SANDY N.

NASA FactSheet

National Aeronautics and
Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Jerry Berg
Marshall Space Flight Center
Huntsville, Ala.
(Phone: 205/544-0034)

June 1991

THE TETHERED SATELLITE SYSTEM

The Tethered Satellite System is comprised of a satellite attached to the Shuttle orbiter by a superstrong conducting cord that will be reeled into space from the Shuttle's payload bay. The system will provide scientists experimental capabilities never before possible.

Operating the tethered system is much like trolling for fish in a lake. But the "catch" is the potential for gathering in valuable scientific data from the vast sea of space. Once the experiments are concluded, the satellite may be reeled back into the payload bay and stowed until the Shuttle returns to Earth.

The concept of tethering or connecting bodies together in space to explore possible engineering applications and scientific merits has been studied for many years by the United States and other countries.

Scientists and engineers are evaluating tethers for their potential uses. One possible technological application is using a long conducting tether to generate electrical power for Space Station Freedom or other orbiting bodies. Tethers may also be used to raise or lower spacecraft orbits. This could be done by releasing a tethered body from the primary spacecraft, thereby transferring momentum (and imparting motion) to the spacecraft. It also is possible that by applying electrical power to a conducting cable, the tether may serve as a thrust generator. Another potential application is the creation of artificial gravity through the rotation of two or more masses on a tether, much like a set of bolas. A downward deployment of the tether would allow aerodynamic and wind tunnel type testing in the region 50-75 nautical miles (90-140 km.) above the Earth.

Scientific applications include the creation and study of a large-scale, tether-generated current system in the Earth's magnetosphere. Scientists may be able to use such a tether-generated current system as a controllable model for studying the natural currents that exist in the polar regions of the Earth's magnetosphere and which, for instance, are responsible for the Northern Lights. This system may also serve as a model for understanding the interaction between Jupiter and Jupiter's moon, Io, as Io moves rapidly through the Jovian magnetosphere, creating intense currents and bursts of radio waves. Other scientific applications may include:

- o Investigation of the generation and propagation of ultra-low-frequency radio emissions and various plasma waves by the tether;
- o Study of the characteristics of the high-voltage plasma sheath around the satellite;
- o Study of ionization processes in the vicinity of the satellite; and
- o Investigation of the interaction of the satellite with the ionosphere while variables such as the satellite's electric potential are carefully controlled.

Interest in a tethered experiment culminated in 1984 with an agreement between NASA and the Agenzia Spaziale Italiana (ASI -- the Italian Space Agency) to jointly pursue the definition and development of a Tethered Satellite System (TSS) to fly aboard the Space Shuttle.

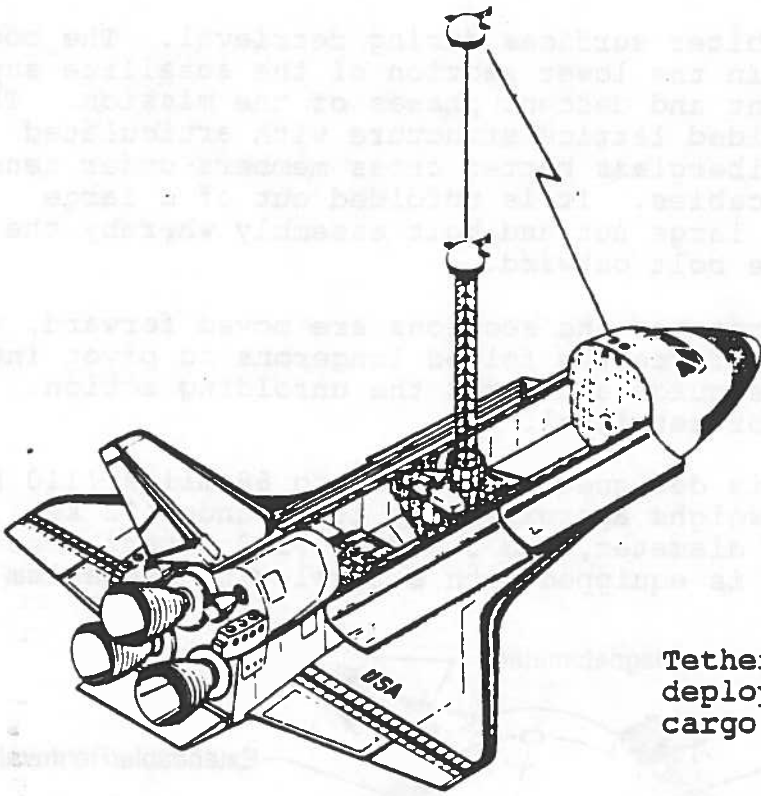
The Tethered Satellite System is being developed to provide a capability to deploy and control a multipurpose satellite as far as 100 kilometers, or 62 miles, above or below the orbiting Space Shuttle. The tether system is being developed as a reusable facility, but since qualifying such a system can only be done in the space environment, the first mission will be used to verify the system design as well as to carry out scientific experiments.

