

# NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PRESS KIT  
APRIL 2002

# AQUA



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RELEASE: 02-75

## **NASA'S AQUA SPACECRAFT TO STUDY EARTH'S WATER CYCLE**

NASA's mission to understand and protect our home planet will mark a major milestone this spring with the launch of the Aqua satellite. Aqua, due to bring us unprecedented insight of our world's global water cycle, is the latest sibling in a family of Earth Observing System satellites dedicated to studying the Earth and our knowledge of global climate change.

The primary role of Aqua, as the name implies, is to gather information about water in the Earth's system. Equipped with six state-of-the-art instruments, Aqua will collect data on global precipitation, evaporation, and the cycling of water.

During its six-year mission, Aqua will gather information on changes in ocean circulation and how clouds and surface water processes affect our climate. This information will help scientists better understand how global ecosystems are changing, and how they respond to and affect global environmental change.

"Aqua will provide unprecedented information on the global water cycle. The spacecraft will enable operational agencies to create more accurate weather forecasts in the future," said Dr. Ghassem Asrar, Associate Administrator for NASA's Earth Science Enterprise, NASA Headquarters, Washington.

"Aqua will observe our Earth's oceans, atmosphere, land, ice and snow covers and vegetation," said Claire Parkinson, the Aqua project scientist at NASA's Goddard Space Flight Center, Greenbelt, Md. "This comprehensive approach enables scientists to study the interactions among key elements of the Earth system so as to better understand our planet."

Aqua will be launched from Vandenberg Air Force Base, Calif. on a Boeing Delta-7920-10L expendable launch vehicle. The 10-minute launch window opens at 2:55 a.m. Pacific Daylight Time (5:55 a.m. EDT). Aqua will fly at an altitude of approximately 705 kilometers (438 miles) above Earth in a near polar and sun synchronous orbit.

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Aqua is the sister satellite to NASA's Terra spacecraft, launched in December of 1999. Aqua will cross the equator daily at 1:30 p.m. as it heads North. The early afternoon observation time contrasts with the Terra satellite which crosses the equator between 10:30 and 10:45 a.m. daily. The two satellites, Aqua's afternoon observations and Terra's morning observations, will yield important insights into the "diurnal variability," or the daily cycling of key scientific parameters such as precipitation and ocean circulation.

Aqua is a joint project between the United States, Japan and Brazil. The United States provided the spacecraft and four of Aqua's six scientific instruments. NASA's Goddard Space Flight Center provided the Moderate Resolution Imaging Spectroradiometer and the Advanced Microwave Sounding Unit. NASA's Jet Propulsion Laboratory, Pasadena, Calif., provided the Atmospheric Infrared Sounder, and NASA's Langley Research Center, Hampton, Va., provided the Clouds and the Earth's Radiant Energy System instrument.

Japan's National Space Development Agency provided the Advanced Microwave Scanning Radiometer. The Instituto Nacional de Pesquisas Espaciais (the Brazilian Institute for Space Research) provided the Humidity Sounder for Brazil.

Aqua is part of NASA's Earth Science Enterprise, a long-term research effort dedicated to understanding and protecting our home planet. Through the study of Earth, NASA will help to provide sound science to policy and economic decision makers so as to better life here, while developing the technologies needed to explore the universe and search for life beyond our home planet.

More information about the Aqua program is available at:

<http://aqua.nasa.gov>

Information about NASA's Earth Science Enterprise can be found at:

<http://www.earth.nasa.gov>

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## 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. On launch day, television coverage will begin at approximately 1:30 a.m. PDT and continue through spacecraft separation. The schedule for television transmissions for Aqua will be available on the NASA Television homepage at <http://www.nasa.gov/ntv/>.

### Audio

Audio only will be available on the NASA Television voice circuits that may be reached by dialing 321-867-1220, 1240, 1260, 7135, 4003, 4920.

### Webcasting

A live webcast of the launch from NASA's Kennedy Space Center, Fla., will be available at <http://www.ksc.nasa.gov>.

Additionally, there will be a live webcast to a worldwide audience from Vandenberg Air Force Base, Calif. This three-hour webcast will start one hour before launch and end two hours after launch. Mr. Al Diaz, the Goddard Space Flight Center Director; Dr. Ramesh Kakar, Aqua Program Scientist; Dr. Claire Parkinson, Aqua Project Scientist; and Investigators from the USA, Japan, and Brazil are expected to participate. A continuous chat session broadcast in three languages will target audiences in Japan, Brazil, Europe, and secondary schools in the U.S. Test your system readiness and view the webcast at URL

<http://aqua.nasa.gov/outreach/webcast.html>

### Briefings

A pre-launch mission science news conference will be held in the James Webb Memorial Auditorium at NASA Headquarters in Washington D.C. on April 22 at 1 p.m. EST. Additional information will be sent in a separate Note to Editors.

A pre-launch readiness news conference is scheduled for April 30 at 1 p.m. PDT. The news conference will be held on-site at Vandenberg Air Force Base, Calif. in the NASA Aqua News Center, Building 840. Additional information on that briefing will be sent in a Note to Editors.

### Launch Media Credentials

U.S. news media desiring accreditation for the launch of Aqua should fax their request on news organization letterhead to:

NASA Vandenberg Resident Office  
Vandenberg Air Force Base, CA  
Attention: Bruce Buckingham  
**FAX: 805/605-3380**

**Foreign news media** desiring accreditation should fax their **request at least 10 days prior** to launch to:

30th Space Wing Public Affairs Office  
Vandenberg Air Force Base, CA  
Attention: Staff Sgt. Rebecca Bonilla  
**FAX: 805/606-8303**

For further information on launch accreditation news media should call the Kennedy Space Center News Center at 321/867-2468. Beginning April 30 media may call the NASA Aqua News Center at Vandenberg Air Force Base on 805/605-3051.

### **News Center/Status Reports**

The Aqua News Center at the NASA Vandenberg Resident Office will open April 30 (L-2) and may be reached at (805) 605-3051. Recorded status reports will be available beginning L-2 at (805) 734-2693.

