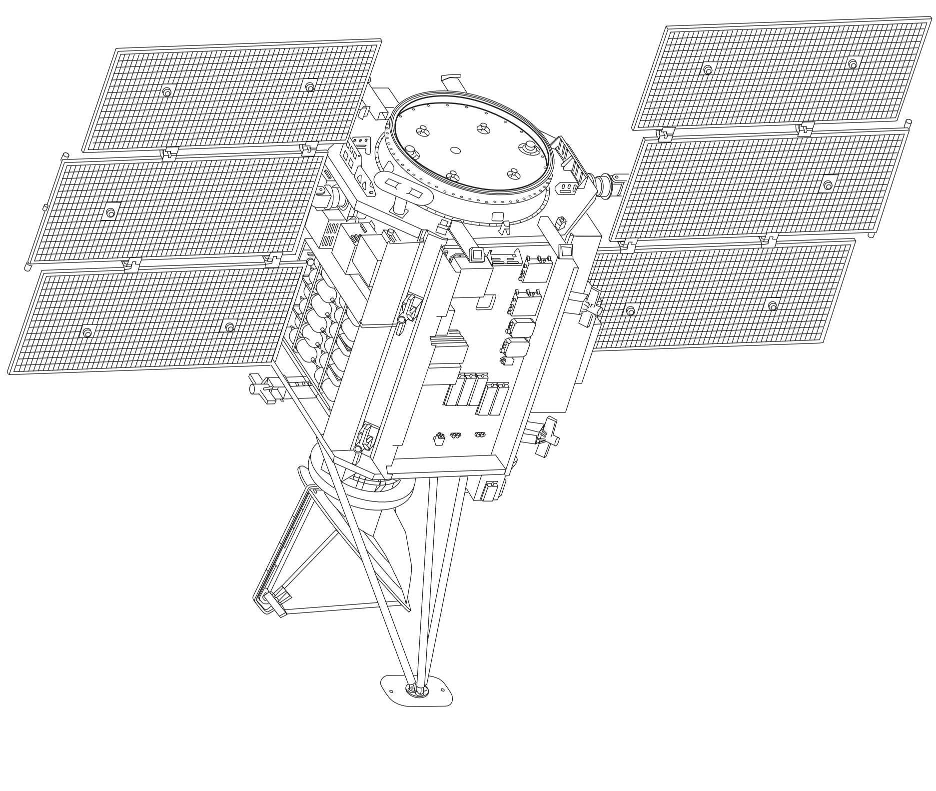
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Quick Scatterometer Launch

Press Kit
June 1999



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RELEASE:

NASA'S NEW OCEAN-OBSERVING SATELLITE SET TO CHASE THE WIND

Built in record time in just 12 months, QuikScat, NASA's new ocean-observing satellite, will be launched on a Titan II rocket from California's Vandenberg Air Force Base at 7:15 p.m. Pacific Daylight Time on June 18. This satellite will be NASA's next "El Niño watcher" and will be used to better understand global weather abnormalities.

The Quick Scatterometer, or QuikScat, will provide climatologists, meteorologists and oceanographers with daily, detailed snapshots of ocean winds as they swirl above the world's oceans. The mission will greatly improve weather forecasting.

Winds play a major role in every aspect of weather on Earth. They directly affect the turbulent exchanges of heat, moisture and greenhouse gases between Earth's atmosphere and the ocean. To better understand their impact on oceans and improve weather forecasting, the satellite carries a state-of-the-art radar instrument called a scatterometer into orbit for a two-year science mission.

"Knowledge about which way the wind blows and how hard is it blowing may seem simple, but this kind of information is actually a critical tool in improved weather forecasting, early storm detection and identifying subtle changes in global climate," said Dr. Ghassem Asrar, associate administrator of NASA's Office of Earth Science, Washington, DC.

The mission will help Earth scientists determine the location, structure and strength of severe marine storms – hurricanes in the Atlantic, typhoons near Asia and mid-latitude cyclones worldwide – which are among the most destructive of all natural phenomena. The National Oceanic and Atmospheric Administration (NOAA), a chief partner in the QuikScat mission, will use mission data for improved weather forecasting and storm warning, helping forecasters to more accurately determine the paths and intensities of tropical storms and hurricanes.

As NASA's next "El Niño watcher," QuikScat will be used to better understand global El Niño and La Niña weather abnormalities. Changes in the winds over the equatorial Pacific Ocean are a key component of the El Niño/La Niña phenomenon. QuikScat will be able to track changes in the trade winds along the equator.

Scatterometers operate by transmitting high-frequency microwave pulses to the ocean surface and measuring the "backscattered" or echoed radar pulses bounced back to the satellite. The instrument senses ripples caused by winds near the ocean's surface, from which scientists can compute the winds' speed and direction. The instruments can acquire hundreds of times more observations of surface wind velocity each day than can ships and buoys, and are the only remote-sensing systems able to provide continuous, accurate and high-resolution measurements of both wind speeds and direction regardless of weather conditions.

The satellite is the first obtained under NASA's Indefinite Delivery/Indefinite Quantity program for rapid delivery of satellite core systems. The procurement method provides NASA with a faster, better and cheaper method for the purchase of satellite systems through a "catalog," allowing for shorter turnaround time from mission conception to launch. Total mission cost for QuikScat is $93 million.

Fifteen times a day, the satellite will beam down collected science data to NASA ground stations, which will relay them to scientists and weather forecasters. SeaWinds will provide ocean wind coverage to an international team of climate specialists, oceanographers and meteorologists interested in discovering the secrets of climate patterns and improving the speed with which emergency preparedness agencies can respond to fast-moving weather fronts, floods, hurricanes, tsunamis and other natural disasters.

By combining QuikScat’s wind data with information on ocean height from another ocean-observing satellite, the joint NASA-French TOPEX/Poseidon mission, scientists will be able to obtain a more complete, near-real-time look at wind patterns and their effects on ocean waves and currents, said Dr. Timothy Liu, QuikScat project scientist at NASA’s Jet Propulsion Laboratory, Pasadena, CA. He added that QuikScat will complement data being collected by other Earth-monitoring satellites such as NASA's currently orbiting Tropical Rain Measurement Mission (TRMM) and Terra, which will be launched later this year.

The 1,910-pound (870-kilogram) QuikScat satellite, provided by Ball Aerospace & Technologies Corp., Boulder, CO, with its 450-pound (200-kilogram) radar instrument, called SeaWinds, will be placed in a circular, near-polar orbit with a ground speed of 14,750 miles per hour (6.6 kilometers per second). The satellite will circle Earth every 101 minutes at an altitude of 500 miles (800 kilometers).

