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Project NOAA-E

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Leon Perry
NASA Headquarters, Washington, D.C.
(Phone: 202/755-8370)

Debra Rahn
NASA Headquarters, Washington, D.C.
(Phone: 202/755-3897)

James C. Elliott
Goddard Space Flight Center, Greenbelt, Md.
(Phone: 303/344-6256)

RELEASE NO: 83-35

SEARCH AND RESCUE INSTRUMENTATION TO BE CARRIED ON NOAA-E

NOAA-E, an advanced TIROS-N (ATN) environmental monitoring satellite, carrying special Search and Rescue instrumentation will be launched from the Western Space and Missile Center, Vandenberg Air Force Base, Calif., no earlier than 7:52 a.m. PST, March 28.

NOAA-E will carry instrumentation for a demonstration to search and rescue (SAR) mission agencies for evaluation of a satellite-aided SAR system that may lead to the establishment of an operational capability.

March 22, 1983

- more -

The SAR program is a joint Canada, France, United States and U.S.S.R. effort. The test program began in September 1982, following the launch on June 30, 1982 of the Soviet SAR-equipped navigational satellite Cosmos 1383. Through February, that satellite had assisted in saving 19 lives.

The U.S. effort in the SAR program is managed by the Communications Division of NASA's Office of Space Science and Applications. NASA's Goddard Space Flight Center, Greenbelt, Md., is responsible for the execution of the program.

The objectives of the search and rescue mission are to demonstrate:

* The ability of a spaceborne system to acquire, track and locate existing Emergency Locator Transmitters (ELTs) and Emergency Position Indicating Radio Beacons (EPIRBs) that currently are being used aboard approximately 200,000 general aviation and other aircraft in the United States alone; are aboard approximately 6,000 U.S. ships; and are operating on 121.5 and 243 Megahertz frequencies.

* The improved capability for detecting and locating distress incidents utilizing new experimental locator transmitters and indicating beacons operating on a 406 Megahertz frequency. This new capability would provide higher probability of detection and location, greater location accuracy, and coded user information, and would allow for the necessary growth of an increased number of users.

In addition, this capability will allow for global coverage by providing spaceborne processing and storage of the 406 MHz data by equipment aboard the spacecraft.

NOAA-E, a 1,712 kilogram (3,775 pound) spacecraft will be launched into an 833-kilometer (450-nautical mile) circular, near-polar orbit with an inclination of 98.7 degrees to the equator. Total orbital period will be 101.35 minutes (67 minutes in sunlight and 34 minutes in the earth's shadow). The orbit is planned to be sun-synchronous, rotating eastward about the earth's polar axis 0.986 degree per day -- the same rate and direction as the earth's daily rotation about the sun.

This precession keeps the satellite in a constant position with reference to the sun for consistent illumination throughout the year. NOAA-E will be launched so that it will always cross the equator at about 7:30 a.m. southbound and 7:30 p.m. northbound local time.

To be launched aboard an Air Force Atlas-E launch vehicle, NOAA-E will transmit data directly to users around the world for local weather analysis.

Operational ground facilities include the Command and Data Acquisition stations in Fairbanks, Alaska, and Wallops Island, Va.; the Satellite Operations Control Center (SOCC) and data processing facilities in Suitland, Md.; and a data receiving location in Lannion, France.

The TIROS program is a cooperative effort of NASA, National Oceanic and Atmospheric Administration, the United Kingdom and France for providing day and night environmental and associated data for operational purposes on daily basis. The U.S. Air Force provides launch support, and General Dynamics Convair (GDC) provides the Atlas launch vehicle. The Astro-Electronics Division of RCA, Princeton, N.J., is the prime contractor for the spacecraft. Canada and France are providing the SAR equipment.

NOAA-E is the fifth in a series of eight satellites developed to give scientists the most comprehensive meteorological and environmental information since the start of the nation's space program. The satellite series is being produced under a $125 million contract at RCA Astro-Electronics, Princeton, N.J., a unit of the company's Government Systems Division.

