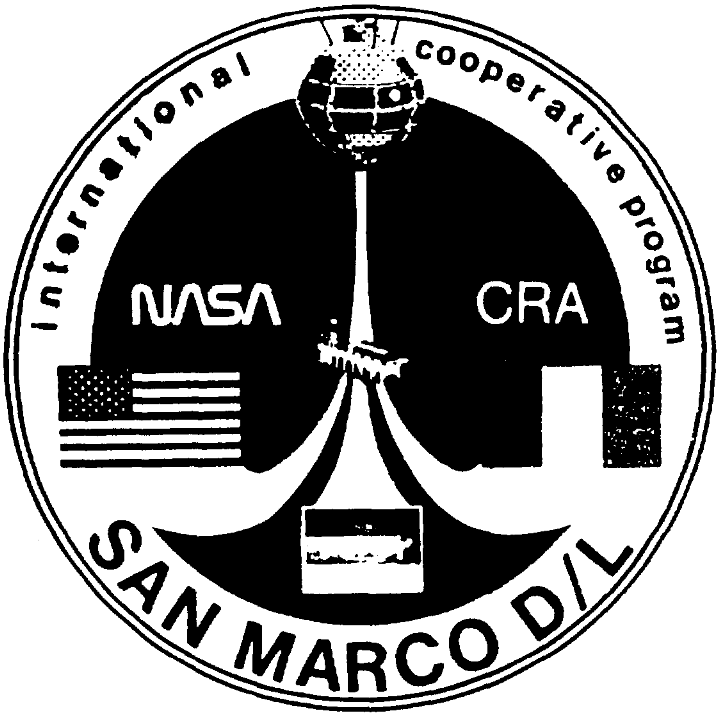
NASA
National Aeronautics and
Space Administration

Mission Operation Report

OFFICE OF SPACE SCIENCE AND APPLICATIONS REPORT NO. E-898-88-05



San Marco D/L

Prelaunch
Mission Operation Report
No. E-894-88-05

March 9, 1988

TO: A/Administrator

FROM: E/Associate Administrator for Space Science and Applications

SUBJECT: San Marco D/L Explorer

The San Marco D/L spacecraft, utilizing a Scout launch vehicle, will be launched from the San Marco Range, located off the coast of Kenya, Africa, no earlier than March 18, 1988. The launch will be conducted by an Italian crew. The San Marco D/L is the fifth cooperative satellite project between Italy and the United States. The purpose of the mission is to explore the relationship between solar activity and meteorological phenomena with emphasis on lower atmospheric winds of the equatorial thermosphere and ionosphere. This information will augment, and be used in correlation with, data and information obtained from a number of ground-based facilities and other satellites.

The San Marco D/L project is the last flight mission in the series of joint research missions conducted under the existing agreement between the National Aeronautics and Space Administration (NASA) and the Italian Space Commission. The San Marco D Memorandum of Understanding (MOU) was signed by the Centro Ricerche Aerospaziali (CRA) for the Italian Space Commission in July 1976 and subsequently by NASA in September 1976. Project management responsibility for the Italian portion of the project was assigned to the Centro Ricerche Aerospaziali (CRA), while the Goddard Space Flight Center (GSFC) was assigned project responsibility for the United States portion. Program management responsibility resides with the Office of Space Science and Applications; responsibility for provision of the Scout launch vehicle resides with the Office of Space Flight. There is also an auxiliary cooperative agreement between the University of Rome and the Deutsche Forschungs Versuchsanstat fur Luft und Raumfahrt (DFVLR) of the Federal Republic of Germany.

In accordance with the MOU, the CRA has provided the spacecraft, its subsystems, and an air drag balance system; the DFVLR has provided an airglow solar spectrometer; and NASA has provided an ion velocity instrument, wind/temperature spectrometer, and an electric field instrument. NASA has also provided the Scout launch vehicle, and extensive technical and consultation support to the Italian project team.

Tracking and data acquisition support will be provided by the Spaceflight Tracking and Data Network (STDN) as well as the Mobile Italian Tracking Station and other foreign ground stations. Certain orbital parameter information will be provided by the North American Air Defense Command (NORAD).

The spacecraft will be launched into an orbit with the following nominal orbital elements: Perigee -- 272 km, Apogee -- 652 km, Inclination -- 2.9 degrees, Period -- 93 minutes. The expected orbital lifetime is 6 months (minimum).

L A Fisk

Lennard A. Fisk

FOREWORD

MISSION OPERATION REPORTS are published expressly for the use of NASA senior management. The purpose of these reports is to provide NASA senior management with timely, complete, and definitive information on flight mission plans, and to establish official mission objectives which provide the basis for assessment of mission accomplishment.

Reports are prepared and issued for each flight project just prior to launch. Following launch, updating reports for each mission are issued to keep management currently informed of definitive mission results as provided in NASA Management Instruction HQMI 8610.1B.

These reports are sometimes highly technical and are for personnel having program/project management responsibilities. The Public Affairs Division publishes a comprehensive series of reports on NASA flight missions which are available for dissemination to the news media.

Published and Distributed by
HEADQUARTERS ADMINISTRATION
NASA HEADQUARTERS

CONTENTS

Page

General 1

NASA Mission Objective for San Marco D/L 5

Spacecraft Description 6

Experiments
- o Neutral Atmosphere Density 8
- o Ion Velocity Instrument 9
- o Wind and Temperature Spectrometer 10
- o Electric Field Instrument 11
- o Airglow Solar Spectrometer 12
- o Gallium Arsenide Panel Flight Experiment 13

Launch Vehicle Description 14

Mission Support 19

Program Management 22

San Marco D/L Project Costs 23

Project Acronyms 24

LIST OF FIGURES

Figure No.	Title	Page
1	San Marco D/L Spacecraft	6
2	Drag Balance	7
3	Satellite Inner Body (General Arrangement)	7
4	Balance Assembly	8
5	Ion Velocity Instrument	10
6	Wind And Temperature Instrument	11
7	Airglow Solar Spectrometer	12
8	Distribution Of San Marco D/L Solar Panels	13
9	Scout Launch Vehicle	14
10	Trajectory Parameters at Event Times	15
11	Axial Acceleration and Dynamic Pressure vs Time	16
12	Orbit Ground Track for First Four Revolutions	17
13	Boost Trajectory Ground Track with Stage Impact Points	17
14	Isoprobability Contours of Apogee - Perigee Devisions	18
15	San Marco Range Location	19
16	San Marco Launch Platform	20
17	Nominal Subsatellite Orbital Path	21

GENERAL

The Spacecraft Act of 1958 authorized the United States to conduct a program of international cooperation with other nations in aeronautical and space science activities and in the peaceful applications of the results thereof.

On May 31, 1962, the first Memorandum of Understanding concerning the San Marco program was signed by the Italian Commissione per le Ricerche Spaziali (CRS) and the National Aeronautics and Space Administration (NASA).

- PHASE I - A suborbital launch from the Wallops Island Station and/or from an Italian platform located near the equator to flight-test the principal elements of the scientific payload.

- PHASE II - An orbital launch of a fully instrumented satellite utilizing a Scout vehicle from Wallops Island Station to qualify the spacecraft and to provide essential launch crew training.

- PHASE III - Launch of a scientific satellite into an equatorial orbit by means of a Scout booster from a platform located in Kenya to obtain air density data, and to qualify the equatorial launch complex as an operating range.

- PHASE IV - This phase is a continuation of Phase III with the launching of a scientific satellite into an equatorial orbit in an effort to explore the relationship between solar activity and meteorological phenomena with emphasis on lower atmospheric winds of the equatorial thermosphere and ionosphere. The satellite will be propelled into orbit by a Scout launch vehicle.

On March 26, 1964, Centro Ricerche Aerospaziali (CRA) successfully launched a two-stage Nike sounding rocket from the Santa Rita launch platform off the Kenya coast, concluding Phase I. It carried basic elements of the San Marco science instrumentation and served further to flight qualify these components as well as provide a means of check-out of range instrumentation and equipment.

The second phase culminated in the launch of the San Marco-I Spacecraft from Wallops Island on a Scout vehicle on December 15, 1964. This launch demonstrated the readiness of the CRA launch crews for Phase III operations and qualified the basic spacecraft design. In addition it confirmed the usefulness and reliability of the drag balance device for accurate determinations of air density values and satellite attitude.

Phase III was completed with the launching of San Marco-II from the San Marco platform off the coast of Kenya on April 26, 1967. The San Marco-II carried the same instrumentation as the San Marco-I, but the equatorial orbit permitted a more detailed study to be made of density variations versus altitude in the equatorial region. The successful launch also served to qualify the San Marco Range as a reliable facility for future satellite launches.

The successful culmination of the first San Marco endeavor paved the way for still closer collaboration in future space explorations.

On November 18, 1967, a second Memorandum of Understanding was signed between the Italian CRA and NASA to continue the cooperation in satellite measurements of atmospheric characteristics and to establish the San Marco-C project. This effort, implemented through the respective agencies, supplemented and continued the drag balance studies of the two previous CRA and NASA cooperative projects, and initiated complementary mass spectrometer investigations of the equatorial neutral particle atmosphere. This phase offered a unique scientific advantage, enabling the simultaneous measurement of atmospheric density from one satellite by three different techniques: direct particle detection, direct drag, and integrated drag.

On August 6, 1974, a third Memorandum of Understanding was signed between the Italian CRA and NASA, to continue and extend their cooperation in satellite measurements of atmospheric characteristics and to establish the San Marco/Atmosphere Explorer Cooperative Project. This effort made possible the measurements of diurnal variations of the equatorial neutral atmosphere density, composition, and temperature for correlation with the AE-C (Explorer 51) data for studies of the physics and dynamics of the thermosphere.