QuikScat is managed for NASA’s Office of Earth Science, Washington, DC, by the Jet Propulsion Laboratory, which also built the Seawinds radar instrument and will provide ground science processing systems. NASA's Goddard Space Flight Center, Greenbelt, MD, managed development of the satellite, designed and built by Ball Aerospace & Technologies Corp., Boulder, CO.

NASA's Earth Sciences Enterprise is a long-term research and technology program designed to examine Earth's land, oceans, atmosphere, ice and life as a total integrated system. JPL is a division of the California Institute of Technology, Pasadena, CA.

[End of General Release]

Media Services Information

NASA Television Transmission

NASA Television is broadcast on the satellite GE-2, transponder 9C, C band, 85 degrees west longitude, frequency 3880.0 MHz, vertical polarization, audio monaural at 6.8 MHz. The schedule for television transmissions for the QuikScat launch will be available from the Jet Propulsion Laboratory, Pasadena, CA; Johnson Space Center, Houston, TX; Kennedy Space Center, FL, and NASA Headquarters, Washington, DC; and also on the Internet at **http://www.nasa.gov/ntv** .

Status Reports

Status reports on mission activities for QuikScat will be issued by the Jet Propulsion Laboratory's Media Relations Office. They may be accessed online as noted below. Audio status reports are available by calling (800) 391-6654 or (818) 354-4210.

Launch Media Credentialing

Requests to cover the QuikScat launch must be sent in advance to the Public Affairs Office, 30th Space Wing, Vandenberg Air Force Base, by fax to (805) 606-8303 or by email to cherryj@vafb3.vafb.af.mil or knowlest@vafb3.vafb.af.mil. Fax requests must be on the letterhead of the news organization and must specify the editor making the assignment to cover the launch.

Briefings

An overview of the mission will be presented in a news briefing broadcast on NASA Television originating from NASA Headquarters in Washington, DC, at 2 p.m. EDT June 3, 1999. A pre-launch briefing at Vandenberg Air Force Base will be scheduled the day before launch.

Internet Information

Information on QuikScat, including an electronic copy of this press kit, press releases, fact sheets, status reports and images, is available from the Jet Propulsion Laboratory's World Wide Web home page at **http://www.jpl.nasa.gov/quikscat** . The QuikScat mission also maintains a home page at **http://winds.jpl.nasa.gov/missions/quikscat/quikindex.html** . The home page for NASA's Office of Earth Science is at **http://www.earth.nasa.gov** .

Quick Facts

QuikScat Satellite
Dimensions: Main bus 6.3 feet (2.2 meters) by 4.9 feet (1.7 meter) by 4 feet (1.4 meter); radar extends 3.7 feet (1.3 meter) from main bus; total wingspan from tip to tip of solar arrays 11 feet (3.8 meters)
Weight: 2,140 pounds (970 kilograms) total, consisting of 1,914-pound (870-kilogram) satellite (including radar instrument) and 167 pounds (76 kilograms) of thruster propellant
Power: Solar panels providing 642 watts

SeaWinds Instrument
Radar: 110-watt pulse at frequency of 13.4 gigahertz, transmitted and received by 39-inch-diameter (1-meter) rotating dish antenna
Weight: 440 pounds (200 kilograms)
Power consumption: 220 watts
Science data rate: 40 kilobits per second average
Coverage: 1,120-mile (1,800-kilometer) swath during each orbit, covering about 90 percent of Earth's oceans every day
Measurements: Wind speeds between 7 and 45 miles per hour (3 to 20 meters per second), with an accuracy of about 4.5 miles per hour (2 meters per second); also wind direction, with an accuracy of 20 degrees

Launch Vehicle
Type: Titan II two-stage liquid-fuel rocket

Mission
Launch: June 18, 1999 from Vandenberg Air Force Base, CA
Daily launch opportunity: 10-minute window opens at 7:15 p.m. Pacific Daylight Time
Primary mission: Two years
Orbit path: Circular 500-mile-altitude (800-kilometer) crossing close to Earth's north and south poles at an inclination of 98.6 degrees; completes one orbit every 101 minutes

Program
Cost: $71 million total (not including launch vehicle), consisting of $39 million for satellite; $13 for radar instrument; $19 million for mission/science operations and other costs

Why Study Ocean Winds?

The Quick Scatterometer, or QuikScat, satellite is a near-term solution to learning about ocean circulation, wind speed and wind directional patterns.

Current knowledge of ocean surface winds is sketchy, coming mostly from localized, infrequent and often inaccurate reports from ships. Earth-orbiting radar instruments called scatterometers are the only remote-sensing instruments capable of measuring wind speed and direction across the globe under all weather conditions. These instruments emit radar pulses which are reflected, or “backscattered,” by rippling wave patterns on ocean surfaces. Automatic analysis of the reflected signal can reveal the speed and direction of the winds that created the ocean rippling.

QuikScat’s radar instrument, called SeaWinds, will map wind speed and direction across 90 percent of the Earth's ice-free oceans, assembling a picture of the entire globe once every two days. By combining wind data from QuikScat with ocean height data from another satellite, the joint NASA-French TOPEX/Poseidon, Earth scientists will be able to obtain a more complete, near real-time look at wind patterns and their effects on ocean waves and currents.

How Scatterometers Work

Scatterometry has its roots in early radar equipment used in World War II. In the 1950s and 1960s, radar operators on naval and merchant ships experienced a troublesome phenomenon called "sea clutter." Appearing on radar screens as noise that obscured small boats or low-flying aircraft, this clutter was in fact radar pulses returned from the ocean surface. Radar reflection or backscattering was caused by the interaction of the radar signal with wind-blown, rippling waves, also called "cat's paws," on the ocean's surface, each about 1/2 to 1-1/2 inch (1 to 3 centimeters) in height. While electronics were developed to reduce this interference in conventional radar, researchers realized that radar instruments could be customized to take advantage of this backscattering.

In the 1960s, scientists established a link between such ocean waves and the speed of wind just above the ocean's surface. By sending radar pulses from an airborne or spaceborne instrument and then measuring the backscattered signal, they could indirectly gauge ocean wind speed. In addition to measuring radar backscatter, they also learned that backscattered signals were influenced by the direction of the wind. By taking into account the angle at which the radar was beaming its pulses down toward the ocean, they could calculate wind direction.

Satellites promised to be far more effective than the prevailing practice of collecting wind readings from ships. Most ocean ship reports are limited in their geographical coverage, and ships necessarily must stay away from active storm regions. Ship reports of wind velocity are also notoriously inaccurate owing to untrained observers, poor quality instruments, questionable measurements caused by the motion of the vessels and a variety of other conditions. Moored buoys gathering wind data are highly accurate, but such buoys are few in number and concentrated in coastal regions in the northern hemisphere.