### **Internet Information**

Information on the Aqua mission, including an electronic copy of this press kit, press releases, fact sheets, status reports and images, can be found at

<http://www.aqua.nasa.gov>

Information on NASA's Earth Science Enterprise, and it's mission to help understand and protect our home planet through the study of Earth System Science, can be found at:

<http://www.earth.nasa.gov>

General information concerning America's space program can be found at:

<http://www.nasa.gov>

## **Aqua Quick Facts**

**Launch Date/Time-May 2, 2002/2:55 a.m. PDT**

### **Spacecraft Dimensions**

**Stowed:** 2.68 meters (8.8 ft) x 2.49 meters (8.2 ft) x 6.49 meters (21.3 ft)

**Deployed:** 4.81 meters (15.8 ft) x 16.70 meters (54.8 ft) x 8.04 meters (26.4 ft)

**Weight at launch:** 2,934 kg (6,468 pounds)

**Power:** 4.6 kilowatts of electrical power from its solar array

**Orbit:** 705 kilometers (438 miles)

**Mission Lifetime:** Six years

### **Science Instruments:**

1. Atmospheric Infrared Sounder (AIRS)
2. The Clouds and the Earth's Radiant Energy System (CERES)
3. Moderate Resolution Imaging Spectroradiometer (MODIS)
4. Advanced Microwave Sounding Unit (AMSU-A)
5. Advanced Microwave Scanning Radiometer (AMSR-E)
6. Humidity Sounder for Brazil (HSB)

Descriptions for each instrument begin on page 12

**Launch Site:** Space Launch Complex (SLC 2) Western Test Range, Vandenberg Air Force Base, Calif.

**Launch Date & Time:** No Earlier Than May 2, 2002 at 2:55 a.m. PDT (5:55 a.m. EST)  
(Aqua has a 10 minute launch opportunity, or "window," that allows the spacecraft to reach an optimal orbit)

**Launch Vehicle:** Boeing Delta 7920-10L

**Spacecraft separation:** 64 minutes after launch

**First Acquisition of Aqua Signal:** 4 minutes 44 seconds after launch

**Beginning of Science Operations:** Approximately 90 days after launch

**Cost:** \$952 million for Aqua development costs, including launch of the spacecraft

**Spacecraft Builder/Integrator:** TRW, Redondo Beach, Calif., under contract with NASA's Goddard Space Flight Center for NASA's Earth Science Enterprise

**Launch Vehicle/Operations:** NASA Kennedy Space Center

**Mission Management:** NASA Goddard Space Flight Center



## **Aqua Science Objectives and Mission Goals**

Earth is a complex and interrelated system of land surface, solid Earth, biosphere, atmosphere and oceans. A change in one element of the Earth's system affects other elements of the Earth's system. However, scientists do not yet fully understand the cause-and-effect relationships well enough to predict what, if any, impacts these changes will have on future climate conditions. The unique vantage point from space is critical for understanding these large-scale systems if we are to better understand and protect our home planet.

Aqua will focus on collecting data for the improved characterization and understanding of atmospheric temperature and humidity profiles, clouds, global precipitation and Earth's thermal radiation balance; terrestrial snow and sea ice; sea surface temperature and ocean productivity; and soil moisture. Data collected by Aqua will make critical contributions to the monitoring of terrestrial and marine ecosystem dynamics and will be used by operational agencies to improve weather prediction.

Aqua will seek to answer the following science questions:

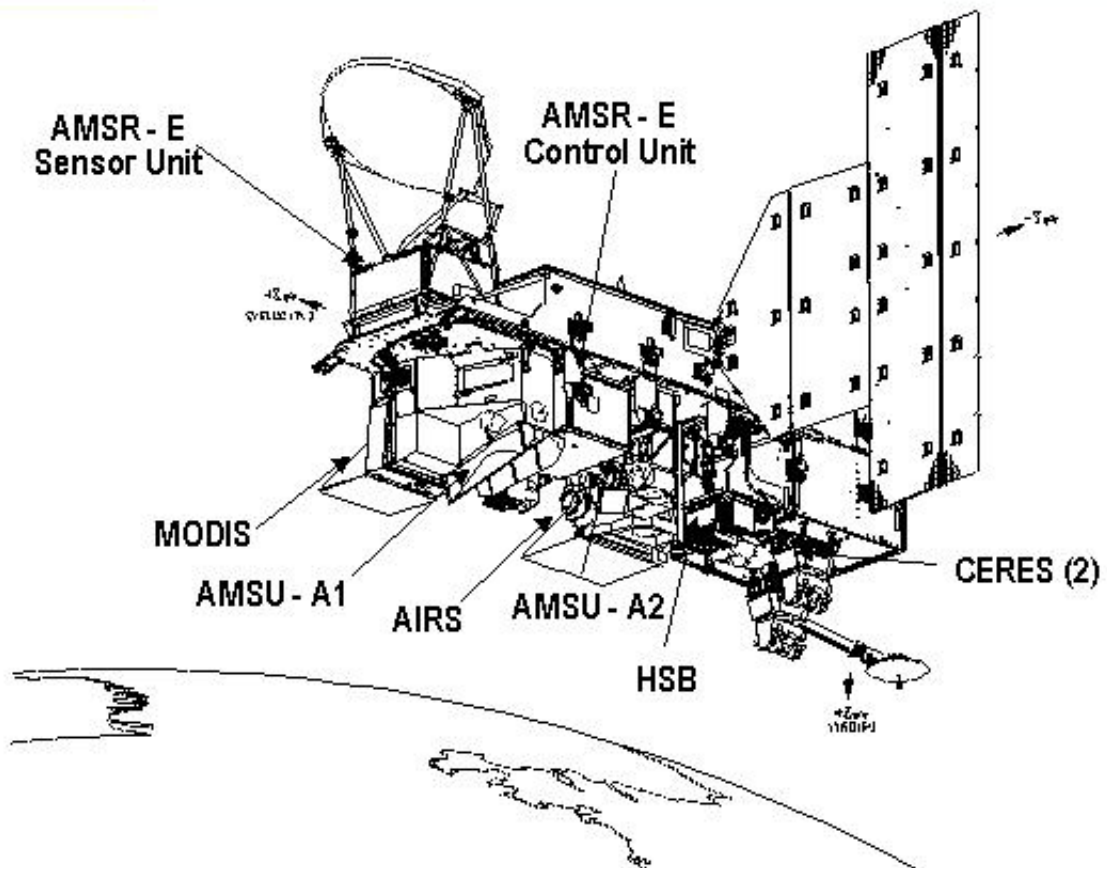
1. How are global precipitation, evaporation, and the cycling of water changing?
2. How is the global ocean circulation varying on inter-annual, decadal, and longer time scales?
3. How are global ecosystems changing?
4. What are the effects of clouds and surface hydrologic processes on Earth's climate?
5. How do ecosystems respond to and affect global environmental change and the carbon cycle?

