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# A Technical Overview of TSS-1: the First Tethered-Satellite System Mission.

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**Summary.** – The Tethered-Satellite System (TSS) was developed to provide the capability of deploying satellites on long, gravity-gradient–stabilized tethers from the Space Shuttle. Although TSS-1 achieved only limited results because deployment was terminated at a distance of only 268 m, it did conclusively show that the basic concept of long gravity-gradient–stabilized tethers is sound, and it provided a unique set of data that will contribute significantly to future missions. In this context, it is important that the configuration, instrumentation, and results of the TSS-1 mission be documented. Here, we provide a brief overview of the TSS, the organization of its instrumentation, and its operations during TSS-1. Detailed descriptions of the various investigations and their specific instrumentation and measurement capabilities are given in the papers that follow.

PACS 94.20 – Physics of the ionosphere.

## 1. – Introduction.

The Tethered-Satellite System was proposed to NASA and the Italian Space Agency (ASI) in the early 1970s by Mario Grossi, of the Smithsonian Astrophysical Observatory, and Giuseppe Colombo, of Padua Universty [1, 2]. A science committee, the Facilities Requirements Definition Team (FRDT), met in 1979 to consider the possible scientific applications for long tethers in space and whether the development of a tethered system was justified. The FRDT report, published in 1980, strongly endorsed a Shuttle-based tether system [3]. A NASA-ASI memorandum of understanding was signed in 1984, in which NASA agreed to develop a deployer system and tether and ASI agreed to develop a special satellite for deployment. A science advisory team provided guidance on science accommodation requirements prior to the formal joint NASA-ASI Announcement of Opportunity (AO) for science investigation being issued in April, 1984. Nine investigations were selected for definition for the first mission (TSS-1) in July, 1985. In addition, ASI agreed to provide CORE equipment (common to most investigations) that consisted of two electron guns, current and voltage monitors and a pressure gauge mounted on the Orbiter, and a linear accelerometer and an ammeter on the satellite. NASA agreed to add a hand-held low light level camera, for night time observation of the deployed satellite. The U.S. Air Force Phillips Laboratory agreed to provide a set of electrostatic charged-particle analyzers, mounted in the Shuttle's payload bay, to determine Orbiter potential and measure return currents during electron gun operations. The investigation titles and Principal Investigators are listed in table I.

The stated goals of the TSS-1 mission were to demonstrate the feasibility of deploying and controlling long tethers in space, and to demonstrate some of the unique applications of the TSS as a tool for research by conducting exploratory experiments in space plasma physics. The specific objectives required to meet these goals are listed in tables II and III.

During TSS-1, the satellite was to have been deployed 20 km outward into space, above the Space Shuttle, on a conducting tether. This would have made TSS-1, electrodynamically, the largest man-made structure ever placed in orbit. It was anticipated that the motion of a long conducting tether through the Earth's magnetic field would create a motional e.m.f. that would bias the satellite to high voltages and drive a current through the tether system that would be closed by

TABLE I. – TSS-1 *investigations.*

| Principal Investigator | Institution | Investigation title |
|---|---|---|
| P. Banks | University of Michigan | Shuttle Electrodynamic Tether System (SETS) |
| C. Bonifazi | ASI | Deployer/Satellite Core Equipment (DCORE/SCORE) |
| D. Hardy/M. Oberhardt | USAF Phillips Laboratory | Shuttle Potential and Return Electron Experiment (SPREE) |
| S. Mende | Lockheed | Tether Optical Phenomena (TOP) |
| M. Dobrowolny | CNR/IFSI | Research on Electrodynamic Tether Effects (RETE) |
| F. Mariani | University of Rome II | Magnetic Field Experiment for TSS (TMAG) |
| N. Stone | NASA/MSFC | Research on Orbital Plasma Electrodynamics (ROPE) |
| R. Estes | SAO | Electromagnetic Emissions in Tethers (EMET) |
| G. Tacconi | University of Genoa | Observations at Earth's Surface of Electromagnetic Emissions (OESEE) |
| S. Bergamaschi | University of Padua | Theoretical and Experimental Investigations on Tether Dynamics (TEID) |
| G. Gullahorn | SAO | Investigation and Measurement of Dynamic Noise (IMDN) |
| A. Drobot | SAIC | Theory and Modeling in Support of Tether (TMST) |

