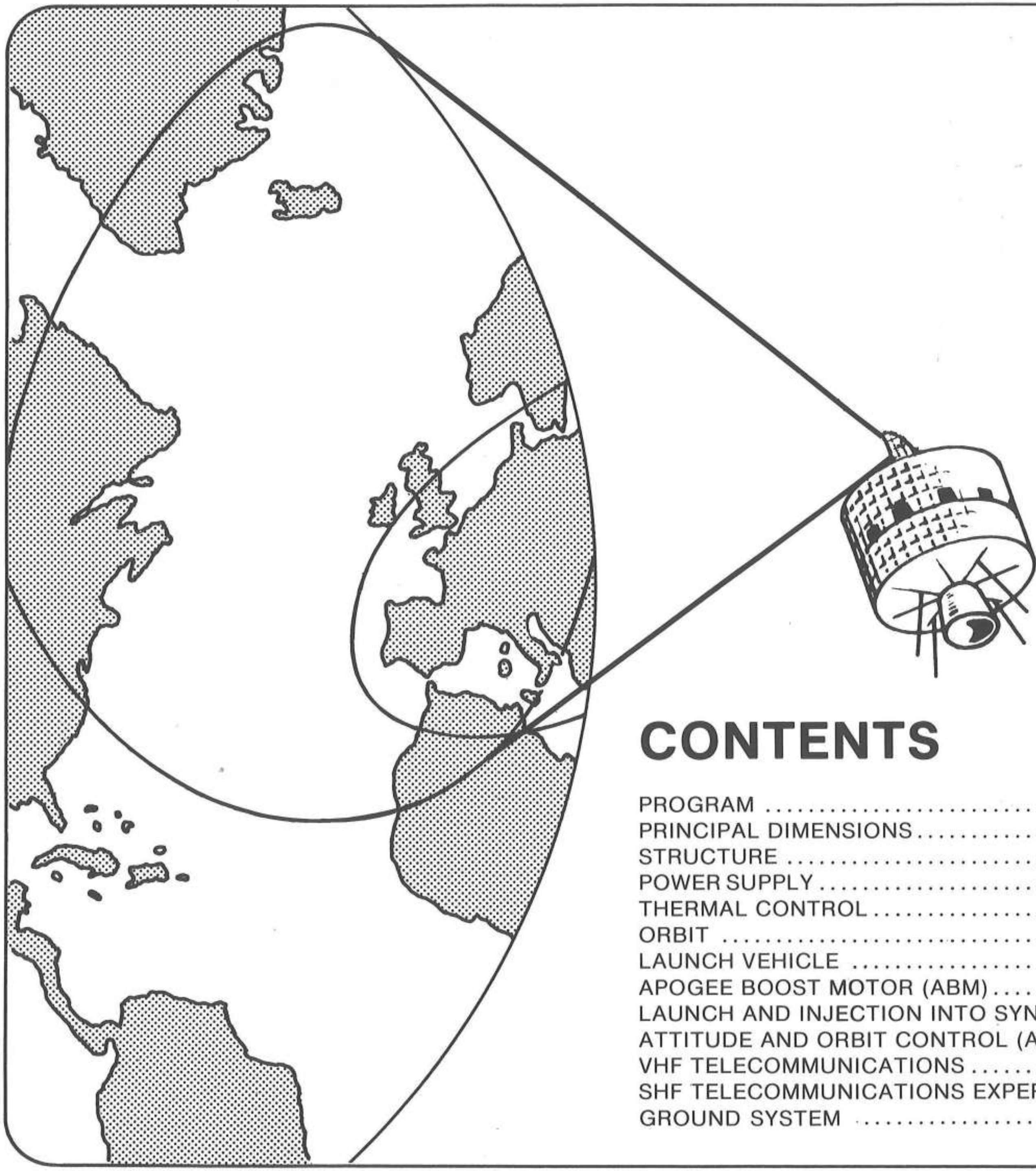
SIRIO

CONSIGLIO NAZIONALE DELLE RICERCHE



CONTENTS

SIRIO CONSIGLIO NAZIONALE DELLE RICERCHE

PROGRAM

The launch of the SIRIO in August 1977 signals the midpoint of an important space research program sponsored by the CONSIGLIO NAZIONALE DELLE RICERCHE (CNR), the National Research Council of Italy, a Government agency for the promotion of interdisciplinary research. The CENTRO STUDI TELECOMMUNICAZIONI SPAZIALI DEL POLITECNICO (CSTS), Milano Institute of Technology, coordinates the telecommunications experiments during the mission lifetime.

The principal experiment is a unique super high frequency (SHF) telecommunications experiment that measures the propagation medium characteristics in the 12- and 18-GHz bands. These measurements are used by various experimenters in Europe and America to determine the effects of varying meteorological conditions on the SHF band.

These frequencies are becoming more important for commercial telecommunications applications, because the 4- and 6-GHz bands currently used are becoming increasingly congested.

Literally translated, SIRIO (Satellite Italiano Ricerca Industriale Orientata) means Industrial Research Oriented Italian Satellite. The acronym also relates to Sirius, the brightest star of the constellation, *Canis Major.*

CNR has given the prime responsibility for the design and development of a spacecraft capable of satisfying the requirements of the SHF experiment to the COMPAGNIA INDUSTRIALE AEROSPAZIALE (CIA SpA) in Roma, Italy, and responsibility for the ground-control system to TELESPAZIO SpA, Roma, and CNUCE, a CNR research affiliate in Pisa, Italy. As part of this effort, CNR has contracted with the U.S. National Aeronautics and Space Administration (NASA) to provide the launch vehicle and ground-control assistance required for launching and positioning the satellite in orbit.

Other Italian companies (CIA SpA subcontractors) participating in the design, development, and testing of the SIRIO spacecraft are:

AERITALIA
CGE-FIAR
GALILEO
MONTEDEL (LABEN and OTE)
OTO-MELARA
SELENIA
SNIA-VISCOSA

A SIRIO team of about 80 engineers support the NASA team at the Kennedy Space Center (KSC) at Cape Canaveral, Florida, during the preparation and launch phases of the program. About 30 minutes after the launch, when SIRIO separates from the launch vehicle, the Multi-Satellite Operation Control Center (MSOCC) at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, takes control of the satellite. A SIRIO project team of about 30 persons works with the NASA mission support team for 30 to 45 days to position the satellite at the desired station point in orbit. From this point until the positioning of the SIRIO satellite in the desired synchronous (geostationary) orbit, MSOCC is the focal point from which all the operations are performed. From MSOCC, a direct contact is established with the NASA ground stations at Guam, Orroral, Santiago, Ascension, and Rosman.

A direct contact is also established with:

- San Marco Mobile Italian Telemetry Station (MITS) located in Kenya, which is the first station to acquire telemetry information, to check the status of the spacecraft starting from about 30 minutes from the spacecraft/third-stage separation.
- SIRIO Italian Operation Control Center (SIOCC) to prepare the handover for the complete control of the mission.

  After position in orbit has been achieved and the satellite system functions have been checked out, control of the SIRIO passes from MSOCC to the SIOCC at TELESPAZIO's control center in Fucino, Italy. This station controls the satellite's health, position in orbit, and performs the telecommunications experiments during the mission in conjunction with other American and European organizations.

The primary objectives of the SIRIO program are:

- To develop experimental data that will:
  - Verify characteristics of the propagation medium at frequencies of 12 and 18 GHz
  - Verify theories and models for the propagation loss (rain, snow-fall, fog, etc.) on Earth/space links.
  - Aid future dimensioning of Earth/space links
- To develop advanced space technologies in the field of telecommunications
- To develop a low-cost satellite for synchronous orbit operations to carry on-board scientific or telecommunications-oriented payloads.

PRINCIPAL DIMENSIONS

	MILLIMETERS	INCHES
DIAMETER	(A)—1433	57
HEIGHT, OVERALL (INCLUDING SHF ANTENNA AND ABM NOZZLE)	(B)—1981	78
MAIN BODY HEIGHT	(C)— 954	38
SHF ANTENNA HEIGHT	(D)— 464	18
SHF ANTENNA WIDTH	(E)— 350	14
ABM NOZZLE LENGTH	(F)— 546	22
ABM NOZZLE DIAMETER	(G)— 416	16

WEIGHT:

AT LAUNCH — 398 kg (877 lbs.)