Aqua's mission goals include:

1. Obtaining vertical temperature and moisture profiles of the Earth's troposphere with higher accuracy than those made with any previous NASA satellite sensor.
2. Extending rainfall characterization to the extra tropics in concert with NASA's Tropical Rainfall Measuring Mission (TRMM) satellite measurements.
3. Producing daily global sea surface temperature maps with higher measurement accuracy than any previous NASA satellite sensor.
4. Producing global soil moisture distribution records for regions with little vegetation that are consistent with the large footprint of the Aqua sensors.

5. Producing additional seasonal/annual cycles of terrestrial and marine ecosystems and atmospheric and cloud properties by augmenting NASA's Terra satellite measurements.
6. Producing additional seasonal/annual Earth radiation budget records by augmenting NASA's Terra satellite measurements.
7. Producing higher spectral resolution global infrared data of the Earth than prior NASA spaceborne measurements.

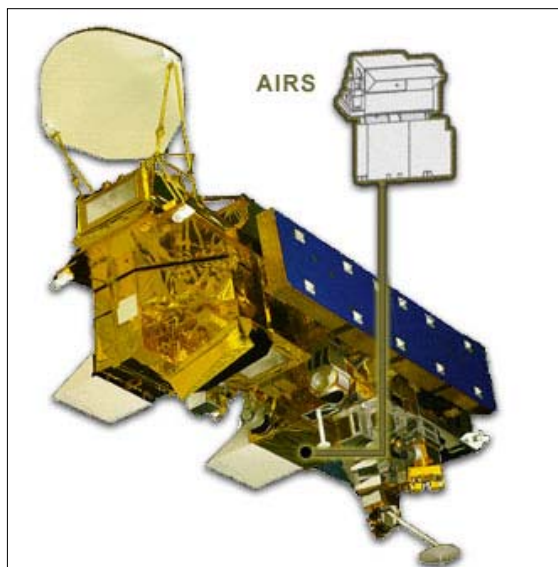
# Aqua Spacecraft Configuration



## Aqua Instrument Package

Aqua will help us to better understand and protect our home planet by answering science questions and meeting science goals through its suite of six high performance instruments. Each instrument is designed to collect measurements on a different aspect of the Earth system – areas vital for achieving a holistic view of our home planet.

### Atmospheric Infrared Sounder (AIRS)



The Atmospheric Infrared Sounder (AIRS) will measure humidity, temperature, cloud properties, and greenhouse gases throughout the atmosphere. These measurements, along with others, will allow scientists and operational agencies around the world to improve weather prediction and to observe changes in Earth's climate.

AIRS will observe and characterize the entire atmospheric column from the surface of Earth to the top of the atmosphere. This sensor will provide data on Earth's surface and atmospheric temperature, humidity, clouds, and the ability of Earth's surface to radiate energy back into space.

AIRS also will measure ozone and other greenhouse gases. These data will help researchers increase their understanding of Earth's global water and energy cycles, climate variation and trends, and the response of the climate system to increased greenhouse gases. The result will be more reliable climate prediction, improved weather forecasts, a better understanding of factors influencing air quality and consequently a better ability to reduce economic and human losses from natural hazards. AIRS data will contribute to NASA's mission to better life here on Earth through our understanding of the Earth system.

The AIRS instrument is one of three microwave sounding instruments aboard NASA's Aqua spacecraft. AIRS, in combination with the Advanced Microwave Sounding Unit (AMSU) and the Humidity Sounder for Brazil (HSB), represents the most advanced and accurate atmospheric sounding system ever deployed in space. This suite of sounding instruments is expected to become the pathfinder for the National Oceanic and Atmospheric Administration's (NOAA) future operational sounding system.

The NOAA National Centers for Environmental Prediction currently uses land-launched weather balloons and satellite data to update forecasts every six-hours. These forecasts are accurate to within 1.1 to 1.3 degrees Kelvin (1.98 to 2.34 degrees Fahrenheit) in regions with good weather balloon coverage. However, the balloons, which measure temperature, humidity and pressure and transmit information to a ground receiver, do not observe the 75 percent of the world covered by oceans and are scarce in Africa, Asia and South America. Obtaining more accurate, detailed satellite information at more frequent sampling intervals is key to improving weather forecasting.

Every 2.67 seconds, AIRS will "plumb" the atmosphere at multiple depths for temperature and humidity. Aqua will observe the Earth and measure the infrared brightness of the atmosphere in many wavelengths. Each wavelength of light emphasizes a particular height in the atmosphere. By having multiple infrared detectors, each sensing a particular wavelength, a temperature profile, or "sounding," of the atmosphere can be made. Unlike previous space instruments that had only 15 detectors, AIRS has 2,378 detectors, or channels, greatly improving accuracy and vertical resolution.

At the heart of AIRS is an advanced, high-resolution spectrometer that measures Earth's infrared spectral region from 3.75 to 15.4 micrometers. As Aqua moves along its flight path, AIRS sweeps the ground below, creating a scan "swath" extending roughly 800 kilometers (497 miles) on either side of the ground track. Each infrared scan produces 90 "footprints" across the flight track, each viewing an area approximately 13.5 kilometers (8.4 miles) in diameter directly below the spacecraft at the Earth's surface. During each scan, AIRS collects 2,378 spectral samples, measuring the complete infrared spectrum. Global coverage is obtained twice daily, except close to the equator.

Infrared energy from Earth's surface and atmosphere enters the AIRS instrument and is directed into the infrared spectrometer and visible/near-infrared photometer. Within the spectrometer, it is further directed into 11 different slits—essentially creating 11 different spectrometers all viewing the same area.

The energy from each slit is then dispersed across AIRS' state-of-the-art focal plane assembly, which consists of an array of mercury-cadmium-telluride (HgCdTe) detectors, each of which views a unique wavelength.

AIRS' visible/near-infrared photometer has a field of view of approximately 2.3 kilometers (1.43 miles) on the ground. It is aligned with the infrared spectrometer to allow simultaneous visible and infrared scene measurement. The photometer, which uses optical filters to define four spectral bands in the 0.4 to 1.0 micrometer region, provides a diagnostic imaging capability for the presence of low-level clouds.

