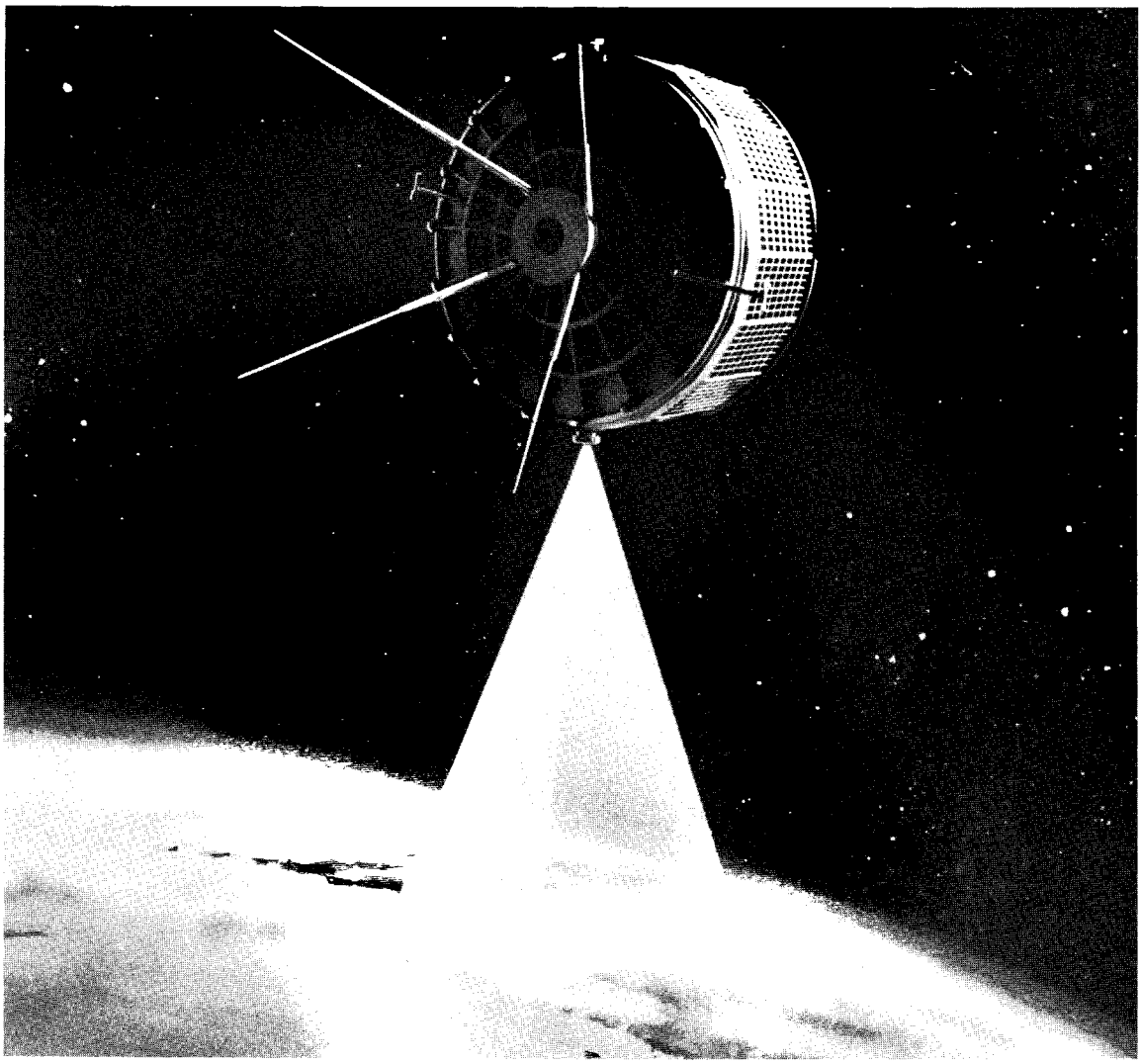
NASA FACTS

An Educational Services Publication of the
National Aeronautics and Space Administration

Vol. II, No. 12
(Replaces B-2-64)

TIROS



The TIROS IX weather satellite.

Carla . . . Donna . . . Esther . . . Flora . . .