IN ORBIT — 218 kg (481 lbs.)

SUBSYSTEMS:

POWER SUPPLY

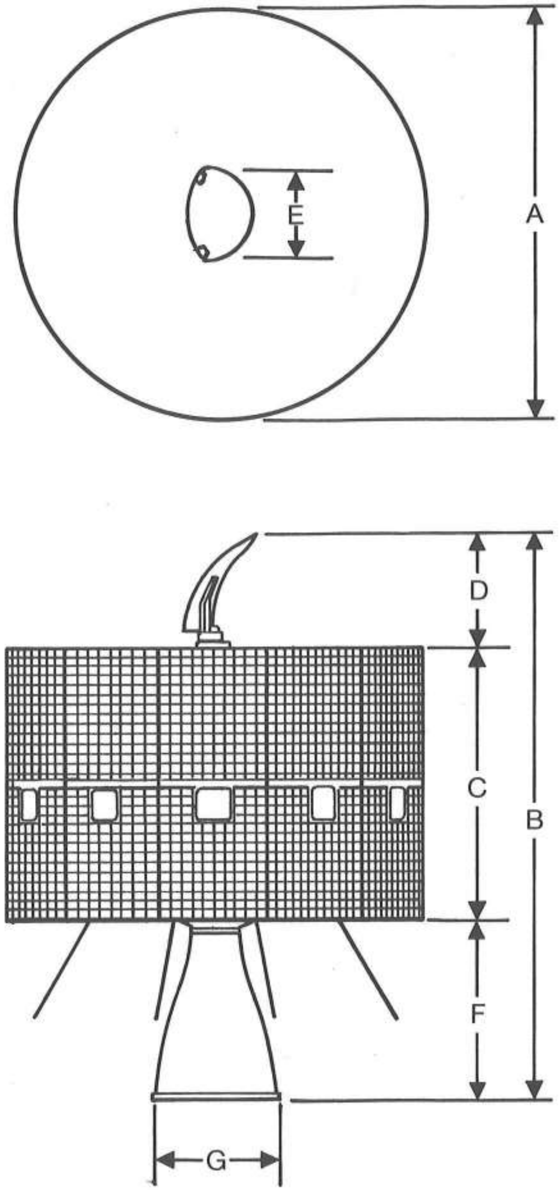
THERMAL CONTROL

APOGEE BOOST MOTOR (ABM)

ATTITUDE & ORBIT CONTROL (AOC)

VHF TELECOMMUNICATIONS

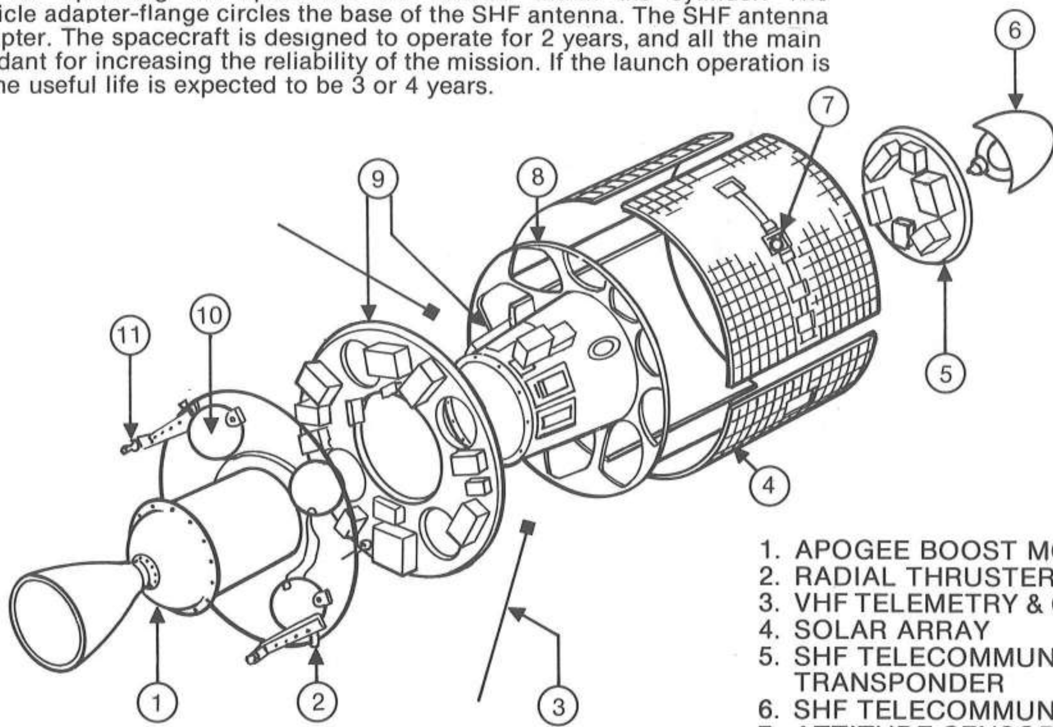
SHF TELECOMMUNICATIONS EXPERIMENT



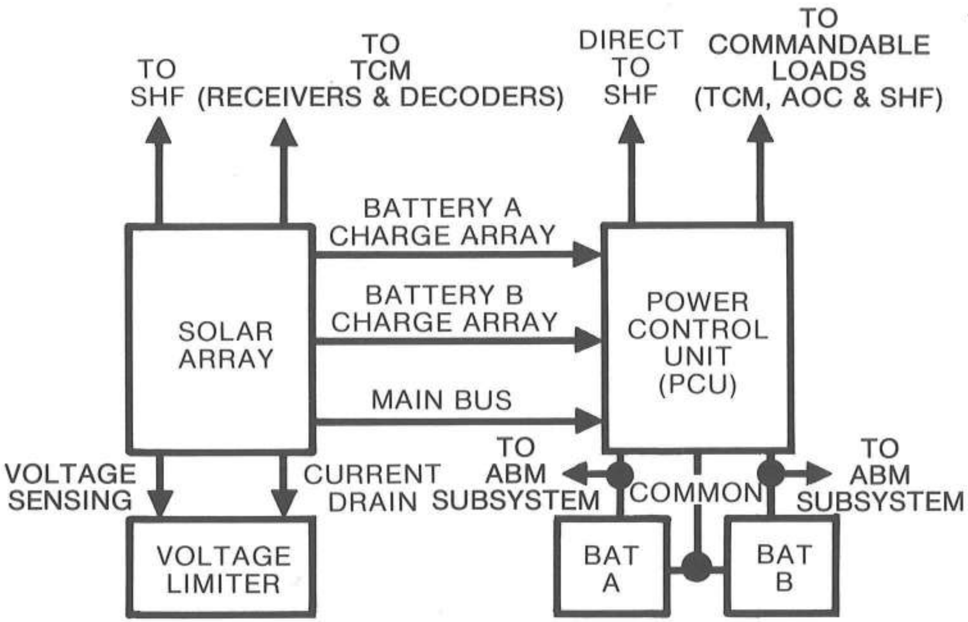
STRUCTURE

The SIRIO spacecraft is cylindrically shaped, and is designed to support the SHF experiment payload and the electronic subsystems required for operation, and is constructed to withstand the anticipated launch-vibration environment. Protruding from one base of the cylinder is the apogee boost motor (ABM) nozzle, and four equally spaced whip antennas, which form a crossed-dipole configuration for use by the very high frequency (VHF) telecommunications subsystem. Protruding from the opposite base of the cylinder is the paraboloid-shaped super high frequency (SHF) telecommunications antenna. A solar array, composed of four curved panels covered with approximately 9,096 solar cells, forms the wall of the cylinder.

Openings in the sides of the panels provide viewing for the attitude sensors. The electronic subsystems required for operating the spacecraft are located within the cylinder. The spacecraft/launch vehicle adapter-flange circles the base of the SHF antenna. The SHF antenna protrudes into the adapter. The spacecraft is designed to operate for 2 years, and all the main subsystems are redundant for increasing the reliability of the mission. If the launch operation is sufficiently nominal, the useful life is expected to be 3 or 4 years.



