NEWS

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PROJECT: SMALL SCIENTIFIC SATELLITE

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SMALL SCIENTIFIC SATELLITE TO BE LAUNCHED

A National Aeronautics and Space Administration scientific satellite is scheduled to be launched by a Scout rocket no earlier than November 11, from an Italian-operated platform in the Indian Ocean off the coast of the Republic of Kenya.

The Small Scientific Satellite, (S^3 or "S-cube"), a 51.9 kilogram (114-pound), highly compact automated space laboratory, will carry seven scientific and three engineering experiments provided by NASA and two U.S. universities, to conduct a detailed investigation of the environment of the Earth's inner magnetosphere. The Earth's magnetosphere is an enormous teardrop-shaped region surrounding the Earth and is formed by the solar wind--a supersonic stream of particles--"blowing" on the Earth's magnetic field.

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In this region, enormously complex electric, magnetic and gravitational forces, invisible to the human eye, interact with one another and with all things that enter the region. Charged particles whirl and rebound from one hemisphere to another in seconds. Electrons speed into the upper atmosphere of the Earth at thousands of miles per second to give off tremendous energies that form the auroras. Magnetic storms occur frequently, creating huge electric ring currents around the Earth which often disrupt long-range radio communications.

Such complex, large-scale phenomena cannot be reproduced and studied in the laboratory. The only research tool available to scientists for these studies is an Earth-orbiting satellite able to make direct measurements from space.

The mission of S^3 is to investigate the causes of world-wide magnetic disturbances associated with large solar flares. These disturbances are produced by the sudden appearance of low energy protons well inside the trapping region of the magnetosphere, but the means by which these protons enter the magnetosphere is at present unknown. The S^3 has been designed and instrumented to map in detail the energy spectra and angular distribution of these particles and to determine the ways in which their motion changes with time. These measurements are expected to furnish clues to the origin of these particles and how they are lost once they become trapped.

Specific S^3 scientific objectives include:

*Study of the development of magnetic storms and the ring current;

*Investigating the relationship between the aurora, magnetic storms and the acceleration of charged particles within the inner magnetosphere;

*Study of time variations of trapped particles ;

*Study of electrostatic waves in the inner-magnetosphere;

*Movement and intensities of electrons and protons;

*Detailed investigation of magnetic field strengths, fluctuations in the field and spectrum of electric fields in the inner magnetosphere.

S^3--to be called Explorer 45 after orbit is achieved--was designed, built and tested at the NASA Goddard Space Flight Center, Greenbelt, Md. From an engineering standpoint, it is the most innovative and compact satellite to date in the Explorer series. For the first time on a satellite, an on-board data handling system can be reprogrammed by ground command to concentrate on specific sets of data which are related, for example, to sudden events such as magnetic storms or to unanticipated phenomena occurring in the inner magnetosphere.

The S^3 structure is made from thin sheet aluminum with riveted joints instead of the traditional machined sections. This technique, comparatively new to satellite construction, reduces the weight and construction costs significantly.

The orbit planned for S^3 is equatorial, inclined only 3.5 degrees, with an apogee or high point of about 28,876 kilometers (17,943 statute miles) and a perigee or low point of 222 kilometers (138 statute miles). It will take eight hours and 37 minutes to complete one orbit around the Earth. Its planned minimum operating lifetime is one year.

The S^3 launching--fourth from the San Marco launch platform--will be conducted by a crew from the Aerospace Research Center of the University of Rome (Centro Ricerche Aerospaziali dell'Universita Degli Studi di Roma). It will be the second domestic U.S. satellite to be launched by Italy under a launching agreement concluded April 30, 1969. The first was Explorer 42 (Small Astronomy Satellite - A), orbited on December 12, 1970, officially renamed Uhuru in honor of Kenyan Independence Day.

The three previous launchings from the platform were the satellites San Marco II and III, Italian spacecraft placed in orbit in a cooperative NASA/Italian Space Commission project and a NASA Small Astronomy Satellite launched by the Italians on a reimbursable basis.

The San Marco launch facility--a unique engineering achievement--consists of a large platform similar to those developed for use as ocean docks or marine oil drilling rigs. A second, smaller platform, called Santa Rita, located about 570 meters (600 yards) from San Marco, serves as the control and operations center for launch operations. The two platforms are connected by 23 underwater cables.