AIRS will provide detailed observations over most of Earth at intervals of about 50 kilometers or 31 miles — about three times better spatial resolution than currently available from satellite observations. This improvement will enable AIRS to detect strong, narrow storms that previously may have gone undetected. AIRS will provide multiple observations at each point, revealing many subtleties that will help improve the weather forecasts of operational agencies.

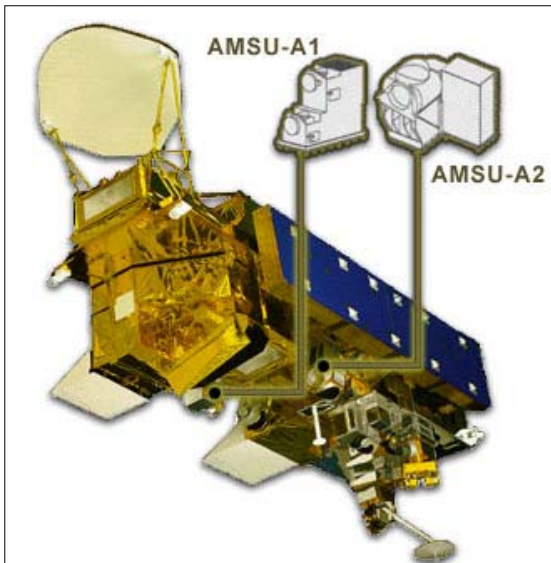
Within a few months of launch, AIRS will provide data to weather forecasters around the world. The program is working with several institutions, including NASA's Data Assimilation Office, NOAA and its National Centers for Environmental Prediction, the European Center for Medium-Range Weather Forecasts, the Japan Meteorological Administration, the Australia Bureau of Meteorology, the British Meteorological Office and the Meteorological Service of Canada.

AIRS will enable an improvement in the useful range of weather forecasts by two to three days. The airline, transportation, agriculture and construction industries will all be major benefactors of improved weather forecasts. NASA is dedicated to developing advanced technologies that will help better life here on Earth while providing the tools needed to explore the universe.

AIRS measures 116.5 by 80 by 95.3 centimeters (45.9 by 31.5 by 37.5 inches) stowed and 116.5 by 158.7 by 95.3 centimeters (45.9 by 62.5 by 37.5 inches) deployed and has a mass of 177 kilograms (390.2 pounds).

AIRS was built by BAE SYSTEMS for NASA's Jet Propulsion Laboratory, Pasadena, Calif. Other members of the AIRS contractor team include TRW, Matra Marconi Space, and Aerojet.

## Advanced Microwave Sounding Unit (AMSU)



The Advanced Microwave Sounding Unit (AMSU) consists of two physically separate units, the AMSU-A1 and the AMSU-A2, and will be used in conjunction with the AIRS instrument to obtain accurate temperature profiles, with the AMSU measurements being particularly important for analysis of the upper atmosphere. AMSU will provide temperature measurements up to an altitude of 40 km (24.8 miles) and has a cloud-filtering capability for observations lower in the atmosphere. Together, the AIRS and AMSU sensors will obtain temperature accuracies of 1 C (1.8F) in 1 km (.6 mile) layers of the lower atmosphere. This is markedly better than any previous space-based measurements.

The AMSU sensor has 15 channels, 12 of which are predominantly for temperature soundings and three of which are for atmospheric water vapor and precipitation measurements. The AMSU data will have horizontal resolutions directly below the satellite of 40.5 km (25.1 miles).

The AMSU and Humidity Sounder for Brazil (discussed below) measure at microwave wavelengths and complement the infrared measurements of the AIRS sensor. The capability to acquire microwave measurements in addition to infrared measurements increases the range of conditions under which accurate science results can be obtained.

AMSU was built by Aerojet under contract with NASA Goddard.

## Humidity Sounder for Brazil (HSB)



The Humidity Sounder for Brazil (HSB) will obtain humidity soundings, and measure precipitation and the total amount of water in the atmospheric column beneath the satellite. HSB is particularly important because of its capability to obtain humidity profiles under conditions of heavy cloud cover. HSB has four channels, and the data from the instrument will have horizontal resolutions of 13.5 km (8.3 miles).

This sounding instrument will help improve global weather forecasting by providing data where radiosonde data is scarce, as is the case in the Southern Hemisphere. HSB also will help in the understanding of the Brazilian rainforest system by providing scientific data to the scientists of National Institute for Space Research (INPE), who constantly monitoring the rainforest environment through satellite imagery.

The HSB instrument aboard Aqua is the result of a memorandum of understanding signed by NASA and the Brazilian Space Agency (AEB) in December of 1996. The development of the instrument has been coordinated by the INPE and is sponsored by AEB.

The HSB was provided to the Aqua mission by INPE with the prime contractor being Matra Marconi Space.



## Clouds and the Earth's Radiant Energy System (CERES)



The Clouds and the Earth's Radiant Energy System (CERES) experiment is a high-priority instrument that will help scientists better understand Earth's total thermal radiation budget. The total thermal radiation budget is the balance between Earth's incoming and outgoing energy. Sunlight or solar energy is the planet's only incoming energy source. Heat emitted from Earth and sunlight reflected by the Earth's surface, atmosphere and clouds make up the planet's outgoing energy. Scientists have been working for decades to understand this critical energy balance.

The energy received from the Sun is at short wavelengths, while the energy emitted by the surface of the Earth, the atmosphere and clouds is at long wavelengths. Greenhouse gases in the atmosphere absorb the long wavelength energy or heat emitted by the Earth. Increases in the amounts of greenhouse gases produced by both natural processes and human activities can lead to a warming of the Earth's surface. Such changes may, in turn, alter the planet's daily weather and climate. Clouds and small particles in the atmosphere called aerosols also reflect some sunlight back into space. Major sources of aerosols include windblown dust, emissions from the burning of fossil fuels, such as gasoline, and the burning of forests and agricultural fields.

CERES will measure energy at the top of the atmosphere, within the atmosphere and at the Earth's surface. Using information from very high resolution cloud imaging instruments aboard Aqua, CERES also will determine cloud properties, including altitude, thickness, and the size of cloud particles. All of these measurements are critical for advancing the understanding and protection of the Earth's total climate system and the accuracy of climate prediction models.