1. APOGEE BOOST MOTOR (ABM)
2. RADIAL THRUSTER (2)
3. VHF TELEMETRY & COMMAND ANTENNA (4)
4. SOLAR ARRAY
5. SHF TELECOMMUNICATIONS TRANSPONDER
6. SHF TELECOMMUNICATIONS ANTENNA
7. ATTITUDE SENSOR (4)
8. MAIN STRUCTURE.
9. ON-BOARD ELECTRONICS (TELEMETRY, COMMAND, RANGE & RANGE RATE, SHF ANTENNA CONTROL, AND POWER CONDITIONING)
10. AUXILIARY PROPULSION TANK (4)
11. AXIAL THRUSTER (2)



TCM — VHF TELECOMMUNICATIONS

POWER SUPPLY

The power subsystem, which provides all electrical power to the satellite loads, includes a solar array, two 3.5 amp-hour, 23-cell nickel-cadmium storage batteries, a voltage limiter, a power control unit, and protective devices.

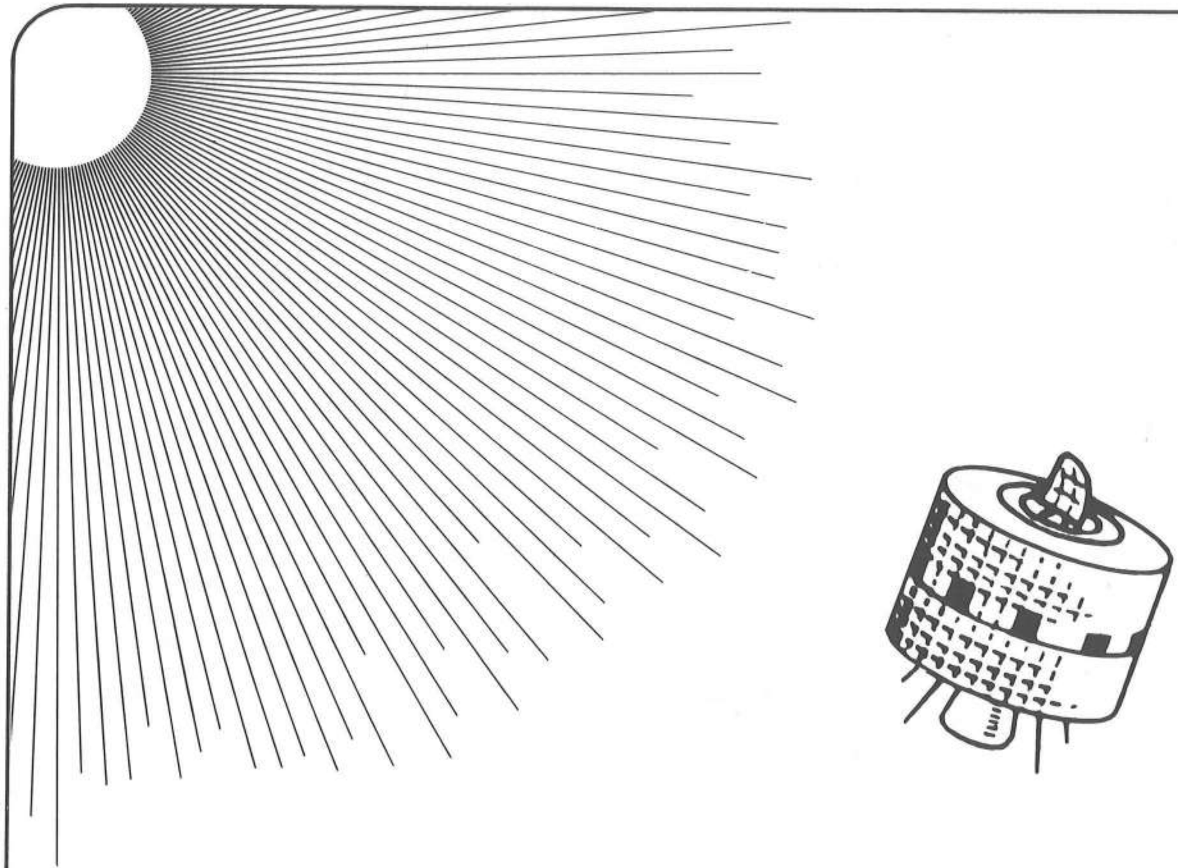
The solar array consists of a main array that supplies the satellite functional subsystems and an auxiliary array that provides the power required for charging the batteries. The main array is composed of 8,496 n-p-n 2- by 2-cm silicon solar cells, and the auxiliary array consists of 600 solar cells of the same type, differing in size (2- by 1-cm).

The solar cells are mounted on the outer surface of the satellite for maximum exposure to the Sun. During the daytime portion of the orbit, these cells convert solar energy to electrical energy for both satellite operation and battery charging. Two storage batteries supply power for eclipse operation and for periods when the satellite power requirements exceed the solar-array capability.

The voltage limiter consists of three (redundant) shunt regulators that prevent the main solar-array output voltage from exceeding the required operating voltage between 24.5 and 32 volts.

The power control unit distributes the power provided by the solar array and batteries to the satellite loads and houses the overcurrent and undervoltage protection circuits, as well as current measuring and battery charge circuits. It also houses the battery discharge control circuits which automatically connect the batteries to the main bus to prevent the bus voltage from falling below 23 volts.

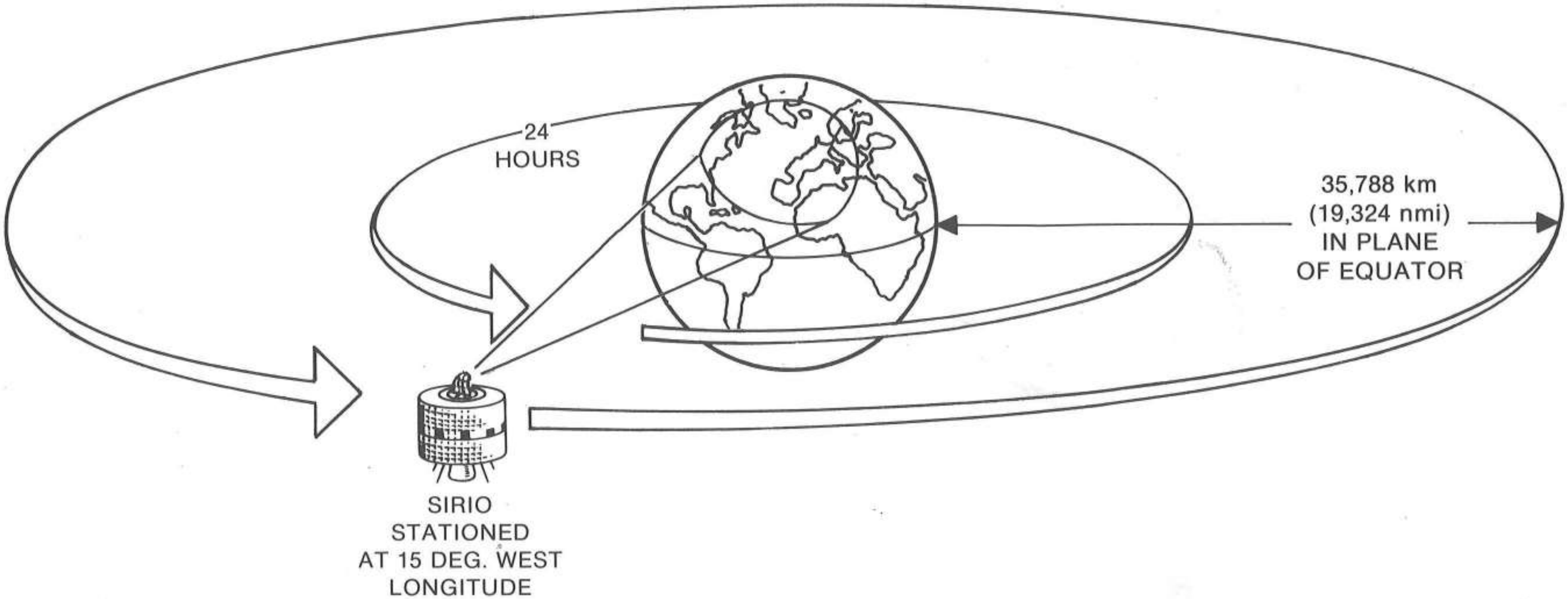
The supply delivers 147 watts of power at the beginning of life and will be reduced to 110 watts at the end of life.