TIROS-N (Television and Infrared Observation Satellite), launched Oct. 13, 1978 at 11:23Z, was the first in the series of a third-generation operational environmental satellite system. TRIOS-N was a research and development spacecraft serving as a protoflight for the operational follow-on series, NOAA-A through G. Advanced instruments on the satellites measure parameters of the earth's atmosphere, its surface and cloud cover, solar protons, alpha particles, the electron flux density, the energy spectrum and the total particulate energy disposition at the satellite altitude. As a part of its mission, the satellite also receives, processes, and retransmits data from free-floating balloons, buoys and remote automatic observation stations distributed around the globe.

Other TIROS-N satellites include:

NOAA-A (6), launched June 27, 1979, is performing satisfactorily, having exceeded its designed two-year lifetime.

NOAA-B, launched May 29, 1980, failed to achieve usable orbit because of a booster engine malfunction.

NOAA-C (7) launched June 23, 1981, is performing satisfactorily.

NOAA-D, not equipped with search and rescue equipment, will be held as a backup for NOAA-E, NOAA-F or NOAA-G.

NOAA-E will be designated NOAA-8 after it is launched. After it is checked out by NASA's Goddard Space Flight Center in Greenbelt, Md., and its orbit is established, the spacecraft will be operated by NOAA.

Primary instruments to be carried by NOAA-E will be:

*Advanced Very High Resolution Radiometer (AVHRR) provided by ITT, for measuring energy emitted from the atmosphere in the infrared spectral band.

*Microwave Sounding Unit (MSU), provided by the Jet Propulsion Laboratory (JPL), Pasdena, Calif., to measure energy from the troposphere.

*Stratospheric Sounding Unit (SSU), provided by the United Kingdom, to make temperature measurements in the upper atmosphere.

*Space Environmental Monitor (SEM), provided by Ford Aeronautics Communications Corp. (FACC), Detroit, to measure the population of the earth's radiation belts and the particle precipitation phenomena resulting from solar activity.

*ARGOS Data Collection System (DCS), provided by France, to collect data from buoys, balloons and remote weather stations.

*Search and Rescue (SAR), with repeater furnished by Canada and the processor provided by France, to detect and locate ELT/EPIRB distress signals.

In addition, a dummy Earth Radiation Budget Experiment (ERBE), provide by TRW, and a dummy Solar Backscatter Ultraviolet Spectral Radiometer (SBUV/2) provided by Ball Aerospace Divis., Boulder, will be flown on NOAA-E for reasons of weight and balance. Subsequent TIROS-N spacecraft will carry operating versions of these instruments.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

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LAUNCH VEHICLE

The spacecraft will be launched from the Air Force Western Space and Missile Center at Vandenberg Air Force Base, Calif., by an Atlas-E launch vehicle. The standard Atlas launch vehicle consists of an E-series Atlas missile that has been refurbished and modified to a standard configuration for use as a launch vehicle for orbital missions. It is capable of launching a spacecraft into a variety of low earth orbits. The launch vehicle is manufactured by General Dynamics Convair, San Diego.

The vehicle stands 28.7 meters (94 feet) tall and is 3 m (10 ft. in diameter. The fairing is 7.4 m (24.3 ft.) long and is 2 m (7 ft.) in diameter. At liftoff, it carries 69 kiloliters (18.294 gallons) of RP-1 fuel, a highly refined kerosene. Engine data are as follows:

	Booster	Sustainer	Vernier
No. of Engines	2	1	2
Thrust per engine (lb)	165,000	57,000	1,000
Thrust per engine (N)	633,920	253,536	4,448
Thrust duration liftoff to	+120 sec	+320 sec	+340 sec

From liftoff to +60 seconds, airborne autopilot programmer in the launch-vehicle flight-control system provides steering and discrete commands. The General Electric Radio Tracking System (GERTS) ground station and guidance computer then perform the guidance function in conjunction with the launch vehicle's pulse beacon system.

The vehicle is powered by one sustainer, two boosters and two vernier engines using liquid oxygen, and liquid hydrocarbon propellants. A 0.97-m (38-inch)-diameter attach fitting fastens the NOAA-E spacecraft to the launch vehicle. The fairing attached to the forward face of the launch vehicle protects the spacecraft from aerodynamic heating during the boost flight.