These were destructive hurricanes which took thousands of lives and caused millions of dollars in damage.

Future counterparts, with other feminine names, will surely be as severe, but their destructive results will be minimized because people will be forewarned through information gathered by meteorological satellites in space, taking pictures of the earth's surface and cloud cover. Such warnings have enabled people in the hurricane belt to prepare themselves for high winds and water, and thus to spare lives and property. Such was the case with Carla.

The NASA weather satellite program which can detect hurricanes in their formative stages, and provide a great deal of other information useful to meteorologists is carried out with TIROS. This satellite name is an acronym for Television Infrared Observation Satellite.

Kites, balloon, airplanes and sounding rockets have been used to gather weather data from varying distances above the earth's surface, with results that were effective—sometimes even startling. But TIROS can go higher, stay aloft much longer, and perform tasks never before possible of accomplishment. TIROS orbits at about 450 miles above the earth, takes its pictures with vidicon (TV) apparatus and transmits them to earth for interpretation by meteorologists. In addition, TIROS has equipment for detecting and reporting infrared radiation reflected by the earth's atmosphere.

DEFINITIONS

(Quoted from the NASA publication SP-1, Short Glossary of Space Terms)

ACQUISITION—the process of locating the orbit of a satellite or trajectory of a space probe so that tracking or telemetry data can be gathered. Also, the process of pointing an antenna or telescope so that it is properly oriented to allow gathering of tracking or telemetry data from a satellite or space probe.

APOGEE—in an orbit about the earth, the point at which the satellite is farthest from the earth; the highest altitude reached by a sounding rocket.

AXIS—a straight line about which a body rotates, or around which a plane figure may rotate to produce a solid; a line of symmetry. Also, one of a set of reference lines for certain systems of coordinates.

COMMAND—a signal which initiates or triggers an action in the device which receives the signal.

ELECTRON—the subatomic particle that possesses the smallest known electric charge.

INFRARED—Infrared radiation; electromagnetic radiation in the wavelength interval from the red end of the visible spectrum on the lower limit to microwaves used in radar on the upper limit.

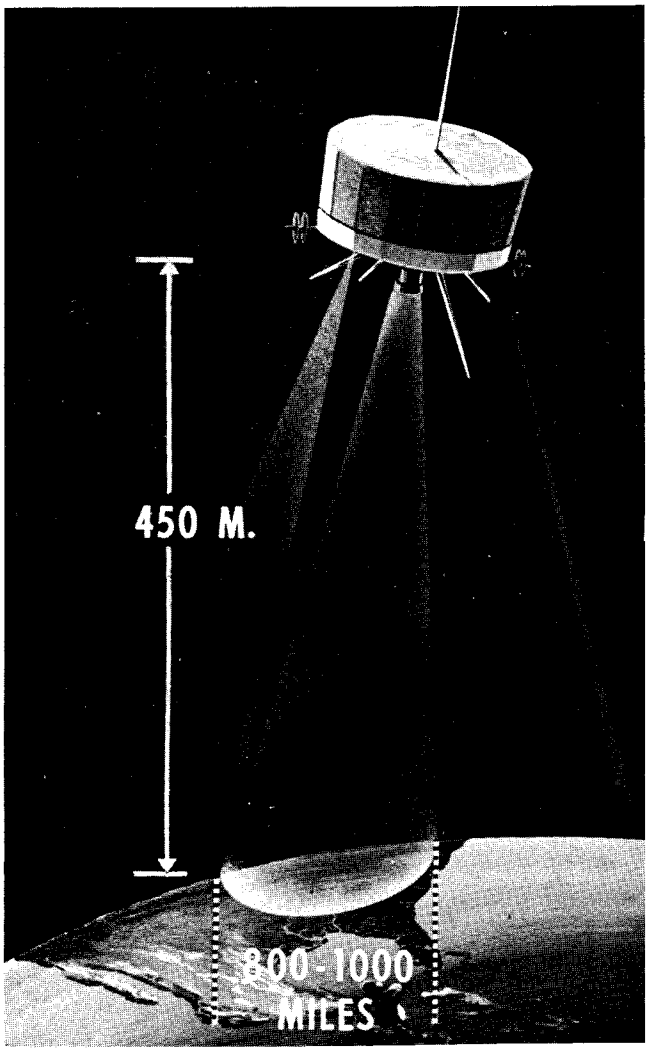
PERIGEE—that orbital point nearest the earth when the earth is the center of attraction.