In September 1976, a fourth Memorandum of Understanding was signed between the Italian CRA and NASA to extend their cooperation in satellite measurements of atmospheric characteristics and to establish the San Marco-D International Cooperative Project. The thrust of this effort was to explore the possible relationship between solar activity and meteorological phenomena, in an effort to further define the structure, dynamics, and aeronomy of the equatorial thermosphere. This effort initially was to employ two satellites: a San Marco D/L spacecraft (low orbit), and a San Marco D/M spacecraft (upper orbit), in an effort to enhance the evaluation of solar-weather relationships. However, due to problems associated with the Italian resource allocations, the program was scaled down to a single-spacecraft program (San Marco D/L). The program was reevaluated and satellite orbit and payload adjustments were made in an effort to assure experimental success and maximize scientific return.

In accordance with the terms of the latest Memorandum of Understanding, each agency agreed to use its best effort to carry out the following responsibilities:

CENTRO RICERCHE AEROSPAZIALI (CRA)

- **Design, develop, and manufacture a flight spacecraft for the San Marco-D/L mission including ground testing, and integration of the spacecraft with the Scout vehicle.**

- **Provide a "drag balance" experiment for neutral density measurement.**

- **Provide an Airglow instrument through the auspices of the Institut fur Physikalische Weltraumforschung (IPW), Federal Republic of Germany.**

- **Integrate all the experiment instruments into the San Marco D/L spacecraft.**

- Assemble, check out, and launch the Scout vehicle and provide range safety.
- Operate the Mobile Italian Tracking Station (MITS) for real time data coverage following the launch.
- Provide for long distance communications from MITS to Goddard Space Flight Center (GSFC) communication terminals for mission operations, and for a "quick look" data exchange system.
- Provide tracking and data acquisition support from MITS in Kenya and other stations, for telemetry support as available and mutually agreed on.
- Provide logistics, spare parts, and materials, and the cost of shipment from the U.S. (or Italy) to Kenya of all materials, including transport of the Scout vehicle from the U.S. to the San Marco Range.
- Perform analysis of the data from the Italian instruments on the spacecraft, and participate with NASA in correlative analysis of such data with data obtained by the NASA and German experimenters.
- Provide spacecraft attitude data for use by NASA.
- Maintain the San Marco Range facilities and their modifications, as required for the San Marco-D/L launch.

In addition to the basic responsibilities, it was agreed in subsequent discussions that CRA would also use its best efforts to accomplish the following:

- Control and operate the spacecraft on orbit;
- Provide orbital determination for the spacecraft;
- Develop software for the operational determination and selection of star sensor threshold; and
- Acquire and use star data for calibration of other attitude sensors.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

- Provide an ion velocity instrument to CRA from the University of Texas at Dallas.
- Provide a neutral mass spectrometer and a temperature and density measurement package for the spacecraft.
- Provide an electric field instrument system.
- Provide a Scout launch vehicle to include the heat shield, spacecraft tiedown, separation mechanism, vehicle spare parts, and vehicle transport to U.S. port of embarkation.

- Assist CRA with the integration of the NASA-provided instruments into the spacecraft.

- Provide technical consultation and review in all areas of the spacecraft design and test verification, experiment integration, launch vehicle, launch, spacecraft operations, attitude determination, and orbit determination.

NOTE: Each agency designated a Project Manager who is responsible for coordinating the agreed functions and responsibilities of his agency. Final determination of launch readiness of the spacecraft will be by agreement between CRA and NASA.

E-894-88-05

NASA MISSION OBJECTIVES FOR SAN MARCO D/L

PRIMARY OBJECTIVE

- To explore the possible relationship between solar activity and meteorological phenomena.

SECONDARY OBJECTIVE

- To determine the solar influence on low atmosphere phenomena through the thermosphere by obtaining measurements of parameters necessary for the study of dynamic processes occurring in the troposphere, stratosphere, and thermosphere.

Charles J. Pellerin, Jr.
Director, Astrophysics Division

Date: 3/3/88

Lennard A. Fisk
Associate Administrator for Office
of Space Science and Applications

Date: [illegible] 9 1988

S. G. Tilford
Shelby G. Tilford
Director, Earth Science and
Applications Division

Date: 3/4/88

SPACECRAFT DESCRIPTION

GENERAL

The San Marco-D/L mechanical structure basic design is derived from the San Marco-C configuration, with those changes necessary to accommodate a larger diameter. The use of the 107 cm Scout launch vehicle heat shield allows this larger diameter.

The San Marco-D spacecraft is a 96.5 cm diameter sphere with four canted 48 cm monopole antennas for telemetry and command (Figure 1). The structure of the spacecraft forms an integral part of the Drag Balance instrumentation system. The drag balance system (Figure 2) consists of a light external shell (3 kg), connected through the elastic elements of the air-drag measuring balance to the massive main structure (234 kg) of the satellite. Figure 3 shows the inner body general arrangement.

SAN MARCO D/L SPACECRAFT

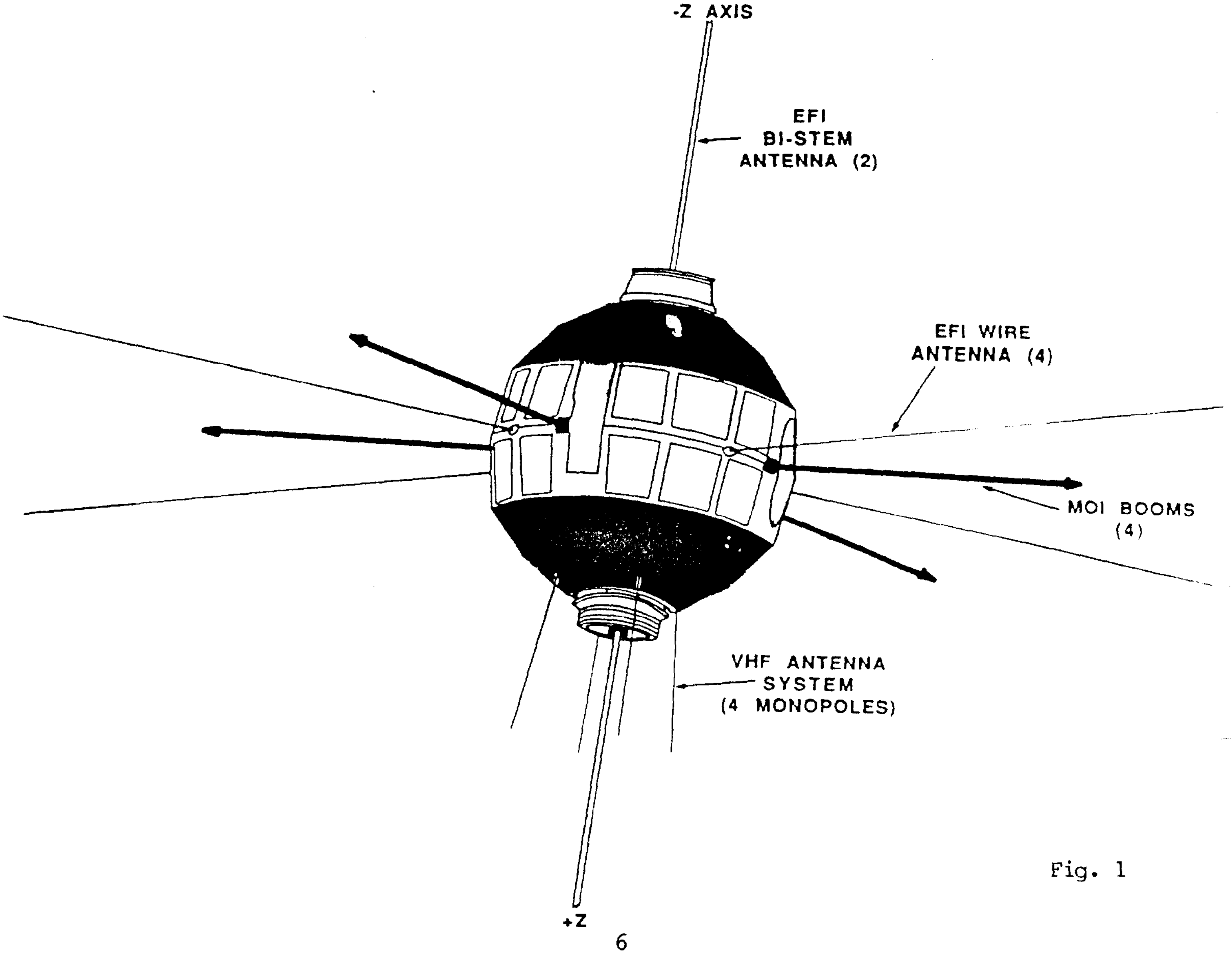


Fig. 1

DRAG BALANCE

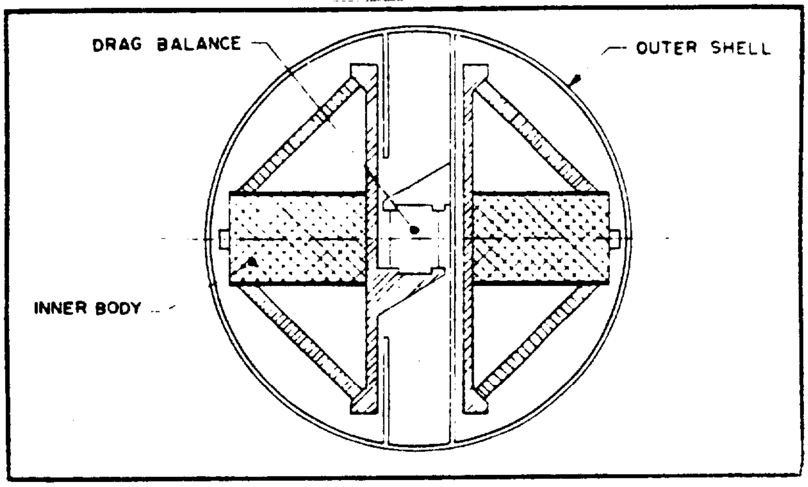


Fig. 2

SAN MARCO D/L GENERAL ASSEMBLY (INNER BODY)

