Polar-Orbiting Weather Satellites

Donald W. Hillger

In a previous article, the author presented a synopsis of current-series geostationary weather satellites. Geostationary satellites, in order to have a 24-hour period, orbit at an altitude of about 36,000 km above the earth. This article covers another type of weather satellite, those which orbit at much lower altitudes, typically between 800 km and 1200 km above the earth. (For comparison, the Space Shuttle orbits at an altitude of between 250 km and 300 km above the earth.)

These lower-altitude weather satellites typically orbit in a plane with an angle of about 99 degrees. (The Space Shuttle for comparison, typically has an orbital plane inclined less than 57 degrees to the equator.) As a result, these satellites pass over the earth's polar regions and are thus called polar-orbiting satellites. This angle, being greater than 90 degrees, signifies that the satellite has an orbit in which the satellite moves in the opposite direction to the earth's rotation on its axis. Such an orbit allows the satellite to orbit in synchronization with the sun. Such satellites are called sun-synchronous, and they view the earth with the sun at a constant angle with respect to the satellite every day throughout the year. The angle relative to the sun depends on the satellite equator-crossing time, which is chosen at the time of launch of the satellite. A satellite in sun-synchronous orbit passes over and views all portions of the earth as the earth rotates underneath the satellite. Each orbit consists of two parts: an ascending (northward bound) pass; and a descending (southward bound) pass on the opposite side of the earth only a few minutes later. However, the parts of the earth being viewed below the satellite are 12 hours apart in local solar time.

Images and other data collected by polar-orbiting satellites complement the data collected by geostationary satellites. Due to their lower orbit, images from polar-orbiting satellites more clearly depict features on the earth than do images from most geostationary satellites. Also, because of the highly-inclined polar orbit, data is available over the polar regions, unlike imagery from geostationary satellites which orbit only over the equator. Geostationary satellites typically don't view the earth well at latitudes greater than about 60 degrees due to the curvature of the earth.

In the United States, the current-series of civilian polar-orbiting weather satellites are called NOAA for the National Oceanic and Atmospheric Administration, the agency that operates these satellites. At any time there are two operational NOAA satellites, one satellite with a morning (AM) equator-crossing time, and the other satellite with an afternoon (PM) equator-crossing time. At this time, the two operational polar satellites are NOAA-12 and NOAA-14, launched in 1991 and 1994 respectively. With these two polar-orbiting satellites, any location on the earth is viewed four times each day, two times from each satellite within each 24 hours, or approximately every six hours due to the staggered equator-crossing times of the satellites.

Images from NOAA satellites are taken in five spectral bands (one visible channel and four infrared channels) each at about one km resolution at the ground. In addition to

SARSAT and COSPAS Satellites
Russia (*Scott* 5603)

imagery, information is also collected in 20 spectral bands that are used to determine the temperature and moisture structure of the atmosphere. These spectral channels are used to 'sound' the depth of the atmosphere. Such instruments are called sounding instruments.

Meteor Satellites Have Two Solar Panels
German Democratic Republic (*Scott* 1364)

Another 4-channel microwave sounding instrument at even lower resolution sends down data for use in cloudy situations where infrared measurements are unable to measure below the clouds.

In addition to the high resolution images, NOAA satellites also transmit lower-resolution visible and infrared imagery in a mode called APT, or Automatic Picture Transmission. This imagery can be picked up anywhere on the earth with much less expensive receiving equipment. This lower-resolution imagery is available to any country or user without the expense required to receive the higher-resolution NOAA imagery that is only available to users who can afford more expensive receiving equipment.

Current third-generation NOAA satellites are featured on four known postage stamps given in the table at the end of this article. The NOAA series has maintained a similar look since 1978, with a single large solar panel extending out from the spacecraft body, although the satellites have grown larger and the sensors have improved over the years. In 1981 Taiwan issued the first and one of the better representations of the current NOAA series on a stamp (*Scott* 2221). The acronym TIROS is occasionally used for these satellites, a flashback to first-generation polar-orbiting satellites which were given the name Television and InfraRed Observation Satellites.

Another important, although secondary, function of current NOAA meteorological satellites is Search And Rescue Satellite Aided Tracking (SARSAT). The SARSAT payload package has been on all NOAA polar-orbiting satellites since NOAA-9 was launched in 1984. The SARSAT system relays distress signals from ground transmitters on downed aircraft and disabled ships. The Soviet equivalent of SARSAT goes by the Russian acronym COSPAS. A souvenir sheet issued by Russia in 1987 (*Scott* 5603) shows both a NOAA satellite (in the margin) and a Russian COSPAS-dedicated satellite within the perforated portion of the sheet.

In addition to U.S. civilian weather satellites, the Department of Defense (DoD) has its own series of weather satellites named DMSP for the Defense Meteorological Satellite Program. These satellites are basically similar to the NOAA series of satellites, but with different equator-crossing times. These military satellites are primarily used to locate cloud-free regions for further surveillance by military spy satellites, and for meteorological analysis and forecasting purposes by the Air Force. The two current primary DMSP satellites are designated F12 and F13, launched in 1994 and 1995 respectively.