TABLE II. – *Category* I: TSS-1 *primary mission objectives. Objectives are listed by priority.* OST-1 *stable configuration at* $L = 20$ km.

| Objective | Description |
|---|---|
| 1) Demonstrate Deployment | Deployment must be to a sufficient distance to accommodate the subsequent Category 1 Mission Objectives (at least to $L = 10$ km). |
| 2) Demostrate Station Keeping | Station positions must be maintained for a sufficient time to execute the FOs required for the subsequent Mission Objectives. Current flow, satellite spin and Deployable Retrievable Boom (DRB) deployment must be accommodated per the requirements given for the Category 1 Mission Objectives. Both locked-reel and tether control modes should be demonstrated. |
| 3) Demonstrate Electrical-Power Generation, Characterize System *I-V* Response | This objective will provide a demonstration of basic power generation and utilization, and will provide the TSS system *I-V* characteristic, which is required for both power generation and an understanding of the basic electrodynamics of the TSS. Primary data is obtained at OST-1. Supplementary data can be obtained during deployment. (*Significant degradation of this objective occurs if* OST-1 *is not attained.*) |
| 4) Characterize Satellite Sheath, Current Collection and Current Closure | Study the physics of the near-satellite environment, current collection and closure, within the external current loop in the ionosphere. (*Significant degradation and elimination of some aspects of this objective occur if* OST-1 *and* -2 *are not achieved.*) |
| 5) Demonstrate Retrieval | This objective is to demonstrate the controlled retrieval at varying tether lenghts and tensions until Orbiter proximity operations replace the deployer control law as the prime control element. Satellite recapture is not necessary to fulfill this objective. |
| 6) Verify Control Laws and Basic Dynamics | The baseline deployment profile will allow an understanding of basic tether dynamics required for future missions an will verify the control laws used for automatic control of the TSS. |
| 7) Recapture Satellite | This objective includes a study of proximity operations and satellite dock and latch down. Return of the satellite is desired for post-flight analysis of accumulated surface effects. |

a large external loop in the ionospheric plasma. While this system provides exciting new research opportunities, it also creates some rather extreme conditions and an unprecedented challenge for scientific diagnostic instruments.

Here, we will give a brief overview of the TSS system hardware and the fundamental dynamic and electrodynamic concepts. The tether current monitoring and control hardware and the science instruments will be introduced in the context of the overall mission diagnostic requirements (TSS-1 is, in essence, a single experiment with various diagnostic and control functions). Detailed descriptions of the specific investigations and their instrumentation and measurement capabilities are given in the papers that follow.

TABLE III. – *Category* II: *additional mission objectives that require the* TSS-1 *configuration. Objectives are listed by priority.*

| Objective | Description |
|---|---|
| 1) Characterize Dynamic-Electrodynamic Coupling | Study Skip Rope mode tether oscillations and possible control by phased pulsing of the tether current. |
| 2) Determine TSS Response to Dynamic Perturbations | Study the inherent stability of the TSS-Orbiter system. |
| 3) Determine the Effect of Neutral Gas on TSS Current Collection | Study changes in the tether current and current collection at the satellite as a result of enhancing the neutral-gas density. |
| 4) Determine TSS Dynamic-Noise Characteristics | Study TSS-Orbiter system dynamical noise with major perturbations inhibited. |
| 5) Characterize TSS Emissions | Observe TSS wave emission using ground sites, on-board instrumentation, and other available *in situ* measurements. |
| 6) Characterize Satellite Plasma Sheath Dynamics | Study plasma instabilities generated by the extraction of high current densities from the ionosphere in the vicinity of the satellite. |
| 7) Determine Orbiter Charging Levels | Study electron return current to the Orbiter and the electric potential attained by the Orbiter for various conditions produced by the TSS. |
| 8) Characterize the Effects of Anomalous Ionization | Investigate the enhancement of current collection at the satellite as a result of ionization of the low-density ambient neutral gas within the satellite's plasma sheath. |
| 9) Study Dynamic Resonance | Determine the location of system dynamical resonant points. |

## 2. – TSS **description.**

The main elements of the TSS, as configured for the first mission, consisted of the NASA-developed deployer system and its 22 km conducting tether, the ASI-developed satellite, tether current monitoring and control instrumentation carried on the Shuttle, and scientific diagnostic instruments carried on both the Shuttle and the satellite.