THERMAL CONTROL

The SIRIO thermal-control subsystem uses both active and passive methods to keep satellite components within acceptable temperature ranges during all phases of flight. Passive thermal control is provided by thermal paints, surface treatments, laminates, and multilayers of thermal insulation. Active thermal control is used to control the temperature of more critical components in which temperature must be controlled continuously, such as the auxiliary propulsion unit and the SHF. Specially designed heaters hold the temperature of these units within specified limits before and during various phases of the mission.

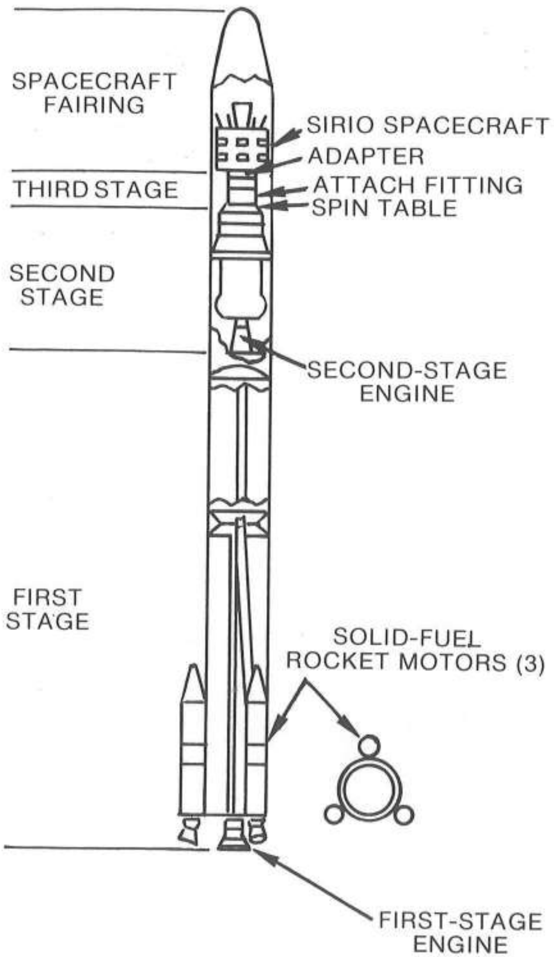
At an altitude of 35,788 km (19,324 nmi), and in the plane of the Equator, the satellite and the Earth's surface have the same angular velocity, so that the satellite is always above the same point on the Equator and remains fixed for a ground station observer.



ORBIT

SIRIO is launched into a 35,788-kilometer (19,324-nautical mile), circular, equatorial orbit and is stationed at 15 degrees west longitude. The orbit is synchronous (geostationary); that is, the satellite's angular speed is synchronized with the Earth's rotation about the axis (1 revolution per day) so that the satellite remains at a fixed point above the Earth. This orbit permits continuous line-of-sight transmission to data-user stations in both Europe and the East Coast of North America. The synchronous orbit also permits continuous and efficient command control of the satellite by TELESPAZIO's Italian Operation Control Center (SIOCC) in Fucino, Italy.

LAUNCH VEHICLE



A Delta 2313 three-stage launch vehicle designed and built by the McDonnell-Douglas Astronautics Company (MDAC) under the technical direction of NASA/GSFC, is used to launch the SIRIO spacecraft from the Eastern Test Range (ETR) at Cape Canaveral, Florida. The launch vehicle has an overall length of approximately 35 meters 9116 ft) and a maximum body diameter of 2.44 meters (8 ft). Nominal launch weight is 105,353 kg (232,263 lbs).

The Delta launch vehicle is managed for NASA's Office of Space Flight by GSFC. The U.S. Government is reimbursed by the Italian Government for the Delta vehicle and all launch operations costs.

FIRST STAGE

The first stage, a modified Thor booster, is powered by a Rocketdyne engine using liquid oxygen and liquid hydrocarbon propellants and three strap-on solid-fuel rocket motors. Two liquid-propellant vernier engines provide roll control throughout first-stage operation.

SECOND STAGE

The second stage is powered by a TRW TR201 engine using liquid propellants. A nitrogen-gas system with eight fixed nozzles provides roll control during the powered and coast flight. Two fixed nozzles fed by the propellant-tank helium-pressurization system provide retrothrust after separation from the third stage.

THIRD STAGE

The third stage is a solid-fuel Thiokol TE-364-3 motor that provides the thrust and velocity required to place the spacecraft into a transfer orbit. Before third-stage separation, spin rockets fixed to the spin table on the second-stage spin the third stage up to 90 rpm for gyroscopic stability.

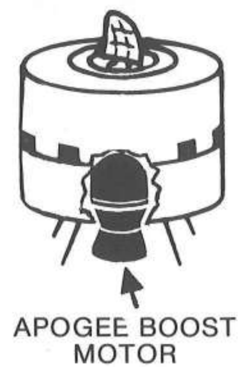
The standard Delta fairing, attached to the forward face of the third stage, protects the spacecraft from aerodynamic heating during the boost flight.

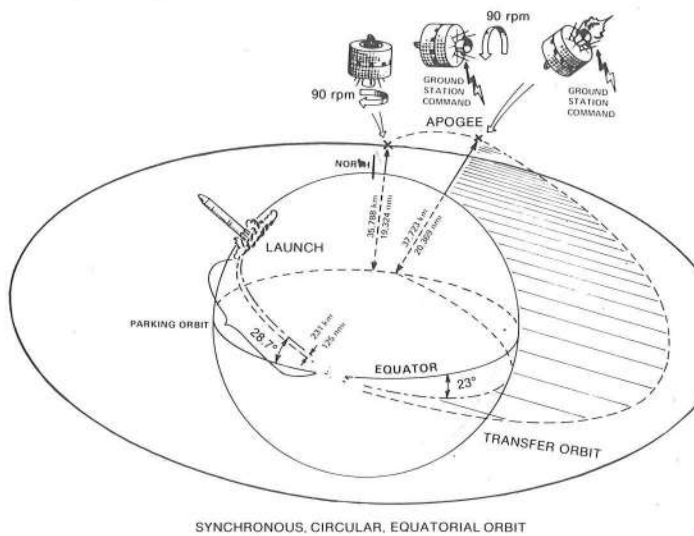
APOGEE BOOST MOTOR (ABM)

SIRIO is launched by the Delta 2313 into a highly-elliptical transfer orbit with an apogee of 37,723 km (20,369 nmi), a perigee of 231 km (125 nmi), and an angle of inclination of 23 degrees to the equator. This orbit apogee is slightly higher than that of the mission orbit 35,788 km (19,324 nmi). The solid-propellant ABM, designed and built in Italy, provides the thrust necessary for moving the spacecraft from the elliptical transfer orbit into the synchronous, circular, equatorial orbit. The ABM is fired by ground-station command near apogee of the transfer orbit to:

- Raise perigee of the transfer orbit to the synchronous altitude of the mission orbit
- Achieve a slight eastward drift rate
- Achieve a near-equatorial drift orbit plane

Following the firing of the ABM, the complete consumption of the propellant reduces the spacecraft mass of 398 kg (877 lbs.) to 218 kg (481 lbs.)