One of the most intriguing questions facing climate modelers today is how clouds affect the Earth's climate and vice versa. The U.S. Global Change Research Program, which NASA is a member of, classifies understanding the role of clouds and the Earth's energy budget as one of its highest scientific priorities.

Understanding cloud effects requires a detailed knowledge of how clouds absorb and reflect sunlight, as well as how they absorb and re-emit outgoing heat emitted by the planet. For example, low, thick clouds primarily reflect incoming solar energy back to space causing cooling. Thin, high clouds, however, primarily trap outgoing heat and produce warming. To date, satellite studies have found that clouds have an overall cooling effect on the Earth.

Water vapor in the atmosphere also impacts our daily weather and climate, though scientists are only beginning to understand how this complex mechanism works. Water vapor acts like a greenhouse gas and absorbs outgoing heat to warm the Earth. Since water vapor also condenses to make clouds, additional water vapor in the atmosphere also may increase the amount of clouds.

CERES consists of two broadband scanning radiometers that measure reflected sunlight, Earth-emitted thermal radiation, and total radiation. Scientists will use CERES observations to study the energy exchanged between the Sun; the Earth's atmosphere, surface and clouds; and outer space.

The CERES Aqua instruments will be the fourth and fifth CERES instruments in orbit. NASA launched the first CERES instrument aboard the Tropical Rainfall Measuring Mission (TRMM) satellite in November 1997. Results of the TRMM mission show that the first CERES provided better measurement capabilities than any previous satellite instrument of its kind. Two other CERES instruments are currently orbiting the Earth on NASA's Terra spacecraft, launched in late 1999. Early CERES results from Terra give new insights into the effects of clouds on climate and how the climate system changes from decade to decade.

The CERES instruments aboard the Terra and Aqua satellites will provide global coverage of energy radiated and reflected from the Earth. Scientists will use measurements from both Terra and Aqua's orbits to improve observations of the daily cycle of radiated energy.

NASA's Langley Research Center manages the CERES mission. The CERES instrument was built by TRW Space & Electronics Group in Redondo Beach, Calif.

## Advanced Microwave Scanning Radiometer for Earth Observing Satellite



The Advanced Microwave Scanning Radiometer for Earth Observing Satellite (AMSR-E), built by Mitsubishi Electronics Corporation, is provided by Japan's National Space Development Agency (NSDA) through partnership with NASA.

AMSR-E will measure Earth's environment in support of several global change science and monitoring efforts.

Precipitation and evaporation are extremely important processes to understand. Through provision of water to the biosphere via precipitation and as an air conditioning agent that removes excess heat from the surface (via evaporation), these processes contribute toward making Earth habitable. Understanding rainfall is vital to our understanding and protecting our home planet.

AMSR-E will measure rainfall rates over both lands and oceans. Over the oceans, the AMSR-E microwave frequencies can probe through smaller cloud particles to measure the microwave emission from larger raindrops.

AMSR-E will provide sensitivity to oceanic rain rates as high as 50 mm/hr (about 2 inches per hour). Over land, AMSR-E can measure the scattering effects of large ice particles, which later melt to form raindrops. In this instance, these measurements are converted to rain rates with the help of cloud models.

Over the oceans, in addition to rain rates, AMSR-E will provide sea surface temperatures through most types of cloud cover. These measurements will supplement infrared-based measurements of sea surface temperatures that are currently restricted to cloud-free areas. Sea surface temperature fluctuations are known to have a profound impact on weather patterns across the globe, and the all-weather capability of AMSR-E may provide a significant improvement in our ability to monitor sea surface temperatures and the processes controlling them.

The total integrated water vapor of the atmosphere also will be measured over the oceans. This variable is important in understanding how water is cycled through the atmosphere. Since water vapor is the Earth's primary greenhouse gas, and contributes the most to future projections of global warming, it is critical to understand how it varies naturally within the Earth system.

The AMSR-E measurements of ocean surface roughness can be converted into near-surface wind speeds. These winds are an important determinant of how much water is evaporated from the surface of the oceans. Winds help to maintain the water vapor content of the atmosphere while precipitation continually removes it.

AMSR-E cloud-water estimates over the ocean will help scientists determine if clouds, with their ability to reflect sunlight, increase or decrease under various conditions. This could be an important feedback mechanism that either enhances or mitigates global warming, depending on whether clouds increase or decrease with warming.

Monitoring of sea-ice parameters, such as ice concentration, type, and extent, is necessary to understand how this frozen blanket over the oceans affects the larger climate system. Sea ice has the ability to insulate the water against heat loss to the frigid atmosphere above it, and at the same time the ability to reflect sunlight that would otherwise warm the oceans. The AMSR-E instrument will take advantage of the marked contrast in microwave emissions of sea ice and liquid water and these measurements will allow for the derivation of sea ice concentrations in both polar-regions.

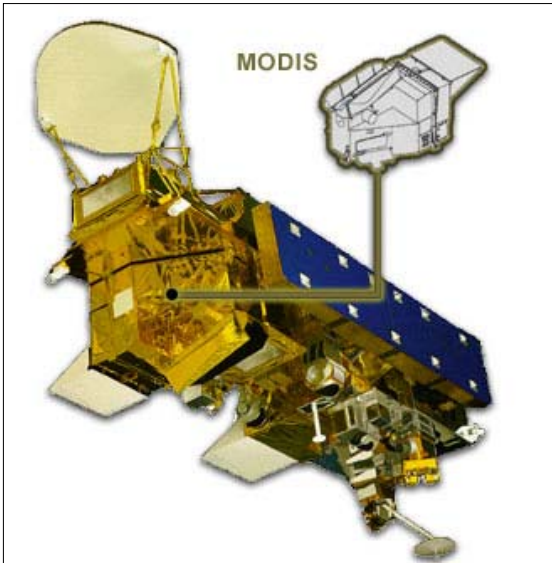
In much the same way as AMSR-E can see large ice particles in the upper reaches of rain systems, it also measures the scattering effects of snow-cover depth. These measurements are empirically related to snow-cover depth and water content based upon field measurements.

Like sea ice, snow cover has a large influence on how much sunlight is reflected from the Earth. Snow also acts as a blanket, keeping heat from escaping from the underlying soil and allowing deep cold air masses to develop during the winter. It further provides an important storage mechanism for water during the winter months, which then affects how much surface wetness is available for vegetation and crops in the spring – important data for agricultural resource management. AMSR-E monitoring of snow cover will allow studies and monitoring of how snow-cover variations interplay with other climate fluctuations.