Objectives

The objectives of the first tethered satellite mission are to demonstrate the capability to safely deploy, control, and retrieve the tethered satellite, and to conduct electrodynamic science investigations. A complement of nine experiments have been selected for the mission, to further our understanding of the electrodynamic processes taking place in the Earth's upper atmosphere, as well as the dynamic forces in effect in a tethered satellite system.

Deployer

Developed by NASA, the deployer consists of a satellite support structure to retain the satellite during launch and landing; an extendable/retractable boom to initially deploy the satellite; a motor and reel assembly to store, deploy, and retrieve the tether which mechanically connects the satellite to the deployer; and a data acquisition and control assembly to provide data and control during the mission.



Tethered satellite being deployed from Shuttle's cargo bay

The deployer systems will be installed on a Spacelab Enhanced Multiplexer-Demultiplexer Pallet. The pallet is a general purpose unpressurized carrier developed for use with partial payloads, such as the TSS, and equipped to provide structural mounting, thermal, power, command and data systems.

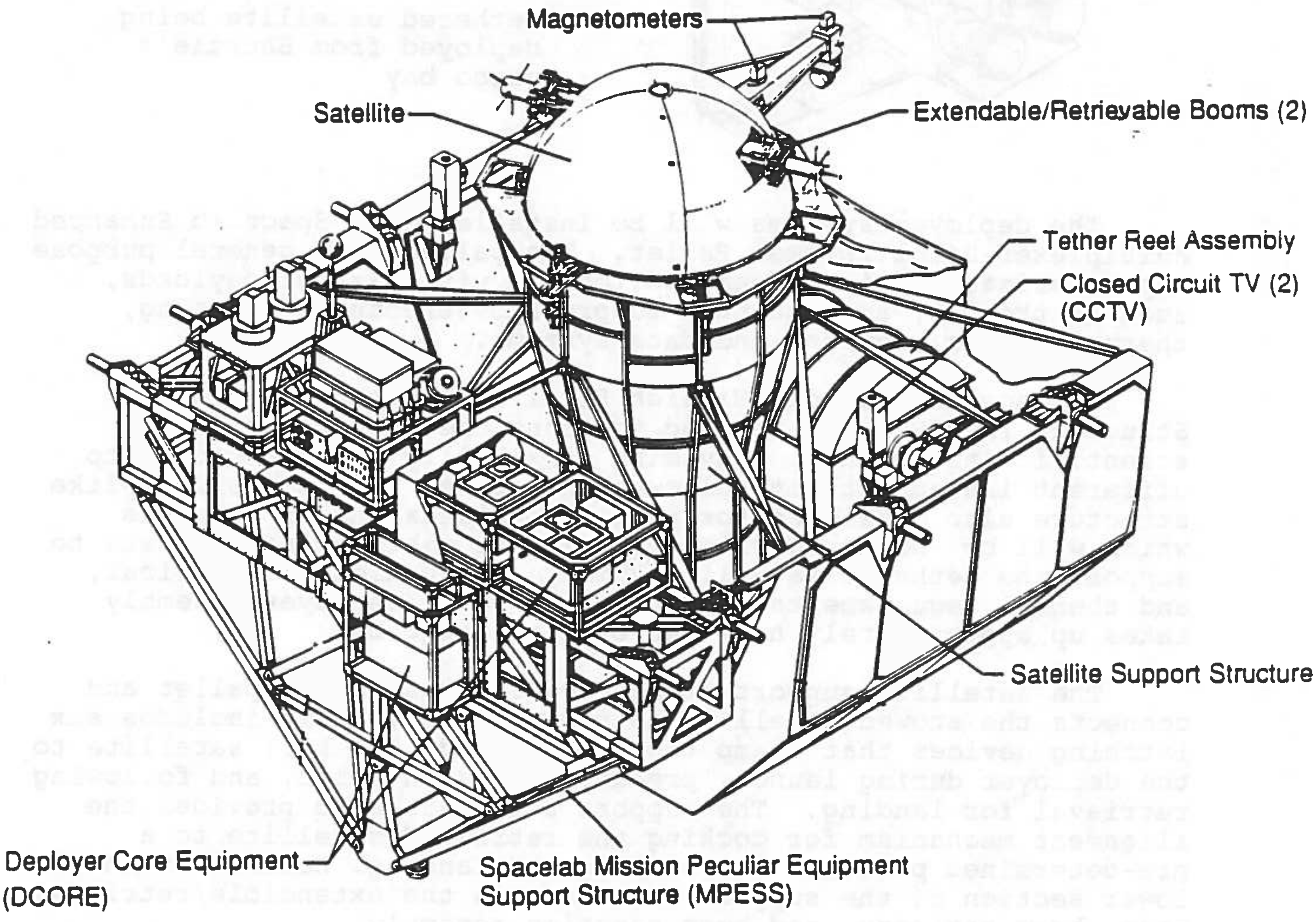
A Spacelab-provided Mission Peculiar Equipment Support Structure (MPESS) will be used to mount the orbiter-based scientific instruments, providing flexibility for changeouts to different instruments in follow-on missions. It is a bridge-like structure also developed for partial payloads and experiments which will be equipped with cold plates, cabling and brackets to support the tethered satellite science, mechanical, electrical, and thermal requirements. In all, the total deployer assembly takes up approximately half the orbiter cargo bay.