The deployer system is mounted on a Spacelab pallet, as shown in fig. 1. This system consists of a reel mechanism, a 12 m extendible deployer boom, and a control computer, the data acquisition and control assembly (DACA). The tether passes from the reel, through a level wind device and over a number of pulleys as it goes from the reel to the upper end of the deployer boom. The level wind device moves back and forth across the reel during tether motion to insure that the tether is uniformly distributed on the reel. At the end of the boom is the outer tether control mechanism, which measures tether tension and deployment length, and includes a motorized pulley to extract the tether from the tether control mechanisms while tension is low. At the top of the deployer boom is a docking ring, on which the Italian satellite is mounted. The docking ring may be rotated to allow satellite alignment prior to flyaway and re-berthing.

The satellite, shown in fig. 2, is a 1.6 m diameter, conducting sphere. It includes a 0.8 m fixed instrument boom and two extendible booms that can be deployed to 2.5 m. The satellite, which operates on batteries, has a conducting

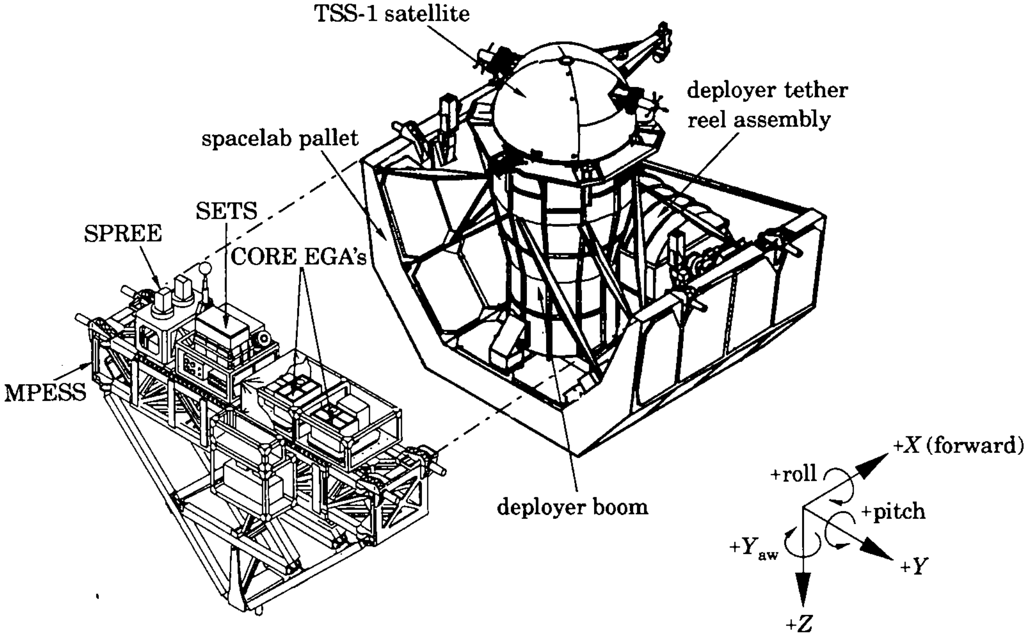

Fig. 1. – TSS-1 Deployer on Spacelab pallet and Shuttle-based science hardware (DCORE, SETS and SPREE) mounted on a Mission-Peculiar Equipment Support Structure (MPESS).

