, the Bahamas, and the Netherlands Antilles. The majority of the countries in the area that we have responsibility for are served by an HF radio facsimile broadcast from Brentwood, New York. We have some problems with that broadcast as a supplier, and we know that receivers have some problems with that broadcast. It is not a full time operation; we operate effectively about 9 hours a day. It is HF; it is subject to all the vagaries of HF; it is subject to all of the problems of maintenance of the equipment at the receiving stations. The quality of the reception varies from one country to another. We have seen a few places where the reception is excellent; we have seen many other places where you can't tell whether you received a meteorological chart or a plate of spaghetti.

It is not very useful, of course, to get that kind of service and we have been looking for alternatives to that kind of service. Our search has been further motivated by the increasing tariff associated with this broadcast. Beginning in January of next year, we will be paying the carrier approximately $300,000 a year for providing that service for us. That is sufficient motivation to be looking at alternatives. We feel that WEFAX from GOES-Central is an attractive alternative. At the Region IV Working Group on Meteorological Telecommunication meeting held earlier this month in Santo Domingo, we took

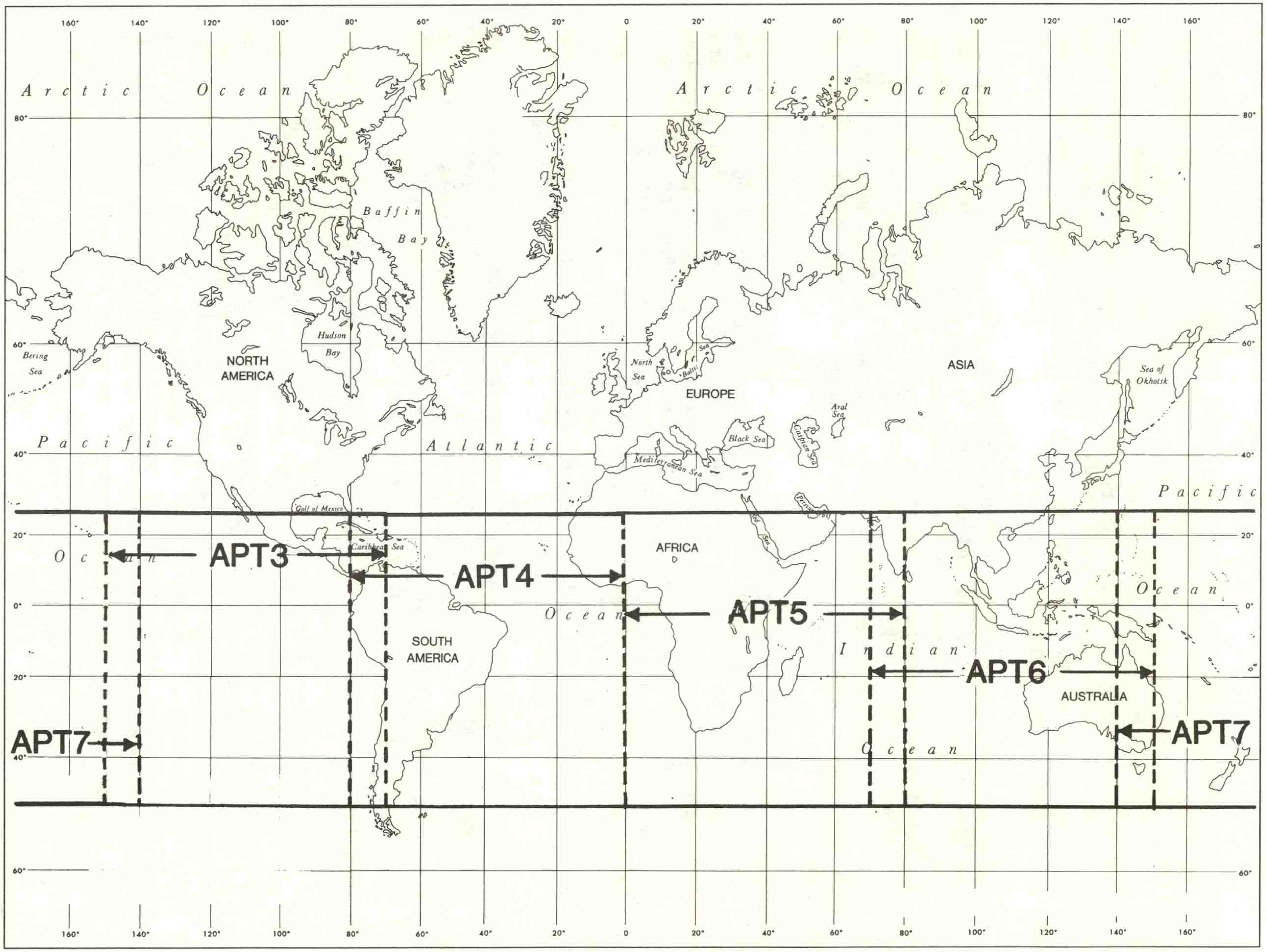


Figure 8-2--Tropical Forecast Sections

two significant steps. One was to include WEFAX in the Regional Telecommunication System Plan. The other was to initiate steps to look at possibilities of dedicated links for providing facsimile services which would parallel those dedicated circuits we have now (ANMET and CEMET). These alternatives are fairly expensive, but they do increase reliability. We feel that our best alternative is the expanded use of the WEFAX; those of you who have seen the products transmitted on WEFAX, and the quality of those products, would agree that they are high quality products.

I am speaking now from a communications point of view. We have always put out high quality forecasts. So we believe that is the path of the future. At first, at least, we will develop this in consultation with our sister service, NESS, by getting their agreement to proceed. We will do this in parallel with the services we have going. If the situation turns out, as I believe it will, that we have in fact provided a significantly improved quality service through WEFAX, then we would look at discontinuing some of our other means of dissemination.

Washington, as a World Meteorological Center, also has a responsibility to Centers in South America. We have direct links to two centers in South America now and an indirect link to a third. We have direct satellite circuits for data to Buenos Aires and to Brasilia. According to the plan, we should be exchanging graphical information with them as well as alpha-numeric information. That is a fairly expensive service, and neither we nor the corresponding Centers in South America have felt the urgency of pursuing that requirement. If WEFAX turns out the way we think it will, it will provide an expanded service. South America can read that broadcast just as clearly as we can, and some countries there are doing that now.