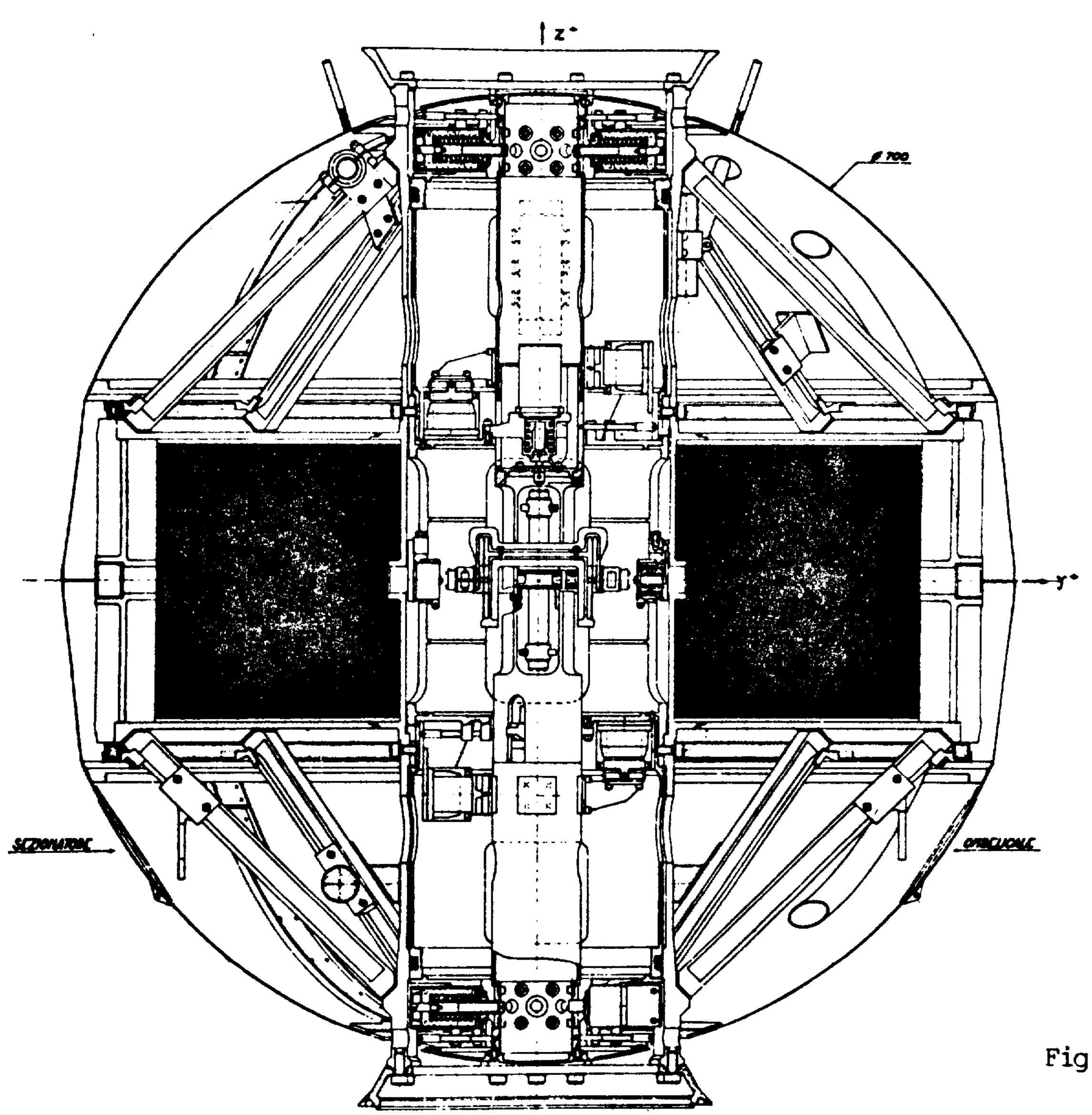


Fig. 3

The outer shell of the satellite, a honeycomb structure, and the arms which connect the outer shell to the drag balance, constitute the movable structure of the vehicle. A series of protective mica windows is provided on the equator of the shell directly over the solar cells which are located on the periphery of the inner structure. This design permits relative movement between the inner and outer structures, maintains the integrity of the spacecraft, and minimizes the complexity of the solar cell power supply subsystem.

The power supply subsystem consists of a solar cell array (32 solar panels) split into two sections, two rechargeable nickel-cadmium (NiCd) batteries, and the associated control and regulation circuits. The solar array is split into two electrically insulated sections, each feeding its own battery.

The weight of the orbiting San Marco-D/L satellite is 237 kg.

The spacecraft is thermally controlled by passive means to maintain the instrumentation within a safe temperature range. Satellite attitude data are provided by a triaxial magnetometer, a horizon sensor, and a digital sun sensor. The main components of the command system are the command receiver, tone decoder, command decoder, and the command combiner. The completely redundant system provides the capabilities for 64 commands, using a PCM/FSK-AM/AM subsystem. The radio link is at 149.52 MHz. The telemetry system radio link is at 136.74 MHz and uses FM/PM modulation.

EXPERIMENTS

Neutral Atmosphere Density Experiment (Drag Balance)

The drag balance principal investigator is Professor Luigi Broglio of CRA, with Professor Carlo Arduini (CRA) as co-investigator.

The instrument is an integral part of the satellite structure, and consists of an inner mass, an elastic element, and an outer shell. The drag balance instrument (DBI) (Figure 4) is the connecting elastic element between the light outer shell and the heavy inner body. The center of the balance is located at the satellite geometric center, or that point which is the geometric center both of the inner body and the shell. While preventing any relative angular displacement, the connecting element, which is the balance itself, allows the relative translation of the outer shell with respect to the inner body in any direction. Any force acting on the shell in any direction causes a relative displacement (translation) of the shell with respect

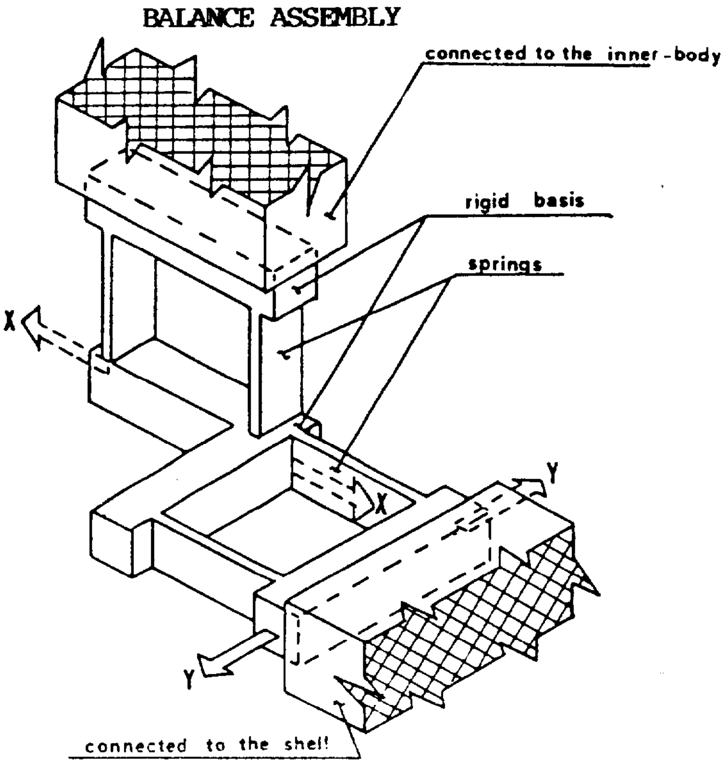


Fig. 4

to the internal body, only in the direction of the applied force, and yields a physical displacement which is linearly proportional to the magnitude of the force.

This integral system measures the relative translations between the shell and the inner body both in value and direction, resolving any relative translation along three mutually orthogonal axes. These three axes are fixed to the body, one of them being coincident with the polar symmetry axis of the satellite. Being fixed to the satellite, the axis rotates with it in the free precession motion around the center of gravity. The balance is designed in such a way that the maximum translation between the shell and the drum is generally of the the order of 0.01 millimeter. At the orbit apogee, in most cases, the drag force is negligible. As a consequence, the apogee data are used to establish inflight calibration of the balance system. The translation of the elastic system is then changed into voltage signals which are amplified and demodulated to obtain dc signals which are proportional to the component force vectors.

The sensitivity of the balance ranges from 1 gram full scale to 35 grams full scale generally corresponding to the range of altitude from 400 Km to 130 Km, respectively.

Ion Velocity Instrument (IVI)

The Ion Velocity experiment principal investigator is W. B. Hanson (University of Texas at Dallas).

The Ion Velocity Instrument (IVI) measures the three-dimensional bulk velocity of the ambient ions in the spacecraft frame. The instrument also measures the ambient plasma concentration and the ion temperature. Data and information obtained from the IVI, in conjunction with other instruments, will aid in answering significant questions concerning the nature of equatorial plasma turbulence, the bulk coupling of ion and neutral gas motions, and the sunspot maximum thermal behavior of the ionosphere.

The instrument (Figure 5) is a derivative of instrumentation successfully developed for the Atmosphere Explorer (AE) and Dynamics Explorer (DE) satellites. It utilizes a planar Retarding Potential Analyzer (RPA) to determine the magnitude of the relative speed between the thermal ions in the F region and the satellite. A square aperture collimator and a split collector are used to determine the arrival angle of ions incident upon another sensor. The combination of these measurements yields the three-dimensional bulk velocity vector of the ambient ions in the spacecraft frame. Since the spacecraft velocity is very accurately known, the ion velocity in the Earth's frame can be simply derived.