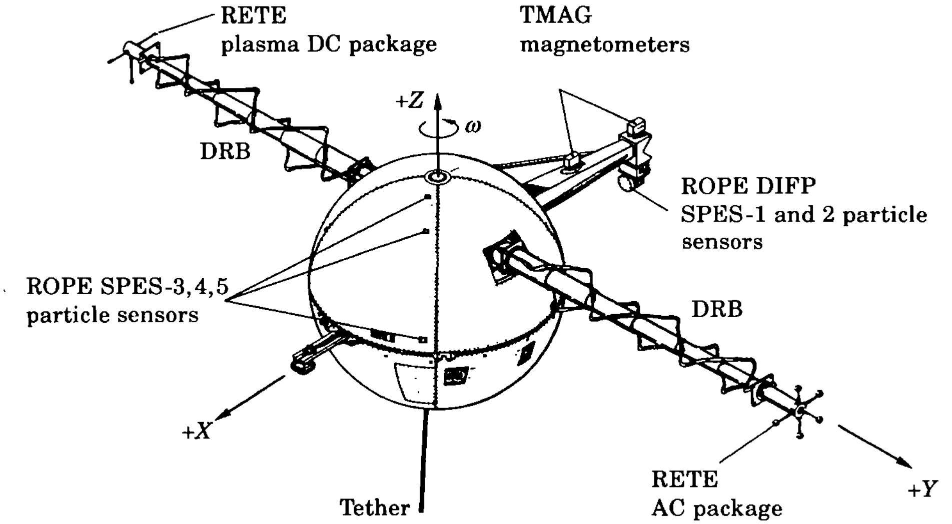

Fig. 2. – TSS-1 Satellite, showing the location of the 0.8 m fixed boom, the two 2.4 m DRBs, and the RETE, ROPE and TMAG instruments.

surface composed of a highly conducting white thermal control coating over aluminum skins. The lower hemisphere of the satellite contains the batteries, all of the systems for power conditioning, the on-board data handling system, the telemetry system, and the attitude control system. The upper hemisphere is the payload module and contains all of the science instrumentation and the three science booms.

The tether, 2.54 mm in diameter, has a core of Nomex that is wrapped with 10 strands of 34 AWG copper wire to provide the electrical conductor. The copper wire is insulated by a Teflon sheath that is covered with bradied Kevlar 29, which provides tensile strength. An outer sheath of braided Nomex provides protection against the atomic oxygen environment in the ionosphere. The maximum tensile strength of the tether is 1780 N while the loading during a 20 km deployment is only about 50 N. The electrical resistance is approximately 2100 Ω for the total tether length of 22 km.

## 3. – Tether dynamic fundamentals.

A satellite remains in a stable orbit when its speed is such that the downward gravitational force is balanced by its upward centrifugal force. If its speed is increased, the centrifugal force will become stronger and the satellite will move upward until the two forces become balanced again. Similarly, if its speed is decreased, the satellite will move downward. In addition, a satellite in a lower orbit has a shorter orbital path and, therefore, a shorter period than a satellite in a higher orbit. However, when two satellites are tethered, they are forced to move around the center of orbit in the same period of time. As a result, the lower satellite must travel at a slower rate than normal and, therefore, tends to drop to a yet lower orbit, while the upper satellite is dragged by the tether to a higher than normal speed, and tends to move to a higher orbit. The net result is tension in the tether that holds both satellites in a stable formation around the center of orbit with the tether aligned with a radius from the center of the Earth. It is this simple principle that allowed the Italian tethered satellite to be deployed in a stable position directly above the Orbiter during the TSS-1 mission.

## 4. – Tether electrodynamic fundamentals.

The orbital motion of the TSS around the Earth results in a relative motion between the conducting tether and the geomagnetic field. This creates a motional e.m.f. that is given by the vector products of the geomagnetic field, the relative velocity of the TSS with respect to the geomagnetic field, and the tether lenght, *i.e.*

$$\text{e.m.f.} = (\boldsymbol{v} \times \boldsymbol{B}) \cdot \boldsymbol{L}\,.$$

For a 28 degree inclination orbit, the magnitude of the induced voltage reaches a maximum value (for best alignment of the vectors) of about 250 V per kilometer of deployed tether length, or about 5000 V for a full 20 km deployment. During the TSS-1 mission, the tether length was 268 m or less (including the 12 m boom lenght), corresponding to a maximum e.m.f. of about 60 V across the tether.

With the satellite deployed above the Space Shuttle, the polarity of the e.m.f. is such that the satellite is biased positive and collects electrons from the ionospheric plasma. This electron current then flows down through the tether to the Orbiter where it is actively injected back into the ionosphere by electron guns. The greatest unknown is how and where the current flows in the external, ionospheric circuit. Current closure must occur, but this may occur locally or in the distant *E*-region ionosphere [4]. In the distant-closure model, the current may flow several hundred kilometers along the geomagnetic field and down into the lower ionosphere, where collisions allow it to diffuse across field lines. The current can then close by flowing between the field lines through which the Shuttle and satellite passed [5]. In the local-closure model, the current is assumed to be carried by plasma (whistler) waves that may allow closure in the vicinity of the TSS (within a few tens of kilometers) due to the fact that this type of wave propagates at an angle to the geomagnetic field [6]. There is also considerable question as to the possible magnitude of the tether current for any given set of plasma conditions—which may change over a wide range; *e.g.*, ionospheric variations caused by day/night cycles, or the presence of neutral-gas clouds that may become ionized.