Only satellite-borne instruments can acquire wind data with global coverage, high spatial resolution and frequent sampling. Certain satellite instruments called altimeters and radiometers can be used to estimate wind speeds. But these instruments do not measure wind direction, thus making them far less useful to scientists who are trying to understand atmospheric dynamics.

Orbiting scatterometers can acquire hundreds of times more observations of surface wind velocity each day than can ships and buoys. These orbiting instruments are also the only remote-sensing systems able to provide accurate, frequent, high-resolution measurements of ocean surface wind speed and direction in both clear sky and cloudy conditions.

Scatterometers must take several readings simultaneously from different angles in order to get a clear picture of how the ocean's surface is reflecting radar signals. They must also covera a wide swath of the sea surface at any given time in order to build up a complete global map on a frequent basis. Both of these factors call for special antennas on the satellite-borne instruments.

History of Scatterometers

Scatterometers have been flown on space missions since the early 1970s. In addition to such experiments on satellites and crewed flights, they have also been tested in flights on airplanes.

Skylab. The first scatterometer in space flew as part of the crewed Skylab missions in 1973 and 1974, and demonstrated that spaceborne scatterometers were feasible. The Skylab missions carried a relatively simple radar instrument, however, which could make only single measurements of wind speeds at one location on the sea surface at any given time. In order to calculate wind speed, wind direction had to be obtained from some other source.

Seasat. In 1978, a scatterometer was flown on NASA's Seasat satellite, which tested a number of different spaceborne oceanographic instruments. This instrument used a total of four fan-beamed antennas to allow it to take readings from a pair of swaths instead of a single point. It was capable of spatial resolution of approximately 30 miles (50 kilometers) in two swaths about 370 miles (600 kilometers) wide. Measurements from the various antennas were combined to provide estimates of wind speed and up to four possible directions. Because of a spacecraft malfunction, the Seasat mission lasted only four months, from June to October 1978. Despite the brevity of the mission, the scatterometer on Seasat achieved a number of major technical milestones and returned a wealth of scientific information.

European Remote Sensing Satellite. This satellite launched in July 1991 carries a radar instrument with a split personality, functioning both as an imaging radar to take pictures of land masses and as a scatterometer to study ocean winds. In its scatterometer mode, the instrument takes readings across a 310-mile-wide (500-kilometer) swath on the starboard side of the spacecraft, sending and receiving radar pulses in the microwave C-band at a frequency near 5 gigahertz. Its coverage is limited by its single-swath design and the narrow width of its swath. On the other hand, the satellite has operated nearly continuously for nearly eight years, providing the longest record of global scatterometer data yet obtained.

NASA Scatterometer. The NASA Scatterometer, or “NSCAT,” was launched in August 1996 by Japan's National Space Development Agency (NASDA) onboard its Midori satellite. Named with the Japanese word for “greenery,” the satellite was also known as the Advanced Earth Observing Satellite (ADEOS).

NSCAT was designed to take 190,000 wind measurements per day, mapping more than 90 percent of the world's ice-free oceans every two days. During its lifetime the instrument provided scientists with more than 100 times the amount of ocean wind information available from ship observations and buoys.

Benefits

QuikScat data will provide benefits in areas ranging from weather forecasting to help for various industries that rely on the sea.

Weather forecasting. Nearly two-thirds of Earth is covered by oceans, where there are no weather stations and only a scattered array of buoys. This lack of information hampers scientists' knowledge of today's weather and impedes their ability to forecast the future. Most of the weather that hits the West Coast of the United States begins over the Pacific Ocean. QuikScat's frequent, extensive and all-weather coverage will alleviate this problem.

The National Oceanic and Atmospheric Administration (NOAA) will process QuikScat data in near real time and distribute it to NOAA's National Weather Service and other users who will incorporate the measurements into their forecast models. The data will be important in short-term weather warnings and forecasts, and will play a key role in scientists' ability to understand and predict complex global weather patterns and climate systems.

QuikScat will also play an important role in NASA's continuing work to monitor global El Niño and La Niña weather abnormalities. Changes in the winds over the Pacific are a key component of the El Niño/La Niña phenomenon. The satellite will be able to track the changes in the trade winds along the equator as a new El Niño develops and will help predict a La Niña condition that might arise in the wake of the El Niño.

Storm detection. QuikScat’s radar will be able to determine the location, structure and strength of storms at sea. Severe marine storms – hurricanes in the Atlantic, typhoons near Asia and mid-latitude cyclones worldwide – are among the most destructive of all natural phenomena. In the United States alone, hurricanes have been responsible for at least 17,000 deaths since 1900, and have caused hundreds of millions of dollars in damage annually. If worldwide statistics are considered, the numbers are substantially higher. And while mid-latitude cyclones are not usually as violent as hurricanes and typhoons, these storms also exact a heavy toll in casualties and material damage.

In recent years, scientists' ability to detect and track severe storms has been dramatically enhanced by the advent of weather satellites. Cloud images from space are now routine on TV weather reports. QuikScat will augment these familiar images by providing a direct measurement of surface winds to compare to observed cloud patterns. These wind measurements can help to identify more accurately the extent of gale force winds associated with a storm, and will provide inputs to computer models that provide advance warnings of high waves and flooding.

Global climate. Another important application of QuikScat data for study of world climate and global warming. Most of the heat absorbed by Earth is stored in the tropics near the equator. The main factor responsible for world climate is heat transport from the tropics to higher latitudes. This heat transport takes place through the process of ocean circulation – and the winds that drive the ocean. Precise knowledge of the winds over the global ocean will enable scientists to better understand this complicated process.

Monsoon monitoring. Monsoons are heavy winds and rain in the tropics that result from seasonal changes in winds caused by differences in temperatures over land and water. Monsoons affect large areas of the world, but are most common in the Indian Ocean and Southeast Asia. Their annual onset, intensity and retreat vary greatly, and the variation of a monsoon has strong economic impact and the potential for widespread human suffering. Besides bringing rain to land, a monsoon also changes ocean currents, and stirs nutrients in the depths of the ocean that sustain great populations of fish and other sea life. QuikScat, with its repeated global observations and unprecedented spatial resolution, will help scientists monitor and understand the development, movement and potential strength of these seasonal weather systems.

Ship routing. Wind observations from QuikScat could be of particular commercial significance to the shipping industry. By identifying storms that might harm vessels and crews, captains of ocean-going cargo ships will be able to chart their courses more efficiently. Prior knowledge of winds will enable ships to choose routes that steer clear of active or potentially active storm centers, especially turbulent seas or high headwinds that could slow a ship's progress and require additional fuel supplies.