NOAA-E INSTRUMENTATION

The instrument systems provide both direct readout (real time) and remote sensing (playback) of environmental data during day and night operation. The primary instruments carried by the NOAA-E spacecraft are:

*Advanced Very High Resolution Radiometer (ITT)

*High Resolution Infrared Radiation Sounder (ITT)

*Microwave Sounding Unit (JPL)

*Search and Rescue
 -SAR Repeater (CRC/Canada)

-SAR Processor (CNES/France)

*Stratospheric Sounding Unit (U.K.)

*Space Environment Monitor (FACC)

*ARGOS Data Collection System (CNES/France)

For reasons of weight and balance, mass property dummy instruments will be flown on NOAA-E. They are:

*ERBE-Scan and Non scan (TRW)

*SBUV (BASD)

Advanced Very High-Resolution Radiometer

The Advanced Very High-Resolution Radiometer (AVHRR), provided by ITT, is a radiation-detection instrument used to remotely determine the surface temperature. This scanning radiometer uses four detectors that collect different bands of radiation wavelengths. Measuring the same view, this array of diverse wavelengths, after processing, will permit multispectral analysis for more precisely defining hydrologic, oceanographic, and meteorological parameters. One channel will monitor energy in the visible band and another in the near-infrared portion of the electronmagnetic spectrum to observe clouds, lakes, shorelines, snow and ice. Comparison of data from these two channels can indicate the onset of ice and snow melting. The other two channels operate entirely within the infrared band to detect the heat radiation from and, hence, the temperature of, the land, water, and sea surfaces and the clouds above them.

Space Environment Monitor

The Space Environment Monitor (SEM), provided by Ford Aeronautics Communications Corp. (FACC), is a multichannel charged-particle spectrometer. It measures the population of the earth's radiation belts and the particle precipitation phenomena resulting from solar activity (both of which contribute to the solar/terrestrial energy interchange.) The monitor consists of three separate sensor units and a common Data Processing Unit (DPU). The sensor units are the Total-Energy Detector (TED) and the Medium-Energy Proton/Electron Detector (MEPED). The lower-energy sensors (the TED, plus the proton and electron telescopes of the MEPED) have pairs of sensors with different orientations because the direction of the particle fluxes is important in characterizing the energy interchanges taking place. The objectives of the Space Environment Monitor are to determine the energy deposited by solar particles in the upper atmosphere and to provide a solar warning system.

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TIROS Operational Vertical Sounder System (TOVS)

The TIROS Operational Vertical Sounder system consists of three instruments: the High-Resolution Infrared Radiation Sounder modification 2 (HIRS/2), the Stratospheric Sounding Unit (SSU), and the Microwave Sounding Unit (MSU). All three instruments measure radiant energy from the atmosphere, and the data are used to determine the atmosphere's temperature profile from the earth's surface to the upper stratosphere.

High-Resolution Infrared Radiation Sounder (HIRS/2)

This instrument, provided by ITT, detects and measures energy emitted by the atmosphere to construct a vertical temperature profile from the earth's surface to an altitude of about 40 kilometers. Measurements are made in 20 spectral regions in the infrared band. (One frequency lies at the high end of the visible range.)

Microwave Sounding Unit (MSU)

This unit, provided by Jet Propulsion Laboratory, Pasadena, detects and measures the energy from the troposphere to construct a vertical temperature profile to an altitude of about 10 km (6.2 mi). Measurements are made by radiometric detection of microwave energy divided into four frequency channels. Each measurement is made by comparing the incoming signal from the troposphere with the ambient temperature reference load. Because its data are not seriously affected by clouds, it is used in conjunction with the High Resolution Infrared Radiation Sounder modification 2 to remove measurement ambiguity when clouds are present.

Stratosphereic Sounding Unit (SSU)
(Provided by the United Kingdom)

Temperature measurements in the upper stratosphere are derived from radiance measurements made in three channels using a pressure-modulated gas (CO_2) to accomplish selective bandpass filtration of the sampled radiances. The gas is of a pressure chosen to yield weighting functions peaking in the altitude range of 25 to 50 km (15.5 to 31 mi) where atmospheric pressure is 15.5 and 1.5 millibars. This gas is contained in cells, one of which is located in the optical path of each channel.