The equatorial location of the San Marco platform is ideal for launching the S^3 into its low inclination orbit. Other launch locations would require larger and more costly booster rockets for this orbit.

The inner magnetosphere--the region where S^3 investigations will be conducted--contains the Van Allen radiation zones. These zones, shaped much like lopsided doughnuts, surround the Earth beginning about 975.400 kilometers (600 miles) above the equator, extending out many thousands of miles. They consist of complex mixes of energetic charged particles in a fourth state of matter since they do not behave like ordinary solids, liquids or gases.

One of the major scientific achievements of the space age has been defining the size and shape of the magnetosphere, and obtaining an insight into the forces controlling it.

Once S^3 is in orbit, data will be acquired by four tracking stations of the Space Tracking and Data Acquisition Network (STADAN): Johannesburg, Republic of South Africa, Orroral, Australia; Quito, Ecuador; and Rosman, N.C. Each station will be capable of providing real-time data transmission to the S^3 Control Center at Goddard. The stations will also relay commands to the satellite, for checkout and operational purposes.

After evaluation and analysis by the principal investigators, the scientific data from S^3 will be deposited in the National Space Science Data Center, Greenbelt, Md., for use by the world scientific community.

The S^3 is part of the Explorer series of scientific satellites directed by NASA's Office of Space Science and Applications. The NASA Goddard Space Flight Center is responsible for S^3 project management. Prime contractor for the Scout launch rocket is Ling-Temco-Vought, Aerospace Corp., Dallas, Texas.

(End of General Release; Background Information Follows)

THE S^3 SATELLITE

As the most compact and advanced satellite in the NASA Explorer series, the 58.6 kilogram (108-pound) S^3 is an eight sides polyhedron structure, 68.5 centimeters (27 inches) across. Its outer surface is covered with solar cells to provide energy from the sun to charge its 18-cell silver-cadmium battery.

Distinguishing physical features of S^3 include:

*A 76.2 centimeter (30-inch) boom protruding from the pyramid-shaped top of the main body;
*Two 2.74 meters (9-feet) booms, deployed after orbit is achieved, to carry electric field sphere detectors;
*Two 60.9 (2-feet-long) booms, also deployed after orbit is achieved, to carry the search coil magnetometers;
*Four 60.9 centimeter (24-inch) antennas mounted around the top of the main body.

The internal structure of S^3 --struts, center tube, the experiment sensor support rack--is fabricated from sheet aluminum using riveted joints. This is a departure from the conventional technique of employing machined sections. The result is savings both in satellite weight and construction costs.

The most important feature of S^3 from an engineering standpoint is the onboard data handling system developed specifically for the satellite. It marks a major technical advance in data handling techniques for unmanned satellites. It is the keystone for successful fulfillment of the scientific mission.

The system consists of five main components: a central processing unit, a program memory, a buffer memory, an input/output module, and a data synchronous clock.

One of the most important features of the system is that in-flight changes in the on-board stored programs can be made by ground command. This permits the experimenter to conduct experiments in space in much the same manner as he would in a terrestrial laboratory.

Data collection can be commanded to carry out a specific set of measurements. Unanticipated events--a sudden magnetic storm or other phenomena--can be investigated in detail by changing the sampling rate of a given experiment sensor or set of sensors.

While actual operating details of the system are exceedingly complex, the significant point is that the experiment data collection techniques are vastly simplified, thus permitting less complex and more economical operations. The end result is more science for the dollar.

S^3 ENGINEERING EXPERIMENTS

The three important engineering experiments are designed to provide information to help in the design and development of future spacecraft.

*Aerodynamic Heating Measurements - Provided by the Goddard Space Flight Center, the experiment involves measuring aerodynamic heating on the satellite after the Scout rocket's protective shroud is jettisoned--at an altitude of about 104 kilometers (65 miles) above the Earth. This is the period when the rocket has passed through the most dense portion of the atmosphere. Since atmospheric density changes with altitude and season, little is known about its effect on a satellite.

To measure this effect, a special thermistor has been placed on the top of the satellite. It will measure the aerodynamic heating up to the point of injection into orbit. The S^3 data handling system will be programmed to transmit the information to the ground at a rate 60 times faster than its normal data collection mode.