Instruments on DMSP satellites are somewhat different than on NOAA satellites. The primary instrument takes visible and infrared images. DMSP spacecraft also carry lower-resolution multi-channel sounding and imaging instruments that measure in the thermal infrared and microwave spectral regions.

No postage stamps are known to show the DMSP series of weather satellites specifically, although it would be hard to distinguish current DMSP satellites from similar-looking NOAA satellites since they are built by the same manufacturer. At some point in the near future, a convergence of the civilian and military meteorological satellite programs will take place. A single, combined satellite series will serve both civilian and military purposes, requiring fewer total satellites and saving taxpayer dollars.

The Russian Federation has a series of polar-orbiting satellites called Meteor. The current operational satellites are Meteor 3-5, a third-generation weather satellite, and Meteor 2-21, a second-generation satellite that is still functional. Meteor satellites, unlike most other weather satellites, are not in sun-synchronous orbits. As a result they view the earth at different local solar times each day. Meteor satellites transmit both high-resolution imagery and lower-resolution APT-type imagery, in a manner similar to NOAA satellites.

Meteor satellites are featured on 18 known postage stamps, listed in the table at the end of this article. In 1983 Cuba issued one of the many stamps (*Scott* 2587), most from former Soviet block countries, featuring the extensive three generations of Meteor satellites begun in 1969. A miniature sheet issued by East Germany in 1972 (*Scott* 1364) gives the best representation of a Meteor satellite on a stamp. All Meteor satellites have two symmetric solar panels, one on each side of the main cylindrical satellite body. A small umbrella-like antenna is also a feature on nearly every stamp showing a Meteor satellite. The basic design has changed only slightly over the years when new generations of Meteor satellites were introduced.

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Meteor Polar-Orbiting Satellite
Cuba (*Scott* 2587)

NOAA (TIROS) Polar-Orbiting Satellite
Republic of China (*Scott* 2221)

The most recent polar-orbiting satellite belonging to the People's Republic of China is FY-1B, launched in 1990. This is China's second polar-orbiting weather satellite, a follow-on to FY-1A launched in 1988. FY is the acronym for Feng-Yun or wind-cloud. Neither satellite is providing operational weather images nor usable data at this time. China's next polar-orbiting satellite, FY-1C, is expected to be launched in 1998. It will carry a multi-channel (visible and infrared) imager, but no sounding instrument. No postage stamps are known to show any of the Chinese FY-series of weather satellites.

India has a long series of sun-synchronous polar-orbiting satellites called IRS for Indian Remote Sensing satellites. The most recent launches were of a second-generation IRS-1C in 1995 and a very similar IRS-P3 in 1996. Imaging instruments on these satellites measure in four spectral channels, mainly in the visible and near infrared portions of the electromagnetic spectrum. Ground resolution is much better than most current-series weather satellites. Only one postage stamp, issued by India in 1991 (*Scott* 1352), is known to show an IRS satellite.

Finally, the newest polar-orbiting weather satellite comes from Japan. Japan has long had several geostationary meteorological satellites, but with the launch of ADEOS-1 in August 1996, Japan began a series of polar-orbiting weather satellites. ADEOS is an acronym for ADvanced Earth Observation Satellite. Numerous instruments provided by several countries measure at higher ground resolution than most polar-orbiting satellites. Both imagery and other data from this satellite will aid researchers the world over in their understanding of our earth's environment. No postage stamps are known to show this satellite, but keep on the lookout for this satellite to appear on a stamp from any of several countries.

Indian Remote Sensing Satellite
India (*Scott* 1352)

Polar-orbiting Weather Satellites

Country	Scott	Year	Satellite
China (Taiwan)	2221	1981	TIROS-N/NOAA
Cuba	2324	1980	Meteor
Cuba	2502	1982	Meteor
Cuba	2587	1983	Meteor
Czechoslovakia	2304	1980	Meteor
French Antarctica	C114	1991	NOAA
Germany (East)	1364ss	1972	Meteor
Germany (East)	1900	1978	Meteor
India	1352	1991	IRS
Korea (North)	Mi2524	1984	Meteor
Laos	784	1987	Meteor (Cosmos)
Madagascar	969	1990	NOAA
Mongolia	C78	1976	Meteor
Mongolia	C90	1977	Meteor
Mongolia	1686	1988	Meteor
Nicaragua	1657	1987	Meteor
Romania	2422	1973	Meteor
Russia	3860	1971	Meteor
Russia	4175	1974	Meteor
Russia	4665	1978	Meteor
Russia	5298	1984	Meteor
Russia	5299ss	1984	Meteor (in margin)
Russia	5603ss	1987	NOAA (in margin)

Mi = *Michel* number (No *Scott* number exists)

In conclusion, a list is provided of all known postage stamps showing current-series polar-orbiting weather satellites. The author would appreciate knowing of any additional stamps that may have been missed. This list does not include the numerous polar-orbiting satellites whose primary purpose is to view earth resources.•

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