The satellite support structure attaches to the pallet and connects the stowed satellite to the deployer. This includes six latching devices that clamp the 1,141-pound (518 kg.) satellite to the deployer during launch, pre-deployment on orbit, and following retrieval for landing. The support structure also provides the alignment mechanism for docking the retrieved satellite to a pre-determined position for stowing and landing. Housed within the lower section of the support structure is the extendible/retrieval boom, boom canister, and boom ejection assembly.

The 12-meter boom assembly will provide the initial separation from the orbiter during deployment and provide clearance from the orbiter surfaces during retrieval. The boom is housed in a canister in the lower section of the satellite support structure during ascent and descent phases of the mission. The boom mast is a four-sided lattice structure with articulated aluminum longerons, fiberglass batten cross members under tension and diagonal tension cables. It is unfolded out of a large cylinder similar to a large nut and bolt assembly whereby the nut rotates and forces the bolt outward.

As the canister rotates and sections are moved forward, the tension-loaded battens force the folded longerons to pivot into place while the cables guide and limit the unfolding action. The process is reversed for retrieval.

The tether reel is designed to hold up to 68 miles (110 km.) of tether. The reel weighs approximately 160 pounds (72 kg.), is 3.3 feet (1 meter) in diameter, and 3.9 feet (1.2 meters) between the reel flanges. It is equipped with a level-wind mechanism to