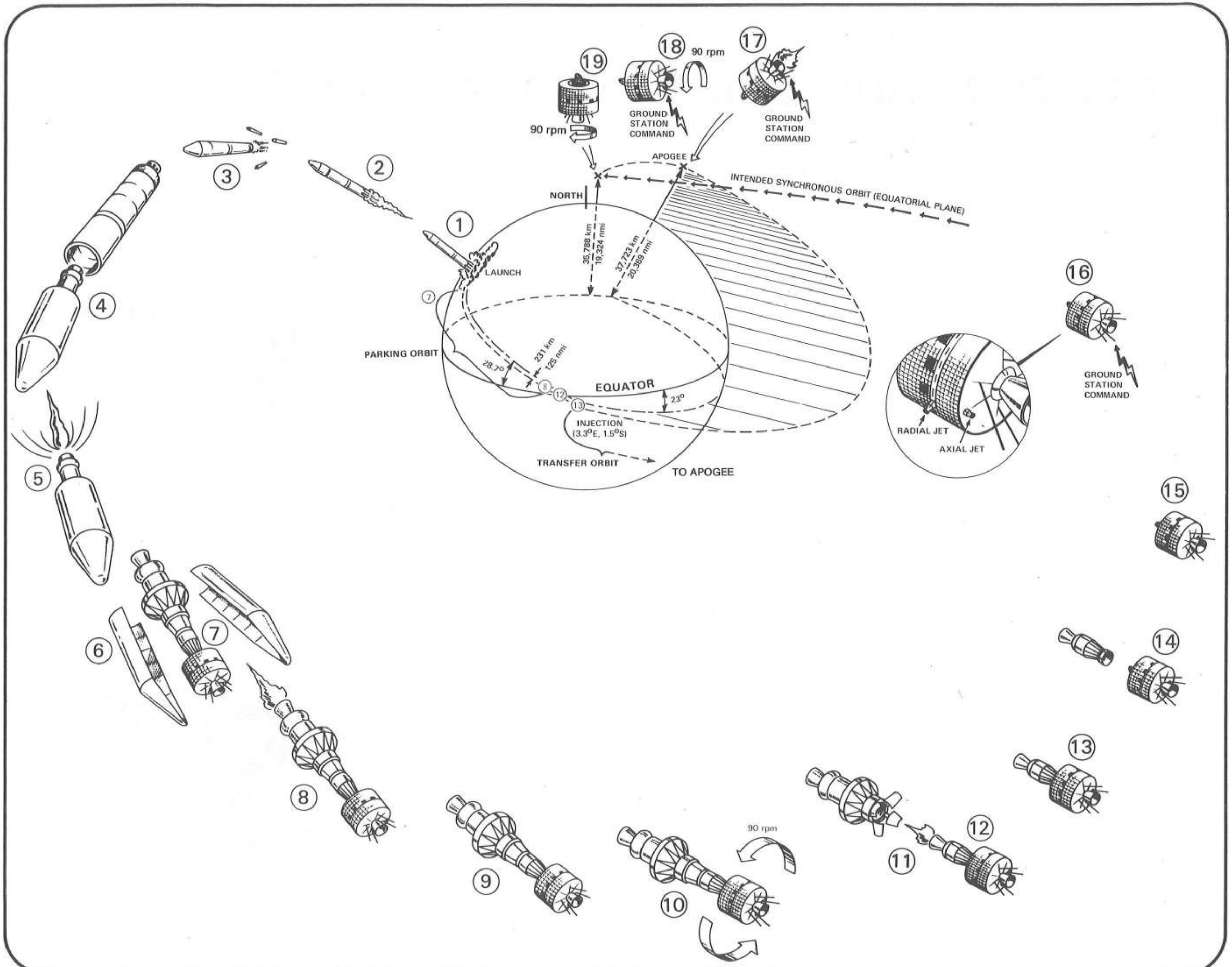




SYNCHRONOUS, CIRCULAR, EQUATORIAL ORBIT

LAUNCH AND INJECTION INTO SYNCHRONOUS ORBIT

NO.	EVENT	TIME
1	First-stage and three solid rocket motors ignition and liftoff	T+0
2	Three solid rockets burnout	T+38 sec
3	Jettison the three solid rockets	T+70 sec
4	First-stage cutoff and first-stage separation	T+228 sec
5	Second-stage ignition	T+241 sec
6	Jettison the fairing	T+295 sec
7	Second-stage initial cutoff and injection into a parking orbit inclined 28.7 degrees to the equator.	T+534 sec
8	Second-stage reignition	T+1315 sec
9	Second-stage final cutoff	T+1328 sec
10	Spin rockets on the spin table operate and spin the third stage and spacecraft up to 90 rpm for gyroscopic stability.	T+1387 sec
11	Second-stage separation	T+1389 sec
12	Third-stage ignition when crossing the equator	T+1431 sec
13	Third-stage cutoff and injection into a highly-elliptical transfer orbit (3.3° E, 1.5° S) in a plane inclined 23 degrees to the equator with perigee and apogee heights of 231 km (125 nmi) and 37,723 km (20,369 nmi), respectively.	T+1475 sec
14	Spacecraft and ABM separate automatically from the third stage by means of spring-ejection mechanisms located on the launch adapter.	T+1547 sec
15	Spacecraft in transfer orbit	T+1547 sec to T+39 hr
16	During the transfer orbit, ground station commands pulse the axial jets once per spin cycle to reorient the spacecraft to the correct position for ABM firing.	T+6 hr with final trim correction at T+28 hr
17	The ABM is fired nominally at fourth apogee by ground station command, (although it could occur as early as the second or as late as the tenth) injecting the spacecraft into a near-synchronous, equatorial, drift orbit with an altitude of 35,788 km (19,324 nmi).	T+39 hr
18	After the ABM is fired, the axial jets operate by ground station command to perform a series of orbital maneuvers to reorient the spacecraft so that its spin axis is lying in the orbit plane and to place the spacecraft in a circular, synchronous orbit at 15 degrees west longitude.	T+57 hr to T + 207 hr
19	The axial jets operate by ground station command to maneuver the spacecraft so its spin axis is parallel to the Earth's polar axis. Final orbit and attitude trim maneuvers are performed by using both the axial and radial jets.	T+249 hr



19
18
90 rpm
17
90 rpm
GROUND STATION COMMAND
GROUND STATION COMMAND
APOGEE
NORTH
INTENDED SYNCHRONOUS ORBIT (EQUATORIAL PLANE)
35,788 km
19,324 nmi
37,723 km
20,369 nmi
3
2
1
LAUNCH
4
PARKING ORBIT
28.7°
231 km
125 nmi
EQUATOR
23°
INJECTION
(3.3°E, 1.5°S)
TRANSFER ORBIT
TO APOGEE
16
GROUND STATION COMMAND
RADIAL JET
AXIAL JET
5
15
6
7
14
13
8
12
9
90 rpm
10
11

ATTITUDE AND ORBIT CONTROL (AOC)

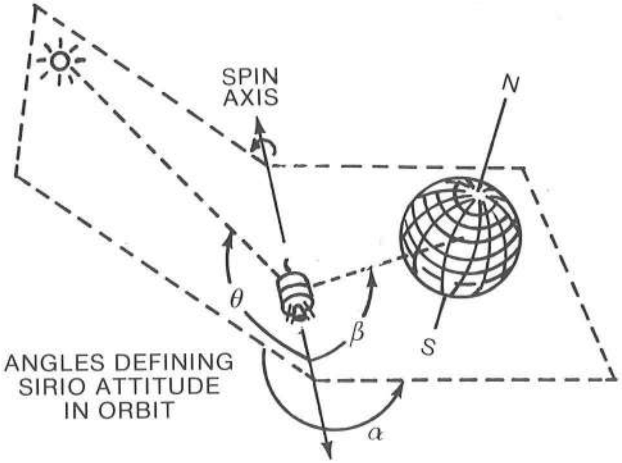
SIRIO is spin stabilized at 90 ±5 rpm about the axis of its cylindrically shaped body. As SIRIO moves through space, external forces (Earth's magnetic and electrical fields, aerodynamic drag, and solar radiation) can induce attitude perturbations (satellite spin axis orintation as well as orbit perturbations (inclination of the orbit plane, position in orbit, etc.). Forces within the satellite, resulting from a series of maneuvers performed to reach the desired station point in orbit, also cause attitude and orbit perturbations. The AOC subsystem is designed to perform all attitude and orbit and corrections required to maintain the satellite position within specified limits throughout the mission.