Search and Rescue (SAR) (Provided by Canada and France)

The search and rescue instruments to be flown on the NOAA-E, -F, and -G satellites will provide the dual capability of detecting and locating existing Emergency Locator Transmitters /Emergency Position Indicating Radio Beacons operating at 121.5 and 243 MHz, as well as experimental ones operating at 406 MHz.

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The 121.5, 243, and 406 MHz will be received by the search and rescue instruments and broadcast in real time on an L-band frequency, which will be monitored by Local User Terminals (LUTs). Reports of locator transmitters and radio beacon signals are forwarded to mission control centers where rescue action can be initiated. The 406-MHz data will be processed and stored on the spacecraft for later transmittal to the ground stations in Alaska and Virginia, thus providing full global coverage. Because of the low power (75-mW peak), frequency instability, and various modulation schemes used, the effectiveness of the system for the existing 121.5- and 243-MHz Emergency Locator Transmitters/Emergency Position Indicating Radio Beacons cannot be determined until after launch. However, it is expected that location will be provided to an accuracy of 10 to 20 km (6.2 to 12.4 mi.). The effectiveness of the new 406-MHz system is expected to be as high as 90 percent with a location accuracy of 2 to 5 km (1 to 3 mi.). The experimental ELT/EPIRBs at 406 MHz will also provide user classification and identification, allow for a global coverage capability by providing spaceborne processing and storage, and permit user growth by providing the capability for 200 (minimum) to 400 (design global) simultaneous distress incidents within the satellite antenna field of view.

ARGOS/Data Collection System (DCS)

The ARGOS/Data Collection System, provided by France, assists NOAA in its overall environmental mission. Approximately 2,000 platforms (buoys, free-floating balloons, and remote weather stations) measure temperature, pressure and altitude, and transmit these data to the satellite. The onboard Data Collection System receives the incoming signal, measures both the frequency and relative time of occurrence of each transmission, and retransmits these data to the central processing facility. The Data Collection System information is decommutated and sent to the Centre National d'Etudes Spatials ARGOS processing center where it is processed, distributed, and stored on magentic tape for archival purposes.

COMMUNICATIONS AND DATA HANDLING

The communications subsystem uses nine separate transmission links to handle communications between the satellite and the ground stations.

Communications and data handling characteristics are:

* TIROS Information Processor (TIP)

* Flexible low-rate data formatter and telemetry processor

* Boost, orbit, and dwell modes

* 8,320 bps (orbit)

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* 16,640 bps (boost)

* Manipulated Information Rate Processor (MIRP)

* High-rate data formatter and processor

* Performs multiplexing, formatting, resolution reduction and geometric correction functions

* Analog Automatic Picture Transmission (APT):Global Area Coverage (GAC) data (66.54 kbps); high-resolution picture transmission (HRPT) data (665.4 kbps); Local Area Coverage (LAC) data (665.4 kbps) outputs.
* Digital Tape Recorder (DTR)

* Five digital data recorders

Advanced Very High-Resolution Radiometery

One of the objectives is to provide timely day and night seasurface temperature and ice, snow, and cloud information to diverse classes of users. The Advanced Very High-Resolution Radiometery is used to obtain these data. Requirements include:

* Worldwide direct readout to ground station of the Automatic Picture Transmission class, at low resolution (4 km)

* Worldwide direct readout to ground station of the high-resolution picture transmission class (1 km resolution)

* Global area coverage (GAC) of onboard data at relatively low resolution (4 km) for central processing

* Local area coverage (LAC) of onboard storage of data from selected portions of each orbit at high resolution (1 km) for central processing

Data Transmission

The sounder system data along with radiometry data will be telemetered through the TIROS Information Processor (TIP) telemetry system on NOAA-E. Data will be transmitted full resolution in the following modes:

*Worldwide direct TIP transmission - beacon link

*Worldwide direct TIP multiplexed with HRPT

*TIP multiplexed with low resolution AVHRR data stored and played back (GAC)

*TIP Multiplexed with full resolution AVHRR data stored and played back (LAC)

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*TIP-only data stored and played back during blind orbits

Command

The Command and data acquisition stations control the operation of the satellite by programmed commands transmitted to the satellite on a 148-MHz radio signal.