That is another reason why we would be adding to our schedule and including Southern Hemisphere products in our transmission schedule. There are a number of other things we would be working with NESS on. Doug has already mentioned some of these; the transmission of digital facsimile, for example, is something which we hope to experiment with in the near future.

We think WEFAX is a winner, a real winner! As we expand that service (there seems to be plenty of time available on GOES-Central), we are not operating in competition with any other service. There is the imagery, of course, from GOES-East and -West to be included, but there still seems to be adequate time to get the products that we feel there is a requirement for transmitted on this service. We need to know from the users, and in this case we will be acting as a user representative, what your requirements are. We would like to be responsive to those requirements. We don't make any guarantees that we are going to provide every product that each individual requests. There is probably no way to satisfy everyone 100 percent, but at least we would, within the constraints that we have, try to satisfy these requirements. We would like to hear from you what your requirements are. We are still working on the schedule, and we have been diverted a bit, but we hope in the next couple of months to be able to formulate this schedule and to have it coordinated with NESS so that we can begin operation this summer.

There are some limitations to what we can do. One of the limitations, of course, is the size of the charts that we can produce. Another limitation is in the number of charts we can transmit. But there are also opportunities. If we were able to add a few satellite images to the GOES East schedule, it would allow us to remove all of the imagery transmissions that we are now sending on the Main Trunk Circuit from Washington to Bracknell. That would leave only the conventional charts which we can send in a digital mode, so that we can get out of the dual mode that we are in now, of switching between data in digital mode and facsimile in analog mode. This would be a big boost for the channel between here and Europe.

We have then a number of things under active consideration. We will be working with NESS to bring them about, and we would like to be working with you, particularly those in the international community, to ensure that our commitments as a regional and world center are met by the most effective means. We are convinced that WEFAX will play a more important role in meeting these commitments in the future, particulary with the implementation of the new capabilities which we have discussed at this meeting.

QUESTIONS/ANSWERS FOLLOWING MR. NEILON'S TALK

Question: As an amateur, I would like to know the HF broadcast schedules.

Mr. Neilon: The frequencies are 9290, 9289.5, 11035, 17436.5. kHz.

Question: Is that single side band?

Mr. Neilon: They are.

Question: Does Miami broadcast?

Mr. Neilon: Miami provides some charts, but they are not broadcast from there.

Question: Is the format of the HF broadcasts and the WEFAX broadcast identical?

Mr. Neilon: No. The areas are quite different because we have the capability for 19 inches wide on the HF broadcast. They cover in general a larger area or are done on a larger scale than the WEFAX broadcasts.

Question: You mentioned getting user input on the proposed new schedules. Do you intend to broadcast a proposed schedule for people to coment on, or what?

Mr. Neilon: I think the most effective way is for us to produce a schedule which we can meet. It will be published and broadcast on the WEFAX service after which comments are welcome.

Question: The point, of course, is that the potential various groups, to become users of the WEFAX surface, depend upon what that schedule of charts is. If there is some other mechanism for letting it be known and getting comments on it, we ought to take advantage of the rules. My interest, as you know, is one that would allow small universities and high schools to get and update for a small scale forecasting. We certainly can't do that now, and certainly the things you mentioned will be coming close to this.

Mr. Neilon: I wanted to postpone user comment until we put a schedule together, because the schedule we put together will eventually be an envelope of what we can do. It may not be everything, but it will be good demonstration of what our capabilities are. From the NWS point of view, we do not intend to use all the available time with our initial proposal. We will leave room for reaction to user comments, both nationally and internationally, because we do have international requirements we hope to meet with this service so that we can discontinue the HF broadcasts. At the moment it appears there is sufficient flexibility that would still allow some time for additional products to be included in the schedule.

Question: Is there any indication that the Weather Service is sufficiently confident that there will be spare spacecraft around to make a commitment to GOES Central?

Mr. Neilon: The advice that I have heard and reiterated here this morning is that there will be another spare spacecraft in orbit within a few weeks. We haven't made a policy statement on this subject, but the available evidence points that way.

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APPLICATIONS SESSION

Overseas Applications/Comments

Speakers:
Mr. Pollanais (TRINIDAD)
Sr. Irabien (MEXICO)
Col. Del Mar (PERU)
Mr. Bayona (PERU)
Mr. Hong (TAIWAN)

Mr. Popham: In this discussion of applications this morning I would like to call on the various organizational entities that are represented here, beginning with the overseas users. They are among our prime users of the WEFAX service. We would like to hear from them, and others of you later, the specific applications that they are making of WEFAX broadcasts. We ask that criticisms of the service be deferred until the forum session; at this time we would like to have the positive side. There certainly will be opportunity for you to voice your pleasure, or displeasure, with the products when we have the panel discussions because the panel will be better able to answer your questions.

I would like to call on the overseas government users first, then follow this with presentations by U.S. Government users, the academic community, the commercial community, and then the radio amateurs. We will give everyone the opportunity to speak about their particular applications, to the extent that time permits.

Mr. Pollenais: As it stands, we use the WEFAX services only. We do not have the capability at the moment for taking information off the orbiting satellites. The WEFAX are used heavily, in terms of the satellite photographs. I do not know if you know exactly where Trinidad is located, but east of us are thousands of miles of unmonitored ocean. And we need information from that area in Trinidad, because that is where most of our weather comes from. We use WEFAX to observe the weather in that area. We use it especially during the hurricane season. By looking at the information on the WEFAX, we at least get disturbance warnings, and can track it by radar.

The Meteorological Service uses WEFAX for any type of research because we are short on staff. We are training people at the moment, but we are losing our staff regularly.

When we get our antenna for copying the orbiting satellites, then we should be able to do a little bit more with it. At present, the WEFAX gives you a resolution of 8 kilometers. You can not do too much with that. It would be much nicer if we could narrow things down a bit and have a closer look at what weather systems exist.

Mr. Popham: When was the last time you had a hurricane in Trinidad?

Mr. Pollenais: Hurricane Thelma, in 1974. It was not a full-fledged hurricane.

Mr. Popham: It is interesting that Trinidad is an island that hurricanes pass very close to, but generally not right over.

Mr. Pollenais: Our latitude is just 10°. At this latitude, the frequency of storms is less then it would be compared, for example, to Antiqua or Barbados.