The AOC subsystem includes all the sensors and electronic assemblies that are necessary for performing the following primary functions:

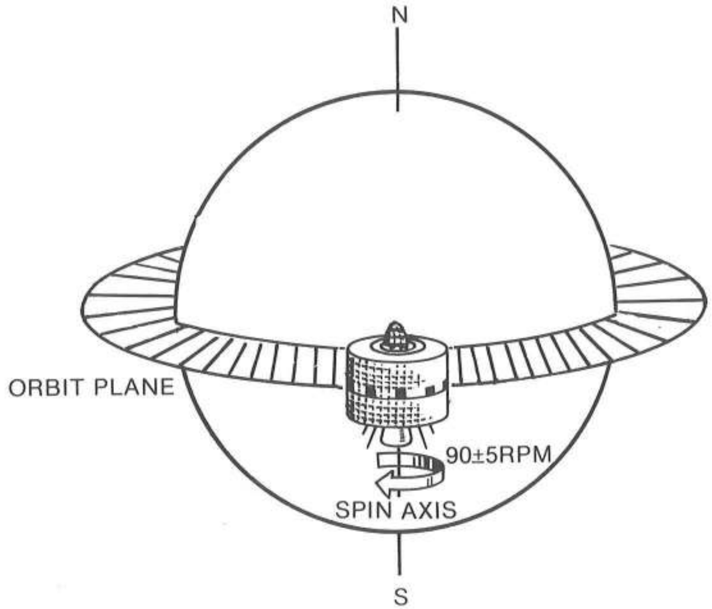
- Provide orbital corrections during drift and synchronous orbits
- Provide spin-axis reorientation during transfer, drift, and synchronous orbits
- Provide necessary signals for synchronizing the SHF despun antenna with the satellite spin rate and for pointing the SHF antenna toward the desired Earth region
- Provide necessary signals for driving the auxiliary propulsion unit firings
- Provide telemetry information to the ground station for operating the axial and radial jets to accomplish orbital maneuvers, attitude control, and satellite spin-rate control.
- Provide necessary passive nutation damping during all phases of the mission

The AOC subsystem consists of the following functional components:

- Four fully redundant attitude-sensor assemblies equally spaced about the satellite periphery. Each one consists of one colatitude sensor and one plane sensor. The colatitude sensor, used to determine the colatitude of the Earth (β) and Sun (θ) consists of one dual-beam infrared narrow-field sensor (also used to synchronize the SHF despun antenna) and one solar V-beam sensor. The plane sensor, used to determine the angle between the Sun satellite spin axis, and Earth's center (α), consists of one infrared large-field sensor and one solar-plane sensor. Collectively, the output of these sensors are used to determine the attitude of the satellite in orbit and to fire the auxiliary propulsion unit.
- A fully redundant auxiliary propulsion unit consisting of two separate fully redundant auxiliary propulsion subsystems, each consisting of two hydrazine propellant tanks and two thrust jets (one axial and one radial) that perform attitude reorientation and velocity-change maneuvers. the 30 kg of GN2 pressurized hydrazine propellant imparts to the satellite a total velocity increment better than 290 meters/second with a continous specific impulse of better than 220 seconds after appropriate commands are sent to the satellite by the VHF telecommunications link to activate the propulsion unit.
- A fully redundant attitude-control logic assembly that selects modes of operation of the auxiliary-propulsion unit, either continuous (axial jets only), single (axial or radial jets), or pulse train (axial or radial jets). The assembly also chooses the proper firing quadrant synchronized with the Sun or Earth, selects the axial and radial jets to be fired, and counts the pulses firing the reorientation maneuvers (when fired in pulse mode).
- An inertial measurement until that provides information to the ground stations concerning axial acceration associated with third-stage launch-vehicle firing, ABM firing, auxiliary propulsion-unit firing, and nutational motion.
- A passive nutation damper, consisting of a tube filled with mercury which operates automatically after launch to provide a damping action for reducing satellite nutational motion (wobble). As the mercury travels up and down the tube because of the wobbling of the satellite, friction caused by its viscosity converts the wobbling, or kinetic energy, into heat. When all of the kinetic energy has been dissipated as heat, the mercury comes to a rest in the tube. The damping action maintains the amplitude of the satellite nutation motion within specified limits.



ANGLES DEFINING SIRIO ATTITUDE IN ORBIT



AOC SUBSYSTEM CHARACTERISTICS

①② AXIAL JETS

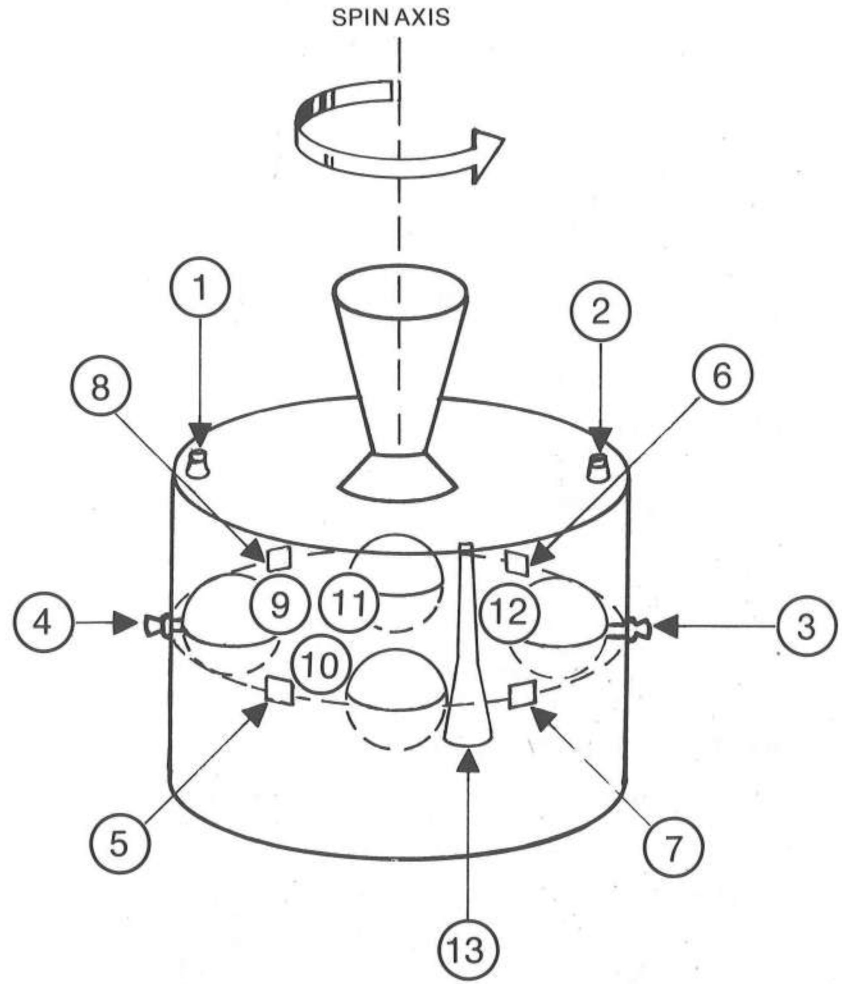
③④ RADIAL JETS

⑤⑥ COLATITUDE SENSOR
- DUAL-BEAM INFRARED NARROW-FIELD SENSOR
- SOLAR V-BEAM SENSOR

⑦⑧ PLANE SENSOR
- INFRARED LARGE-FIELD SENSOR
- SOLAR-PLANE FIELD SENSOR

⑨⑩ ⑪⑫ HYDRAZINE TANKS

⑬ NUTATION DAMPER



VHF TELECOMMUNICATIONS

The VHF telecommunications subsystem consists of two redundant VHF transponders and associated antenna (four monopoles), diplexers, processors, decoders, encoders, hybrid balun, and control circuitry to provide for command, telemetry, and tracking telecommunications between the satellite and ground stations located in both the United States and Italy. The VHF telecommunications subsystem operates at VHF frequencies using the transponders for command, telemetry, and tracking functions. The command receiving and telemetry/tracking links use the same antenna.

COMMAND

The SIOCC station at Fucino, Italy, operated by TELESPAZIO, controls the operation of the satellite by computer-controlled commands transmitted to the satellite by a 148.26-MHz radio signal. The receiver part of the VHF transponders receives the command signals and sends them to one of the command decoders. Throughout all phases of the mission, the command decoder processes the commands and distributes them to the applicable units within the satellite.

COMMAND CHARACTERISTICS

Two redundant systems, each one can decode 100 commands
A tone digital: PDM/AM/AM (NASA standard)
Carrier frequency: 148.26 MHz
Subcarrier (tone) frequency: 8673 Hz
Four address codes are required: RRB-Rx 3 (13,11); 4(14,13); RRA-Rx 10(15,10); 7(11,07)

TELEMETRY

Redundant encoders on board the satellite process and multiplex data signals from the satellite subsystems. Two redundant 136.14-MHz VHF transponders transmit these signals through four antenna monopoles to the ground stations at a rate of 512 bps. Telemetry signals provide housekeeping, sensor, attitude determination, and command verification data to enable SIOCC personnel to evaluate the performance of the satellite and its subsystems for operational control and maneuvering of the satellite. The telemetry signal can also be transmitted by the SHF transponder.