A spin synchronous (nadir) timing pulse will be utilized to record an RPA characteristic curve in the ram direction. This information will be stored in a buffer to be read out continuously over a full spin period. The two transverse ion arrival angles will be measured every minor telemetry frame (approximately 8 times per second each) utilizing a synchronized switching of the log-electrometers to the collector segments.

ION VELOCITY INSTRUMENT (IVI)

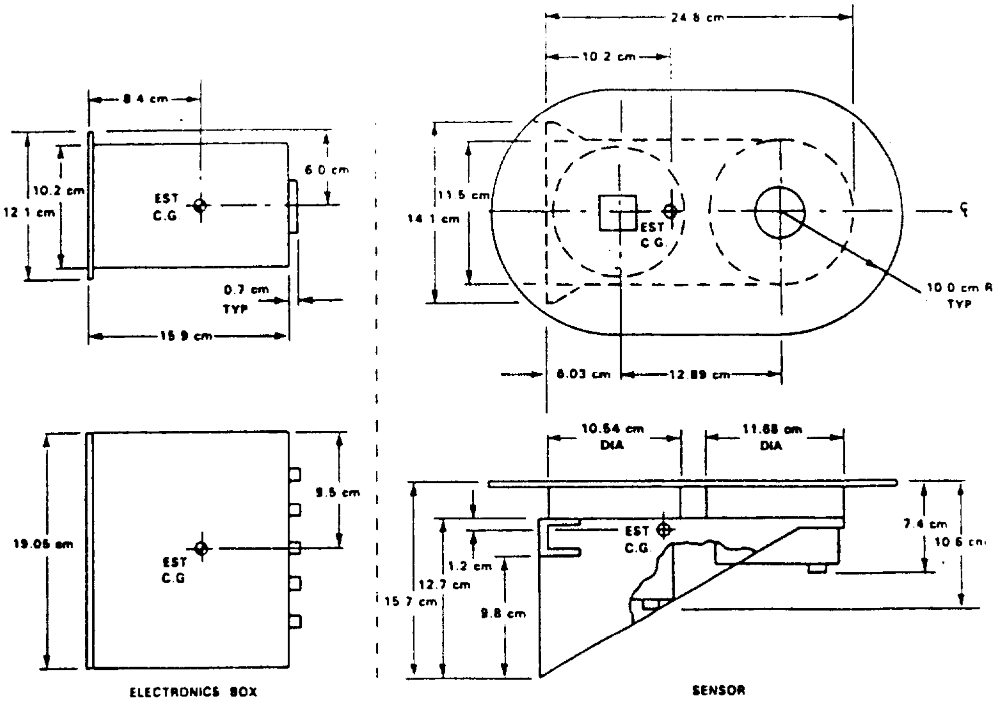


Fig. 5

A complementary feature of the San Marco D/L satellite is a negatively biased, axially symmetrical, ion collector ring. During instrument operations, the system current is continuously sampled, at 12 Hz, providing ion concentration values.

The full ion velocity vector will be measured during every spin (10 seconds). In addition to the aforementioned basic information the ambient plasma concentration and the ion temperature will also be determined for each spin. These two parameters are derived from the same data analysis program that provides the longitudinal velocity component.

Wind and Temperature Spectrometer Instrument (WATI)

The Wind and Temperature Spectrometer Instrument (WATI) experiment principal investigator is N. W. Spencer (GSFC), with G. Carignan (University of Michigan) as the co-investigator.

Two components of the wind (1) horizontal and normal to the orbit plane, and (2) vertical and in the orbit plane, together with the kinetic temperature will be measured. These measurements will be obtained using a technique developed for the AE and DE satellites but modified for a spinning spacecraft. This technique employs a scanning baffle which modulates the particle flow into the entrance port of a mass spectrometer. From a density versus time measurement of a selected gas species (usually molecular nitrogen or atomic oxygen) the direction of the incoming flux of particles with respect to the spacecraft can be determined. From these data and the measured spacecraft attitude, the wind components are calculated. In addition, the shape of the density versus time curve, are used in calculating the velocity distribution, and temperature. The WATI system is shown in Figure 6.

WIND AND TEMPERATURE SPECTROMETER (WATI)

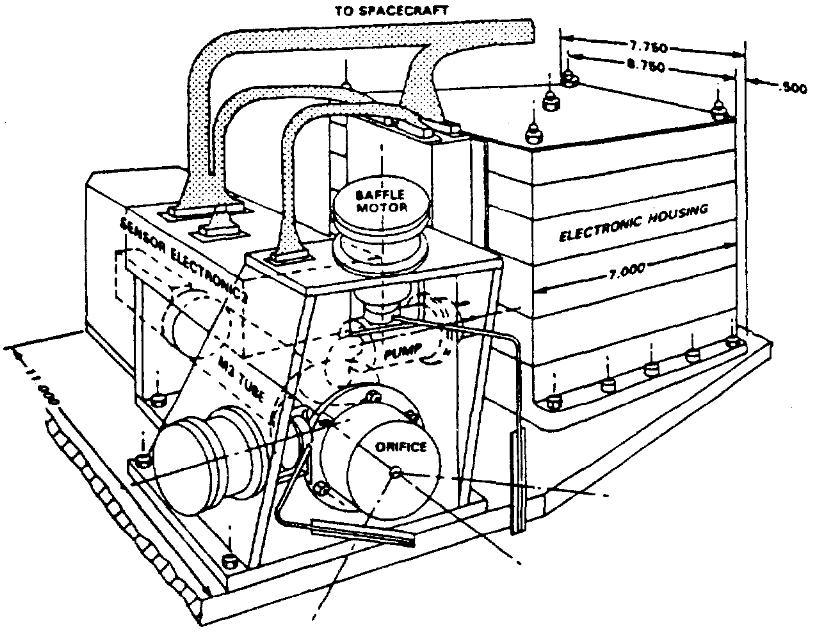


Fig. 6

Electric Field Instrument (EFI)

The Electric Field measurement experiment principal investigators are N. C. Maynard and T. Aggson (GSFC), with J. P. Heppner (GSFC) as co-investigator.

The electric field sensors for this experiment consist of two orthogonal 40-meter (tip-to-tip) wire antenna pairs which will be extended in the spin plane of the satellite, and a more rigid shorter antenna pair to be deployed along the spacecraft spin axis (Figure 1). The instrument utilizes these antennas in the double floating probe mode to measure the dc electric field with 0.125 second resolution in the real-time domain, and the rms wave electric field, in filter banks ranging from 4 to 10,000 Hz, in the Fourier domain.

The double floating probe technique is a reliable, proven method for direct in-situ measurements of electric fields in the plasma medium. A body in a plasma will establish a potential relative to the plasma so as to maintain a current balance. If no current is drawn from the body, its potential will depend on the properties of the medium, including differences of potential existing in the medium. This technique used for the EFI is to measure the floating potential of each of two symmetric probes with respect to the spacecraft, and then subtract these two sets of potentials to remove the effects of the spacecraft floating potential. If no electric field exists, stationary probes will float at the same potential, and the results will be zero (that is, there will be no difference in these measured potentials).

The symmetry, the probes, and a relatively large separation between the probes and the spacecraft are critical to making the double-floating probe technique work. These requirements are met with the San Marco D/L configuration.

The dc electric field measurements will involve an extended data analysis to quantitatively subtract the V x B field (of the order of 200 mV/m), induced by the 8 km/s satellite motion, to obtain the ionospheric electric fields. These electric fields are expected to be about 1-5 mVm at equatorial latitudes in the F region. The dc and wave electric field measurements, together with ground-based and in-situ plasma drift observations, will provide a critical morphological survey of equatorial electrodynamics, including plasma transport and instability processes.

Airglow Solar Spectrometer (ASSI)

The principal investigator for the Airglow Solar Spectrometer experiment is G. Schmidtke from the Institut fur Physikalische Messtechnik with Max Roemer from Astronomische Institute Universitaet Bonn and Peter Seidl from Physikalisch-Technische Studien (PTS) participating as co-investigators.

The Airglow Solar Spectrometer Instrument (ASSI) will measure the equatorial day and night airglow, solar radiation reflected from the surface and clouds, solar radiation and the radiation of interplanetary and intergalactic origin reaching the satellite. The system is extremely wide band and will measure wavelengths ranging from the extreme ultraviolet spectra through the visible spectral regions. Four spectrometers with solar pointing control cover this broad region, taking measurements in 18 overlapping wavelength ranges with spectral resolution from 0.8 to 3.0 nm (Figure 7). Large dynamic ranges up to 10E11 permit the measurement of very faint airglow or interplanetary radiations as well as intense solar emissions.

AIRGLOW SOLAR SPECTROMETER

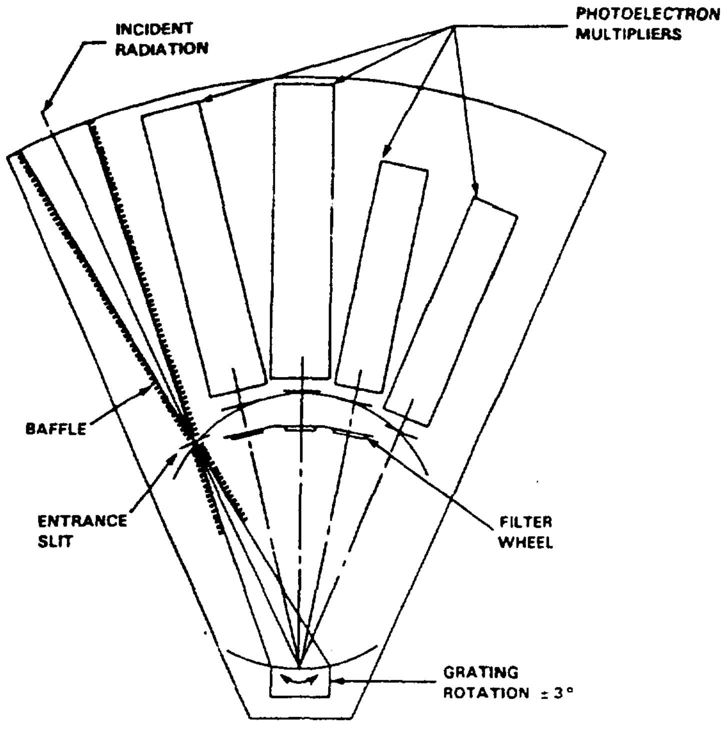


Fig. 7

The instrument system consists of two physically separated units. Each unit contains two spectrometers based on Rowland circle geometry, with toroidal gratings of R = 115.5 mm and 1200, 2400 lines/nm (ASSI-A I/III) and 1200, 3600 lines/nm (ASSI-B II/IV), respectively. The holograph formed from the lines of the gratings are curved when viewed at normal incidence, to decrease aberration. Along each Rowland circle, four to five photoelectron multipliers are positioned behind the exit slits. There are a total of 18 detectors.