Mr. Irabien: In Mexico, the WEFAX Service has been mostly for the use of the forecast office. There is at this time some interest in Mexico in the distribution of rain. We are trying to stimulate rain. We plan to use our WEFAX service to make an evaluation of simulation. One of the big problems with the stimulation of precipitation program is to rate whether the program is successful or not. I understand there is some means to evaluate the increase or decrease in precipitation by study of the satellite photographs.

That is the main use we are making of it. We are very successful and very proud that we have been able to install a very high resolution system, and it would help more with our problems.

Mr. Popham: How many stations do you have in Mexico?

Mr. Irabien: Three. We also will be installing five DCP's.

Col. Del Mar: In Peru we have problems with cloudiness, and we need some information especially in the outer earth and the ocean. We receive the WEFAX and the APT Information, but we do not receive the facsimile very much.

Mr. Bayona: We are trying to develop maritime meteorology in my country. We have about 2100 miles of coast with practically no information at all over the open sea. It is very difficult to make a consistent or current meteorological model. Nevertheless, we have to infer or deduce many things. Certainly that is not objective. So we are very interested in developing first of all the observational means for making a better model along the coast. Besides this, on the other side of the mountains, despite our concern with maritime meteorology, we cannot divorce the kind of weather we have over the jungle. We all know how dependent the weather is over the open sea and the weather over the jungle. Nevertheless, in the Naval Meteorological Office, we are trying first of all to establish several good meteorological stations. Then we are very concerned about the necessity of developing upper air observations. We know the importance that this satellite technology can offer us. We can think of Peru as a climatological laboratory. We have all kinds of weather. We have a different range of temperatures, from the polar temperatures in the upper mountains to the very high temperatures along the coast.

Question (Anderson): Do you have much fishing interest?

Col. Del Mar: Thank you for asking the question, because it reminds me of something very important. We have a tremendous amount of fish especially along the central and northern part of the coast. Peru is really, perhaps, one of the countries where fishing is most important. From time to time, we have a terrific phenomenon we call the El Nino, the invasion of warm water coming from the north. On those occasions all of the fish will disappear. The problem we have in the Navy, for meteorological development, is trying to make long range forecasts, which is very difficult. First of all we understand we have to get the models. So we are very interested in trying to make, first of all, a prognosis from 30 or 40 years of observations in the Southern Hemisphere. On the basis of those prognosis, we had to work the deviations, and on the basis of that we will try to do long range forecasting. That is very difficult, because the observation program is just beginning. We have practically no information over the open oceans. So this is going to be very difficult work; therefore we will depend very much on satellite technology.

Question (Don Hall): Col. Del Mar, you indicated that you were interested in facsimile products. By this did you mean weather charts, as opposed to satellite pictures?

Col. Del Mar: We would prefer weather charts plus the other information we could get from the satellites. Then we would try to match the weather charts and the satellite photographs. We are working with the 1000-millibar level and certain other upper levels. Most of the time we do not get information from Brazil, which is very important to us. Brazil has, for instance, X number of radiosonde stations. We do not receive more than four or five of these radiosonde observations. You Americans do not know how difficult it is to work in South America because of observational and communication problems. We are receiving some information about the sea surface temperatures. The Department of Oceanography is receiving them, very good information. I think this is in periods of 2 weeks or so.

Mr. Hong (Taiwan): First of all, I would like to express our appreciation to have the opportunity to attend this conference. We have had APT stations since 1967 and even then we used this APT station to help our WEFAX low-resolution capabilities several years ago. We can receive the WEFAX satellite imagery only from the Japanese GMS satellite. No weather charts are broadcast through this satellite. And we established an HRPT station early this year. We are interested in receiving the weather chart broadcasting from the U.S., especially the Northern Hemisphere pilot chart if possible, which we would like to see transmitted through the Japanese geosynchronous satellite. I hope that at the next conference, the GMS WEFAX problem could be covered.

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APPLICATIONS SESSION

U. S. GOVERNMENT

(tape begins near end of talk)

Major Thoma: .....We also rely quite heavily on the GOES-TAP system. As far as direct use of WEFAX, we have two sites in the continental United States, with the potential for more later. One of these is the Geophysical Laboratory at Hanscom Field in Massachusetts.

Our basic use of WEFAX would be at remote locations where it would be difficult or impossible to receive satellite data via landline.

Question: You say your own service; do you mean your own series of satellites?

Major Thoma: No; we do not have Air Force satellites that provide WEFAX broadcasts.

Mr. Popham: The U.S. Navy representative is not here, but I believe that I know enough about their status to say that the Navy has about 14 WEFAX stations, primarily aboard ship but also some at training stations in the U.S.

As for other U. S. Government WEFAX uses, we support a permanent WEFAX station on the R/V GLOMAR CHALLANGER, and other research vessels from time to time, maintain monitoring stations at NESS, and provide WEFAX data to overseas sites as explained yesterday by Mr. Neilon.

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APPLICATIONS SESSION

Academic Applications/comments

Speakers:
Dr. John Dutton - - Pennsylvania State University
Dr. Ralph Taggart - - Michigan State University
Mr. Joseph Summers - - Chambersburg Area High School (Pennsylvania)
Dr. Noel Petit - - University of Minnesota

Dr. Dutton: I think that the WEFAX system provides a very important opportunity for academic meteorology. It is especially so today with some of the changes that are going on with data sources and data methods, and as the National Weather Service makes changes in its own procedures. The situation we have is that a wide diversity of possibilities exist in the academic field. On the one hand, institutions like Florida State and Penn State have large dedicated computer systems, access to a variety of data, and process them in a variety of interactive modes. From that level of sophistication, we go to the institutions that need some source of data for teaching purposes and student research. Correction; I appear to be making a distinction there that is not necessarily a valid one, between student and professional. I am talking about research with training in mind.

The situation we have gotten into in accessing ordinary data now concerns the blind charges involved. As the National Weather Service goes to the AFOS system, there are less Government drops and longer lines on the standard facsimile machines. The result is that the line charges alone are becoming prohibitively expensive for some academic institutions in order to have such conventional data available.

The result is that if it were possible to have some sort of a single source of graphical and image data, it would be extremely advantageous to a variety of academic institutions, both universities and high schools, that are engaged in meteorological programs. I see a potential for the WEFAX system to provide exactly that source of data. The only reason that I was giving Mr. Neilon a little bit of a hard time about the schedules yesterday is that I am extremely concerned with what that schedule is going to be. The reason is that, in addition to the satellite imagery on WEFAX, I would hope it would be possible to have a schedule of graphical products that included charts that would involve surface data, some upper air charts, and a series of prog charts sufficiently diverse that forecasting could be done with the data. It would essentially be weather forecasting for training purposes, not weather forecasting for operating airlines. The students are going to come out of college and work for commercial and Government concerns, and to know something about forecasting, they will have to know something about it while they are being trained.