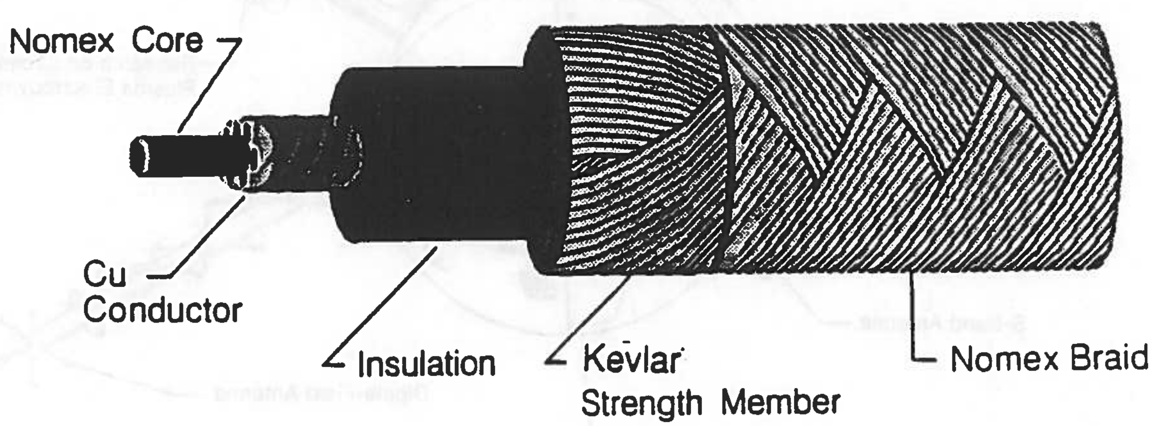
Tethered Satellite System and its support structure assure uniform winding on the reel, a brake assembly for control of the tether, and a drive motor. The drive motor is a 5 horsepower brushless direct current motor capable of driving the reel between 0 and 600 rpm.

A DC-DC converter conditions orbiter power for use by the reel motor. During the electrodynamic mission, the converter provides 26 volts DC to the reel motor. The converter also supplies the satellite with 33 volts DC for pre-deployment checkout.

The TSS-1 control and data system includes the equipment to interface with the orbiter, satellite, and ground systems. The deployer avionics include a computer which interfaces with the satellite while in the pre-deployed mode. The Shuttle crew will control the deploy and retrieval from the aft flight deck.

Following deployment the orbiter S-band Payload interrogator provides control to and receives telemetry data from the satellite. Using on-board sensors and pre-programmed functions, the computer controls the tether system. The orbiter Ku-band system will be used to help track the satellite. Sent back to Earth as part of the orbiter's data stream, experiment data will be relayed through the Tracking and Data Relay Satellite System to ground stations at NASA's Marshall and Johnson Centers, giving investigators the capability for real-time viewing and controlling of the science operations during the mission.

The tether itself will provide the structural connection between the deployer and the satellite. For the first flight, the tether will be a conducting cable, to aid in studying the electrodynamics of an upward-deployed satellite. The tether is a multi-layer insulated copper conductor with a stranded Nomex core. The conductor is a 10-strand #34 AWG tin-coated copper bundle wrapped around the Nomex core. Insulation for the conductor is provided by an extruded Teflon coating. Strength for the tether is provided through a braided Kevlar section outside the