READOUT—the action of a radio transmitter transmitting data either instantaneously with the acquisition of the data or by play of a magnetic tape upon which the data have been recorded.

TELEMETRY—the science of measuring a quantity or quantities, transmitting the measured value to a distant station, and there interpreting, indicating, or recording the quantities measured.

TIROS I was launched at Cape Canaveral (now Cape Kennedy) on April 1, 1960. Successor TIROS satellites have followed: TIROS II through IX and Nimbus. (See Nasa Facts, Nimbus, Vol. II No. 7.)

Operating in a near-circular orbit more than 400 miles above the earth (apogee, 461 miles, perigee, 436 miles) TIROS I made meteorological history by giving meteorologists an unprecedented opportunity to study the earth's cloud patterns and relate them to the weather. Among the striking patterns seen for the first time in their entirety



Artist's concept illustrates TIROS I through VIII

TIROS has various sensors, or sensing elements, which "sense" information and convert it into signals which can be measured. These include two TV cameras to photograph cloud cover; a multi-channel scanning radiometer to observe water vapor, night clouds, reflected sunshine, emitted heat and loud resolution cloud mapping; and non-scanning radiometers to measure total radiation and thermal radiation.

were large-scale cyclones with spiral bands sometimes covering areas a thousand miles across.

Photographs transmitted by the satellite's two television cameras also indicated the presence of jet streams (currents of air blowing at speeds of 200 miles an hour or more, at high altitudes) regions of moist and dry air, thunderstorms, weather fronts, and many types of cloud patterns.

TIROS I stopped transmitting about midnight of June 29, 1960, after 1,302 orbits of the earth, when its power supply failed. It had transmitted 22,592 pictures.

HURRICANE DETECTION

What does early detection of a hurricane mean in terms of saving lives?

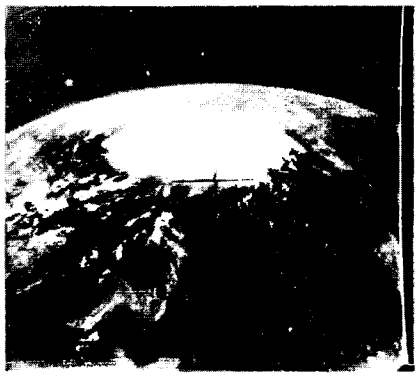
Information from TIROS III in September of 1961 gave warning of Hurricane Carla in time to make possible the largest mass evacuation ever to take place in the United States. More than 350,000 people fled from the path of the storm and a relatively small number of deaths was attributable to Carla as it swept across the country.

President Lyndon B. Johnson, when he was Vice President and chairman of the National Aeronautics and Space Council, estimated the following national cost savings, based on the accurate predictions of weather only five days in advance include:

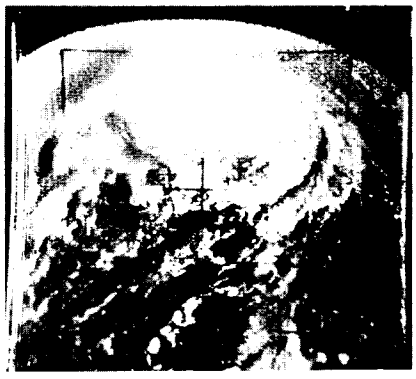
$2.5 billion a year to agriculture.
$45 million to the lumber industry.
$100 million to surface transportation.
$75 million to retail marketing.
$4 billion in water resources management.