* Command-link bit rate: 1,000 bits per second

* Stored commands

* Table capacity: 129 commands at launch and on orbit until Stored Command Table (SCT) Extension

* Table capacity: 2,300 commands on orbit after SCT Extension (launch plus 2 days)

* Time tag: 1.0-second granularity, 36-hour clock

Ground System

A principal operating feature of the TIROS-N system is the centralized remote control of the satellite, through command and data acquistion, by the NOAA National Environmental Satellite Data and Information Service (NESDIS) Satellite Operation Control Center (SOCC). The ground system is made up of the Data Acquisition and Control Subsystem (DACS) and the central processing system designated the Data Processing Services Subsystem (DPSS).

National Environmental Satellite Data and Information Service Satellite Operation Control Center

The central operations and control center for satellite operation is located in Suitland, Md. Satellite Operation Control Center is responsible for operational control of the entire ground system. Specifically, it is responsible for the following.

Command and Data Acquisition Stations

The primary command and data acquistion stations are located at Fairbanks, Alaska, and at Wallops Station, Va. Through a cooperative agreement between NOAA/NESDIS and the Etablissement d'Etudes et de Recherches Meteorologiques (EERM) in France, stored and real time TIROS Information Processor data can be relayed from the Lannion Centre de Meteorologie Spatiale (CMS) via the GOES satellite.

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The Command and data acquistion stations transmit command programs to the satellite, acquire and record meteorological and engineering data from the satellite. All data are transmitted between CDA and Suitland via commercial communications links. Commands are transmitted between SOCC and CDA via commercial communications links.

Ground Communications

The ground communications links for satellite operations are provided by SATCOM and NASCOM. NASCOM provides any launch-unique communications links for satellite launch. This support is defined in the Network Operations Support Plan (NOSP) and the NASA Support Plan (NSP). SATCOM provides all voice and data links between the SOCC and the CDA stations after launch. SATCOM is provided and operated by the National Environmental Satellite Data and Information Service.

National Environmental Satellite Data and Information Service Data Processing Services Subsystem (DPSS)

Data Processing Services Subsystem acquires data from the Command and Data Acquisition stations via Satellite Operation Control Center and is responsible for the data processing and generation of meteorological products on a timely basis to meet the TIROS program requirements. NOAA provides all hardware and software for Data Processing Services Subsystem. NOAA will provide ephemeris data and strip-out Search and Rescue data from Manipulated Information Rate Processor/Global Area Coverage data dumps and transmit to U.S. and Canadian Search and Rescue Mission Control Centers.

Goddard Space Flight Center (GSFC) Facility Support

Office of Space Tracking and Data Systems (OSTDS) associated support is requested through the Support Instrumentation Requirements Document (SIRD), with other support as described in Memoranda of Understanding.

During launch and early orbit (approximately 24 hours), special Spacecraft Tracking and Data Network (STDN) support for telemetry reception and contingency commanding is required as described in the Support Instrumentation Requirements Document. There is a requirement for STDN to provide emergency support for TIROS spacecraft if requested during their operational lifetime, provided STDN VHF capability exists.

NORAD has prime responsibility for orbit determination, which includes establishing the initial orbit and providing routine orbital parameters throughout the life of the missions. NORAD provides determined orbital information through Goddard communications to the National Oceanic and Atmospheric Administration /Satellite Operation Control Center.

Goddard will provide nominal prelaunch orbitial and prediction information, special support for initial orbit estimation, and initial quality-control checks of the NORAD orbital data. All attitude determination is to be accomplished by the NOAA central data processing facility.

SEARCH AND RESCUE SATELLITE PROGRAM DESCRIPTION

The satellite-aided search and rescue project (COSPAS/SARSAT) is a multilateral cooperative project involving the United States, Canada, France and the Soviet Union. The goal of this humanitarian project is to demonstrate the effectiveness of satellites in reducing the time required to rescue air and maritime distress victims and increase significantly the possibility of saving lives.