Utilizing this unique approach, a single Airglow Solar Spectrometer can measure the solar radiation, backscatter radiation (e.g. from clouds), and comparably weak airglow emissions.

Gallium Arsenide Panel Flight Experiment (GAPFE)

The principal investigator for the Gallium Arsenide Panel Flight Experiment (GAPFE) is Terry Trumble from U.S. Air Force Wright Aeronautical Laboratories.

The GAPFE will measure, both the Gallium Arsenide (GaAs) and Silicon (Si), solar panel temperature, current, and voltage. The San Marco D/L solar array consists of 2 identical sections of 14 parallel connected panels, 1 GaAs solar cell panel, and 13 Si solar panels, shown in Figure 8. Each section consists of consecutive connected panels alternating from the upper and lower loops so that the spin-averaged output current for the two sections will be equal for all sun angles. The only exception is for the solar array flight experiment in which the in-flight performance of Si and GaAs solar cell panels will be compared. The panels are physically located together and electrically connected to the same operating point. The performances of only one pair of panels (1 Si and 1 GaAs) will be monitored in flight.

DISTRIBUTION OF THE SAN MARCO D/L SOLAR PANELS

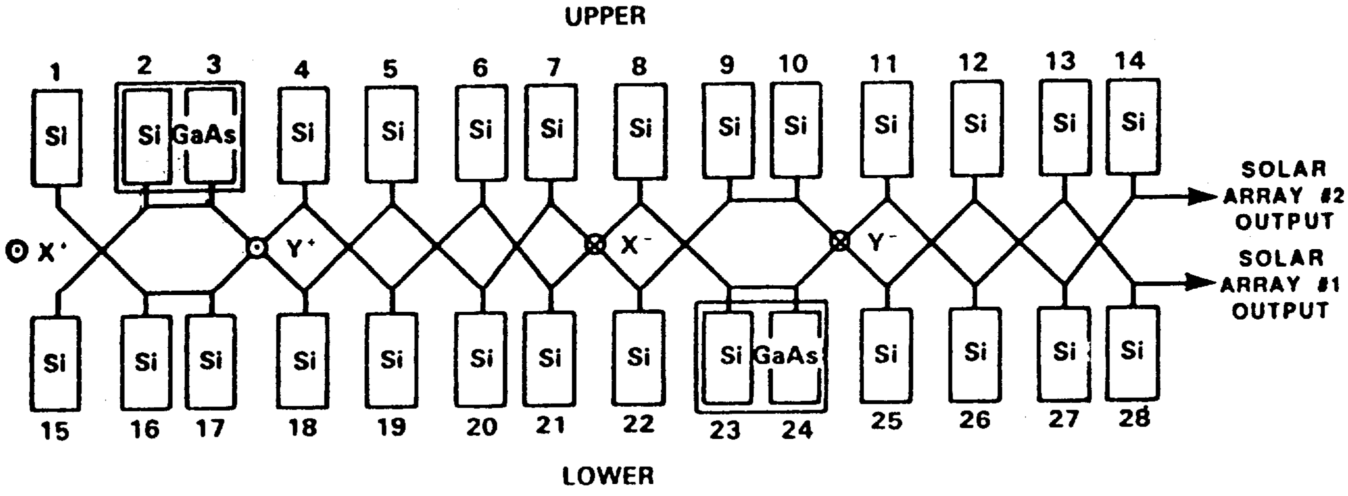


Fig. 8

LAUNCH VEHICLE DESCRIPTION

The San Marco D/L mission will be launched by a four-stage Scout G-1 solid propellant launch vehicle. A schematic of the Scout is shown in Figure 9. The Scout G-1 configuration motor stack consists of Algol IIIA, Castor IIA, Antares IIIA, and Altair IIIA motors. The vehicle will use a 1.067 meter (42 inch) diameter heatshield. Four (4) spin motors will be used to spin stabilize the payload and fourth stage motor prior to third stage separation from the fourth stage.

SCOUT LAUNCH VEHICLE

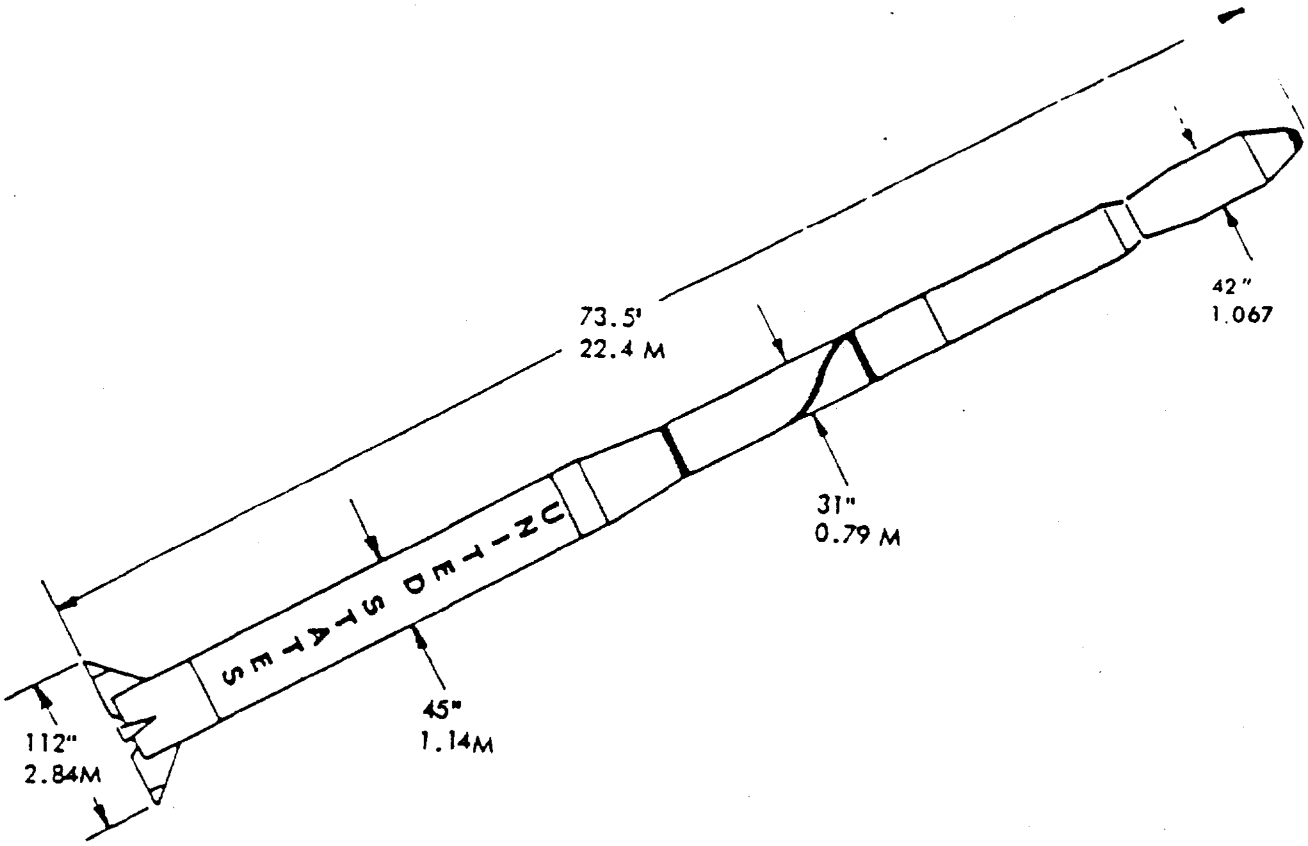


Fig. 9

The Algol IIIA first stage weighs 14,255 kg and produces a thrust of 4684,822 newtons; aerodynamic fin tips and jet vanes provide first stage control. The Castor IIA second stage weighs 4,432 kg and produces a thrust of 266,465 newtons. Hydrogen peroxide motors provide second stage control. The Antares IIIA third stage weighs 1,395 kg and produces a thrust of 80,624 newtons. Hydrogen peroxide jets provide the third stage control. The Altair IIIA fourth stage weighs 301 kg and produces 25,875 newtons of thrust. This stage is spin stabilized. Guidance for the first three stages is provided by an open loop inertial system.

SEQUENCE OF MAJOR FLIGHT EVENTS

EVENT	TIME - SECONDS
Liftoff	0.00
Start timer	0.10
1st Stage Burnout	84.01
2nd Stage Ignition (Prior to 1st Stage Burnout)	87.33
2nd Stage Burnout	128.72
Separate Heatshield	142.98
3rd Stage Ignition	144.68
3rd Stage Burnout	193.18
Spin Motor Ignition	446.87
3rd Stage/4th Stage Separation	448.37
4th Stage Ignition	453.22
4th Stage Burnout	487.04

The vehicle trajectory parameters at motor burnout and ignition times are summarized in Figure 10. Vehicle axial acceleration and dynamic pressure versus flight times is shown in Figure 11.