TIROS III HURRICANE DATA

ANNA

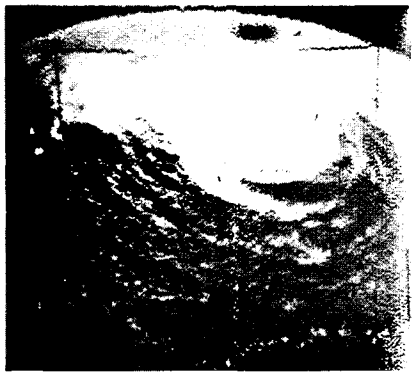


BETSY



CARLA

DEBBIE

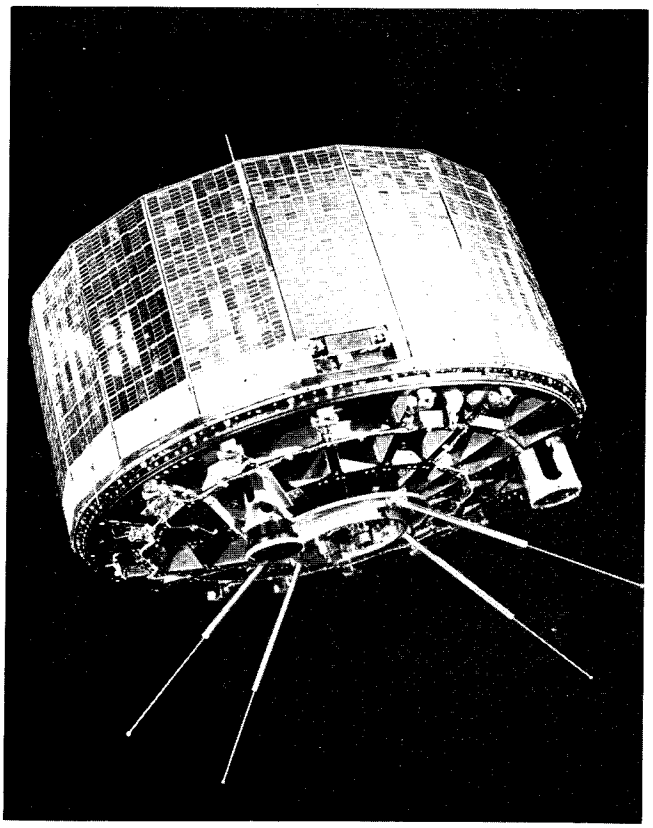


ESTHER

Pictures of hurricanes taken by TIROS.

THE TIROS SYSTEM

The TIROS satellite is a cylindrical, 300-pound, 18-sided polygon resembling a bass drum or an oversized hat box. It stands 22 inches high and measures 42 inches in diameter. Its sides and top are covered with more than 9,000 solar cells which, when exposed to the sun's rays, produce electrical power to recharge the satellite's 63 nickel-cadmium batteries.

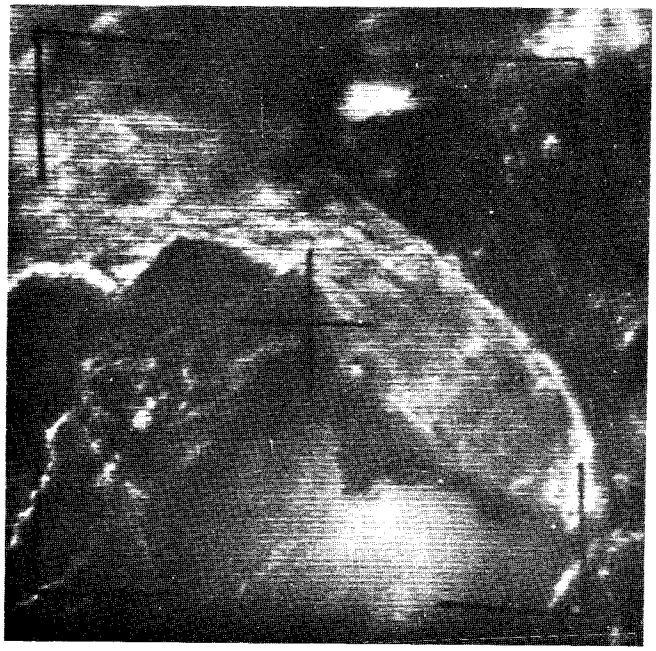


A diagram of a standard TIROS configuration.

Protruding from the top of the satellite is an 18-inch receiving antenna through which it receives commands from ground stations. At the bottom, four 22-inch transmitting whip antennas are spaced at 90-degree intervals. Through these antennas the satellite's transmitters relay TV pictures, infrared data and telemetry information relating to spacecraft temperature, pressure, battery charge levels, spin rate and so forth.