In areas of very little surface vegetation, the AMSR-E sensor can identify the moisture content of soil. AMSR-E will provide data that will allow scientists to determine how useful low-frequency (6.9 GHz) microwave observations can be to monitoring surface wetness. Surface wetness is important for maintaining crop and vegetation health, and monitoring soil moisture on a global basis will allow drought-prone areas to be checked for signs of drought.

AMSR-E will provide unprecedented detail and accuracy in the global, all-weather measurement of these variables and thereby will allow a more-complete understanding of climate variability, ultimately enabling better climate prediction.

## Moderate Resolution Imaging Spectroradiometer



The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument is designed to provide observations that scientists can use to increase understanding of global dynamics and processes occurring on the surface of the Earth and in the lower atmosphere.

The MODIS instrument is part of the sensor package aboard NASA's Terra satellite and, in combination with Aqua, this instrument will yield simultaneous, congruent observations of high-priority atmospheric (cloud cover and associated properties), oceanic (sea-surface temperature and chlorophyll), and land-surface features (land-cover changes, land-surface temperature, and vegetation properties).

The MODIS instrument employs a conventional imaging-radiometer concept, consisting of a cross-track scan mirror and collecting optics, and a set of linear detector arrays with spectral interference filters located in four focal planes. The optical arrangement will provide imagery in 36 discrete bands from 0.4 to 14.5  $\mu\text{m}$ , selected for diagnostic significance in Earth science. MODIS instruments will provide daylight reflection and day/night emission spectral imaging of any point on the Earth at least every two days.

The instrument is expected to make major contributions to the understanding of the global Earth system, including interactions between land, ocean, and atmospheric processes.

The Moderate Resolution Imaging Spectroradiometer (MODIS), was built by Raytheon Santa Barbara Remote Sensing, under contract with Goddard Space Flight Center.

## **NASA's Earth Science Enterprise**

Since its creation in 1958, NASA has been studying the Earth and its changing environment by observing the atmosphere, oceans, land, ice, and snow, and their influence on climate and weather. NASA's unique technical capability to pursue science through space-based observation allows researchers to observe Earth on a global scale – as a planet.

In 1991, NASA began a comprehensive program to study the Earth as an environmental system. This program, now called the Earth Science Enterprise, is dedicated to understanding the total Earth system and the effects of natural and human-induced changes on the global environment.

The mission of NASA's Earth Science Enterprise is to develop a scientific understanding of the Earth system and its response to natural or human-induced changes to enable improved predictive capability for climate, weather, and natural hazards. In short, NASA's Earth science Research Program is devoted to answering the following question:

### ***How is the Earth changing and what are the consequences for life on Earth?***

The scientific strategy to answer this immensely complex question is laid out in five steps.

1. How is the Global Earth System Changing?
2. What are the Primary causes of the Earth System Variability?
3. How does the Earth system respond to natural and human-induced changes?
4. What are the consequences of change in the Earth system for human civilization?
5. How well can we predict future changes in the Earth system?

Scientists now realize that the key to gaining a better understanding of the global environment is exploring how Earth's land surface, solid Earth, biosphere, atmosphere and oceans interact with each other. This interdisciplinary approach -- called Earth System Science -- pulls from fields such as geology, biology, meteorology, oceanography, and the atmospheric sciences.

The unique vantage point of space provides information about Earth's land surface, solid Earth, biosphere, atmosphere and oceans that is obtainable in no other way. Programs of the Enterprise study the interactions among these components to advance the discipline of Earth System Science, with a near-term emphasis on global climate change. NASA's Earth science research results contribute to the development of sound environmental policy and economic investment decisions.

NASA's Earth Science Technology Program, in conjunction with commercial sector and international partners, enables Earth science research through the planning and development of advanced Earth observing satellite systems.

NASA's Earth Science Applications Program is committed to extending the benefits of NASA's Earth science technology, discoveries, data and knowledge beyond the traditional science community with the goal of evolving Earth science results and technical capabilities into practical tools for solving practical problems.

NASA's Earth science applications are programs, projects and partnerships that use NASA's unique Earth science research results, data and technologies to enable more informed decisions at all levels of government and within the private sector. Benefits have been shown in areas of natural resource management, disaster management, community growth and infrastructure and environmental assessment. These benefits are realized through critical partnerships with Federal operational agencies, the commercial sector, the academic research community, and state and local government end-users of geospatial information.

Earth Science discoveries are shared with the public to enhance science, mathematics, and technology education and increase the scientific and technological literacy of all Americans. NASA's Earth science education program invests in a complementary set of activities that help the Nation meet its formal education, informal education and workforce development needs. One of NASA's goals is to yield a more interdisciplinary community in the near term to analyze data from the Earth Observing System missions and provide accurate information on global change to policymakers. NASA recognizes the Agency must invest resources to educate present and future teachers if its results and discoveries are to reach a national, diverse population of students.

By using satellites and other tools to intensively study the Earth, NASA hopes to expand the scientific understanding of how natural processes affect human populations, and how we might be affecting them. Such studies will yield improved weather forecasts, tools for managing agriculture and forests, information for fishermen and local planners, and, eventually, the ability to predict how the climate will change in the future.

NASA's Earth Science Enterprise has three main components: a series of Earth-observing satellites, an advanced data processing system, and teams of scientists who will study the data. Key areas of study include clouds; water and energy cycles; oceans; chemistry of the atmosphere; land surface; water and ecosystem processes; glaciers and polar ice sheets; and the solid Earth.

NASA's research efforts help us to better understand and protect our home planet, while developing the technologies needed to explore the universe and search for life elsewhere. Through science and technology development NASA hopes to inspire the next generation of our world's explorers.



## **Aqua Summary**

NASA's commitment to studying the Earth as a global system continues with the Aqua spacecraft, and represents a key contribution by NASA to the U.S. Global Change Research Program. Aqua's six state-of-the-art instruments will provide high measurement accuracy, spatial detail, and temporal frequency of key components of the Earth's system. This comprehensive approach to data collection enables scientists to study the interactions among the four spheres of the Earth system – the oceans, lands, atmosphere, and biosphere.