*Radiation Damage Experiment - Provided by the Goddard Space Flight Center, the experiment is designed to determine the effects of radiation on advanced, exceedingly small integrated circuits. This experiment is especially appropriate for the S^3 satellite since it will spend much of its time in the most intense region of the radiation zone. The experiment includes integrated circuit devices called MOSFET and COSMOS. The COSMOS circuits were developed in mid-year for use on the forthcoming NASA Atmosphere Explorer spacecraft.

*Scanning Celestial Attitude Determination System (SCADS) - Developed by the Goddard Space Flight Center, SCADS is a new, light-weight device (3.5 pounds - 1.57 kilometers) which will provide information on the attitude of the satellite within .1 degree. It is designed to demonstrate the feasibility of providing highly accurate attitude data with a lightweight, star-sensing system. It will also be used operationally to assist in analysis of data from the scientific experiments.

Scientific Objectives

In an egg-shaped orbit above the Earth's geomagnetic equator, S^3 will spend its operational lifetime investigating in detail a region never before fully explored.

Earlier NASA scientific satellites--particularly Explorers 12, 14, 15 and 26 and three of the Orbiting Geophysical Observatory series--were launched from Cape Kennedy, Fla., in moderately high inclination orbits which carried them through this region only part of the time.

These earlier investigations provided a general picture of the region. A general understanding of major particle populations, the structure of the radiation zone, the interplay between the magnetosphere and particles, and the dynamic characteristics of particle transport, acceleration and loss mechanisms emerged.

This new knowledge presented a far more complex picture of the region than had been envisioned, raising a host of new questions about the complex mechanics of the inner magnetosphere.

Scientific "firsts" hoped for from the S^3 include:

*First detailed measurements of the particles of the inner magnetosphere;

*First measurement of all particles of the ring current--a little-understood westward-moving electric current that becomes intensified particularly after a disturbance on the Sun;

*First coordinated program to investigate simultaneously particles, magnetic fields and electric fields in the region.

The seven integrated scientific experiments carried by S^3 will concentrate on studies in three major categories: charged particles, magnetic fields and electric fields. The interrelationship of these phenomena is exceedingly complex. To fully understand them requires advanced training in physics.

Energetic Particle Experiments

The energetic particles, trapped in the Earth's magnetic field, are atomic particles carrying electric charges. These trapped particles move in complex paths. They spiral about the magnetic lines of force, darting from the Northern Hemisphere along a magnetic field line to a conjugate point in the Southern Hemisphere and back. Their forward velocity is greatest and their spiral movement less over the equatorial region. As they approach the polar regions, the spiraling action becomes tighter and their forward velocity decreases.

Finally the forward velocity reverses and the particle retraces its path to the other hemisphere. The full cycle may take seconds or minutes.

To further complicate the problem, as the particles move back and forth across the equator, they also drift around the equator, electrons to the east and protons to the west. A complete revolution of the Earth may take minutes or hours. The movement may be altered by magnetic storms or to a lesser extent by little-understood wave motions in the thinly-spaced particles.

*Channel Electron Multipliers Experiment - Provided by the Goddard Space Flight Center, the purpose of this experiment is to conduct a census of electrons and protons in specific energy ranges - 700 electron volts to 25,000 electron volts. The device consists of charged particle counters which operate in conjunction with what are called curved-plate electrostatic analyzers.

*Solid State Proton Detector - Developed by the Goddard Space Flight Center, the experiment is a compact package of two solid state detector telescopes which will measure protons and heavier ions along the path of the satellite's orbit. A special magnet device, operating like a broom, will sweep away electrons. Measurements conducted by the experiment will concentrate on protons with energies ranging from 25,000 electron volts to 2.35 million electron volts. The device is one of the most advanced and compact proton-measuring instruments ever developed. For the first time it will also measure alpha particles (the nuclei of helium atoms) and heavier ions in the equatorial region.

*Solid State Electron Detector - Developed by the Goddard Space Flight Center, this experiment will measure electron intensities all the way from 35,000 to 400,000 electron volts. It consists of solid state detectors of an advanced design behind a magnet which separates the electrons according to their energy.

Magnetic and Electric Field Experiments

The Earth's magnetic field is enclosed in the magnetosphere. A little-understood electric current system flowing within the molten, metallic core of the Earth is responsible for the Earth's main magnetic field.