TELEMETRY CHARACTERISTICS

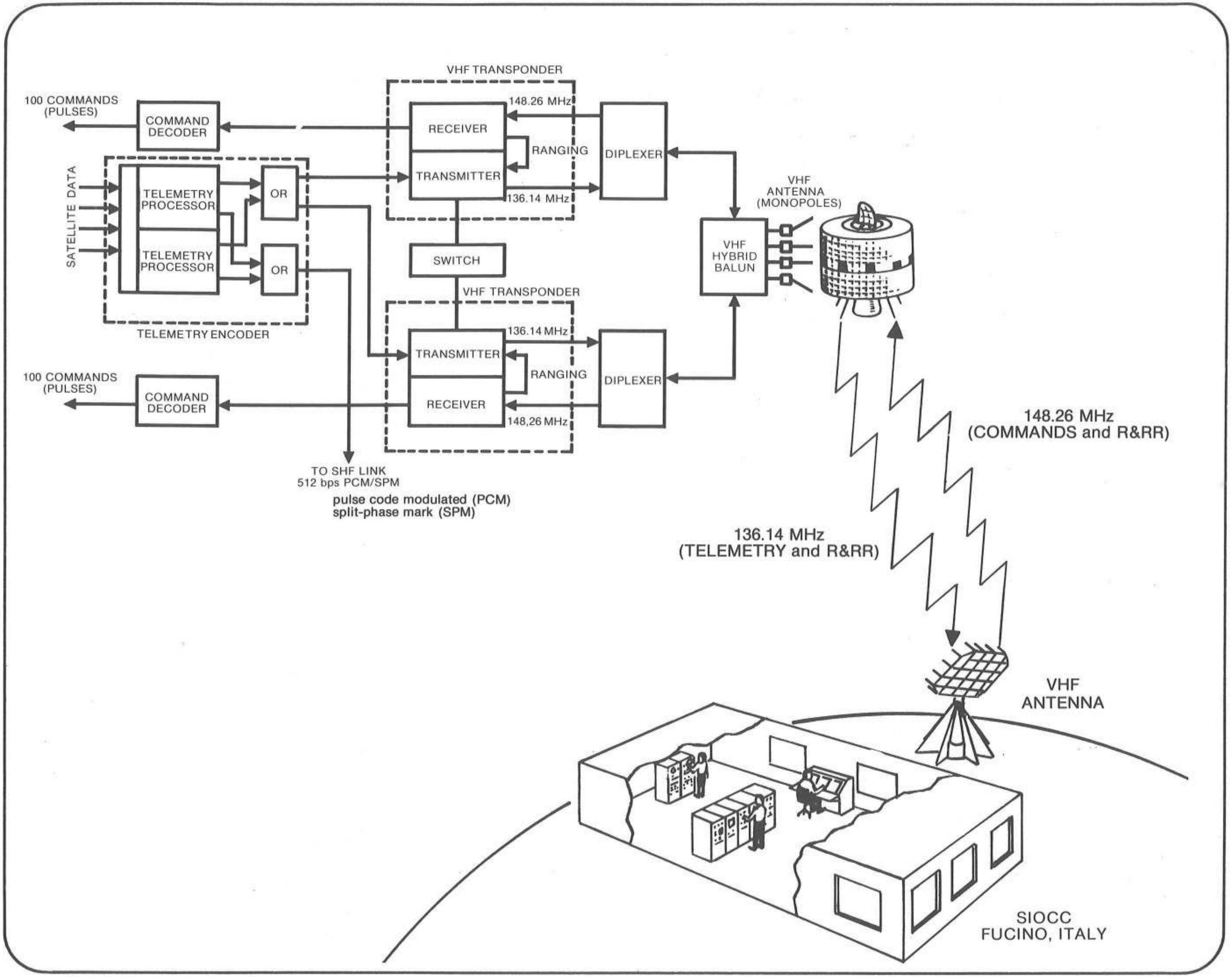
Two redundant VHF systems
512 bps PCM/SPL (VHF) or PCM/SPM (SHF)
151 analog channels
80 parallel digital channels 1 bit
32 16-bit time channels
Two 8-bit serial digital channels
Power: 6 watts at 136.14 MHz

RANGE AND RANGE RATE (R&RR)

Redundant 136.14-MHz VHF transponders transmit R&RR signals on command to the ground stations. Transmission of both the telemetry and R&RR signals can be performed simultaneously. The ranging signals permit tracking of the satellite at all times during launch and operation. NASA's worldwide space-tracking and data-acquisition network (STDN) stations intercept the ranging signals at scheduled intervals for use in orbit determination. NASA performs ranging operations during launch, transfer orbit, drift orbit, and the first 3 months of the operational life of the satellite. Beginning in 1978, the ranging operations will be performed from the SIOCC ground station using the SHF telecommunications transponder.

R&RR CHARACTERISTICS

Two redundant systems
Carrier frequency: 148.26 MHz/136.14 MHz
Subcarrier (tone) frequency: 775 kHz
Major ranging tone: 20 kHz



VHF TRANSPONDER
100 COMMANDS
(PULSES)
COMMAND
DECODER
RECEIVER
148.26 MHz
RANGING
DIPLEXER
TRANSMITTER
136.14 MHz
SATELLITE DATA
TELEMETRY
PROCESSOR
TELEMETRY
PROCESSOR
OR
OR
SWITCH
TELEMETRY ENCODER
VHF TRANSPONDER
136.14 MHz
TRANSMITTER
RANGING
DIPLEXER
100 COMMANDS
(PULSES)
COMMAND
DECODER
RECEIVER
148,26 MHz
TO SHF LINK
512 bps PCM/SPM
pulse code modulated (PCM)
split-phase mark (SPM)
VHF
ANTENNA
(MONOPOLES)
VHF
HYBRID
BALUN
148.26 MHz
(COMMANDS and R&RR)
136.14 MHz
(TELEMETRY and R&RR)
VHF
ANTENNA
SIOCC
FUCINO, ITALY

SUPER HIGH FREQUENCY (SHF) TELECOMMUNICATIONS EXPERIMENT

The SHF experiment performs propagation and telecommunications experiments to study the influence of various meteorological conditions on the SHF propagation medium in the 12-GHz band for the downlink (satellite to Earth) and the 18-GHz band for the uplink (Earth to satellite).

The principal objectives of the SHF telecommunications experiment are to:

- Perform a systematic evaluation of the propagation performance at the 12- and 18-GHz bands
- Measure absolute and relative attenuation at the edges of a band that is about 800 MHz wide in the uplink and about 550 MHz wide in the downlink.
- Perform a narrowband telecommunications experiment with multiple access in frequency division.
- Perform a wideband telecommunications experiment for a single television link

The SHF experiment consists of a transponder assembly and a mechanically despun antenna. The transponder assembly performs the following operations:

- Converts the 18-GHz band signals received from ground (uplink) to a 12-GHz signal for retransmission to ground (downlink) by means of an RF-to-IF conversion, followed by an IF-to-RF reconversion, the bandwidth being appropriate to the particular type of experiment.
- Transmits a reference RF signal to ground in order to evaluate the uplink absolute and differential attenuation.
- Transmits to ground a signal, which is modulated by the satellite telemetry data, simultaneously with other signals related to the chosen experiment.
- In addition, it is possible to command the changeover from one experiment to another without following chronological or preferential criteria.

