Spartan
Science with Efficiency and Simplicity

NASA
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Spartan

Over the centuries, the word "Spartan" has come to embody the image of efficiency and simplicity. The early Greek warriors who bore this title carried only the barest of essentials with them to do their jobs. They performed with distinction.

The National Aeronautics and Space Administration (NASA) now applies this same distinctive approach to scientific investigations with the Spartan Program. Each Spartan is an autonomous subsatellite deployed from and retrieved by the space shuttle. Three Spartan missions are currently under development, each with a different scientific instrument. Spartan allows NASA to accomplish a single and specific scientific objective with efficiency and simplicity.
The Space Research Carrier

For over 20 years, NASA has been conducting basic and relatively inexpensive scientific research, using sounding rockets to carry instruments into the upper atmosphere and nearby outer space. These vehicles were originally built with surplus military hardware and later evolved into a special class of vehicles specifically built for space research.

Sounding rockets continue to be an essential tool for obtaining quick and reliable information on the aurora and the nature of the upper atmosphere. The onboard instruments provide data on ionization, temperature, wind, air density, and chemical composition. In addition, rockets have become a tool for astrophysics and solar physics, carrying telescopes and cameras above the obscuring effects of the Earth’s atmosphere. Because the flight time of a sounding rocket is limited to a few minutes, restrictions are placed on the types of research performed. Scientific instruments, developed for the study of high-energy astrophysics, solar physics, and ultraviolet astronomy, can benefit from observation periods that are longer than the observation periods offered by sounding rockets.

The opportunity now exists to place a sounding rocket type of experiment into Earth orbit via the space shuttle. Spartan will replace the sounding rocket as the carrier and will accommodate existing types of scientific instruments. This program offers the valuable gain in flight time required for increased observations and new types of research.

The space shuttle has proven itself to be a remarkably successful and adaptive tool. It has conducted commercial, technical, and scientific services from space, such as the Satellite Business Systems and TELESAT Canadian Limited launches and the Office of Space and Terrestrial Applications 1 (OSTA-1) and Office of Space Science 1 (OSS-1) pallet operations. One unique and entirely new capability is the deployment and retrieval of satellites by the shuttle crew, as demonstrated by the Shuttle Pallet Satellite (SPAS). Spartan makes use of this capability.

The space shuttle will transport Spartan to space, with the carrier attached within the payload bay. Spartan controls will be activated prior to deployment by commands from the shuttle.
crew. The shuttle remote manipulator system will grapple Spartan, lift it out of the payload bay, and release it. The Spartan pointing system will then position the payload, and operations will begin.

While in orbit, Spartan is an autonomous subsatellite, free from the constraints of the space shuttle. This autonomy allows the scientist to plan the operation of his instrument as precisely as he desires without placing any requirements on the shuttle crew or on the shuttle attitude. The scientist can preplan a pointing sequence for an extensive selection of celestial objects or a particular area of the solar surface, which is executed by Spartan to minutes of arc precision. The observations are automatically stored on board the carrier on a tape recorder.

After a flight duration of up to 40 hours, Spartan will be retrieved by the shuttle and returned to Earth. A comprehensive data tape will be created and sent to the scientist for analysis. The scientific analysis of the data is then carried out by the science team. The results are shared with the scientific community through articles, seminars, and other media forms; all data are deposited into the National Space Science Data Center for accessibility by interested scientists.

Future Spartan missions will possess additional capabilities to fulfill increased technical requirements. These capabilities will be enhanced as required in an evolutionary manner similar to the style for the sounding rocket program. “Man in the Loop,” additional power, extended mission time, greater pointing accuracy, increased data handling, and command capability are possible future enhancements.
Spartan . . . Simplicity

The Spartan Program follows the same fundamental philosophy as the sounding rocket program: keep it simple; keep the cost down. NASA engineers have found that since rocket flights are short and vehicles are inexpensive, it is more efficient and cost effective to build simple systems and accept a higher risk. This philosophy has demonstrated a greater than 85-percent success rate in rocket flights. Furthermore, the design, test, and documentation requirements for Spartan are modest when compared to the requirements for major satellite missions.

As a carrier, Spartan is designed to provide the barest essentials needed to operate the instrument, such as battery power, stellar pointing, and data recording. NASA is designing Spartan to use attitude control systems, data encoding systems, batteries, timers, and other control hardware that have been developed and flight proven as part of the sounding rocket program. However, there are differences: both thermal control and more sophisticated automation are necessary for the longer flight time.