Search and rescue instrumentation will be carried on three National Oceanic and Atmospheric Administration (NOAA) satellites, the first of which will be NOAA-E. Demonstration tests will be conducted with the NOAA satellites once they are in orbit. Canadian agencies are providing three transponders (one for each U.S. satellite), are establishing ground terminals in Canada and are participating in performance tests of the system. France is providing three onboard receiver/processors (one for each U.S. spacecraft), are providing a ground terminal in France and conducting performance tests in France. U.S. agencies are providing the spacecraft and integration and launch of the spacecraft, and are establishing three ground stations in the United States. They also will conduct performance tests. The NOAA-E spacecraft will be the first SARSAT equipped spacecraft.

An agreement with the Soviet Union called for interoperability between the SARSAT system and a similar Soviet system called COSPAS. The understanding established a cooperative demonstration and evaluation program which is more effective than would have been possible with either system alone.

Canada and France are together investing approximately $24 million in this project. The U.S. agencies are spending approximately $29 million (NASA $24 million; Air Force $2.5 million; and Coast Guard $2.5 million). A Soviet spokeman has said that that nation's expenitures for the project amount to "several million dollars."

The COSPAS/SARSAT partners originally had hoped for nearly simultaneous launch of SARSAT-equipped NOAA spacecraft and the Soviet COSPAS-equipped spacecraft. However, NOAA's previously launched meteorological satellites continued to operate effectively beyond their designed life time, and no replacement was necessary. As a result, the planned 1982 launch of NOAA-E was postponed, allowing the Soviets to launch their satellite first. Several successful rescue operations with the COSPAS/SARSAT system have been carried out saving lives and dramatically reducing search times and costs.

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NASA and the Canadian Department of Communications joined forces in defining a joint satellite-aided search and rescue system demonstration program in the fall of 1976. That program was expanded into a trilateral effort in December 1977 when the French Centre National d'Etudes Spatiales (CNES) joined the project. In 1980, an agreement was reached with the Ministry of Merchant Marine (MORFLOT) for the Soviet Union to become a partner in this search and rescue program.

A search and rescue satellite system uses multiple satellites in low, near-polar orbits "listening" for distress transmissions. The signals received by the satellites are relayed to a network of ground stations where the location of the emergency beacon is determined by measuring the Doppler shift between the satellite (with its precisely known orbit) and the distress signal. This information is then relayed to a rescue control center. The rescue center then begins the actual search and rescue operation.

On June 30, 1982, the Soviet Union launched Cosmos 1383, the first COSPAS satellite.

After a period of joint technical checkout which all four nations began on Sept. 1, a joint demonstration and evaluation period lasting a minimum of 15 months was started to evaluate the system's effectiveness in locating downed aircraft and distressed vessels.

In addition to the four nations involved in the COSPAS/SARSAT Project, Norway and the United Kingdom will participate in the evaluation of the system, and final negotiations with Finland are being worked on concerning its possible participation.

The rapid detection and location of downed aircraft or a ship in distress is of paramount importance to the potential survivors and to the search and rescue teams responsible for their rescue. Studies have shown that even those who survive an initial aircraft crash have less than a 10 percent chance of survival if the rescue is delayed beyond two days. In contrast, if the rescue can be accomplished within eight hours, their survival rate is better than 50 percent. Moreover, rapid location can reduce both search and rescue costs significantly and lower the length of exposure of search and rescue teams to hazardous conditions frequently encountered during these operations.

In 1970, the U.S. Congress passed a law requiring that general aviation aircraft carry an Emergency Locator Transmitter (ELT) that can be activated manually or by the typical stresses of an accident.

In 1972, the National Transportation Safety Board recommended that the Coast Guard and the Federal Communications Commission require ocean-going vessels to carry an Emergency Position Indicating Radio Beacon (EPIRB) that could be activated manually or automatically when immersed in water.

These two types of emergency beacons became the U.S. aircraft and maritime distress-alerting devices. These small, lightweight, shock-resistant, self-energizing beacons are capable of 48 hours of continuous broadcasting. They use a distinct "wow-wow" modulated tone on one or both of the emergency distress frequencies. These frequencies are 121.5 and 243 MHz. In the United States alone, there are more than 200,000 aircraft and approximately 6,000 maritime beacons installed.