## 5. – Current control hardware and science instrumentation.

The basic electrical circuit of the TSS is shown in fig. 3. Electrons, collected by the positive satellite, flow down through the tether. At the Shuttle, a switching network allows the TSS to be configured in several ways. The entire Shuttle end of the system can be isolated from the tether by the deployer main switch (DMS). Below this switch, the SETS hardware includes a tether current and voltage monitoring (TCVM) system that includes a number of switches that allow connec-

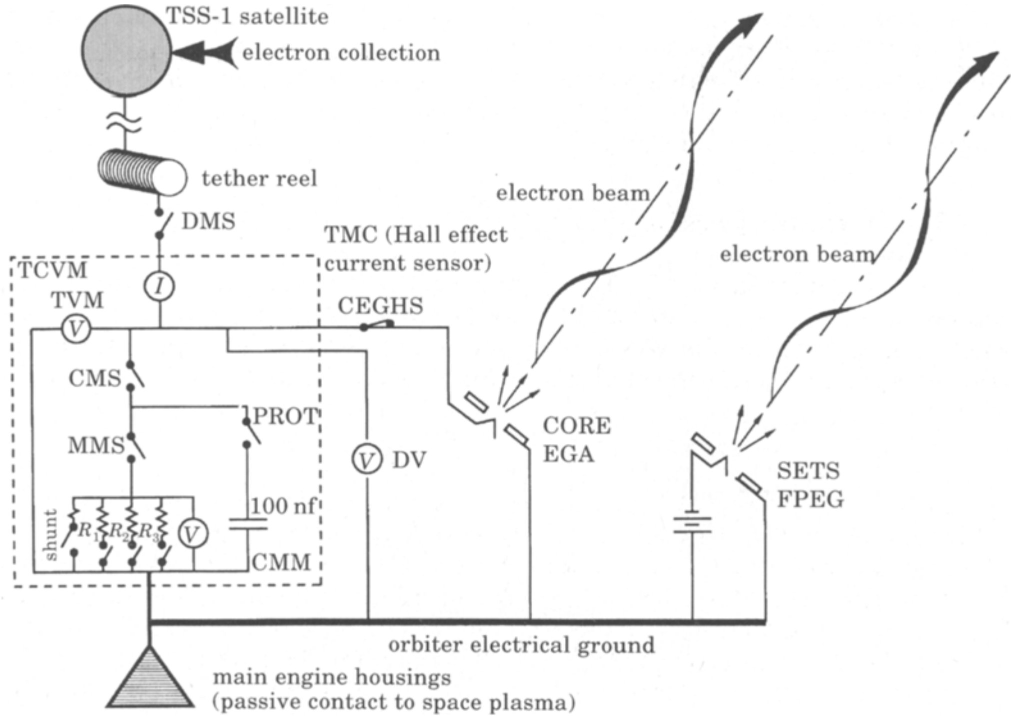

Fig. 3. – TSS-1 electrical schematic showing the possible current paths.

tion of the tether to Shuttle ground through the SETS shunt (15 Ω) resistor, or through 25 kΩ, 250 kΩ or 2.5 MΩ resistors. When current flow is through one of the SETS TCVM resistors to Shuttle ground, contact with the ionspheric plasma must be made by either passive collection of positive ions from the ambient medium (very limited in amplitude), or by emission of an electron beam from the SETS fast-pulsed electron gun (FPEG). The tether current can also pass through the TCVM to the DCORE EGAs. When the tether is connected to either of the EGAs, it is isolated from the Orbiter and the current flows straight to the gun cathode and is emitted directly back into the ionosphere.