Spartan will operate for up to 40 hours outside of the shuttle payload bay. This time period for observation is an increase of 100 to 1000 times that of sounding rockets. Battery power and gas for the attitude control system are the major limitations on the observation time. Spartan records all data on a large-capacity, onboard tape recorder and makes up for the lack of a command link by using a microprocessor-based programmed controller. Spartan is efficient, not elaborate.

Scientists using Spartan will find the carrier to be flexible in accommodating instruments required for specific investigations. The initial instruments scheduled for the early Spartan missions will study high-energy astrophysics processes, solar physics phenomena, and ultraviolet astronomy. Each instrument has a successful record on sounding rocket missions, but each instrument — and each discipline — has unique requirements. Several of the high-energy astrophysicists need large-area array detectors, the ultraviolet astronomers need telescopes, and both require stellar pointing. The solar physicists utilize telescopes, but require solar pointing. The basic Spartan concept has been adapted to fulfill these initial requirements.
Spartan 1

The Spartan 1 carrier, supporting high-energy astrophysics, will provide a structure with an optical bench to accommodate a variety of rectangular array detectors. It is designed to point at stellar objects.

Spartan 2

The Spartan 2 carrier, supporting solar physics, will accommodate a 17-inch-diameter telescope. It will use a solar fine-pointing capability to allow it to view selected points on the surface of the Sun.

Spartan 3

The Spartan 3 carrier, supporting ultraviolet astronomy, will use concepts and hardware developed for the first two Spartans. It will accommodate a 22-inch stellar telescope, which is externally similar to the telescope of Spartan 2. Spartan 3 will use a stellar fine-pointing system similar to the one developed for Spartan 1.
Spartan 1: High-Energy Astrophysics

Brilliant and turbulent clusters of galaxies exist throughout the Universe, emitting energy over a wide portion of the electromagnetic spectrum. A very important part of this radiation emerges in the form of X-rays, which originate in a hot gas pervading the cluster and sometimes the interior of the galaxies themselves. Astronomers studying cosmic X-ray sources have detected clusters that are millions of light years away. Although many other X-ray sources (including pulsars and black holes) have been identified over the past two decades, clusters of galaxies hold special fascination.

Astronomers ponder the development and distribution of galaxies in the Universe. Are all galaxies uniform in chemical composition? What is the source of the very intense high-energy emission observed at the center of some galaxies? Is there sufficient matter present in the hot gas to bind the cluster together? The X-rays are the key to understanding the structure, temperature, composition, dynamics, and evolution of clusters.

Spartan 1 is specifically designed to provide astronomers with the opportunity to map X-rays emanating from clusters of galaxies and to explore the center of our own galaxy. In the summer of 1984, Spartan 1 will offer a 40-hour view of the heavens unobstructed by the atmosphere of the Earth. The high-energy astrophysics payload will consist of a Naval Research Laboratory instrument, containing two large X-ray counters equipped with collimators to define the direction of the incoming X-ray sources. This type of instrument has previously provided brief "snapshots" of X-ray sources within the sounding rocket program.

Spartan 1 will point the instrument with the stellar attitude control system. This maneuver will allow the instrument to systematically scan the sources of X-rays and to reconstruct a two-dimensional picture of the X-ray emission. Thus, clusters will be mapped and data will be gathered on the temperature of the intracluster gas and on galactic evolution.

Because the carrier has a modular design, the X-ray detectors can be replaced after the first Spartan mission with other types of instruments for future missions — the Spartan is entirely reusable.
This soft X-ray map of the Puppis A supernova remnant has been produced from High-Energy Astronomy Observatory 2 (HEAO 2) data. Note the interaction between the hot, X-ray emitting gas and the cooler gas in nearby space. Spartan 1 will map X-ray emitting gas within high-energy supernova remnants and clusters of galaxies. Spartan 1 will investigate the processes that heat and cool the gas and the processes that allow the heavier elements to settle at certain points within the clusters.
Spartan 2: Solar Physics

The solar wind accelerates electrons, protons, and heavy ions out into space from the outer atmosphere of the Sun. The forces behind the solar wind are presently thought to be "non-thermal;" that is, the wind is driven by hydrodynamic waves, electrical currents, or some other process. Solar physicists are seeking to define these forces in order to identify the energy transfer processes and energy balance within the Sun.