SCOUT S-206, SAN MARCO D/L MISSION TRAJECTORY PARAMETERS AT EVENT TIMES

EVENT	TIME SEC	WEIGHT LBS	INERTIAL VELOCITY FPS	GEODETIC ALTITUDE NM	RANGE NM	GEODETIC LATITUDE DEG NORTH	LONGITUDE DEG EAST
LIFTOFF	0.00	47953.	1523.94	0.01	0.00	-2.9383	40.2125
STAGE 1 B/O	84.01	19765.	5702.00	18.89	22.55	-2.9376	40.5881
STAGE 2 IGN	87.33	15455.	5658.96	20.01	24.59	-2.9375	40.6222
STAGE 2 B/O	128.72	7170.	12112.64	37.43	68.83	-2.9358	41.3591
H/S EJECTION	142.98	7170.	11996.34	44.68	92.28	-2.9347	41.7497
STAGE 3 IGN	144.68	4824.	11983.45	45.49	95.06	-2.9346	41.7961
STAGE 3 B/O	193.18	1960.	20144.92	70.16	203.03	-2.9281	43.5946
STAGE 4 IGN	453.22	1229.	19440.54	145.96	947.93	-2.7939	56.0021
STAGE 4 B/O	487.04	620.	25720.83	145.80	1060.81	-2.7603	57.8820

EVENT	TIME SEC	INERTIAL PATH ANGLE DEG	RELATIVE PATH ANGLE DEG	INERTIAL HEADING DEG	RELATIVE HEADING DEG	RELATIVE VELOCITY FPS	INTEGRATED AXIAL LOAD FACTOR-FPS
LIFTOFF	0.00	0.000	0.000	90.000	0.000	0.0	0.00
STAGE 1 B/O	84.01	21.700	29.244	89.897	89.855	4315.6	6313.70
STAGE 2 IGN	87.33	20.747	28.069	89.893	89.850	4260.3	6308.92
STAGE 2 B/O	128.72	15.648	17.887	89.889	89.872	10637.4	13179.10
H/S EJECTION	142.98	14.036	16.079	89.865	89.845	10505.4	13177.68
STAGE 3 IGN	144.68	13.842	15.860	89.863	89.842	10490.7	13177.63
STAGE 3 B/O	193.18	9.662	10.466	89.775	89.756	18613.8	21648.24
STAGE 4 IGN	453.22	0.494	0.538	89.099	89.019	17852.1	21648.24
STAGE 4 B/O	487.04	-0.250	-0.266	89.008	88.942	24132.4	27928.41

Fig. 10

SCOUT S-206, SAN MARCO D/L MISSION
AXIAL ACCELERATION AND DYNAMIC PRESSURE VS. TIME

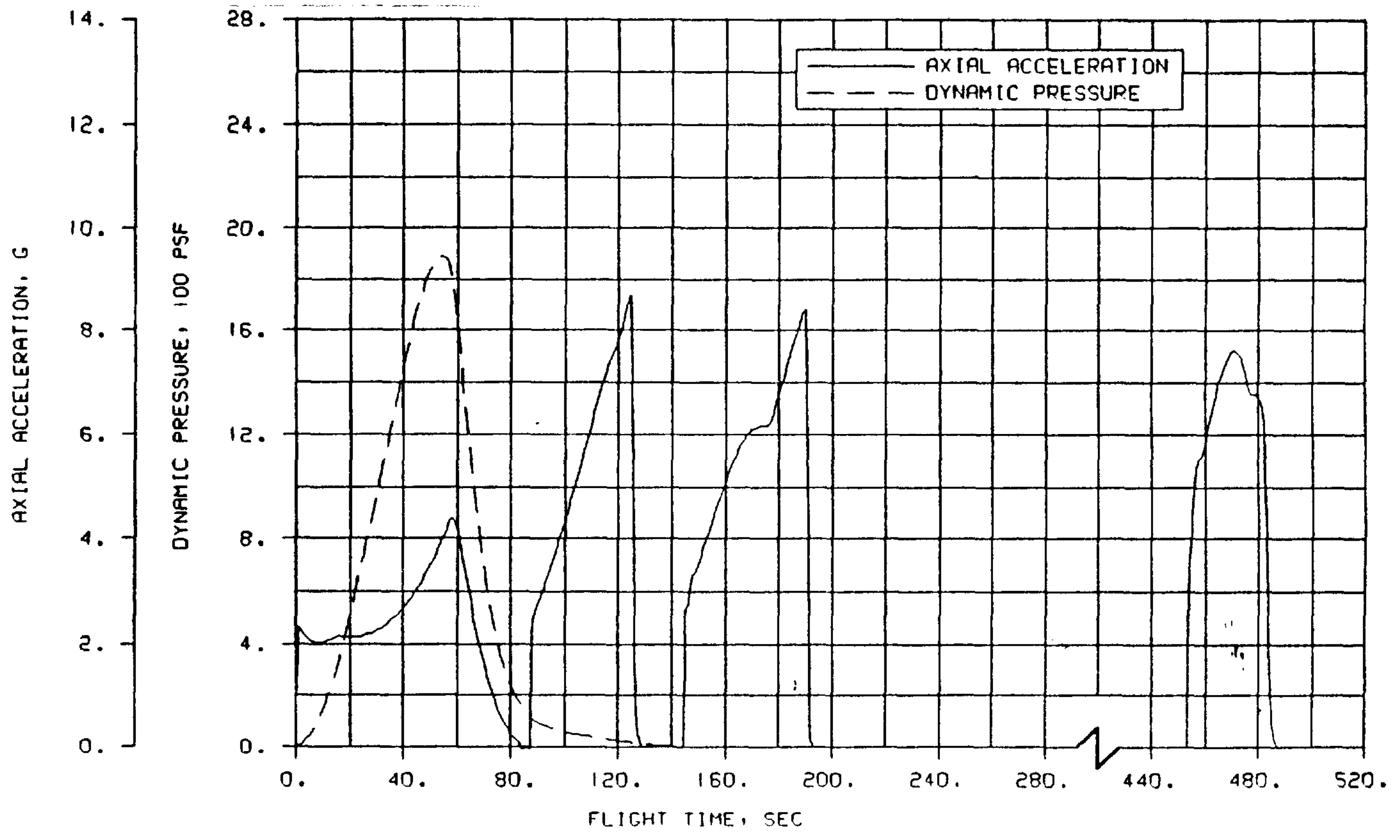


Fig. 11

The orbital ground track for the first four revolutions is shown on Figure 12. The vehicle boost trajectory ground track and stage impact points are presented on Figure 13. Probability distribution curves for achieving the planned orbit are shown in Figure 14.

SCOUT 206, SAN MARCO D/L MISSION ORBIT GROUND TRACK FOR FIRST FOUR REVOLUTIONS

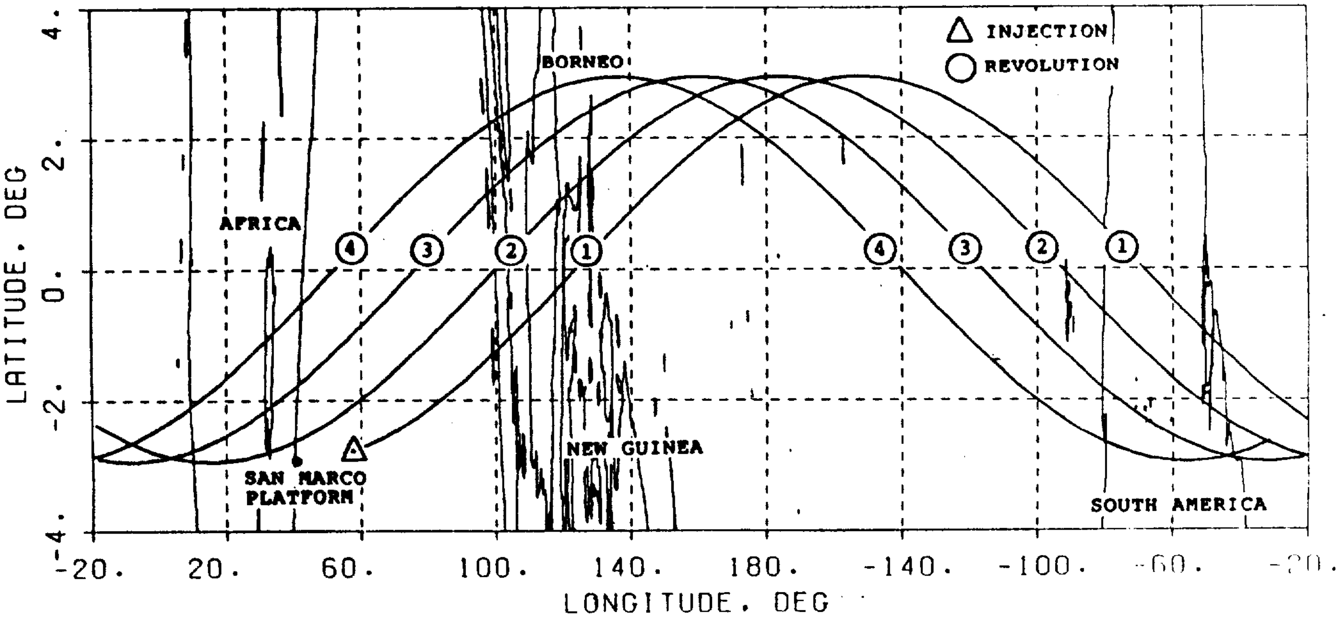
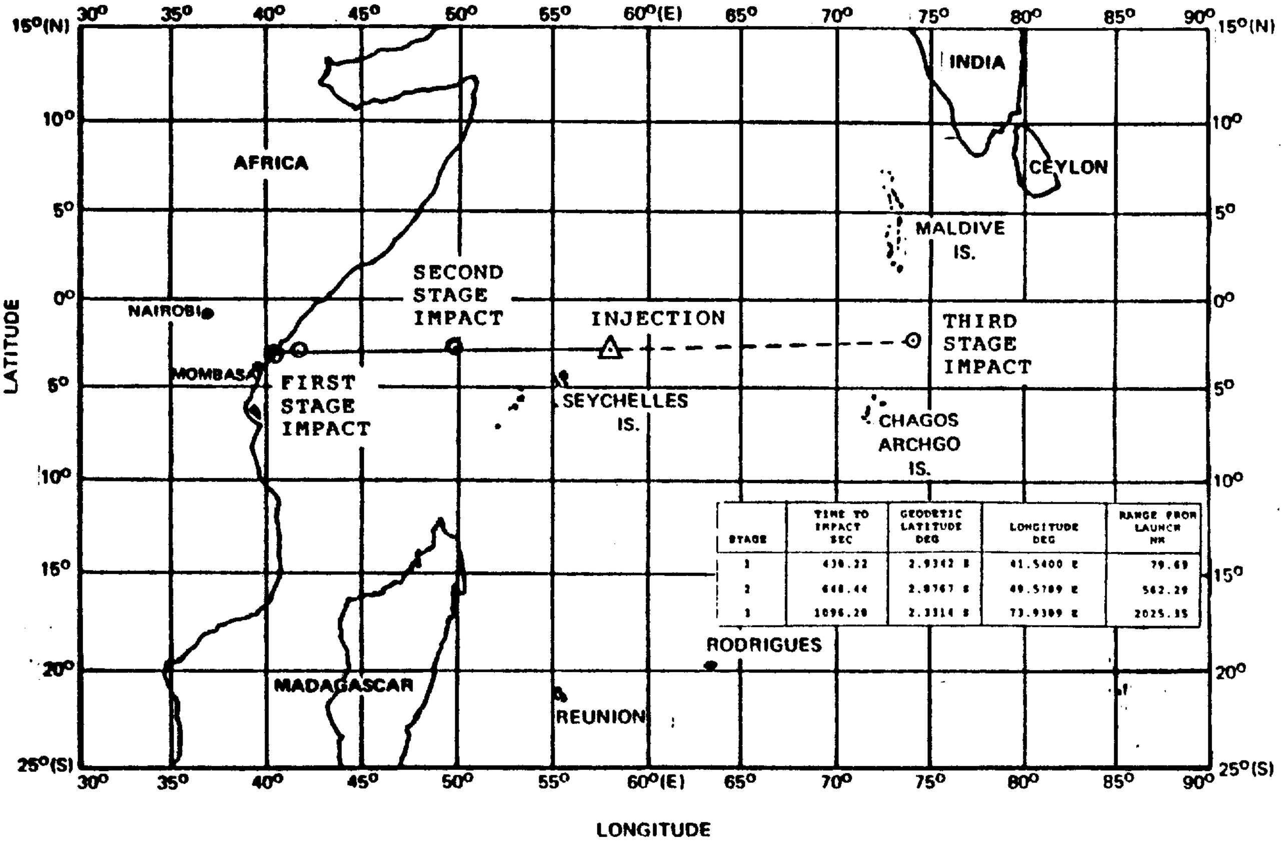