Oil production and cleanup. Oil and gas production takes place at numerous offshore sites around the world – the Gulf of Mexico, the North Sea, the Persian Gulf and other areas. Thorough knowledge of the historical wind and wave conditions at any specific location is crucial to the design of drilling platforms. In the event of an oil spill, information on surface winds will be key to determining how the oil will spread. QuikScat data could help cleanup efforts and aid containment crews in minimizing the environmental effects of such a disaster.

Mission Overview

QuikScat is a rapidly developed mission intended to replace the capability of the NASA Scatterometer (NSCAT) instrument on Japan's Midori satellite (previously known as the Advanced Earth Observation Satellite (ADEOS)), which lost power in June 1997 nine months after launch in September 1996.

QuikScat will be launched on a Titan II vehicle from Vandenberg Air Force Base, CA, entering a north-south orbit that will take it over nearly the entire surface of Earth. Its primary mission is scheduled to continue for two years.

Launch Site

Vandenberg Air Force Base stands on 98,400 acres (39,800 hectares) of what was once open grazing land for wild game and cattle on California's central coast some 140 miles (225 kilometers) northwest of Los Angeles. In 1941, the U.S. Army established a training center for armored and infantry troops called Camp Cooke that operated during World War II and the Korean War. In 1957, the facility was transferred to the U.S. Air Force and acquired its present name. In the decades since, it has served as a staging ground for ballistic missile tests as well as the launch of space-bound rockets. Today the base is operated by the Air Force Space Command's 30th Space Wing.

Vandenberg's location, with a stretch of clear ocean for thousands of miles to the south,

Launch Events

Time	*Event*
-3.2 sec	Titan II's first stage ignites
0	Liftoff, Titan II begins vertical flight
9 sec	Begins roll to direction of flight
19 sec	Ends roll
2 min 31 sec	First-stage engine shuts down
2 min 32 sec	Second stage ignites
2 min 33 sec	Second stage separates from first stage
3 min 37 sec	Fairing (nose cone) jettisoned
5 min 36 sec	Second-stage engine shuts down
5 min 52 sec	Turn to shield QuikScat satellite from sunlight
53 min 38 sec	Turn to orient QuikScat satellite for thruster firing
55 min 48 sec	Farthest point in orbit from Earth; thrusters on Titan II's second stage fire for 15 seconds to adjust orbit
58 min 43 sec	QuikScat satellite separates from Titan II's second stage
60 min	QuikScat deploys solar arrays
76 min	QuikScat's first signal picked up by station at Svalbard, Norway

makes it ideal for the launch of satellites that are designed to orbit Earth in so-called "polar" orbits from north to south. The base has eight active launch pads for Atlas, Delta, Titan, Taurus and other rockets. Titan II vehicles are launched from Vandenberg's Space Launch Complex 4-West.

Launch Vehicle

The Titan II is a decommissioned intercontinental ballistic missile (ICBM) that has been refurbished as a space launch vehicle. It is a medium-lift launch vehicle, capable of lofting about 4,200 pounds (1,900 kilograms) to low-Earth orbit.

It was the first launch vehicle to use "hypergolic" propellants, meaning chemicals that spontaneously burn when they are combined. The propellant is Aerozine 50, a mixture of hydrazine and unsymmetrical dimethyl hydrazine (UDMH), and nitrogen tetroxide as the oxidizer.

The Titan II's first stage is 70 feet (21 meters) long and 10 feet (3 meters) in diameter, with an engine thrust of 474,000 pounds (2.1 million newtons). The second stage is 40 feet (12 meters) long and 10 feet (3 meters) in diameter, with an engine thrust of 100,000 pounds (445,000 newtons). For the QuikScat launch, the nose cone, or fairing, is 20 feet (6.1 meters) long and 10 feet (3 meters) in diameter. Fully fueled on the launch pad, the rocket stands 130 feet (39.6 meters) tall, is 10 feet (3 meters) in diameter and weighs 408,000 pounds (185,000 kilograms).