Spartan 2 will probe the acceleration of the solar wind in the autumn of 1985. The solar physics payload will measure aspects of the corona and the velocity of the solar wind. Temperature profiles for hydrogen gas, hydrogen ions, and electrons will be gathered. The densities of hydrogen ions and electrons will be determined. The results of the second Spartan mission should suggest solutions to the most perplexing questions of coronal and solar wind physics with dramatic observations.

The solar physics payload consists of a 17-inch-diameter solar telescope derived from a sounding rocket solar telescope. It includes an ultraviolet coronagraph and a white-light coronagraph to measure the intensity and scattering properties of solar light. Spartan 2 will provide the solar pointing system and the thermal control system to protect the instruments from the heat of the Sun.

Spartan 2 will carry heavier science instruments than Spartan 1. Spartan 2 will also be able to accommodate other solar payloads for future missions.

This visible light photograph of the solar corona has been produced from the Solar Maximum Mission (SMM) coronagraph, using colors to intensify coronal features. Regions of enhanced electron density, assumed to result from the solar magnetic field configuration, are indicated in brighter colors. Spartan 2 will map the regions of enhanced electron density, including structure and temperature. These measurements will lead to the determination of coronal heating and solar wind acceleration.
Spartan 3: Ultraviolet Astronomy

The Universe, as seen in the far ultraviolet, is rich in phenomena... and information. Vast and mysterious nebulae glow intensely in the far ultraviolet. Young stars, white dwarfs, and hot subdwarfs release far-ultraviolet signatures that narrate their fates. Far-ultraviolet radiation curiously permeates the entire background of space. However, much of the ultraviolet radiation reaching the Earth is absorbed in the upper atmosphere, making ground-based observations impossible. Cameras on sounding rockets provide glimpses of this far-ultraviolet radiation. Sources are identified, but due to the lack of observing time, in-depth study is difficult.

Spartan 3 will offer the opportunity to conduct a far-ultraviolet survey of selected star fields. The mission is currently planned for the spring of 1987. The positions and far-ultraviolet brightnesses of stars will be obtained. Far-ultraviolet images of nebulae and nearby external galaxies, such as the Magellanic Clouds and the Andromeda Galaxy, will be captured. The radiation intensity and spectral absorption/reflection data will indicate composition, temperature, and dynamics of far-ultraviolet sources.

The Spartan 3 telescope payload will consist of a Mark-II Schmidt electrographic camera, which photographs in the 1230 to 1600 Å range. The camera has been successfully flown on sounding rocket missions. The Spartan 3 carrier will provide stellar pointing for the camera as it performs its observations in the shadow of the Earth. During each 90-minute orbit, 30 minutes of observation time will be available for each source.
This false-color ultraviolet image of the Orion Nebula has been developed from a 20-second sounding rocket exposure; the square inset at the Nebula's center has been developed from the same flight with a 1-second exposure. The three intensity peaks at the top, center, and bottom are the three "stars" in Orion's sword visible to the unaided eye from the Earth's surface. The variations in ultraviolet intensity are due to the distribution of interstellar dust within the Nebula. Data from this flight have shown that the Orion Nebula reflects primarily in the ultraviolet.
The Future with Spartan

The space shuttle now offers easy access to a variety of systems that can conduct scientific investigations from above the Earth's atmosphere. Spartan is one of these systems, providing a capability somewhere between small attached payloads and the large, long duration, free-flying satellites.

Spartan has evolved using sounding rocket class instruments to perform the scientific studies. This system provides a significant increase in observing time compared to sounding rockets. The simple and efficient Spartan carriers are reuseable and can accommodate a variety of scientific instruments on a low cost per flight basis.

Since the technology and the instruments already exist, early Spartan missions can move quickly from the investigation concept to the launch pad. Additional Spartans are currently being planned so that, in the near future, payloads for high-energy astrophysics, solar physics, and ultraviolet astronomy will be joined by payloads for other scientific disciplines and types of research. In a few years, Spartan carriers will fly several times each year as part of routine space shuttle flights.

Spartan answers the scientist's search for a simple, reuseable, and low cost space carrier deployed from the space shuttle. Spartan will become an ideal tool for investigating a range of science problems from atmospheric dynamics to perplexing mysteries of the cosmos.

Spartan is simple.
Spartan is low cost.
Spartan is fast.
Spartan is ready.
Spartan is exciting.