Conducting tether

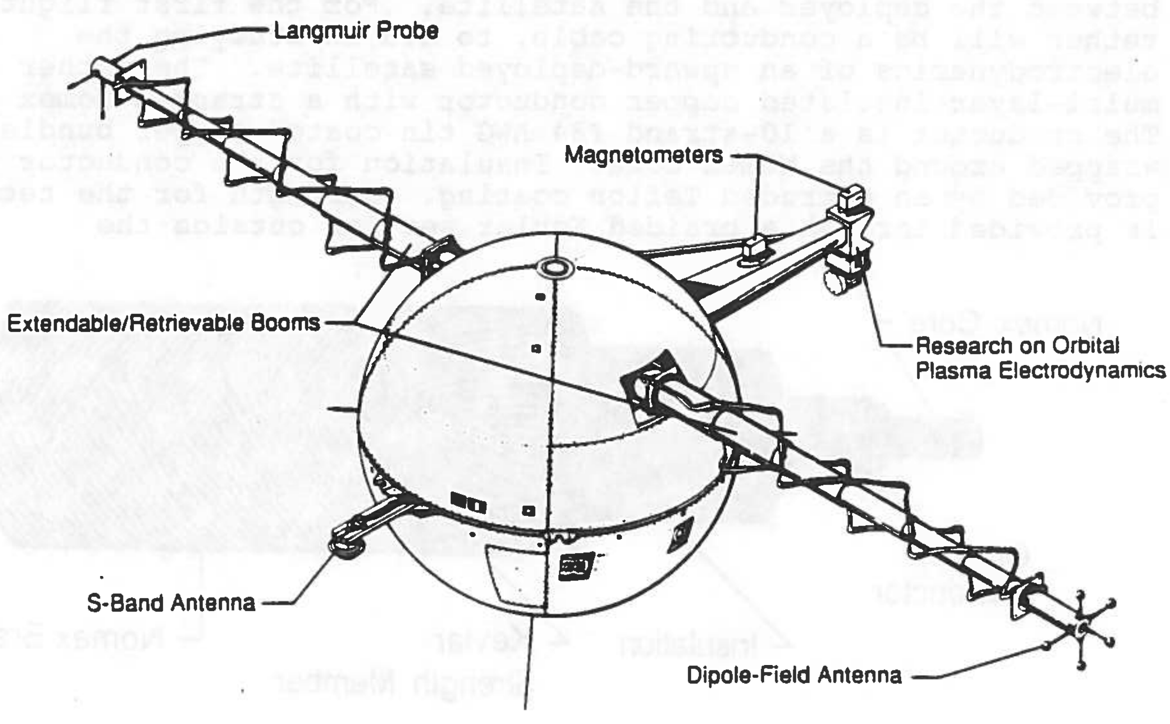
insulation with a final outer braid of Nomex for atomic oxygen protection. The diameter of the cable is approximately 0.1 inch (2.5 mm), or approximately the diameter of a match stick. It can carry 1 ampere of current at 10 kv with a maximum leakage of 5 mA.

Satellite

Developed by ASI, the 1,141-pound (518 kg.) satellite is a little more than 5 feet (1.6 meters) in diameter and mounts atop the deployer satellite support structure. The payload module of the satellite contains scientific instruments and support systems for functions such as electrical power, data handling, attitude measurement and control, and an auxiliary propulsion system. The satellite is made up of several replaceable subsystems.

A service module provides electrical power, on-board data handling, attitude measurement and control, and telemetry and telecommand operational support to the satellite. The auxiliary propulsion module controls two sets of half-pound (2.0 newton) in-line thrusters, two sets of 0.6-pound (2.5 newton) thrusters for control of dynamic modes, two sets of 0.6-pound yaw thrusters, and a high pressure gas storage bottle. The payload module contains the scientific experiments support facilities for structural, thermal, electrical power and data and control.

The spherical shape of the satellite is composed of eight exterior sections with access doors for servicing batteries, windows for Sun and Earth sensors, and surface mounted umbilical



Satellite with extendable booms deployed connectors. The satellite also has an S-band antenna and a fixed boom for mounting science instruments. In addition, it has two opposing deployable/retrievable booms capable of extending 2.5 meters from the satellite to support science instruments. The tether is attached at the polar cap of the satellite and is integrated into the in-line thruster assembly.

Science Experiment Instrumentation

NASA and Italy, in a cooperative effort, selected nine scientific investigations for the TSS-1 mission. The science instrumentation will provide measurements of the behavior of charged particles at the satellite and orbiter, and magnetic and electric fields at the satellite. The selected investigations represent a wide range of scientific interests and institutions and will provide a good understanding of the basic electrodynamic tether-space plasma interactions and tethered satellite dynamics.

The instrumentation includes electron guns and tether current-control hardware, along with a set of interdependent diagnostic instruments, provided by the TSS-1 investigators, that will measure the behavior of charged particles and electric and magnetic fields. To supplement the primary experiment instrumentation, a set of core equipment, common to most of the tethered satellite experiments, is being supplied by both NASA and ASI. Core equipment elements will provide a higher capacity electron gun and additional diagnostic instruments.

# # #