In order to understand the electrodynamic behaviour of the TSS, it is necessary to measure the characteristics of the particles and fields at its end bodies as well as the current and voltage generated in the tether. At the satellite, measurements of the behavior of charged particles and electric potentials were provided by ROPE, measurements of the AC and DC electric fields and the electric potential in the plasma sheath were provided by RETE, while the primary AC and DC magnetic-field measurements were provided by TMAG. Tether current at the satellite and satellite accelerations were measured by the SCORE. At the Shuttle, the tether current and voltage were measured by the DCORE and by SETS while return currents to the Shuttle were measured by the SETS and SPREE experiments. The location and function of the TSS-1 science instruments are given in fig. 4. The reference coordinate systems for the Shuttle and the satellite are given in fig. 1 and 2, respectively. In addition to the above experiments, the TMST investigation is responsible for general electrodynamic theoretical support and modeling.

Investigations of electromagnetic emissions from the TSS-1 were also planned

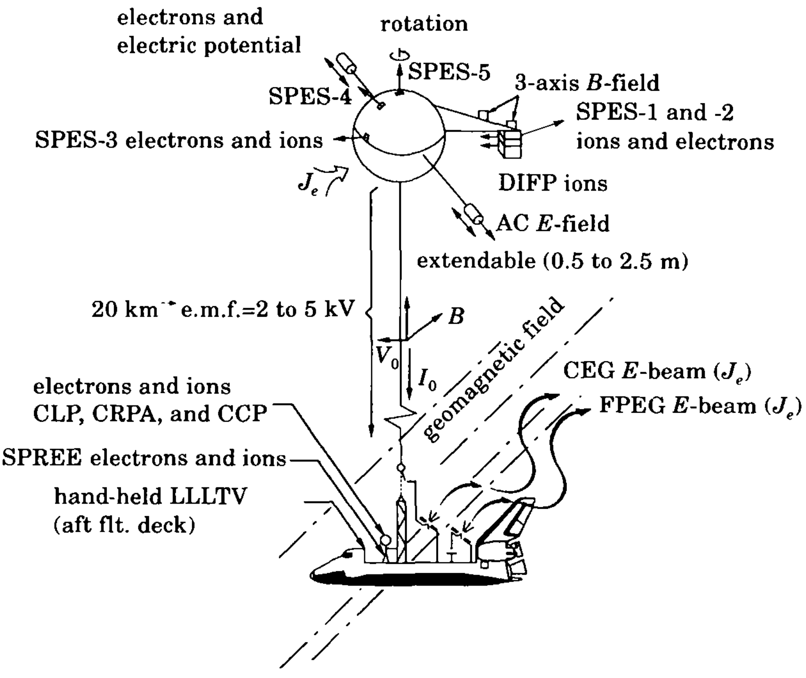

Fig. 4. – Schematic layout of the entire TSS-1 and its science instrumentation.

by the OESEE and EMET investigations. Ground-based receivers were located on Mona Island near Puerto Rico, in the Canary Islands off the west coast of Africa, and on Bribie Island off Australia. In addition, the Arecibo Observatory was used.

Data for tether TEID and IMDN dynamic investigations was obtained from a 3-axis linear accelerometer and gyroscopes mounted on the satellite, tether lenght and tension measurements from the TSS deployer system, and Shuttle accelerometers and gyroscopes.

## 6. – Operations.

Effective operation of such a complex experiment on orbit requires that many operations be pre-planned. Therefore, a number of «standard operation cycles» were developed that coordinated the use of the various current control elements, *i.e.* the SETS TCVM switching network and FPEG operations, and the CORE-EGA operations. With the exception of DEP101 and IV8 (Hybrid), these cycles were set up in a standard format, each being composed of either 6 two-minute steps or 6 four-minute steps for a total duration of 12 or 24 minutes, respectively. In this way, the different cycles could easily be interchanged and moved around in the mission timeline, as required.

Although the mission was not executed as planned, several of the Standard Ops Cycles were used and we provide a description of those that were executed. Table IV lists each of the Standard Ops Cycles used and the number of executions. The detailed make-up of each cycle is given in tables V-IX.