Aqua, Latin for "water," is named for the large amount of information that the Aqua spacecraft will collect about the Earth's water cycle. In particular, the Aqua data will include information on water vapor and clouds in the atmosphere, precipitation from the atmosphere, soil wetness on the land, glacial ice on the land, sea ice in the oceans, snow cover on both land and sea ice, and surface waters throughout the world's oceans, bays, and lakes. This information will help scientists improve the quantification of the global water cycle and examine whether or not the cycling of water might be accelerating.

In addition to information about the water cycle, Aqua will enable studies of the intensity of radiation from the Sun and from the Earth that combine to constitute the Earth's radiation balance. It also will enable studies of small particles in the atmosphere, termed "aerosols," and trace gases such as ozone, carbon monoxide, and methane. Each of these trace gases potentially contribute to global warming, whereas the aerosols are more likely to have a cooling effect on our environment. Aqua will provide observations on vegetation cover on the land, phytoplankton and dissolved organic matter in the oceans, and the temperatures of the air, land, and water. All of these measurements will contribute to an improved scientific understanding of the changes occurring in the global climate and the role of the interactions among the various elements of the climate system.

One of the most exciting of the potential practical benefits likely to derive from the Aqua data is improved weather forecasting. Aqua will carry a sophisticated sounding system that will allow determination of atmospheric temperatures around the world to an accuracy of 1° Celsius (1.8 F) in 1-kilometer-thick (.6 mile) layers throughout the troposphere. The troposphere is the lowest part of Earth's atmosphere and extends to an altitude of about 10-15 kilometers (6-9 miles), depending on geographic location, and contains most of the global cloud cover. The anticipated 1° Celsius (1.8 F) accuracy far exceeds current accuracies from satellite observations and, in conjunction with the moisture profiles also obtainable from the Aqua sounding system, will offer the potential of improved weather forecasting. NASA is working with NOAA and the European Centre for Medium-Range Weather Forecasts to facilitate the incorporation of the Aqua data into their operational weather forecasting efforts.

### **Aqua International Partnerships**

Aqua is a joint project between the United States, Japan, and Brazil.

## **The Spacecraft**

The spacecraft was designed and built by TRW in Redondo Beach, Calif. Aqua is based on TRW's modular, standardized AB1200 common spacecraft bus. This design features common sub systems that can be scaled to the mission-specific needs of Aqua. Instrument payloads can be attached on a "mix and match" basis with minimal changes to the overall design or subsystem support requirements.

## **Management**

NASA's Goddard Space Flight Center manages the Aqua mission and managed the integration and testing of the spacecraft. The Aqua data will be processed, archived, and distributed using distributed components of the Earth Observing System Data and Information System. This system also provides the mission operations systems that perform the command and control functions of the spacecraft and instruments. NASA's Kennedy Space Center is responsible for the launch operations, including Boeing's Delta launch vehicle and the pre-launch integrated processing facility at Vandenberg Air Force Base. The U.S. Air Force is responsible for all range-related matters concerning the launch.

## **Data Processing and Distribution**

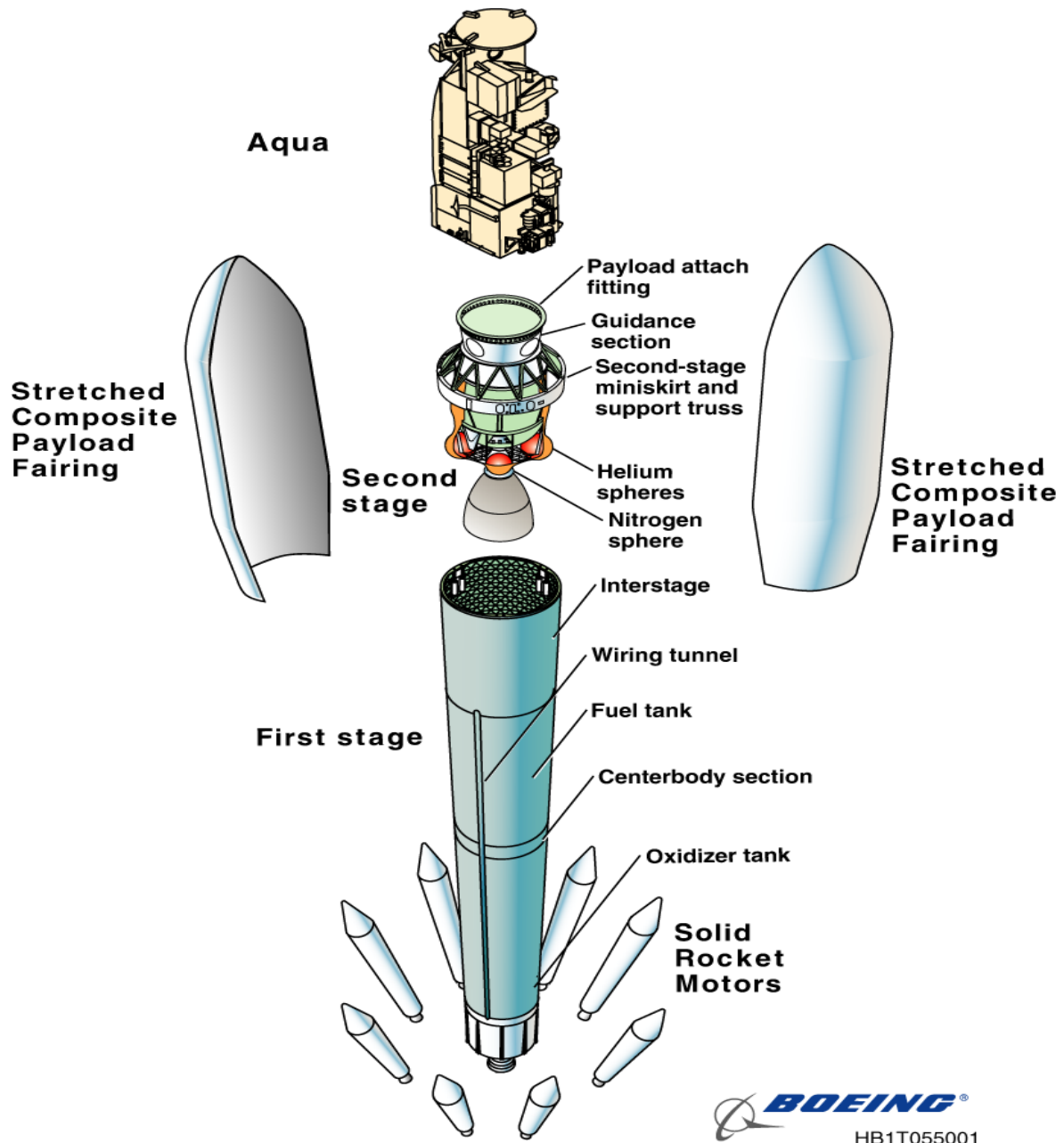
Aqua data will populate a major part of a multi-decade environmental dataset focusing on global change. The Aqua instruments will produce more than 750 gigabytes of data per day, which is equivalent to 75 personal computer hard drives at 10 gigabytes each per day. This massive amount of information will be handled using the Earth Observing System Data and Information System. This system presently handles nearly 3000 gigabytes per day and will provide the high-performance computing resources needed to process, store, and rapidly transmit terabytes (thousands of gigabytes) of incoming data daily. The system has several distributed sites, called Distributed Active Archive Centers, or "DAACS," that perform the data processing, storage and distribution functions.