There are a variety of student research projects that can be done with these data. I don't think I particularly need to go into that area.

In summary, I think the WEFAX system has the potential for being an important source of graphical data and imagery data for academic institutions. I think it has another important impact in that it is perhaps going to be the mechanism or the procedure whereby we find our way into the satellite transmission of all meteorological data rather than relying on land lines, at least many of us in the academic community are very interested in that possibility, and I know the weather service is too. I think the day has arrived, and with the WEFAX system we are getting some experience with it, and we are becoming knowledgeable in it as we try to cooperate in thinking what the weather system of the late 1980's ought to be. I think it ought to be a satellite based communications system.

Comment (Mr. Popham): There are approximately 85 academic institutions worldwide currently utilizing satellite data from the direct readout broadcasts, either APT or WEFAX. The academic interest, as you see, is very high.

Dr Taggart: The APT system and the WEFAX system at Michigan State are used primarily in support of classroom instruction. It is used on-line to demonstrate to students the potential involved in real time data gathering with meteorological satellites. It also is used to support student laboratory on-line projects, where they may look at the development of weather systems over a period of several days, or several weeks. The future of WEFAX, in the university context, is going to depend upon the nature of products that are available. Certainly there is dissatisfaction with the rising costs associated with landline chart distribution.

There are several distinct places on a campus our size -- we have agriweather offices, remote sensing centers, and a geography course which teaches basic meteorology -- there are as many as 1/2 dozen places on our campus alone where machines are leased or rented, and we pay for connecting phone lines. There is strong interest in having a central campus WEFAX station linked in by telephone lines, which we have some of and which are not too terribly expensive.

So the charts would be one very important thing; the other important thing would be some mechanism for generating higher resolution imagery.

The Great Lakes do marvelous things to our weather -- we would like to have some of the people from the National Weather Service up here to study it sometime. There is a potential and an interest in a State like ours, surrounded as we are by the Great Lakes, in looking into detail at the small-scale weather phenomena and at the dynamics of the atmosphere as it is affected by the Great Lakes. In order to use WEFAX in that mode, there would have to be an opportunity to have a schedule, particularly from the central satellite, to slip in some high-resolution products. Eight-kilometer data will not support high-level faculty research. The biggest problem right now is that our research people are getting their tapes from Washington, but 2 weeks old. They don't want it from 2 weeks ago. We have a certain amount of ambivalence that we are not going to be able to resolve. I think that the charts are very important for the future of WEFAX if we can generate enough flexibility in the central schedule to slip in a little more of a selection of high-resolution products while supporting the concept of an earth disc and IR every 3 hours. I think we can reach some sort of a compromise.

Mr. Summers: I feel that I should comment a little bit from the high school teacher level rather than from the academic level of the other people who have spoken. I am primarily interested in APT from a high school level, of introducing the technology into more high schools in this country, and also in introducing a possibility for some student research on a lower level than you would find at colleges and universities.

One of my main interests is to stimulate other people in the high school community to install APT stations. In order to do that, it has to be very low-cost, because high school budgets are not like the University of Michigan. With Dr. Taggart's help, through his Weather Satellite Handbook, I was able to install an APT station at our high school for less than $1200 total, by scrounging used equipment wherever I could find it. I knew "zero" about electronics and "zero" about meteorology when I started, because I am a biology teacher. If I can do it, I am sure that others can do it. One of the things is to stimulate this type of learning experience, and the other is to develop some sort of cirriculum at the high school level that would allow some sort of marriage between satellite technology and earth-atmosphere sciences such as microcomputers, and meteorology. The potential is there. What needs to be done is that the information needs to be gotten out to the high schools, and that is my purpose for being here today.

Dr. Petit: I am going to bring up four unrelated items real rapidly about WEFAX. Each concerns different users that I foresee, or items in which we have interest in the State of Minnesota. The first one is the State of Minnesota, and the physics teacher who is not a geologist in the small college. Most are geologists or oceanographers, and they came to this small college to teach. We have five or six who are very interested in getting WEFAX data. Their need is to have data perhaps 2 months out of the year, the 2 months during which they teach the course. They need something which is very inexpensive, and not permanent. Most of them would go to Atlantic Radio Sales in New York and purchase a facsimile machine; they need something that is very inexpensive. The general user that we have had has gotten HF signals off of the HF radio fax, and they are not satisfied with that, obviously.

For meteorological courses at the University of Minnesota, we have replaced NAFAX with WEFAX. The pictures are fine, but if any of you are acquainted with Minnesota, we have more meteorologists in our TV stations than the National Weather Service. One station has nine meteorologists on its staff. We don't need meteorological information at the University of Minnesota, since one station is one block to the east, and three stations are four blocks to the west. However, for our use, it would be very nice if the WEFAX broadcasts contained surface, 500- and 200-millibar charts. One comment I would like to make is that our prog can be verified quite accurately, because it usually arrives at the same time the 24-hour verification period is up. It would be nice to throw away the 24 and give us a 72, and we would work on that.

We do use the charts for plotting on a day-to-day basis for forecasting from those charts in our dynamic meteorology courses. For research, we have three groups that are using WEFAX; the Balloon Facility at Palestine, Texas. They will be dragging along a WEFAX receiver and will be getting up-to-date data from that. They do have a weather service office there as well. Rocket launching in Alaska -- they take the WEFAX with them too.

The biggest user we have on the campus is the Solar Energy Research. They want to know if we should do a data run today. They want an up-to-date picture. Up to this point, what they have been doing is watching A.M. weather. There is nothing wrong with A.M. weather, but they would like to have pictures on an up-to-date basis to check against their data. Actually our biggest user will be their outside research, research done away from the campus or away from the physics department.

The fourth use that we would have of WEFAX is we have a number of different places around the State which are demonstration areas -- one up in the Iron Range -- to demonstrate how to take iron ore out of the ground. We have a good demonstration of how it could be done. They will be setting up a weather station with WEFAX transmitted to them as a very useful part of their public service demonstration. That will be tied to a community college.

So there are the four uses that we have in Minnesota. They are not related, unfortunately to the governmental work that we have talked about. I think that, with the help of some other speakers, we can install some interest in some of those levels of uses although they are not similar.