TV CAMERAS

Two independent television camera systems, capable of separate or simultaneous operation, make up the heart of the TIROS satellite. These cameras are aligned parallel to the satellite's spin axis and extend several inches below the baseplate. Each camera system consists of a vidicon tube and a focal plane shutter which permits pictures to be stored temporarily on the tube face plate for a brief period.



Florida during the time of Gordon Cooper's flight in Faith 7.

The Great Lakes region as seen by TIROS.

An electron tube beam converts a stored picture into a TV-type electronic signal which is transmitted to a ground station or processed on a magnetic tape recorder from which it is sent to earth at a later time, when the satellite is within a 1,500 mile radius of a Command and Data Acquisition station.

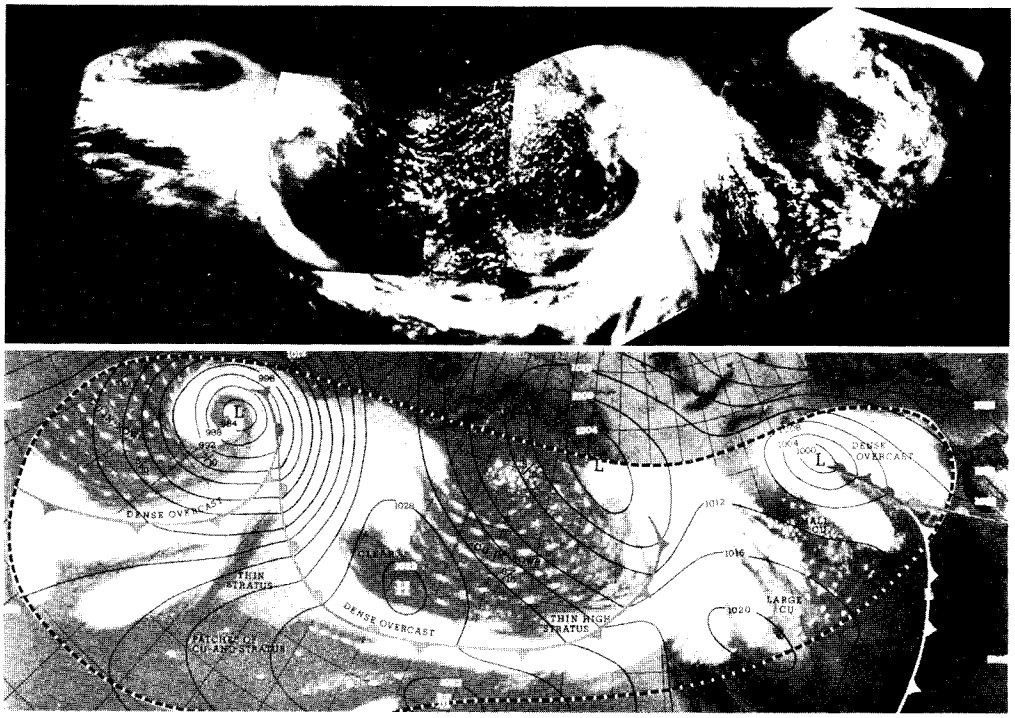
Up to 64 pictures—32 on each tape—can be recorded and stored by TIROS during each orbit. "Read-out," or sending, which takes about three minutes, is accomplished at a ground station by radio command. This process automatically erases the tapes which are then rewound and ready for use as the satellite begins another orbit around the world.

Operation of the cameras, by direct read-out or magnetic tape storage techniques, is based on radio commands relayed from a ground station. These commands set timers in the satellite which activate the camera system when the satellite passes over an area from which cloud cover pictures are desired.