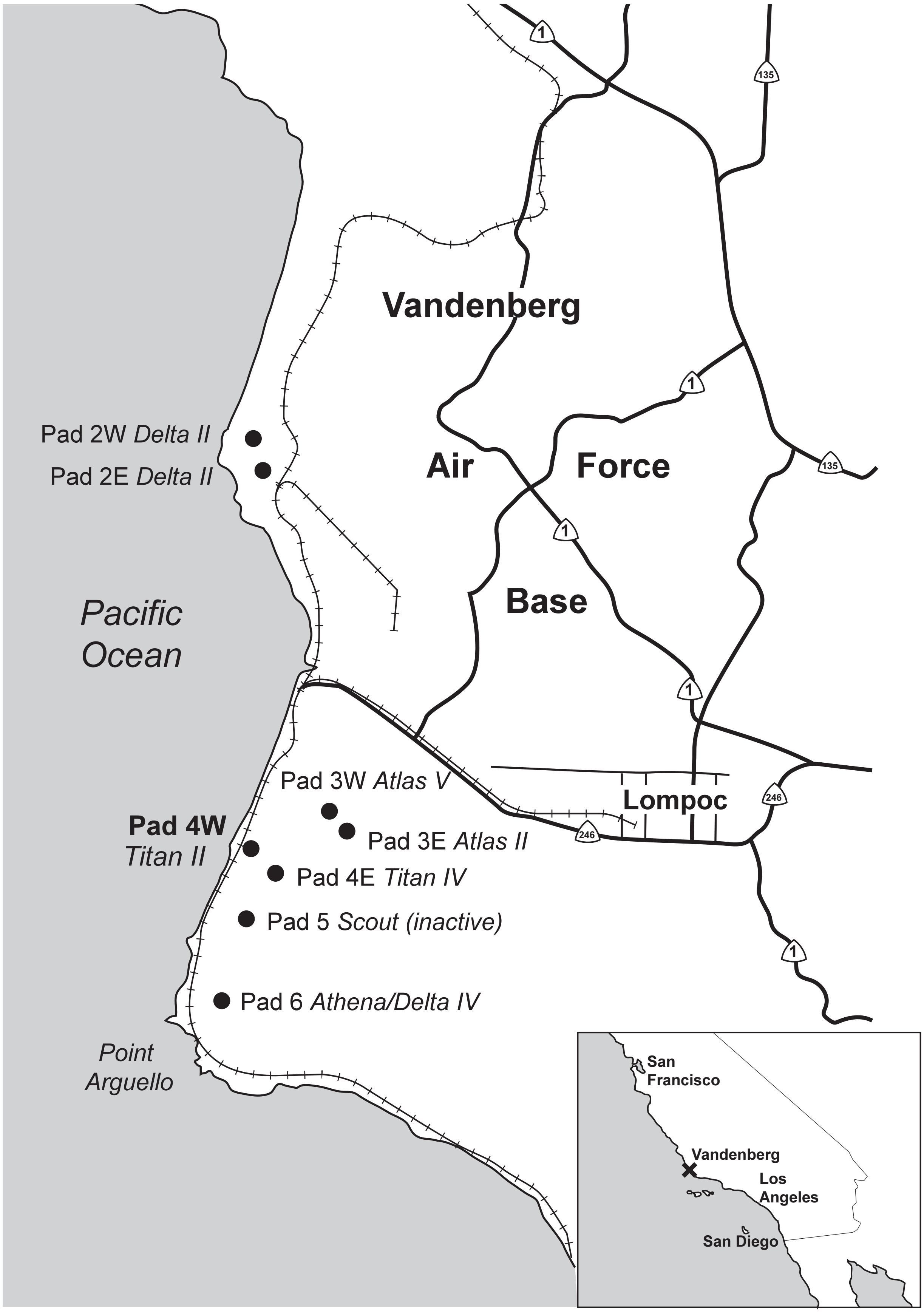
Launch Timing

Unlike spacecraft sent to other planets, comets or asteroids, the launches of Earth-orbiting satellites such as QuikScat do not need to be timed based on the alignment of the planets. The launch date is based only on the readiness of the QuikScat satellite, the Titan II launch vehicle and the launch range at Vandenberg Air Force Base.

Earth-orbiting satellites do, however, need to be launched during particular windows within any given 24-hour day in order to get into the proper orbit around Earth. QuikScat will assume what is called a "Sun-synchronous" orbit flying close to Earth's north and south poles. In order to achieve this orbit, the satellite must be launched during a daily 10-minute launch window that opens at 7:15 p.m. Pacific Daylight Time. The window remains the same for any launch date. Launch is currently scheduled for June 18, 1999.

Launch Events

Liftoff takes place when the Titan II's first stage engine ignites and the rocket rises vertically from the launch pad. Nine seconds later, the Titan II rolls so that its flight path takes it in a south-southwesterly direction, crossing the California coastline and climbing into space as thousands of miles of unbroken Pacific Ocean pass underneath.



Vandenberg
Air
Force
Base
Pacific
Ocean
Pad 2W *Delta II*
Pad 2E *Delta II*
Pad 3W *Atlas V*
Pad 3E *Atlas II*
Pad 4W
Titan II
Pad 4E *Titan IV*
Pad 5 *Scout (inactive)*
Pad 6 *Athena/Delta IV*
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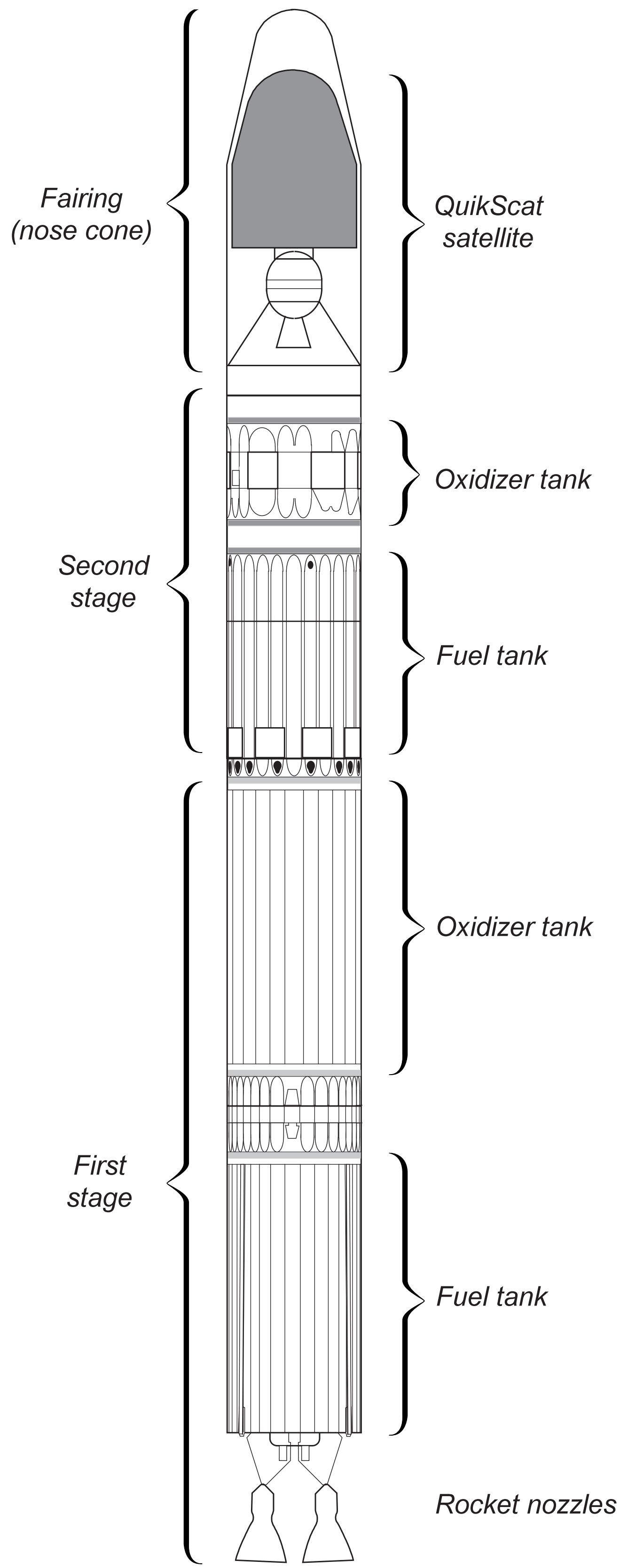
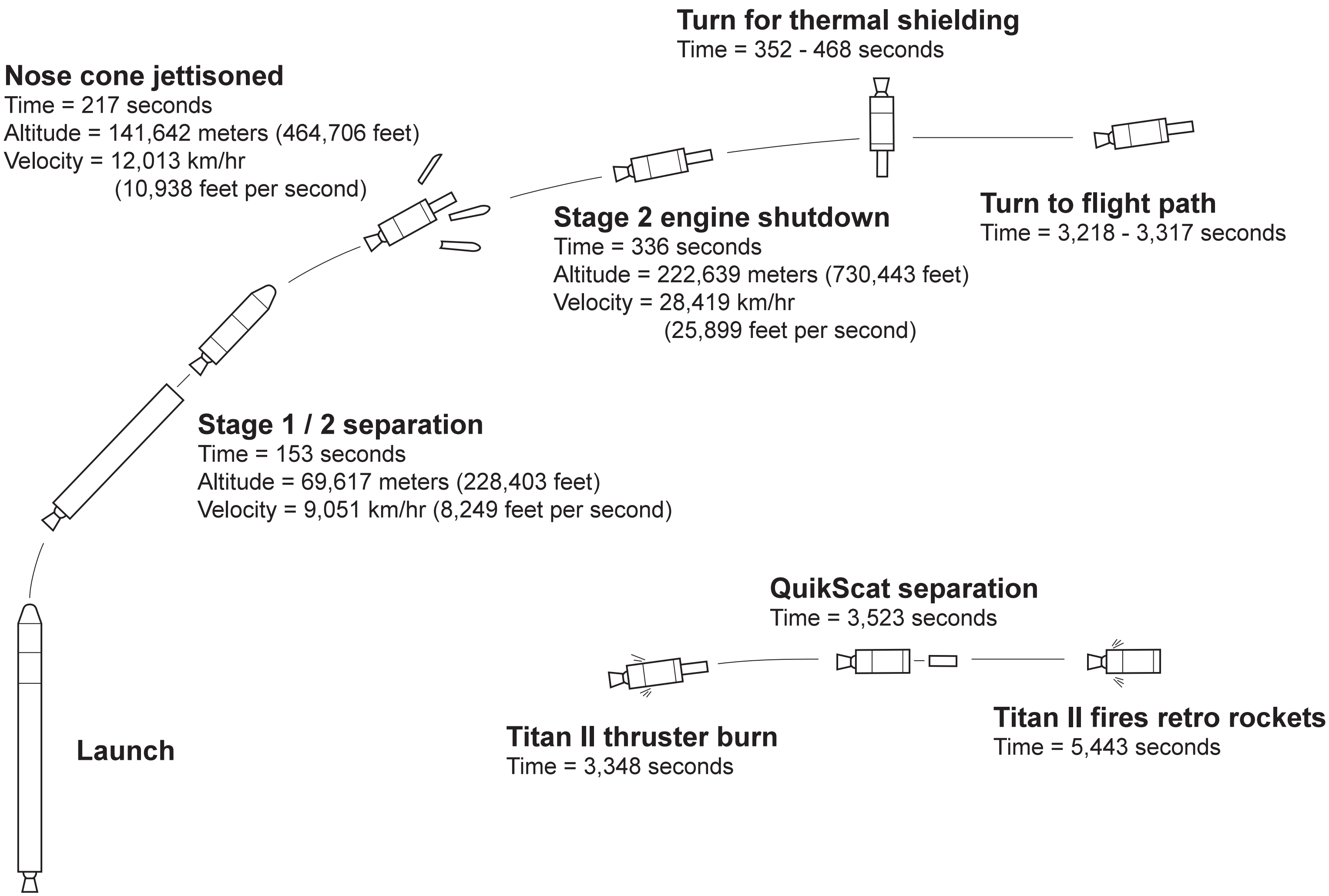
Los
Angeles
San Diego