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APPLICATIONS SESSION

Commercial Applications/comments

Speakers:
Mr. Carlo Vanoni - TECHNAVIA, INC. (Switzerland)
Mr. A. Coatsworth - MUIRHEAD SYSTEMS, LTD. (Canada)
Mr. F. Simpkins - ALDEN ELECTRONIC IMPULSE AND RECORDING COMPANY, INC. (U.S.)
Mr. D. Lichenheim - P& P INDUSTRIES (U.S.)
Dr. R. Taggart - METSAT (U.S.)
Mr. F. Griswald - F. G. ENGINEERING (U.S.)

Mr. Vanoni: First of all, thank you for doing what you have done for all of us. Second, I have a small complaint. You described me as a vendor; I am very happy to be referred to as a vendor, but I have only been a vendor for little over 1 year. Basically, I am a user, and I started my users operation with ATS-3 WEFAX.

Currently, we have used METEOSAT, which failed about one and a half years ago, for more than a year. In Europe, we experience very interesting weather problems. Of course we have no typhoons, but we have terrible fog, and we have bad pollution, too. We were doing extensive studies that had to be stopped when METEOSAT failed, and which we hope to start again, on pollution and saving of electrical energy. When a cold mass of air is approaching big towns, the national electric company can start to generate more electricity. We also have started some experiments to establish, through infrared, the vertical thickness of the fog. We have smoke pollution from thermal power plants, we have big chimneys, and we have fog that, when it is below 120 meters or 500 feet, gives no problems, but when it is thicker, about 1,000 feet thick, all the pollution comes down into the town. We have a very high level of pollution in such cases. Through the European satellite, we are trying to establish the thickness of the fog.

Another important use is related to disaster warnings. We do not have many remote areas, but we have populated areas with very little meteorological warnings. Through the satellites we can forecast that heavy thunderstorms are approaching.

We are very recently participating as users in the typhoon program with GMS. I'm sorry that I do not have direct experience except a few pictures we took about 10 days ago in the Phillipines with a starting typhoon that after 2 days disappeared.

Another thing is cooperation with oil platforms, for security insurance programs. As you know, in the North Sea between England and Norway, a platform recently tipped over and many people were killed.

And finally, as a user, we have in our company plane a portable WEFAX station which we carry with us. That proved to be the most interesting device on that plane. We fly the North Atlantic; we stay out from the typhoons in your area and Central America -- really, peace of mind, thanks to your weather satellite. One time we went to the Bahamas, my family and me, and we were really scared because all around there were typhoons. I just passed Typhoon Claudette. Your NWS forecast told me that the typhoon had moved to the North Atlantic and just disappeared. We were in the peripheral areas of the typhoon; it was really a bad situation. I wasn't really scared, to speak of. But with the weather satellite, it really gives you peace of mind. We can watch typhoon cyclogenesis.

I think that's all. I hope that in a few months, if the French rocket works, that we will have in Europe the beautiful METEOSAT II. As a user, we can give better help to the human community.

Question: You say you have a satellite receiving station in an airplane?

Mr. Vanoni: That is correct. We use a 2-foot parabola that we put out of the plane, when we are on the ground. In flight, we switch and receive radio facsimile.

Comment: Then you don't actually try to use the satellite receiver when you are in flight?

Mr. Vanoni: No. We expect to have a parabola, but up until now it has not been installed in the big Canadian jets (Chancellor).

Mr. Coatsworth: Muirhead is an international organization headquartered in England. Consequently we have worldwide interests in users of WEFAX, both in North America and in Europe and Asia. As a supplier of hardware, one of the areas that Muirhead is unique in is that we have equipment at four different levels of sophistication, or types. I don't think that we will run into too many other people who are competing as we do. We have electrolytic recorders, electrostatic recorders, dry silver laser recorders, and wet photo chemical recorders. Those four different types of recorders cover the usages that are needed by users who have a low-quality or a low-resolution demand or the researcher who needs the highest resolution he can glean from the information transmitted.

I really do not have anything more to say except that, but we are here, and if anyone wants to look at high-, low-, or medium-resolution imagery, we would like to meet with you, talk with you, and try to help you in any way we can. Thank you.

Mr. Simpkins: You may have noticed our truck out front with the antenna on the roof. We have a complete WEFAX ground station here, just down the hall. We have been in the satellite business since 1963; I believe we received the first APT picture from TIROS 8 in December 1963. It was a cold winter day, and we had the antenna pointing northeast. We had a 5° elevation; we believe we got the first picture. That was an orbiter, which transmitted in the APT/WEFAX format.

We have a monitor station in Westboro, Massachusetts, and we monitor all three GOES from time to time. We also get METEOSAT; in fact, I think we are the furthest station west to receive METEOSAT.

I think the WEFAX service now is just scratching the surface of what could be done. The bandwidth capability would allow you to send the entire DIFAX map of 24 hours in less than 1 minute. The capability is there, but we are using very little of it. I think in the future we will see greater use of satellites for transmission and broadcasts of digital facsimile data.

In the short term, we have changed the format and use the WMO standard, which is 19 lines to the inch. The bandwidth is there; we could run up to 240 scans per minute. This would allow those people who have our weather recorders to use them. The 19-inch format does not work too well for WEFAX; it gives you a very large picture. There is a possibility of speeding up the service and utilizing a lot of the recorders that are around the world today.

I heard an interesting comment from one of the speakers yesterday. He said our recorders could run upside down, underwater, without spare parts. That was good!

Mr. Lichenheim: I would just like to say very briefly that P&P Industries is a very small company at this time, but we are expanding very quickly. We have three basic systems; a low-cost APT system which all educators might be interested in; another system which we call the color interactive system -- I think that is a very useful instrument for meteorologists that like to work with real-time data or do a lot of processing very quickly. The third system is for high resolution satellites. We are presently getting ready to install this system in the People's Republic of China.