The as-flown deployment profile is given in fig. 5. The main events are 1) flyaway at GMT 217/22:50:52, 2) the initial system jam at GMT 217/23:43:25 when the satellite was deployed 179 m, 3) the ramp-up in deployment speed to break-through of the initial jam at GMT 218/01:46:28, 4) the second jam at GMT 218/01:55:38 when the satellite was deployed 256 m, 5) a third jam at GMT 218/13:22:48 after the satellite had been reeled in to 224 m, 6) initiation of retrieval at GMT 218/21:52:48, and 7) a nominal final retrieval and dock at GMT 218/22:53:28.

TABLE IV. – *Standard cycles executed during deployed operations.*

| Cycle | No. repetitions | Time (MET) |
|---|---|---|
| DEP101 | 67 | various |
| IV8 (hybrid) | 8 | 218/01:05:28, 03:33:15, 17:24:58<br>19:44:11, 20:23:03, 21:17:43<br>21:47:24, 22:55:07 |
| IV12 | 1 | 218/09:04:25 |
| IV24 | 3 | 218/03:45:59, 09:47:44, 17:37:42 |
| AC12 | 5 | 218/19:57:46, 20:36:40, 21:23:15<br>22:00:59, 22:38:43 |
| SETS FO14 | 9 | 218/18:37:46, 18:59:50, 19:24:47<br>19:52:13, 20:31:06, 21:17:42<br>21:55:27, 22:33:09, 23:10:52 |

Table V. – DEP 1 *operating cycle.*

| Tether current path | Step number | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| SETS TCVM | | | | | | |
| DCORE EGA Mode | — | — | — | — | | |
| $R = 15\ \Omega$ | — | × | × | — | | |
| $R = 25\ \mathrm{k}\Omega$ | — | × | × | — | | |
| $R = 250\ \mathrm{k}\Omega$ | — | × | × | — | | |
| $R = 2.5\ \mathrm{M}\Omega$ | — | × | × | — | | |
| DCORE EGA | — | — | — | — | | |
| SETS FPEG | × | × | — | — | | |
| System current capacity (mA) | 0 | (a) | (a) | 0 | | |

(a) In nominal operations, all four load resistances stepped through in sequence. Current limited to 200 mA.

Table VI. – *I-V* 8 *(hybrid) standard operating cycle.*

| Tether current path | Step number | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| SETS TCVM | | | | | | |
| DCORE EGA Mode | × | × | | | | |
| $R = 15\ \Omega$ | — | — | | | | |
| $R = 25\ \mathrm{k}\Omega$ | — | — | | | | |
| $R = 250\ \mathrm{k}\Omega$ | — | — | | | | |
| $R = 2.5\ \mathrm{M}\Omega$ | — | — | | | | |
| DCORE EGA | stepped | stepped | | | | |
| SETS FPEG | — | — | | | | |
| System current capacity (mA) | (a) | (a) | | | | |

(a) Current capacity of EGA steps (mA): 12, 21, 30, 42, 51, 75, 102, 126, 150, 201, 252, 300, 351, 402, 450, 501.

Table VII. – *I-V* 12 *and I-V* 24 *standard operating cycles.*

| Tether current path | Step number | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| SETS TCVM | | | | | | |
| DCORE EGA Mode | × | — | — | × | — | — |
| $R = 15\ \Omega$ | — | — | — | — | — | — |
| $R = 25\ \mathrm{k}\Omega$ | — | × | — | — | × | — |
| $R = 250\ \mathrm{k}\Omega$ | — | × | — | — | × | — |
| $R = 2.5\ \mathrm{M}\Omega$ | — | × | — | — | × | — |
| DCORE EGA | stepped | — | — | stepped | — | — |
| SETS FPEG | — | DC | — | — | DC | — |
| System current capacity (mA) | (a) | 2–200 | 0 | (a) | 200–2 | |

(a) Current capacity of EGA steps (mA): 12, 21, 30, 42, 51, 75, 102, 126, 150, 201, 252, 300, 351, 402, 450, 501. I-V 12 step durations are 2 min. I-V 24 step durations are 4 min.