The use of these automatic radio frequency distress transmitters offered the possibility of dramatically shortening the time required to alert rescue forces and locate the victims. However, for a distress transmitter to be successful, its transmitted signal must be received. International Civil Aviation Organization (ICAO) regulations require that aircraft making long flights over water monitor the distress frequencies for possible transmissions from maritime vessels. Unfortunately, no similar aircraft monitoring regulations govern flights over land.

The most significant constraint, however, has to do with basic geometry. Even if a passing aircraft is monitoring for distress signals, it will detect the transmitting beacons of downed aircraft to distressed vessels only if it is in direct line of sight to the craft. This means that unless the aircraft is within about 300 km (185 mi.) from the distress location there is little chance of detection. The effectiveness of these aircraft and ship distress systems is limited to the chance that an overflying aircraft has its distress monitor on and is near enough to the distress location to receive the signal.

Since the mid-1970s, several nations have been interested in using satellites equipped with suitable receivers to detect and locate emergency transmissions from aircraft and ships.

The COSPAS/SARSAT system concept uses low-altitude, polar orbiting satellites and ground-derived Doppler position fixing of emergency signals to locate downed aircraft and distressed ships.

The system is composed of three main subsystems: the emergency beacons, the COSPAS or SARSAT repeater/processor and the ground station. These components will be used in two different coverage modes for the detection and location of the emergency beacons operating in three frequency bands -- 121.5, 243 and 406 MHz. The two coverage modes are the regional coverage and global coverage mode.

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In the U.S. spacecraft, a repeater data system will relay 121.5, 243 and 406 MHz signals and an onboard signal processor will receive the 406 MHz signals, process and record the data for transmission to the ground both in real time and at a later time in the playback mode. At the ground station, electronic signal processing is used to separate the weak distress signals from background static, recover the Doppler information and determine the distress beacon position. The COSPAS system does not relay the 243 MHz band.

The 406 MHz distress system was specifically designed for the search and rescue mission based upon technology demonstrated by the NASA satellite data collection program. The signal also contains, as part of the transmitted tone, information as to what type aircraft or ship, the registry number and owner. A 406 MHz data processor will be on both the COSPAS and SARSAT spacecraft.

Distress 406 MHz signals are received by the satellite the same as the 121.5 and 243 MHz signals. The Doppler frequency is measured and the identification and status data are recovered. This information is time-tagged, formatted as digital data and transferred to both the repeater downlink for real-time transmissions to the ground station and recorded by the spacecraft telemetry computer for storage and later transmission to the National Oceanic and Atmospheric Administration ground stations in the case of SARSAT and to any ground station in the case of COSPAS.

The regional coverage mode is used in areas where the spacecraft is mutually visible to distress signals and ground stations, an area approximately 4,000 km (2,500 mi.) in diameter centered on the ground station location. The regional coverage data processing is performed at the ground station.

The global coverage mode provides full-earth coverage by storing data in the spacecraft on a tape recorder until it is transmitted down at the next available ground station. This enables large maritime areas out of range of ground stations to be covered. This mode only operates with the experimental 406 MHz distress signal units.

Frequency of coverage is dependent on the number of satellites in orbit. It is also latitude dependent with more frequent coverage at higher latitudes. Assuming a single satellite in operation, the maximum time between successive detections at the equator would be 12 hours. If four search and rescue equipped satellites were in operation at the same time, distress signals would be detected within a very few hours.

A fundamental requirement imposed on this demonstration project was that it work with existing emergency beacons operating at 121.5 and 243 MHz.

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Although not designed with satellite detection and location in mind, Doppler positioning, using the relative motion between the spacecraft and the ground station, serves as a practical method to determine beacon location. All that is required of the emergency beacon is that it emit a carrier frequency, with reasonable stability, during the duration of visibility. The carrier frequency stability is required for the electronic Doppler information extraction.

To optimize Doppler-positioning performance, a low-altitude polar orbit was chosen. The low altitude allows for low emergency beacon transmitter power, good Doppler -- shift characteristics and short time delays between successive passes. The polar orbit results in coverage of the whole earth.

It is important to note that two distinct experiments are being conducted which are different both in their implementation and in their projected effectiveness.