In addition to the main magnetic current existing within the Earth, other electric currents flow within the magnetic field and cause numerous variations in the magnetic field of the magnetosphere. Depending on the type of variations they are called magnetic waves, magnetic storms and substorms. Magnetometers are the primary instruments used to study magnetic fields.

Fairly steady electric fields also exist within the magnetosphere due to the rotation of the Earth and the interaction of the solar wind with the outer magnetosphere. In addition, rapidly varying electric fields result from complicated interactions between the charged particles and the magnetic fields. These fields will be observed by two electric field experiments.

*<u>Flux-Gate and Search-Coil Magnetometer Experiments</u> - The two magnetometer experiments were provided by the Space Science Center of the University of Minnesota. They are designed to make measurements of variations in the magnetic field in different frequency ranges. The Flux-Gate Magnetometer, a square-shaped box, is mounted on a boom extending from the top of the satellite. It will measure field strengths from 0.6 gammas to 3,000 gammas. The Search-Coil Magnetometers are mounted on the two short booms extending from the sides of S^3. They are similar to the magnetometers carried by the Orbiting Geophysical Observatories. They will detect magnetic fluctuations ranging from 1 to 3,000 Hz.

*<u>DC Electric Field Experiment</u> - Another Goddard-provided experiment, the DC Electric Field Experiment will study the field by means of sensing spheres mounted on the ends of the two long booms extending from the S^3. In addition, there are four spectrometer channels involved with the experiment to measure low-frequency variations between 0.3 and 30 Hz.

*<u>AC Electric Field Experiment</u> - Developed by the Department of Physics and Astronomy of the University of Iowa, this device will measure rapid changes in high frequencies of the electric field in the range of 20 Hz to 300 kHz. The sensors will concentrate on frequencies at which electrostatic waves phenomena may be expected. The sensors for this experiment, the spheres, are the same as those for the DC Electric Field Experiment.

THE SAN MARCO LAUNCH FACILITY

The San Marco launch facility is owned and operated by the Italian government. It is composed of two off-shore platforms stationed in Formosa Bay about three miles off the coast of Kenya 2.9 degrees south of the Equator. The launch platform San Marco, is located 570 meters (621 yards) from the Santa Rita platform which houses the control and operations center and supporting range equipment. The platforms are connected by underwater cables.

The launch platform has 20 steel legs embedded in the sandy seabed at latitude 2 degrees 56 minutes 40 seconds South, longitude 40 degrees 12 minutes 47 seconds East -- ideal for equatorial space launchings. A 36.5 meter (120-foot) shelter, which houses the Scout vehicle during vehicle checkout prior to launch, provides an air-conditioned environment for the vehicle while on the launcher. A large pit on the launch platform, open to the sea, will absorb the rocket exhaust of the Scout first-stage motor.

The Santa Rita platform, a LeTourneau oil drilling platform modified by the Italian firm Nuova Pignone, contains the nerve center of the project, the control room, and houses the tracking and instrumentation required to launch and track the Scout.

There are 23 cables, linking the San Marco launch complex with its sister platform. Some idea of the complexity of the operation can be gained from the fact that there are more than 3,000 connections of various kinds linking the two platforms. Independent generators at the two locations produce electricity at two voltages to meet the requirements of the scientific equipment and the housing and other facilities.

Logistical support for platform operations is provided by a base camp facility located on the shore of Formosa Bay at Ngomeni Point. Here, communications, supply, mess and housing facilities are available to range users.

S^3 FACT SHEET

Launch: From San Marco Equatorial Range, Indian Ocean, Republic of Kenya.

Launch Rocket: Four stage, solid-fuel Scout rocket.

Planned Orbit: Apogee: 28,704 kilometers (17,940 statute miles)
Perigee: 288 kilometers (180 statute miles)
Inclination: 3.4°
Period: 8 hours, 24 minutes

Operating Lifetime: At least one year.

Satellite Weight: 48.6 kilograms (108 pounds) with experiments accounting for one-third of overall weight.

Main Structure: Main body polyhedron-shaped, 68.5 centimeters (27-inches) in diameter, 73.6 centimeters (29-inches) tall.