Dr. Taggart: As we are a very small company, we make a very basic system. There are no frills, bells, or whistles associated with it. As such, we added a new range of users -- some in the educational community, such as high schools and colleges that were simply not aware that that type of service was available or that it was affordable. It never occurred to me that such a large number of individuals would, as a hobby or anything else, really be involved in this sort of thing. I knew some crazy friends of mine that are affected this way, but it didn't occur to me that this disease could be so widespread. I'd say that at least one third of our business has been people who are intensely interested in weather for all kinds of reasons, but none of them having any direct commercial or educational application. They are scattered all over the world, in basements and apartment houses, etc. WEFAX is important to them. Fishermen, isolated marinas, little airstrips out in the middle of nowhere, where they don't really get the kind of weather information they need to support their local operations -- a whole host of potential small users, most of whom are operating on a shoestring. They know that they would like to have better weather data than they are getting, and they are not usually professional or sophisticated about their weather operations, but again, the way they have to use weather, they don't necessarily have to be. The small weather stations are a case in point. What they want is an instant cross-check with what they are getting from the nearest forecast center to see how relevant it may be.

So there has been a tremendous range of opportunity out there. The biggest problem is that so few people know that this capability exists. We fail to realize what a limited group this is. We know that those satellites are up there, what they are doing now, and what they could do with a given level of programming. But they represent an international resource of the highest order, one of the most cost-effective ways that we can tell people important things about the planet on which we live.

So all I can say, Bob, is keep up the good work and, to the extent that we can let everyone know that they have a tap onto the resources and dynamics of weather, we will be ahead of the game.

Mr. Griswald: The F.G. Engineering Company is very small and I design and market down-converters, receivers, transmitters, and preamps. Everything I produce is my design -- I am an RF-circuit designer and the only engineer. The only thing I offer is custom modifications. The main problem I have is finding out what everybody wants. The main reason I am here is to get feedback from users so that I can make my designs more responsive. My products are primarily in the area of weather satellite reception and also data collection. I make data collection transmitters and also phase lock receivers.

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QUESTIONS/ANSWERS

Question (to Dr. Taggart): Suppose that I wanted to build the kind of station that you have been talking about in my apartment, how much would it cost?

Dr. Taggart: Do you want to build one or buy one?

Statement: Buy one.

Dr. Taggart: If its a very small apartment with a very small balcony, we could give you a system supported by a 2-foot dish, which would cost you about $4,500.

Question: If I were going to buy the parts myself, how much would it cost?

Dr. Taggart: That is an impossible question to answer. It would depend upon how good of a scrounger you are. I have had high school students build an APT station from discarded television sets for less than $200, and it makes very pretty pictures. Whenever someone asks me anything about building it, there is no price tag that you can put on it, because it depends upon how resourceful you are.

Mr. Vanoni: I'm speaking as a vendor. I am a vendor of a system in Switzerland, namely Technavia. We are involved in the satellite business, a very small business, but a growing business, which needs a very high technology. What we are trying to do is to provide, on a turn-key basis, an acceptable SDUS station. We work with Harris in Florida, and we have a close connection with a Swiss company known as Schedelsky, known here in the States for tape recorders, and manufacturing also an image recorder on metalized paper.

In the last year and a half, we have put systems in 14 or 15 countries, on four continents. The price, which I think is very important problem anywhere, is from a few thousand dollars for a school or amateur or private user, to over $150,000 for the beginning part of the station itself.

We have stations operating in the Far East, and in Africa, but mostly in Europe. Just 15 years ago we provided a station to the Brussels airport which is the center of the European community. We have a few stations here in the States and we hope to continue our cooperation with the meteorological offices worldwide and also with other vendor companies too.

Wednesday April 28, 1982

APPLICATIONS SESSION

Amateur Applications/comments

Speakers:
Dr. D. Hauck
Mr. T. Vilov
Mr. J. Nagle
Mr. C. Bristor
Mr. J. St. Clair
Mr. R. Schloeman

Dr. Hauck: Thank you Bob. I am far from a professional WEFAX user; I am an eye surgeon by trade, but enjoy copying the satellite. I appreciate your inviting us here from the amateur group.

Yesterday I found out that I was really a member of the secondary group. I was told in the lecture that the primary policy is U.S. Government usage first, private citizens secondary. I appreciate being here from the secondary group.

I copy the orbiting satellites and GOES-East and GOES Central, but I spend most of my time with GOES West. Southern California is the main reason. I can divide my users into three sections. I am a member of a 150-member family flying group, and flight planning is being done continuously. There are never less than two flights a month. Most of the flying pilots of our group are very anxious to know what the weather is going to be. They do not want to get caught off of home base and make that commercial flight home with the family; they want to make every flight count and conserve fuel. We watch A.M. weather all week, but they shut down on the weekends. Flight service stations are overburdened. You can dial a phone and listen while the phone rings for over an hour and then give up in frustration. So then my phone starts ringing, usually on Friday night. I share my weather pictures with my group and they are always requesting visible pictures -- they don't like the infrared pictures, we are not trained meteorologists -- and we want more visible spectrum pictures. But perhaps we can talk about that later.

We put the picture in our pocket and take off. We don't have a receiver in the plane like Mr. Vanoni has in his Golden Eagle. We have only 12-volt systems.

The second use is that I am an amateur radio operator with a group of amateur fast scan television enthusiasts in the Los Angeles area. By fast scan I mean just like the commercial television you see on your screens. We have two repeaters in the L.A. area -- wide, broad coverage of easy commercial type quality pictures from Palm Springs all the way up to Santa Barbara. San Diego is easy, and requests come all during the week, especially on weekends. "Hey, let's see the picture coming in. And let's see the picture right now. We want a real-time picture." All it takes is to point a camera to the picture coming in on a P-7 phosphorous tube the way I'm using it, and a polaroid film later, polaroid processed to take the picture where they can see the scan being done. The P-7 phosphorous has quite a retention of image, but you can't make much out of it. When I put the polaroid camera in front of it, and broadcast out on 434

MHz, they are as thrilled as I am.

I guess the third use is my own personal thrill of getting up there in the early morning hours in my bathrobe and slippers, putting a bath towel over the polaroid system of my little television screen and seeing that picture coming in -- the sights and sounds of outer space give me a thrill every time, so I appreciate the service very much and want to share it with as many people as I can.

Mr. Vilov: Bob, I have a question which I would like to direct to the manufacturers. Just recently I had an occasion to pick up a copy of EEM. That is a copy of a directory for electronic and corporate manufacturers. It is amazing sometimes that as many people that are manufacturing equipment, when you go to that directory which is supposedly THE directory for the electronics field, how few people are listed in it. For example, I turned to facsimile equipment. There are just a handful of people listed. For those of you that are in the business and not listed, you may want to entertain the thought of looking into advertising or being listed in that directory.

Mr. Nagle: The Electronics Magazine also has an annual yearbook they might want to read. It is published by McGraw-Hill.