Titan II launch vehicle



Launch events

About two and a half minutes later when the rocket is west of Mexico's Baja California peninsula, the Titan II's second stage engine ignites, and the first stage shuts down and falls into the sea. A minute later, the fairing or nose cone separates into two halves like a clamshell and falls away. Two minutes later, the Titan's second-stage engine shuts down. About 16 seconds later, the Titan turns to reorient itself in order to shield the QuikScat satellite from sunlight; this prevents the satellite from becoming too hot.

The Titan and satellite then coast for 48 minutes, sailing over Antarctica and then heading north-northwesterly toward Africa. The Titan reaches the farthest point in its orbit from Earth when it is over Madagascar; at this point, thrusters on the Titan's second stage fire to adjust the orbit.

Just off the coast from Mozambique, the QuikScat satellite separates from the Titan II's second stage about 59 minutes after launch. Four explosive devices, or pyros, fire, allowing a set of six springs to push the satellite away from the launch vehicle at about 10 inches per second (25 centimeters per second). The QuikScat satellite is now in a looping orbit that takes it as close as 173 miles (279 kilometers) to Earth and as far away as 501 miles (807 kilometers).

Twenty-seven minutes after spacecraft separation, when it is passing over Greenland and Canada's Queen Elizabeth Islands, the Titan II's second stage turns to a new orientation. Five minutes later when it is over Canada's Northwest Territories, the Titan II's second stage fires its thrusters to increase its distance from the QuikScat satellite. Two and a half minutes later, now over the Pacific Ocean west of British Columbia, explosive devices called pyros are fired to vent the propellant tanks on the Titan II's second stage. The second stage is expected to remain in orbit about a year and a half before it falls back into the atmosphere and burns up.

The QuikScat satellite, meanwhile, deploys its solar arrays about one minute after separating from the Titan II's upper stage. About 15 minutes later – or 1 hour, 16 minutes after launch – the first signal from QuikScat is expected to be picked up by a tracking station at Svalbard, Norway.

Fine-tuning the Orbit

In order to carry out its science mission, QuikScat must get into a circular orbit about 500 miles (800 kilometers) above Earth. The launch, however, leaves it in a looping orbit that takes it much closer to Earth once every revolution around the planet. One of the first orders of business will therefore be to fine-tune QuikScat's orbit so that its flight path is as circular as possible.

During the first two weeks after launch, QuikScat will fire its thrusters as many as 25 times to gradually smooth its orbit. The thruster firings will be carried out in up to five clusters of five burns apiece. During each cluster, the thrusters will fire for 10 minutes, then will rest for two orbits, then will fire again for 10 minutes until a total of five burns are performed. The clusters will be spaced two days apart.

About 18 days after launch, the SeaWinds science instrument on QuikScat will be turned on for the first time. Members of the science team will spend about a week and a half calibrating the data they receive from the satellite. Then, about 30 days after launch, QuikScat will formally begin its primary mission of mapping ocean winds. The primary mission is scheduled to continue for two years.

Satellite Operations

Spacecraft operations for QuikScat will be handled by the Laboratory for Atmospheric and Space Physics at the University of Colorado, Boulder, CO, under a subcontract to Ball. Staff at the Colorado facility will plan and schedule satellite operations; monitor and control the satellite; determine the satellite's orbit; and analyze many megabytes of engineering data on the health and status of the satellite. Twenty or more students at both graduate and undergraduate levels are expected to participate in QuikScat mission operations. A mission center at the Jet Propulsion Laboratory, Pasadena, CA, will monitor the satellite and serve as an emergency backup for spacecraft operations.

The network of ground stations communicating with the satellite will be managed by NASA's Wallops Flight Facility, Wallops Island, VA. Wallops will operate tracking stations at Wallops Island; Poker Flats, AK; Svalbard, Norway; and McMurdo, Antarctica. QuikScat will be the first space mission in which the ground stations will be completely computer-controlled without human operators. The stations at Poker Flats, Svalbard and Wallops Island use dish antennas 37 feet (11.3 meters) in diameter, while McMurdo is equipped with a dish antenna 33 feet (10 meters) in diameter.