COMMAND AND DATA ACQUISITION STATIONS

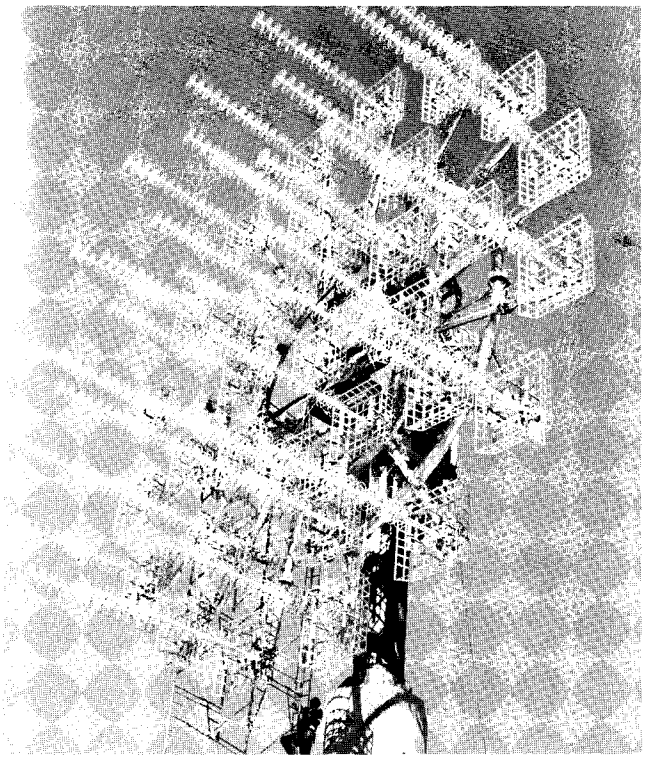
Three Command Data Acquisition Stations, the NASA Wallops Island Station, Wallops Island, Virginia, the Pacific Missile Range Station, on San Nicolas Island, California and the Alaska Station at Fairbanks, Alaska, support the TIROS project. TV pictures from the satellite are flashed on special screens and photographed by 35 mm. cameras at these ground stations. Meteorologists analyze the photographic data almost immediately.

MOSAIC OF TIROS PHOTOGRAPHS



WEATHER MAP, MAY 20, 1960, WITH TIROS CLOUD DATA

A mosaic of cloud pictures, and a weather map based upon it.



This antenna at Wallops Island, Virginia, receives signals from TIROS.

CONTROL CENTER

The TIROS Technical Control Center at the Goddard Space Flight Center, Greenbelt, Maryland, monitors operations of the satellite once orbit has been achieved. This Center directs the TIROS command and data acquisition network and monitors the spacecraft and the performance of the three TIROS Command and Data Acquisition Stations.

EXPERIMENTS

In addition to television observations of cloud cover, TIROS obtains measurements of infrared radiation. This is invisible heat radiation, or radiant heat, comprised of rays similar to visible light, but below the red band of the visible light spectrum. Instruments for making infrared measurements are called radiometers.

The infrared detectors carried by TIROS take readings to provide information on how the sun's energy is absorbed and reflected by the earth's atmosphere. The equipment records data on tiny tape recorders for playback on command by a ground station.

Since the amount of infrared radiation received by the earth from the sun is fairly well known, the measurements by TIROS of energy reflected and radiated back into space enable scientists to estimate the amount retained to produce or affect weather.

The infrared observations are transmitted as data—not pictures—and must be reduced, analyzed, and plotted on maps to be interpreted. Hence, they are not useful for operational weather observation in the same manner as the TV pictures. But they are of great significance for scientific studies. Also, the infrared experiments are part of a continuing program to develop techniques for data collection for use in preparation of infrared nighttime cloud cover maps to supplement the daytime TV picture data.

DATA UTILIZATION

Each of the three TIROS ground stations has meteorologists on site as an integral part of the station team, responsible for making rapid analyses of the TIROS TV picture.

These analyses are transferred to a map chart (nephanalysis) in the form of graphic identifications of the cloud elements observed, and transmitted to the National Weather Satellite Center via the Goddard Space Flight Center.