The 121.5 and 243 MHz experiment uses the existing family of emergency beacons transmitting at one or both of the frequencies. All of the present beacons were designed and implemented without consideration of potential detection by a satellite system. Because of this, the signal characteristics such as output power, frequency stability and modulation format are far from ideal for satellite detection. This rules out the use of a simple spacecraft onboard signal processor.

For the existing emergency beacons, the SARSAT equipped spacecraft are limited to serving as repeaters, for the 121.5 and 243 MHz beacons, relaying the signals to the ground stations where sophisticated signal processors can determine the Doppler shift and determine the beacon's location. The COSPAS satellite receives the 121.5 MHz frequency, but not the 243 MHz signals. This repeater system requires mutual visibility of the beacon, the spacecraft and the ground station.

U.S. and Canadian ground stations are at Kodiak, Alaska; Point Reyes, Calif.; Scott Air Force Base, Ill.; and Ottawa, Ontario. These four stations provide complete coverage of the U.S. inland and coastal regions including Alaska and very substantial Canadian coverage. France will operate a ground station at Toulouse providing coverage for Europe's inland and coastal regions, parts of North Africa and the Mediterranean. The U.S.S.R. will operate three ground stations, Moscow, Archangelsk and Vladivostok. The ground stations of all nations involved will track both COSPAS and SARSAT satellites and maintain communications through the U.S. Mission Control Center at Scott Air Force Base, located at Belleville, about 25 miles east of St. Louis, Mo.

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In spite of the limitations of the 121.5/243 MHz system, the four COSPAS/SARSAT partners expect the system will substantially improve the present emergency beacon detection and locations system by providing regular systematic coverage within the geographic areas described above and by providing location accuracies of 10 to 20 km (6 to 12 mi.).

The COSPAS/SARSAT demonstration experiment using 406 MHz is based upon technology proven over the past several years with meteorological data collection. The random access measurement system on the Nimbus spacecraft, the French "Argos," and the data collection system on the TIROS-N spacecraft have been used to demonstrate a sailboat search and rescue experiment. They also tracked the manned balloon "Double Eagle" during both the unsuccessful and successful trans-Atlantic crossing and tracked a number of sailships during a European sail race in 1979.

The 406 MHz experiment relies on beacons specifically designed to take advantage of the satellite detection system. The higher power and improved frequency stability of the 406 MHz units will have a greater performance capability than the 121.5/243 MHz system. The probability of detection of normally transmitted signals will be 95 percent greater and the location accuracy will be 2 to 5 km (1.2 to 3.1 mi.). The 406 MHz search and rescue frequency was approved during the last World Administrative Radio Conference of the International Telecommunications Union, held at Geneva, Switzerland, in 1979.

Other significant advantages of the 406 MHz system include distinguishing whether the signal is from an aircraft or vessel, its country of origin, the nature of the distress or the elapsed time since the accident, the registration of the vessel or aircraft and even, if known, the location of the emergency as determined by the vessel. This additional information is of great value to search and resuce forces in responding to the needs of the victims.

Another advantage is that the coherent carrier portion of the transmission can be processed by a spacecraft computer to accurately determine its frequency. This frequency information, along with the time of measurement and the decoded message, can then be relayed to ground stations in real time and can also be stored in spacecraft memory and transmitted to the next available ground station. This not only greatly simplifies the ground station equipment, but eliminates the requirement for mutual visibility of the spacecraft and the ground station while the distress transmission is taking place. Full global coverage, including the Arctic regions, can be achieved with a relatively small number of low cost ground stations with the 406 MHz system.

The 406 MHz system was also designed for the future to provide an even better system which combines the advantages of low-orbiting satellites with the immediate alert provided by geosynchronous satellites over many areas of the earth.

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A demonstration of that combined capability is planned using special repeaters aboard the NOAA geosynchronous GOES satellite system in the 1985 - 1986 time frame.

The United States' part of the COSPAS/SARSAT program is managed by the Communications Division of NASA's Office of Space Science and Applications. NASA Program Manager is Thomas E. McGunigal. NASA's Goddard Space Flight Center, in Greenbelt, Maryland, is responsible for the execution of the program. Bernard J. Trudell is the SARSAT Mission Manager at Goddard.

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