Fifteen times a day, QuikScat will send science data to ground stations. For routine operations, the satellite will communicate with a given ground station for 8 to 10 minutes at a time.

During launch, the network of ground stations will be supplemented by a station in Kenya and one of the complexes of NASA's Deep Space Network near Canberra, Australia. The ground station in Kenya will be used to observe the Titan II's final propulsive burn and to confirm separation of QuikScat from the Titan II.

Science data from QuikScat will be processed at two facilities. The National Oceanic and Atmospheric Administration (NOAA) will process data at a facility in Suitland, MD, forwarding them to meteorological agencies around the world and to the general public. In addition, data will be processed by NASA's Physical Oceanography Distributed Active Archive Center located at the Jet Propulsion Laboratory. JPL will archive science data and present them on a web page at **http://winds.jpl.nasa.gov** .

The QuikScat Satellite

The QuikScat satellite is based on a satellite design developed by Ball Aerospace & Technologies Corp., Boulder, CO, called the Ball Commercial Platform 2000. The version for QuikScat was bought under a NASA program managed by the Goddard Space Flight Center, Greenbelt, MD, called Indefinite Delivery/Indefinite Quantity, created to support rapid ordering and delivery of satellites.

The satellite's main structure, or bus, is a 6.2- by 4.9- by 4-foot (2.2- by 1.7- by 1.4-meter) box made of aluminum honeycomb panels tied together by corner posts made of extruded aluminum. Most of the satellite's electronics are mounted inside the box, as are the propulsion subsystem, torque rods, reaction wheels and inertial reference units. Subsystems mounted outside include various antennas including the rotating radar antenna, star trackers and magnetometers. Most subsystems on the satellite are redundant, so that if one fails a backup unit can take over. The satellite is designed to survive for five years.

Main computer. The command and data handling subsystem receives, stores and executes all commands that control the satellite. It also collects, stores and transmits both housekeeping data from the satellite and radar, as well as science data from the radar.

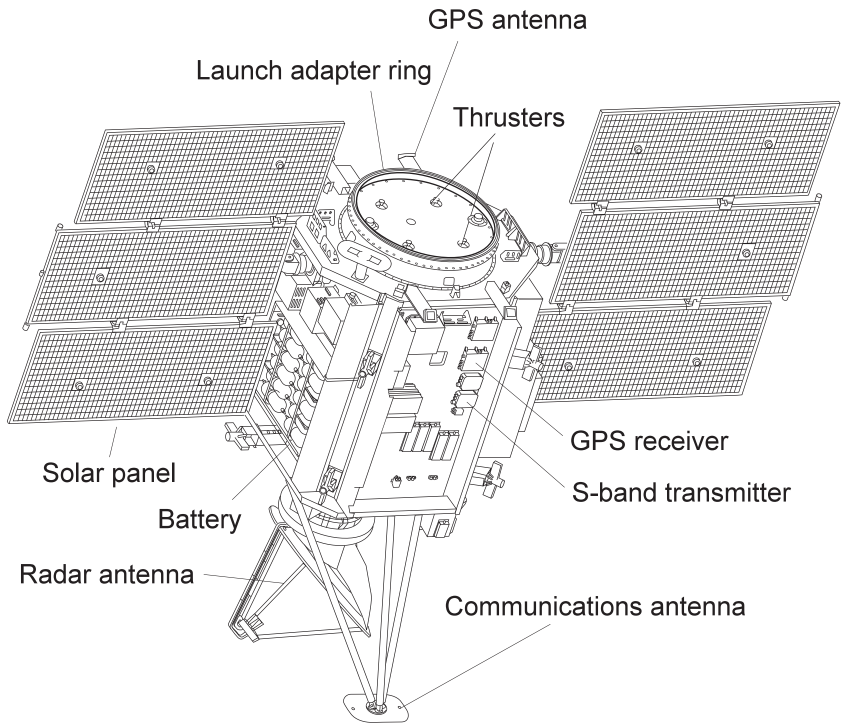
At its core the computer system uses a processor card called the RHC-3001 based on a radiation-hardened application-specific integrated circuit (ASIC) that is used in a variety of satellites. A watchdog timer resets the computer if no central processor activity occurs within any two-second period. The computer stores data on an onboard 8-gigabit solid state recorder capable of simultaneous recording and playback.

Attitude control. The satellite uses a variety of devices to determine and change its orientation, or "attitude," in space. Three magnetometers sense Earth's magnetic field to provide an approximate picture of the satellite's orientation. A total of 14 Sun sensors are mounted on two panels of the satellite and on its solar arrays.

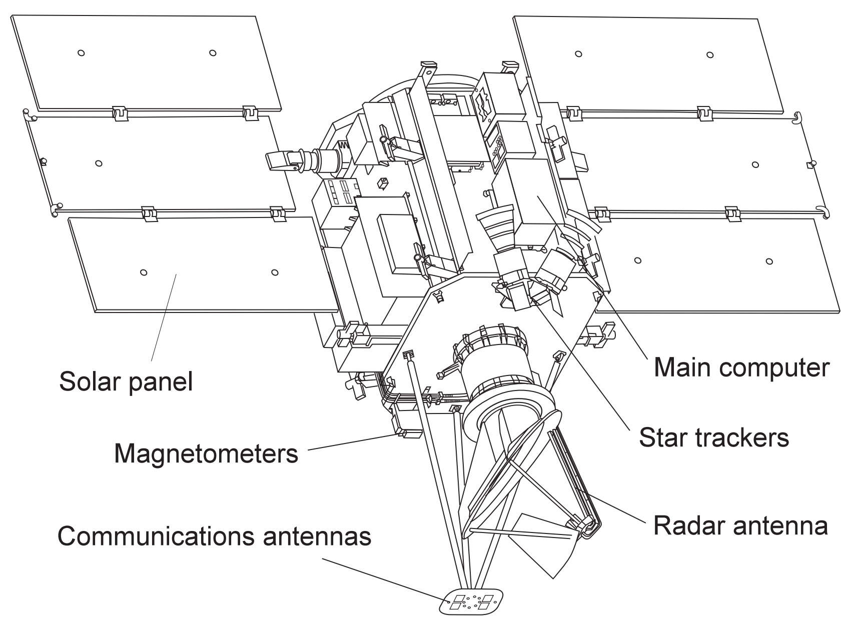
More precise information on the satellite's orientation comes from a pair of star trackers that periodically take pictures of reference stars. They are 8 to 10 times more accurate than Sun sensors and Earth horizon sensors usually used by Earth-orbiting satellites.

QuikScat also has two devices called inertial reference units, which use gyroscopes to sense the satellite's orientation. In addition, the satellite has two Global Positioning System (GPS) receivers, which use information from an orbiting constellation of satellites to determine QuikScat's position. They are similar to GPS receivers used on the ground in a wide variety of fields from boating to mountaineering.