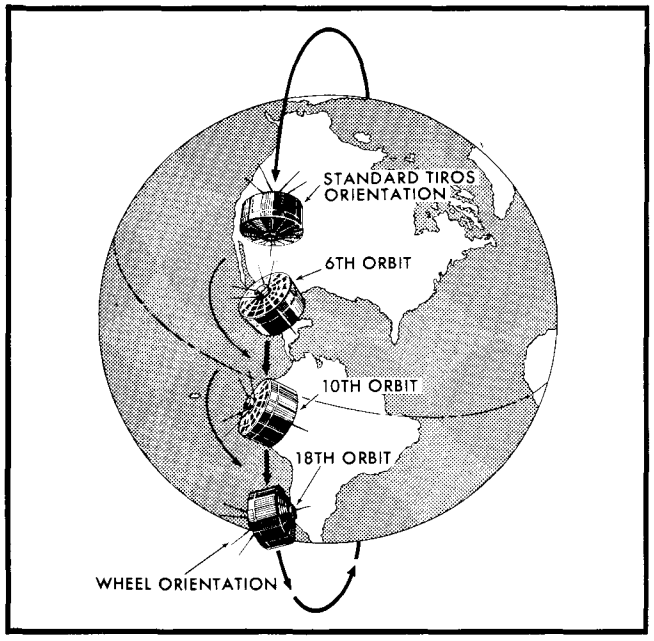
The nephanalyses are checked for quality, then are redrawn and transmitted to about 600 recipients in the U.S. They are retransmitted from points on the west, east, and southwest U.S. coasts, to the Far East, Europe and South America.

TIROS IX

TIROS IX, launched January 22, 1965, provides complete coverage of the earth compared to the 25 percent coverage provided by earlier TIROS craft. TIROS IX is the forerunner of the joint NASA–U.S. Weather Bureau TIROS Operational System (TOS).

Several innovations are responsible for the improvement in coverage made possible by TIROS IX. One is the location of two cameras viewing in opposite directions from the satellite's curved outer rim. In orbit, TIROS IX is tilted on its curved side so that it resembles a cartwheel rolling along an imaginary track. The cameras take pictures when they are aimed at earth.

Another innovation is the launch of TIROS IX into a near-polar, or north-south, orbit. Such an orbit provides global coverage because of the satellite's movement and the earth's rotation. Earlier TIROS satellites were launched into east-west orbits. Moreover, the orbit of TIROS IX is nearly sun-synchronous. This means that the precession, or normal westward drift of the orbit, is so paced that the sun is always behind TIROS IX during daylight, or northward, passes, thus providing ideal photographic lighting conditions.



Sketch shows how TIROS IX turned on its side to roll through space like a slow-turning wheel.

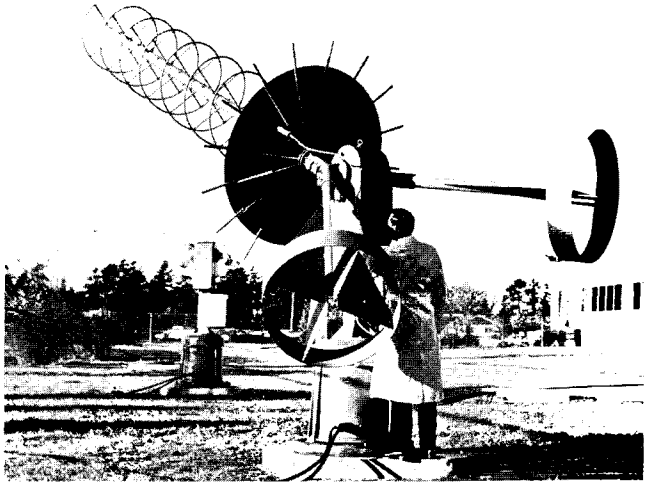
AUTOMATIC PICTURE TRANSMISSION (APT)

A new "automatic picture transmission" system (APT) is being successfully tested on TIROS VIII and IX.

Unlike the transmission system carried in the early TIROS satellites which displayed each TV line on a tube, built a picture on a screen, and then photographed the screen, the APT system transmits pictures by a process similar to that used to send radio photographs. These pictures will appear on facsimile machines as they are received.

When this photo system becomes operational it will provide cloud-cover pictures at relatively low-cost to ground stations anywhere in the world, whenever a satellite is within radio range.

Cost of a typical ground station equipment for the APT system, which consists simply of a receiving antenna and amplifier, an FM receiver and the facsimile recording equipment, is about $30,000.



The antenna for the new Automatic Picture Transmission system.