Mr. Bristor: Bob, I just wanted to get in a couple of licks here. I was reminded here yesterday in the discussion of the future, one of the bullets said digital WEFAX. I would like to make a pitch for some beginning effort, despite all of the appeal of WEFAX and imagery, I would urge that consideration be given by the manufacturers to organizing some capability for direct local acquisition of digital weather data. Early interest in APT was aroused within the amateur ranks, but they tell me now that in the Washington area there are 5,000 micro-processors in the home. These have nothing to do with the commercial endeavor or any kind of a business application. It seems to me that with the polar orbiter beacon channel at 1823 bits per second, there would be a fertile field for experimentation among computer amateurs who might want to dabble with sounding data. The TIROS sounder has 27 channels; there are 20 IR channels with a foot pad of 17 kilometers. There are three stratospheric channels, and four microwave channels.

I would think that this would be a very interesting data base for high school students with micro-processors. There could be a lot of experimentation done, treating this as low-resolution imagery or using it to experiment with stratospheric charts. One of the channels peaks at 25 millibars. If one really plotted this as a stratospheric pattern, you would see the thickness, that is, the relative mean temperature profile of the entire stratosphere. There are moisture channels and there are many thermal channels, so that one could experiment with instability indices which would relate to the threat of convective storms, or moisture content which would relate to the potential for heavy rainfall. There would be a lot of things that meteorologists at the high school level could do while acquiring familiarity with the satellite and combining this experience with micro-processors. I just suggest this to the vendors. This is a 137-MHz signal, it seems to me that it would be fairly easy to build a front end that would not be significantly more expensive than the present analogue front end, and feed this into a microprocessor.

Mr. St. Clair: Firstly, I would like to say how very much I have enjoyed this conference, meeting so many interesting people. Up until about 1970, my friends, and particularly my family, considered me a reasonably sane individual. Then two people came into my life. Firstly, someone sent me a copy of Chuck Vermillion's article on building APT stations. The second thing was that I got in correspondence with Bob Popham. Life has not been quite the same since. I have had to move into several larger and larger houses to store the amount of junk that I have accumulated.

Anyway, Bob Popham at the start of this conference introduced himself. If I had had the opportunity to introduce him, I would have said, "Here is a man who has more pen pals in more parts of the world than anybody else you can think of." I think that certainly speaking from the amateur community, we are all tremendously grateful for the response we get to our correspondence and the kind of input to the data.

I travel quite a lot around the world. By asking Bob, "Do you know anybody else that is interested in this or anybody that can help me with that particular feature," he has put me in touch with a lot of people. It has spread. I go around the world three or four times a year. In between doing some work to earn my living, I slip off sideways, like I am here for the moment, to meet with some people in the satellite fraternity. It's a wonderful bunch of people. It is a fascinating hobby, and once it bites you, there's no looking back.

I think that one of the things that's fascinating to an amateur is how much you can get of all this wonderful scientific performance with comparatively little investment, in other words, if you really want to go the hard way, you can get hold of a lot of junk and you can put a lot of stuff together, and as somebody mentioned this morning, you could build a station for a couple of hundred dollars. I wish I could have succeeded in doing that, but I've had a lot of fun trying. I feel a little bit of a traitor to Bob and his colleagues -- at the moment METEOSAT came on the air, I got tired of tracking this ruddy cross yaggy around the sky and I swung over and said, "Thanks Bob, we'll keep in touch." That was two years ago. But then that thing fell out of the sky in November 1979. I was back, sort of sheepishly, looking at NOAA 5 and 6 just to keep myself in the business, as it were.

Again I would like to say how much I have enjoyed the hospitality offered by the vendors here. Not only does their equipment sort of make my mouth water, but the nourishment they provided also has been excellent. But speaking on behalf of the amateur community, we always enjoy that sort of treatment. Thank you very much.

Mr. Schloeman: As Bob alluded to, we do have frequent exchanges on the phone. One of the primary activities that we as amateurs have addressed is the monitoring of the service. You all found out just recently that about a year ago, or less than a year ago, they were finally able to get some dishes and equipment here in Maryland to monitor WEFAX service. Up until that time they just had a log that said, "Yes, we sent it." I had a record of a roundup that said, "No, you didn't." I just turned in a four-page report that I prepared beginning back in December, listing the various types of problems that they have had on WEFAX, from all three satellites. It turned out that my products were products on GOES-Central, the ones that I monitored the most. I had eight categories of problems. Of the 139 transmissions that I monitored, 76 had problems of one kind or another (excluding the start times) all the way from no data at all to the wrong product at the wrong time, or the wrong satellite, or a grid dropout, or short frame, or no stop tone, etc. This was something that I felt was constructive to them, and I hope that it is, or will be. It has been remarkable that about the 11th or 12th of March, something happened. None of us on the ground in the user community didn't know about it, perhaps some of those here in the Government didn't know about it, but they made a very dramatic change. One of the things that used to drive us up the walls was that I would take maybe one transmission a day. That was my sole source of information for that day. I would sit there and wait, and wait, and wait. Then the anxiety and frustration would begin to mount. Ten seconds would go by, 15 seconds would go by and I would ask myself, "Are they going to send it?" Finally, it would come through. On the 11th of March, something happened. All of a sudden, when the transmission that I copy at 0205Z had 2050Z bingo -- there it was. The deviation was right on the button. The product was remarkable for a small inexpensive station, which, by the way, with regards to the cost of an amateur station, that is the only piece of information that could be truly classified as secret or confidential, because if our wives ever found out how much it actually cost........

But anyway, the monitoring and assistance to NOAA and NESS has been our primary objective, to help them and assist them, so that when problems occur we can provide a remote site with additional information to compile to assist them in determining what the problems are, whether it being polar orbiting, over which there have been few. I can only remember one problem with the NOAA 2, 3, 4, and 5: one of them had a sunglint on the side that was reflecting off of the side of the sunshield. It took a while for Chuck Vermillion to figure it out for us, but it only occurred just north of the Equator, in February, when we were at perigee.

The amateur community is very diverse in its background. I happen to be an engineer, and I live in Arizona where we have absolutely no weather at all. The satellite provides me an opportunity to see some. The people that I work with rely on me for what they hope and expect are forecasts, but I am not a meteorologist, and I do not qualify them as forecasts. But they are deathly afraid that they might go up in the mountains and get rained on. So I have to let them know that there will not be any clouds in Arizona today. I can be 90% sure without a satellite, actually.