Fig. 12

SCOUT S-206, SAN MARCO D/L MISSION BOOST TRAJECTORY GROUND TRACK WITH STAGE IMPACT POINTS



STAGE	TIME TO IMPACT SEC	GEODETIC LATITUDE DEG	LONGITUDE DEG	RANGE FROM LAUNCH NM
1	430.22	2.9342 S	41.5400 E	79.69
2	648.44	2.8767 S	49.5709 E	562.29
3	1096.20	2.3314 S	73.9309 E	2025.35

Fig. 13

SCOUT S-206, SAN MARCO D/L MISSION
ISOPROBABILITY CONTOURS OF APOGEE - PERIGEE DEVIATIONS

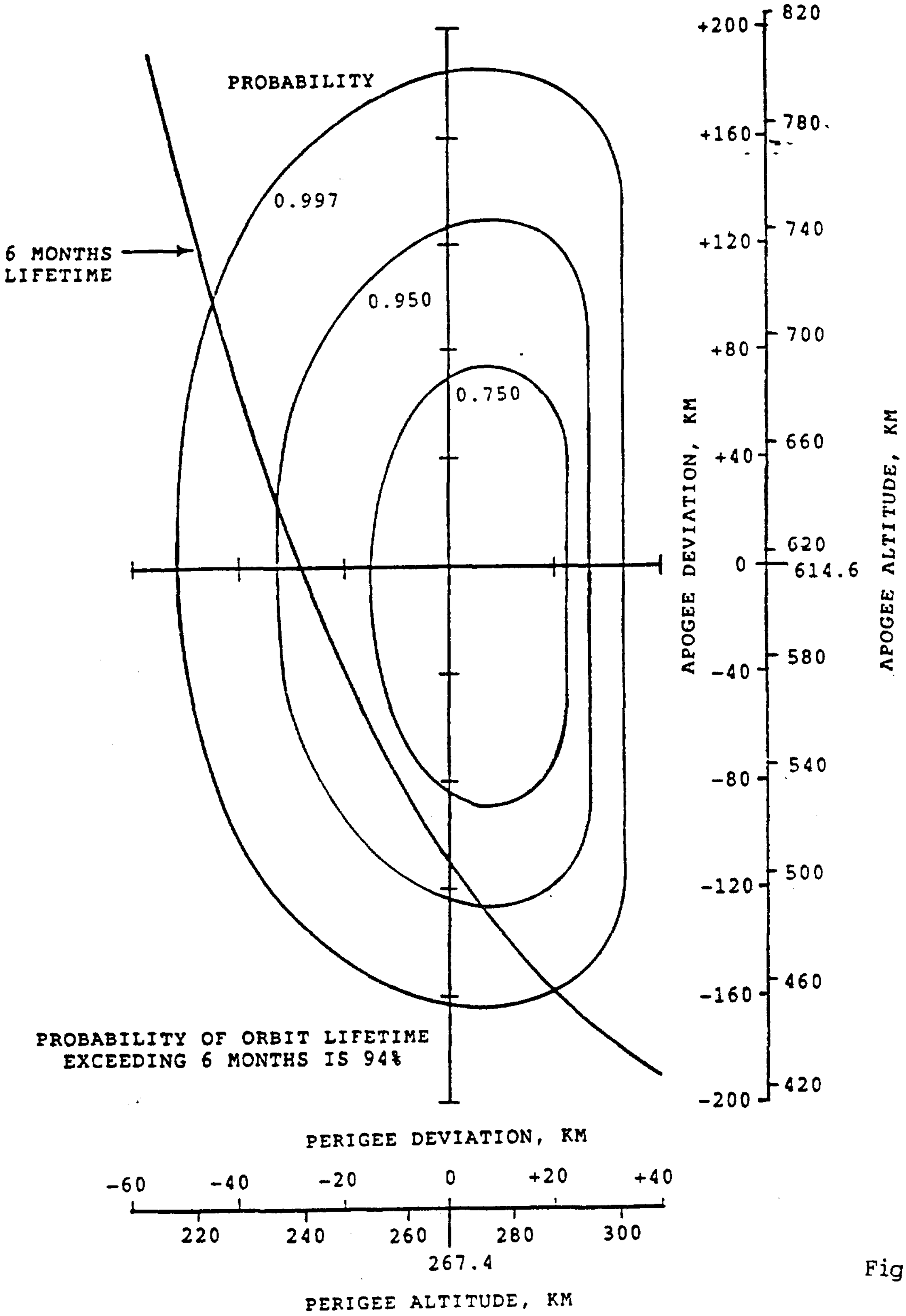


Fig. 14

MISSION SUPPORT

LAUNCH FACILITIES

The satellite will be launched from the San Marco Equatorial Range. The range, located in the Formosa Bay 3 miles off the coast of Kenya, Africa, was established by the Italian Government, in conjunction with the Kenya government, as an independent operating range. Its location was influenced by the desire to launch scientific satellites into equatorial orbits from international waters. Figure 15 shows the relative location of the launch site in Kenya. The Centro Ricerche Aerospaziali (CRA), University of Rome, is responsible for the management and direction of the San Marco Equatorial Range.