TIROS LIFETIME

Original useful life expectancy of TIROS satellites was about three to four months. However, all but the first TIROS have exceeded this life span, providing research and development knowledge for NASA and cloud-cover photos for use by the U.S. Weather Bureau in daily operations. TIROS I operated 2½ months, TIROS II, 10 months, TIROS III and IV, 4½ months, TIROS V, 10½ months, TIROS VI, 13 months. TIROS VII, launched June 19, 1963, and TIROS VIII, December 21, 1963, were still operating when this was written.

TIROS satellites took approximately 300,000 photos during the first three years of operation.

DELTA LAUNCH VEHICLE

TIROS is launched by the 90-foot, 57-ton, three-stage Delta booster. The nation's most reliable space booster, Delta scored 21 straight launch successes from 1960 to 1963.

The Delta first stage is the DM–21 Thor, a 57-foot, liquid-fueled rocket which generates approximately 170,000 pounds of thrust during its burning time of two minutes and twenty-five seconds.

The liquid-fueled second stage produces about 7,500 pounds of thrust for 160 seconds. The TIROS mission calls for Delta to coast for about six minutes following second stage burnout.

The Delta third stage is a solid fuel, 3,000 pound thrust engine, which burns about 40 seconds.

HURRICANES

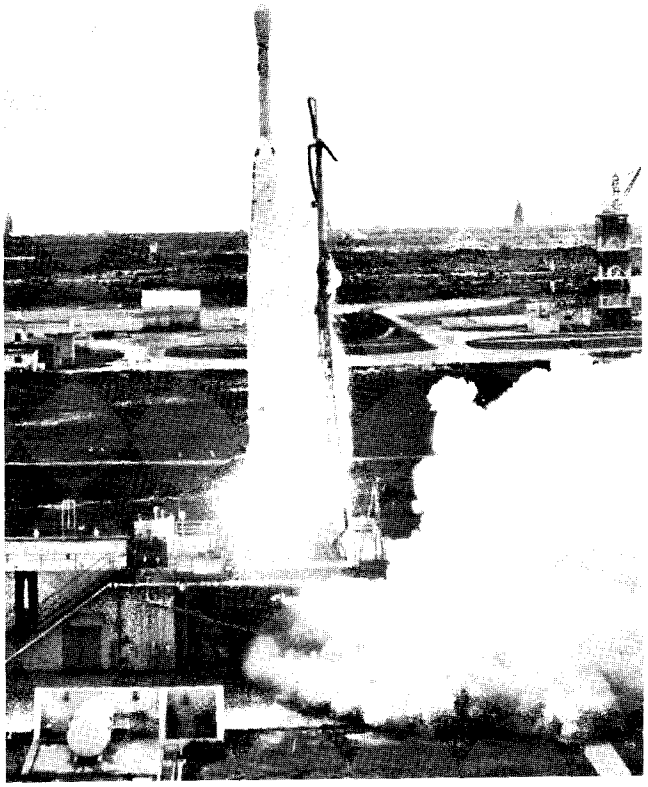
Any intense storm originating in the tropics which has winds of 74 miles per hour or stronger is considered a hurricane. If the strongest winds are less than 74 miles per hour, it is called a tropical storm.

Although meteorologists don't know just how a hurricane is formed it is believed that large bodies of warm, moist air are the breeding grounds for hurricane development. Tropical oceans near the equator which have these characteristics are the Atlantic near the Cape Verde Islands, just off the westernmost tip of Africa, the Caribbean Sea and the Gulf of Mexico.

Most of the hurricanes which affect North America occur during the months of August, September and October.

The highest wind speed observed during a hurricane was 186 miles per hour recorded in New England in 1938. However, wind damage indicates that speed in excess of 200 miles per hour have occurred. Winds of 90 and 100 miles per hour are fairly common in well-developed hurricanes.

A Delta launch vehicle at lift off with TIROS.



NASA FACTS format is designed for bulletin-board display uncut, or for 8 x 10½ looseleaf notebook insertion when cut along dotted lines and folded along solid lines. For notebook ring insertion, punch at solid dots in the margins.

NASA FACTS is an educational publication of NASA's Educational Programs and Services Office. It will be mailed to addressees who request it from: NASA, Educational Publications Distribution Center, AFEE–1, Washington, D.C., 20546.

U.S. GOVERNMENT PRINTING OFFICE : 1965 OF—766-057

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 – Price 15 cents per copy