Amateur radio has also provided us an excellent opportunity to have a one-on-one contact with other individuals throughout the United States, Canada, and throughout the world, to exchange both technical and meteorological information from the satellites. Each Sunday morning, for example, at 1800Z, I meet with approximately five to seven radio amateurs throughout Canada and the United States. We sit and discuss and cuss the problems with the satellites and the imaging systems, the problems that they have noted, to sort out whether or not we have found a ground receiving problem, or whether there has actually been some type of problem in the uplink or downlink system. We have wide, diverse types of equipment, mostly home-built. We drool at all of this commercial equipment. All of us find a different use for the products. We had one individual who passed away not long ago who spent his mornings talking to private individuals who were sailing their boats up and down the west coast of Baha. There is very little weather information available in that part of the world, but an excellent view from the GOES-West satellite in that area, and even the polar-orbiting satellite.

The Chibascos, as they are called, which occur off the west coast of Mexico are very devastating and very unusual, and it is hard to determine when they are going to occur. Over a period of years, we have learned to recognize the weather patterns which produce them. By our own persistence, we have been able to provide some sort of service on an amateur basis. That is really what I have found to be the most exciting part about amateur involvement in the weather service.

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Question: Could you tell us what frequency you operate on?

Answer: I operate two times on Sunday morning; first, at 1630 GMT with the West Coast group of radio amateurs on 7.170 MHz, and at 1800Z we meet on 14.328 to 14.330 kilohertz. We really get clobbered up there with a lot of activity that goes on.

Question: Is that 40 meter single sideband?

Answer: Both of them are single sideband.

Question: What is your call sign?

Schloeman: My call letters are WA7MOV. We have Canadian and stateside stations in there all of the time. We are happy to have any amateur join us.

Question: It is up around 14 and lower on blank?

Schloeman: Yes, it is the standard upper and lower situation........End of tape.

Open Forum - Questions from the Floor

Wednesday April 29, 1981

Question: Mr. Johnson indicated in his opening remarks that the first priority for WEFAX broadcasts is the needs of the U.S. Government. Aside from the needs of the Navy, what are the Government's WEFAX needs?

Answer: The Government has a commitment to the Navy and Air Force to provide WEFAX broadcasts. The National Weather Service has commitments to provide meteorological data to certain NOAA stations, such as the Glomar Challenger, and to a number of overseas stations. It hopes to use WEFAX to replace certain landline and radio-facsimile communications links.

There is an even longer-standing commitment to the World Meteorological Organization, a U.N. body, dating back to the earliest days of weather satellites, when we agreed to provide satellite products to member nations as part of the international cooperative meteorological program.

Question: WEFAX broadcasts of full earth disc images always begin with north-east and southeast sectors followed by northwest and southwest sectors. Why can they not begin with the northeast/northwest sectors or northwest/southwest sectors?

Answer: Ground equipment hardware and software, especially with regard to the Facsimile Encoder Transmitter, was designed to process the data from north to south. This enables us to perform automatic data extraction; otherwise, we would have to manually transfer recorded tapes back and forth between computers.

Question: WEFAX broadcasts do not include visible images of the West Coast of the U.S. What can be done to include such broadcasts?

Answer: Only a limited number of open WEFAX transmission slots are available and Department of Defense requirements are further west than the U.S. West Coast. Therefore, visible imagery of the U.S. West Coast is very limited on GOES-West.

Question: WMO facsimile broadcast formats and WEFAX broadcast formats do not conform in some areas. WMO broadcasts, for example, begin with 20-second start tone, WEFAX with a 5-second tone. Test patterns also are not the same. Can these be made to conform?

Answer: A 5-second start tone is built into our computer equipment and FET's. Therefore, we cannot conform to the WMO 20-second start tone. The WMO test pattern is presently being transmitted on GOES-C WEFAX.

Question: What is the smallest temperature difference (in degrees Celsius) that can be detected in WEFAX images?

Answer: It is impossible to determine temperature or exact temperature difference. There is only a linear transmission of temperature from 0-255 counts.

Question: What kind of coordination exists between FB#4, where the WEFAX signal originates, and Wallops Station, which transmits the signal to the spacecraft? In particular, with regard to GOES East, the carrier may be brought down before a stop tone is sent.

Answer: Wallops transmits a stop tone automatically on GOES-E and GOES-W before the carrier is taken down.

Question: In other cases, the signal strength of the stop tone is significantly less than that of the start tone?

Answer: The start and stop tone should be the same.

Question: There appears to be some frequency standard differences between image broadcasts and chart broadcasts. Is this true?

Answer: Frequency standards for image broadcasts and chart broadcasts are the same.

Question: Users have a problem with WEFAX data calibration and gray scale. What range does NESS use?

Answer: NESS currently uses a linear scale from 0-4.2 volts (white to black, 0-255 counts).

Question: Are there any plans to use different frequencies for WEFAX broadcasts?

Answer: No.

Question: What is the meaning of the alpha-numeric group in the header of each WEFAX broadcast? How are these inserted?

Answer: The header is inserted by a synchronizer/data buffer (S/DB). S/DB performs the key actions by separating the digital bit stream into visible, IR and format identification channels. These are inserted in the stretched-VISSR at Wallops before retransmission to the satellite and direct VISSR receivers.

Question: Is it possible to include voice transmissions on GOES, i.e., use voice communications to convey information about WEFAX operations?

Answer: No.

Question: Can there be a standard or routine time to notify users of changes in schedules, no transmission, or anomalus operations? For example, a row of asterisks on an image, or a different tone?

Answer: Users are notified by using the Operational Message period and WEFAX coded messages that are inserted at the end of the alpha-numeric header of VISSR images.

Question: What plans are there, and what problems, relative to digital WEFAX transmissions via GOES?

Answer: Digital WEFAX tests have been conducted by the NWS and preliminary results look favorable.

Question: Why do GOES-West WEFAX broadcasts contain the word "TEST" in the header?

Answer: The word "TEST" is no longer transmitted in the header for WEFAX.

Question: Sometimes I get a "reversed", or negative WEFAX image -- black is white, and vice versa. Why does this happen?

Answer: This reversed image happens when the FET is misconfigured and a land line facsimile product is broadcast in a WEFAX slot.

REGISTERED ATTENDEES AT THE
WEFAX USERS CONFERENCE
WASHINGTON, D.C. APRIL 28-29, 1981

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