Appendages: Flux-gate magnetometer boom, 76.2 centimeters (30 inches long).
Electric field sphere booms, 2.74 meters (9-feet long).
Search coil magnetometer booms, 60.9 centimeters (24-inches long).
Four antennas, 60.9 centimeters (24-inches long).

Power System: Solar cells mounted on 22 panels on outer surface of satellite main body to provide power to 18-cell silver-cadmium battery.
Power requirement: 21 watts average.

Communications and Data-Handling System:

Telemetry: Pulsed-Code Modulation/Phase Modulation (PCM/PM) operating at 136.830 MHz. Wide-band analog data at 139.95 MHz.

Commands: Handles 80 Pulse-Code Modulation commands at 148.980 MHz with 12 sequential tone backup commands.

Tracking and Data Acquisition: Stations of the world-wide Space Tracking and Data Acquisition Network (STADAN) operated by the Goddard Space Flight Center.

S^3 VEHICLE 163 FLIGHT SEQUENCE

	TIME-SECONDS
Lift-off	0.00
First Stage Burn out	77.10
Second Stage Ignition	80.77
Second Stage Burn out	121.73
Heat shield Ejection	159.84
Third stage Ignition	161.54
Third Stage Burn out	198.23
Spin up	430.13
Third Stage Separation	431.63
Fourth Stage Ignition	436.48
Fourth Stage Burn out	472.55
Spacecraft Separation	772.55

Orbital Parameters

Inclination	3.5 degrees
Eccentricity	0.68461
Period	8 hours 37 minutes
Perigee	222 kilometers (138 miles)
Apogee	28,876 kilometers (17,943 miles)
Spacecraft Weight	51.9 kilograms (114 pounds)

S^3 PROJECT OFFICIALS

NASA HEADQUARTERS

Program Manager:	John R. Holtz
Deputy Program Manager:	Raymond Miller
Program Scientist:	Lawrence D. Kavanagh
Scout Program Manager:	Paul E. Goozh

GODDARD SPACE FLIGHT CENTER

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Project Scientist:	Dr. Robert A. Hoffman
Assistant Project Manager:	Frank A. Carr
Project Coordinator:	Kenneth O. Sizemore
Project Operations Director:	Sterling R. Smith
Electronic Systems Manager:	Robert G. Martin

AEROSPACE RESEARCH CENTER, UNIVERSITY OF ROME (CRA)

Director of CRA:	Professor Luigi Broglio
Range Manager:	Professor Michele Sirinian
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LANGLEY RESEARCH CENTER

Head, Scout Project Office	M. D. English
Head, Advanced Planning	A. Leiss
Head, Launch Operations	C. W. Winters & Rodney Duncan
Electrical Systems	Joe Dixon
Scout Payload Coordinator	Joe Talbot

S^3 EXPERIMENTS AND INVESTIGATORS

Scientific Experiments

Charged Particle Detectors

Channel Electron Multipliers - Goddard Space Flight Center
Dr. Robert A. Hoffman, Goddard Space Flight Center
David S. Evans, NOAA Space Disturbance Laboratory

Solid State Proton Detector - Goddard Space Flight Center
Dr. T.A. Fritz, NOAA Space Disturbance Laboratory
Dr. Donald J. Williams, NOAA Space Disturbance Laboratory
Dr. A. Konradi, NASA Manned Spacecraft Center

Solid State Electron Detector- Goddard Space Flight
Dr. Donald J. Williams, NOAA Space Disturbance Laboratory

Magnetic Field Detectors

Flux-Gate Magnetometers
Search-Coil Magnetometers - University of Minnesota
Dr. L. J. Cahill, Jr., Space Science Center

Electric Field Sensors

DC Electric Field Meaurement - Goddard Space Flight Center ---- Dr. Nelson C. Maynard
AC Electric Field Measurement - University of Iowa
Dr. D.A. Gurnett, Department of Physics and Astronomy
G.W. Pfeiffer, Department of Physics and Astronomy

Engineering Experiments

Aerodynamic Heating - Goddard Space Flight Center
John E. Oberright
Radiation Damage Experiment - Goddard Space Flight Center
Robert G. Martin
Harry E. Wannemacher
Scanning Celestial Attitude Determination System (SCADS)
Goddard Space Flight Center
William D. Hibbard