The Earth Observing System Data and Information System uses an "open" architecture to allow insertion of new technology while enabling the system to support the changing mission and science needs throughout the Earth Observing System Program.

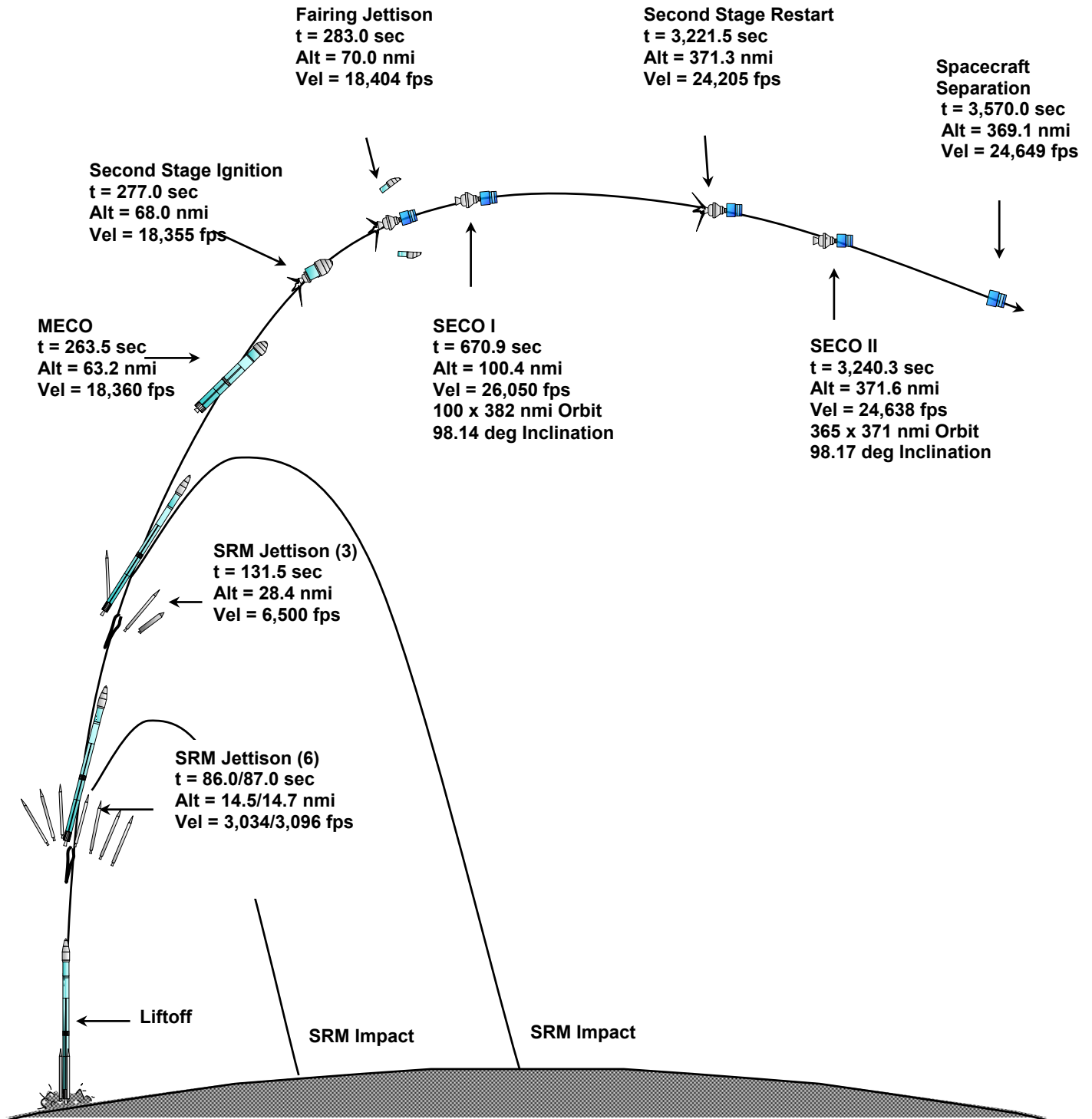
Further information on Aqua can be found at:

<http://aqua.nasa.gov>

# Delta Configuration



# Aqua Boost Profile



## Launch Sequence

Main Engine Start	Launch + 0 minutes
Solid Rocket Motor Jettison (6 of 9)	Launch + 1 minute 26.5 seconds
Solid Rocket Motor Jettison (3 of 9)	Launch + 2 minutes 11.5 seconds
Main Engine Cutoff	Launch + 4 minutes 23.5 seconds
2nd Stage Ignition	Launch + 4 minutes 37 seconds
Fairing Jettison	Launch + 4 minutes 43 seconds
Acquisition of 1 <sup>st</sup> Signal @ NASA's Tracking and Data Relay Satellite (TDRS)-West	Launch + 4 minutes 44 seconds
Second Engine Cutoff I	Launch + 11 minutes 10.9 seconds
2nd Stage Restart	Launch + 53 minutes 41.5 seconds
Second Engine Cutoff II	Launch + 54 minutes 0.3 seconds
Acquisition of Signal @ Alaska Ground Station	Launch + 6 hours 50 minutes 55 seconds
Operations:	
Check Out of Instruments	Launch + 2 to 3 months
First Images Received	Launch + 3 months