The satellite can change its orientation either by firing its thrusters or using a set of four reaction wheels. These devices, akin to gyroscopes, use the momentum of spinning wheels to nudge the satellite's orientation in space. The spacecraft can dump or cancel out excess



Sun-facing side



Dark side

QuikScat satellite

momentum in the reaction wheels by activating its torque rods. These rods are essentially large electromagnets – wire wound around steel rods. When electrical current is sent through the wire, the rod creates a magnetic field and tries to align with Earth's magnetic field. This in turn stabilizes the spacecraft and slows down any spinning.

Telecommunications. QuikScat communicates with Earth through a radio transmitter and receiver, both of which operate in the microwave S-band. The satellite transmits house-keeping data at 4, 16 or 256 kilobits per second, and science data at 2 megabits per second. The transmitter puts out 5 watts of power. The satellite receives encrypted commands from the ground at 2 kilobits per second.

Communication takes place over two S-band low-gain antennas. One of them, mounted near the radar instrument's rotating dish antenna, is the primary communications antenna. A second S-band low-gain antenna is used only to receive commands from the ground if the satellite is in a contingency mode.

Power. The satellite's power comes from a pair of solar wings, each of which consists of three hinged panels studded with gallium arsenide solar cells. Each of the panels is 28 by 66 inches (71 by 168 centimeters). During launch, the wings are wrapped against the satellite's main structure. During deployment, each wing is unfolded and rotated to face the Sun. Altogether the solar panels put out a total of 642 watts of power. When the spacecraft is in Earth's shadow, power is provided by a 40-amp-hour nickel hydrogen battery.

Propulsion. QuikScat can adjust its orbit or orientation by firing any combination of four onboard thrusters, each of which puts out 1 pound (4.4 newtons) of thrust. The thrusters' hydrazine propellant is stored in a 22-inch-diameter (56-centimeter) titanium tank pressurized with gaseous nitrogen.

Thermal control. The temperature environment of the satellite is controlled chiefly through passive design elements such as multilayer insulation blankets. Twenty-seven heaters can be used if parts of the satellite become too cold, while four radiators and panel fins are used to throw off excess heat.

The SeaWinds Instrument

The SeaWinds instrument studies ocean winds by transmitting radar pulses toward Earth. Pulses are reflected, or "backscattered," from the ocean's surface and received back on the satellite. Automated analysis of the reflected signal provides a signature of ripples on the ocean's surface, which in turn reveals the speed and direction of winds that create them.

QuikScat's orbit will allow the radar instrument to view 90 percent of the world's ice-free ocean surface, assembling a complete map of the world's oceans every two days. On each 101-minute orbit, the instrument will collect and forward 282 megabits of science data. The accuracy of the wind speed measurements is better than 4.5 miles per hour (2 meters per second) for wind speeds from about 7 to 45 miles per hour (3 to 20 meters per second), and within 10 percent for winds from about 45 to 70 miles per hour (20 to 30 meters per second). Wind direction is accurate to within 20 degrees.

The instrument consists of a radio transmitter and receiver, rotating dish antenna, instrument controller and data handler, stable time reference and power converters. It switches back and forth between transmitting and receiving pulses some 200 times per second.

The rotating antenna represents a design departure from the instrument's predecessor, the NASA Scatterometer (NSCAT). NSCAT transmitted and received its radar pulses through a collection of stick-like antennas on one end of its host satellite. The SeaWinds instrument was designed so that its antenna could occupy a more compact position on the central body of the satellite. Its dish antenna rotates 18 times a minute, allowing it to observe a 1,120-mile-wide (1,800-kilometer) swath passing underneath on Earth.

Science Objectives

A team of 17 scientists will work with the data provided by the SeaWinds instrument on QuikScat. To structure their investigations, the team developed a list of five science objectives for the mission:

❑ **Acquire all-weather, high-resolution measurements of near-surface winds over global oceans.** Wind stress is the single largest source of momentum to the upper ocean, and winds drive oceanic motions on scales ranging from surface waves to basin-wide current systems. They also alter flows of heat, moisture, gases and particles such as dust, thus regulating global and regional climate. An orbiting radar satellite will be able to obtain global coverage of the ways in which winds interact with the surface of the ocean.

❑ **Determine atmospheric forcing, ocean response and air-sea interaction mechanisms on various spatial and temporal scales.** "Atmospheric forcing" means the exchange of heat and water between the atmosphere and ocean. Driven by winds, this global air-sea engine is responsible for the creation of ocean currents and waves, and regulates the planet's perpetual exchange of energy.

QuikScat Science Team

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Dr. Frank Wentz, Remote Sensing Systems Inc., Santa Rosa, CA

❑ **Combine wind data with measurements from other scientific instruments to help us better understand the mechanisms of global climate change and weather patterns.** QuikScat data will complement information acquired by the currently orbiting Topex/Poseidon satellite, which uses an instrument called an altimeter to measure the height of sea surfaces around the world. Data will also be combined with information from other instruments, such as a color sensor onboard the Sea-viewing, Wide Field-of-View Sensor (SeaWiFS) satellite, which is providing scientists with more information about the types and quantities of marine phyto-plankton present in the ocean.

❑ **Study both annual and semi-annual rain forest vegetation changes.** Wind speeds and direction influence the climate and vegetation of Earth's rain forests. QuikScat data will augment information from the currently orbiting Tropical Rainfall Measuring Mission, a joint U.S.-Japanese satellite that monitors rain over the tropics, to help scientists better determine changes that might be occurring in the types of vegetation found in rain forests.

❑ **Study daily/seasonal sea ice-edge movement and Arctic/Antarctic ice pack changes.** QuikScat data will increase scientists' knowledge of rising sea levels and help them examine the climate change of Earth's atmosphere in more depth. An increased understanding of the winds and how they play upon the world's oceans, coupled with information on climate trends such as the sudden "calving," or breakup of huge ice shelves in the Arctic and Antarctic, will improve researchers' ability to predict weather and longer term climate change.

Program/Project Management

The QuickScat misson is managed for NASA's Office of Earth Science, Washington, DC, by the Jet Propulsion Laboratory, Pasadena, CA.

At NASA Headquarters, Dr. Ghassem Asrar is associate administrator for the Office of Earth Science. Dr. Jack Kaye is director of the Office of Earth Science's Research Division, and Eric Lindstrom is the QuikScat program executive.

At the Jet Propulsion Laboratory, James E. Graf is the QuikScat project manager and Dr. W. Timothy Liu is the project scientist. Dr. Michael Freilich, Oregon State University, Corvallis, OR, is team leader for the science team. JPL is a division of the California Institute of Technology, Pasadena, CA.

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