SAN MARCO RANGE LOCATION

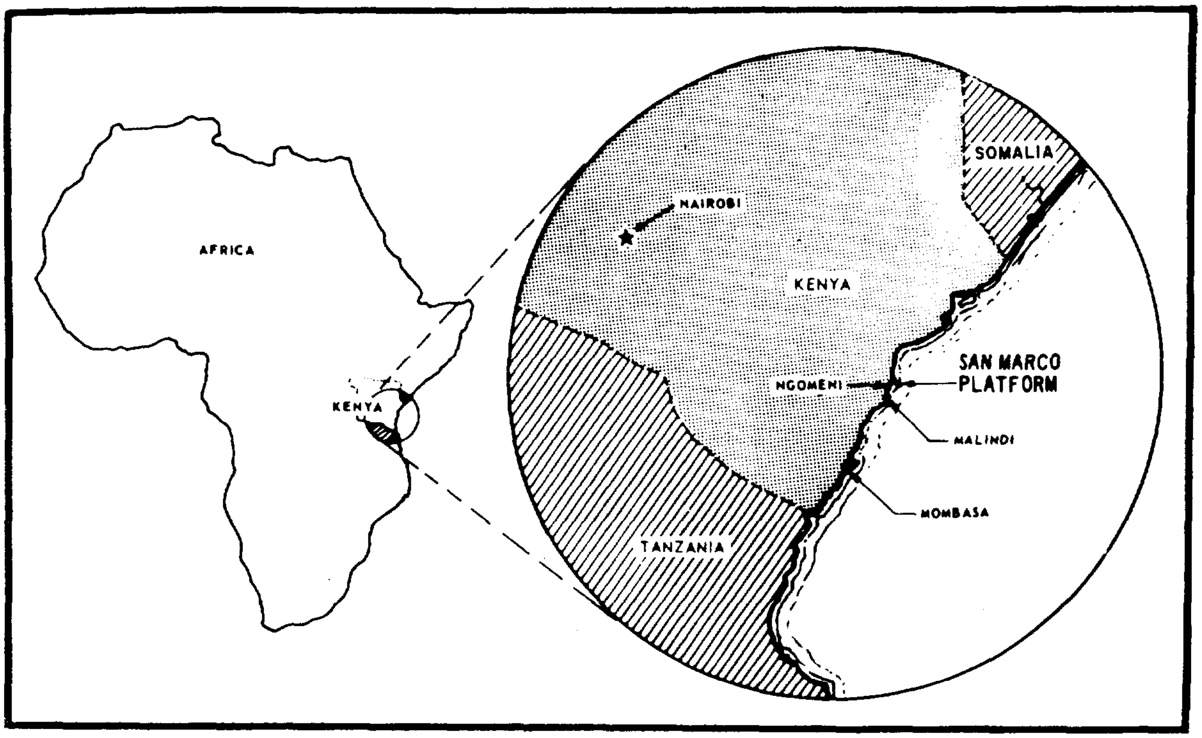


Fig. 15

The main components of the San Marco range are the launch platform, the control and radar platform, the logistic support center, and a ground telemetry and command station. The launch platform, containing the launcher and ground support equipment for assembly and checkout of the vehicle and payload, bears the name of San Marco. The control platform, containing equipment for remote control of vehicle launch, trajectory tracking, and data acquisition, is named Santa Rita. One small platform, adjacent to Santa Rita, supports the motor generators that supply power to the Santa Rita platform and, during the countdown, to the San Marco Platform. Another small platform, also adjacent to Santa Rita, houses both the S-band and C-band tracking radars. The logistic support center, referred to as the Base Camp, is located on the mainland near Milindi, Kenya. Figure 16 shows the range platform.

SAN MARCO LAUNCH PLATFORM

Fig. 16

TRACKING AND DATA ACQUISITION

Tracking data during the launch and early orbit phase will be obtained by the following stations:

- Santa Rita Station - S and C band radar tracking.
- Mobile Italian Telemetry Station (MITS) in Kenya - Doppler tracking.

The North American Air Defense Command (NORAD) stations also will provide early orbit tracking where possible. Figure 17 shows the spacecraft orbital path and tracking and data acquisition stations. After the spacecraft orbit has been determined at GSFC, updated orbital predictions will be forwarded to MITS. The above stations then will have tracking and data acquisition responsibilities as follows:

- Data Acquisition - Telemetry data acquisition will be the responsibility of MITS. MITS will acquire data from four or five passes per day.

- o Command - The MITS will be the primary station for commanding the spacecraft.
- o Launch - The U.S. Air Force Satellite Tracking Station at Sunnyvale, California, will be utilized to obtain telemetry data from the third and fourth stages of the Scout launch vehicle.

NOMINAL SUBSATELLITE PLOT

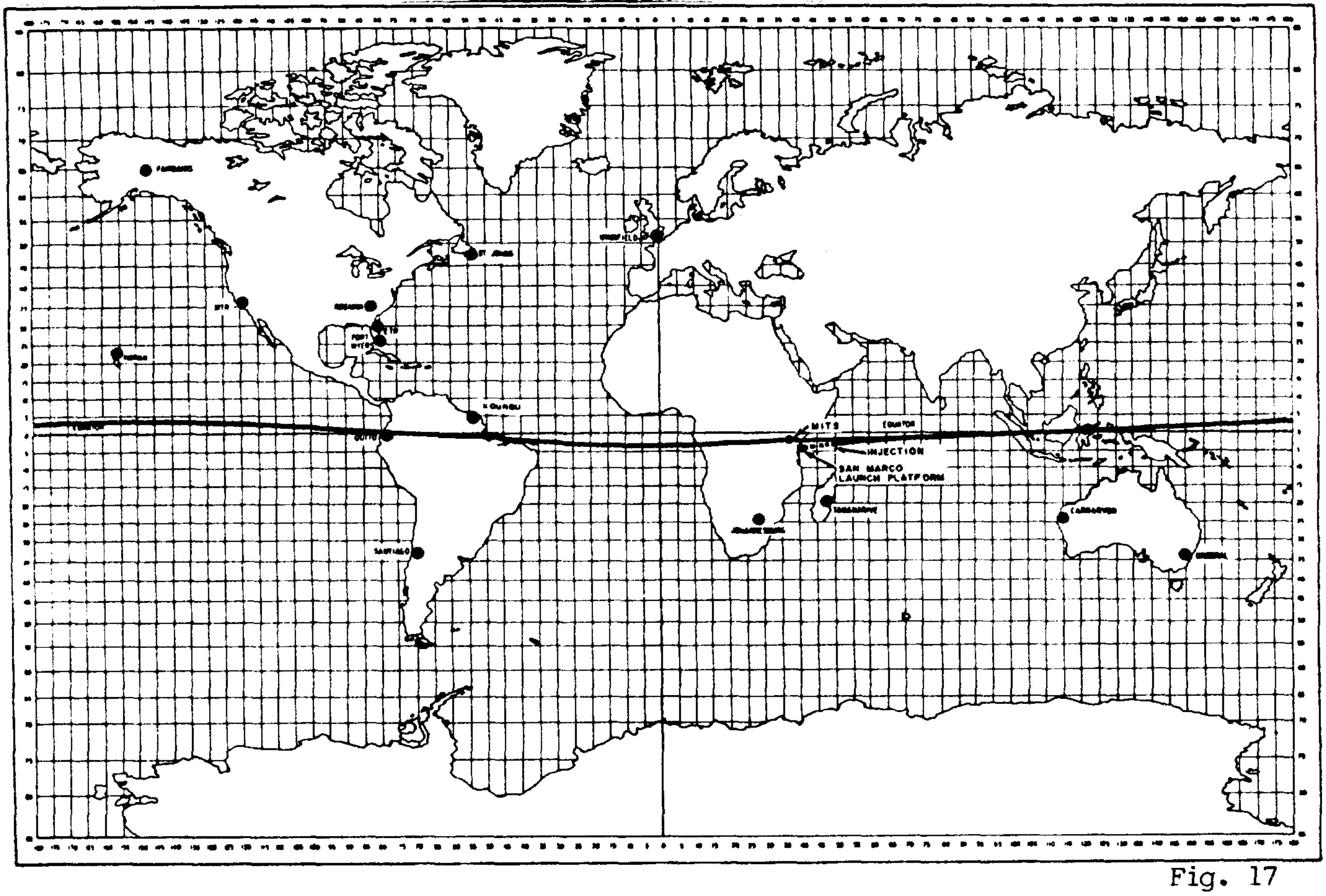


Fig. 17

GODDARD DATA ACQUISITION STATION IN KENYA

The GSFC experimenter's facility located at the base camp, near MITS, serves as the primary control, and data acquisition center for the GSFC instrument packages. Experimenter personnel, who man the facility, will analyze the status of the GSFC instruments and request the MITS to transmit the necessary commands to put their instruments into the correct mode.

DATA REDUCTION AND ANALYSIS

CRA and GSFC will each be responsible for processing and analyzing their respective scientific data.

ORBIT COMPUTATION

All orbit computations will be performed by CRA.

PROGRAM MANAGEMENT

The Office of Space Science and Applications (OSSA), NASA Headquarters, is responsible for the overall direction and evaluation of the San Marco-D/L Program. The Associate Administrator for OSSA has assigned Headquarters' responsibility for this program to the Director of the Astrophysics Division, and science responsibility to the Director of Earth Science and Applications Division. The Director of Astrophysics Division has located the San Marco-D/L Project in the Flight Programs Development Branch. The Goddard Space Flight Center has been assigned Project Management responsibility. The Office of Tracking and Data Acquisition, NASA Headquarters, has overall tracking and data acquisition responsibility. The Scout launch vehicle management is the responsibility of Goddard Space Flight Center.

The responsible personnel within these areas are:

TITLE	NAME	ORGANIZATION
Associate Administrator for Space Science and Applications	L. A. Fisk	NASA Headquarters
Program Director	C. J. Pellerin Jr.	NASA Headquarters
Program Manager	D. Broome	NASA Headquarters
Program Scientist	S. Tilford	NASA Headquarters
Associate Administrator for Space Flight	R. H. Truly	NASA Headquarters
Scout Program Manager	P. Goozh	NASA Headquarters
Scout Project Manager	J. van Cleave	LaRC
Director, Goddard Space Space Flight Center	J. W. Townsend, Jr.	GSFC
Project Manager	R. Adkins	GSFC
Project Scientist	N. Spencer	GSFC
Deputy Project Manager	M. Donahoo	GSFC

SAN MARCO D/L PROJECT COSTS

Estimated NASA cost of the Scout services and hardware are:

Launch vehicle hardware costs	$2,300,000
Launch services and mission support	$1,400,000

RUNOUT COSTS

U.S. Instruments	4.5 million
CRA	12.0 million

RUNOUT MANPOWER	70 man years

PROJECT ACRONYMS

AE	Atmospheric Explorer
ASSI	Airglow Solar Spectrometer
CRA	Centro Ricerche Aerospaziali
CRS	Commissione per le Recherche Spaziali
DBI	Drag Balance Instrument (Italy)
DE	Dynamics Explorer
DFVLR	Deutsche Forschungs Versuchsanstat fur Luft and Raumfahrt
EFI	Electric Field Instrument (GSFC)
GAPFE	Gallium Arsenide Panel Flight Experiment
GSFC	Goddard Space Flight Center
IPW	Institut fur Physikalische Weltraumforschumg
IVI	Ion Velocity Instrument (Univ. Texas)
MITS	Mobile Italian Tracking Station
MOU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NORAD	North American Air Defense
OSSA	Office of Space Science and Applications
PTS	Physikalisch-Technische Studien
U.S.	United States
WATI	Wind and Temperature Instrument (GSFC/U. Michigan)