TABLE VIII. – AC 12 *standard operating cycle.*

| Tether current path | Step number | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| SETS TCVM | | | | | | |
| DCORE EGA Mode | × | — | — | × | — | — |
| $R = 15\ \Omega$ | — | — | — | — | — | — |
| $R = 25\ \text{k}\Omega$ | — | — | — | — | × | × |
| $R = 250\ \text{k}\Omega$ | — | — | — | — | — | — |
| $R = 2.5\ \text{M}\Omega$ | — | — | — | — | — | — |
| DCORE EGA | AC | — | — | AC | — | — |
| SETS FPEG | — | AC | — | — | DC | DC |
| System current capacity (mA) | 501 at 0.5 Hz | 0 | 0 | 501 at 0.5 Hz | 200 | 200 |

TABLE IX. – SETS FO14 *operating cycle.*

| Tether current path | Step number | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 [(a)] | 5 [(a)] | 6 |
| SETS TCVM | | | | | | |
| DCORE EGA (Mode) | — | — | — | — | — | |
| $R = 15\ \Omega$ | × | × | — | × | × | |
| $R = 25\ \text{k}\Omega$ | (b) | (b) | (b) | (b) | (b) | |
| $R = 250\ \text{k}\Omega$ | (b) | (b) | (b) | (b) | (b) | |
| $R = 2.5\ \text{M}\Omega$ | (b) | (b) | (b) | (b) | (b) | |
| DCORE EGA | — | — | — | — | — | |
| SETS FPEG | — | X | X | — | — | |
| System current capacity (mA) | <200 [(c)] | <200 [(c)] | 0 [(c)] | <200 [(c)] | <200 [(c)] | |

(*a*) Crew coordinated Orbiter thruster firings occur in steps 4 and 5.
(*b*) Selectable to control current and charging rates—only the 15 Ω used for TSS-1.
(*c*) Current flow duration is 2 s in each of steps 1, 2, 4, and 5.

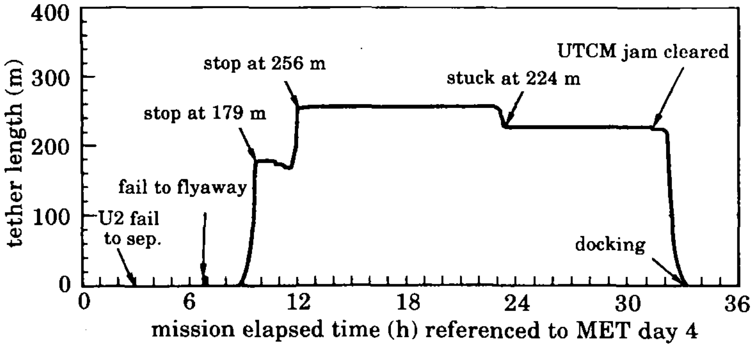

Fig. 5. – The as-flown TSS-1 deployment profile (distance is measured from the tip of the 12 m deployer boom).

## 7. – Data acquisition and processing.

The variety of instruments and measurement involved in TSS is quite complex and the data produced are diverse in their basic formats. To allow effective, simultaneous evaluation of data from all instruments, a science data handling, archiving and display system was developed. This system deconvolved and archived the Shuttle down-link telemetry stream, broke out each investigation's data, loaded it into a standard format block with a standard header, and distributed it over a local area network to the science support teams. In addition, joint displays were provided for the Principal Investigator team in which the key elements from all instruments on the satellite were shown on a single display with a common time base. The key elements from all instruments on the Shuttle were shown together on a second display with the same, common time base. In this way, during the mission, a coordinated view of all the current monitoring and control hardware and diagnostic instruments at both ends of the tether system was easily accessible to the investigators.

Post-mission, the TSS data, along with required Shuttle ancillary data, was archived by the science data system and distributed to all PI science teams for analysis. Each team has access to the data through a science data system work station that contains the necessary read and display software.

## 8. – Conclusions.

Although it was planned for the Italian satellite to be tethered 20 000 m above the Shuttle Orbiter during the TSS-1 mission, a simple technical problem with the deployer reel mechanism resulted in deployment being terminated at a distance of only 268 m. The short deployment clearly prevented accomplishment of the primary mission goals and objectives—to evaluate the dynamic and electrodynamic characteristics of a long tethered system in space, and to demonstrate its scientific applications. However, in the most fundamental sense, TSS-1 showed that long tethered systems are both feasible and safe, and it provided a set of very unique data that will prove valuable to future tether missions. In this light, the following papers describe the objectives, capabilities and operations of the various TSS-1 science instruments. These same instruments will be flown on the TSS-IR (re-flight) mission presently manifested for a February 1996 launch.

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