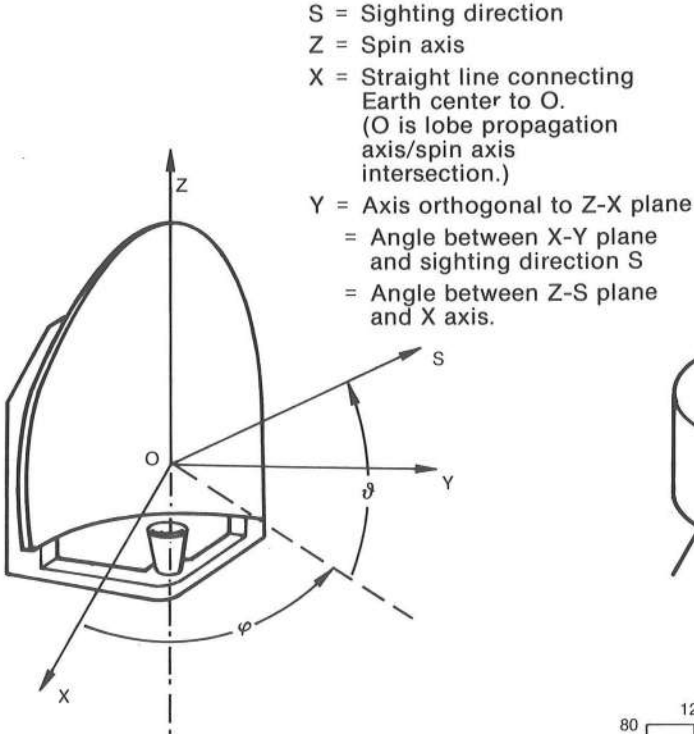
A motor drives the mechanically despun antenna at a rotation speed of 90 rpm. Because the mechanism rotates the antenna reflector in the opposite direction of the 90-rpm rotation of the spin-stabilized satellite, the antenna reflector points toward the Earth in a fixed direction. By means of ground command, it is possible to choose between two antenna-pointing directions, about 4 degrees apart, in the azimuth direction. One pointing direction (sighting A) is used to carry out experiments in connection with ground stations located in the Italian (sighting A1) and European (sighting A2) areas. The other pointing direction (sighting B) is used to carry out experiments between stations located in Europe and in the East Coast area of North America. The antenna works with opposite circular polarizations in transmission and reception, and its beamwidth covers only a part of the Northern Hemisphere with a 6-degree bandwidth in the zenithal plane at -3dB.

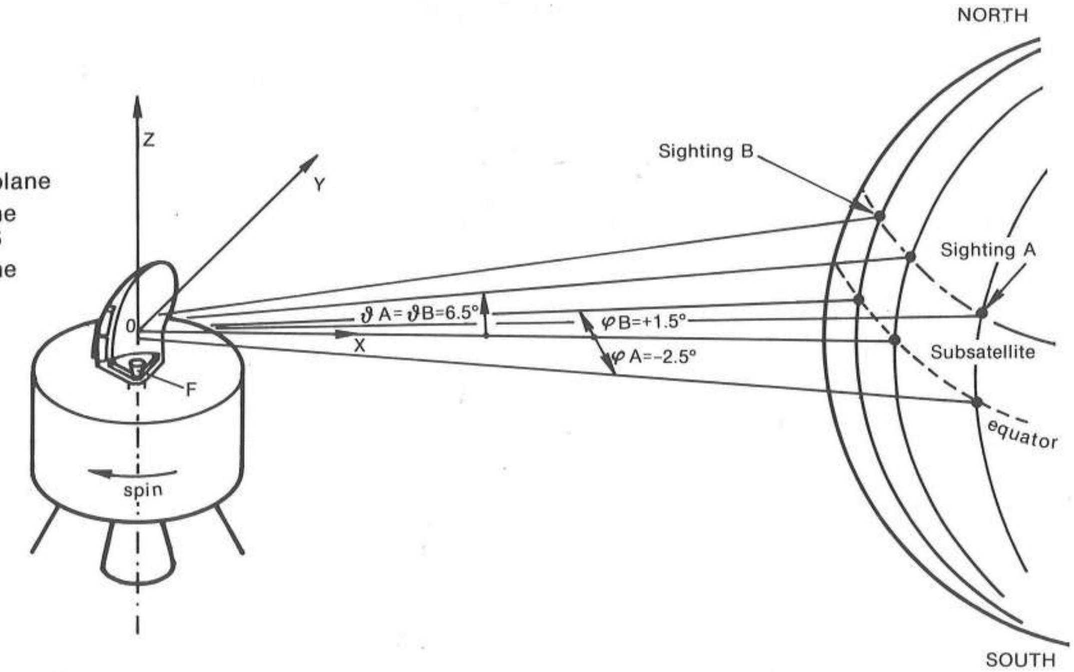
To permit coverage of both the European and the North American (East Coast) areas, the -3dB antenna beamwidth (in its azimuthal plane) is approximately 12 degrees wide.

On the nominal subsatellite point (15 degrees west longitude and 0 degrees latitude), the antenna electric axis is pointed 6.5 degrees northward and 2.5 degrees eastward for sighting A, or 1.5 degrees westward for sighting B, in relation to the satellite's subsatellite straight line.

SHF TELECOMMUNICATIONS EXPERIMENT CHARACTERISTICS

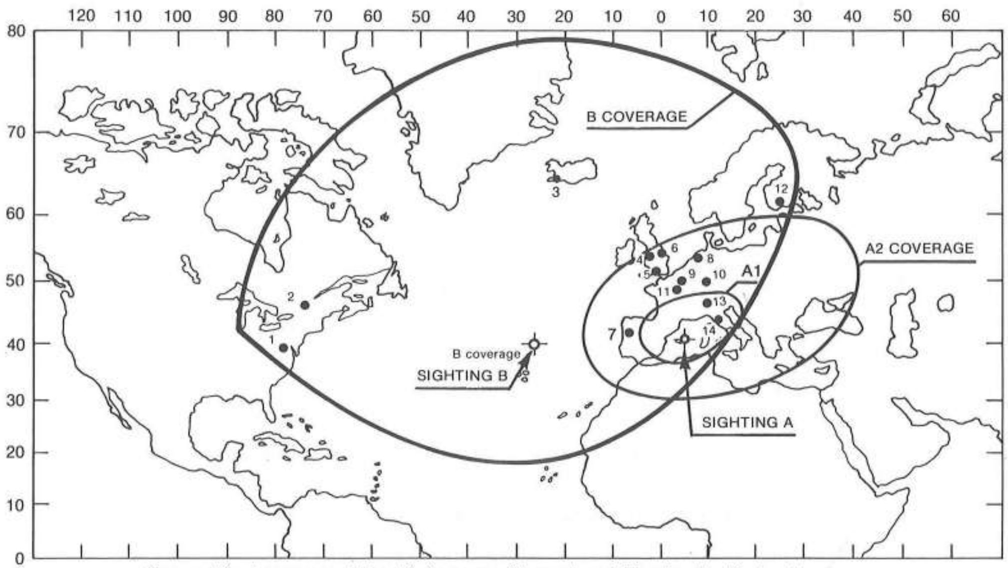
BAND: PROPAGATION EXPERIMENT
17395.2 ± 386.56 MHz up-link
11596.8 ± 265.76 MHz down-link
20-MHz band
BAND: COMMUNICATIONS
17395.2 ± 292.4-MHz uplink
11596.8 - 70-MHz downlink
1.5 MHz: narrowband
35 MHz: wideband
ANTENNA COVERAGE (WIDEBAND COMMUNICATIONS EXPERIMENT)
+ 75 dBm on the European stations
+ 54 dBm at the boundary of Europe and USA
POLARIZATION
LHC at 18 GHz
RHC at 12 GHZ
POLARIZATION PURITY
1.5 dB of ellipticity
TRANSMISSION POWER
10 watts
MASS (WEIGHT)
27 kg (60 lbs.)
CONSUMPTION
80 watts max.





SIRIO SHF EXPERIMENT PARTICIPANTS

1. COMSAT (Washington)
2. Communication Research Center (Ottawa)
3. ESRO (Reykjavik)
4. Birmingham University
5. Scientific Research Council
6. British Post Office (Martlesham)
7. Porto University
8. Netherlands Post Office (Leidschendam)
9. Louvain University (Haverlee)
10. Fernmeldetechnisches Zentralamt (Darmstadt)
11. CNET (Issy-Les Moulineaux)
12. Helsinki University
13. Milan Polytechnic
14. Telespazio (Rome)



Geographical coverage: Italy elliptic cone with aperture 1.8° azimuth, 1° elevation.
Europe elliptic cone with aperture 5° azimuth, 3° elevation.
Europe/USA elliptic cone with aperture 10° azimuth, 8° elevation.

SHF ANTENNA COVERAGE WITH SATELLITE STATIONED AT 15 DEGREES WEST LONGITUDE

GROUND SYSTEMS

The ground system consists of: • NASA's Multi-Satellite Operations Control Center (MSOCC) at Greenbelt, Maryland • NASA's worldwide space-tracking and data-acquisition network (STDN) stations at Guam; Orroral, Australia; Santiago, Chile; Rosman, North Carolina; and the Ascension Islands • CENTRO RICERCHE AEROSPAZIALI (CRA) ground station at the San Marco base camp in Malindi, Kenya. • TELESPAZIO's control center and SHF/VHF ground stations at Fucino and Lario, Italy • CNUCE's computer center at Pisa, Italy

MULTI-SATELLITE OPERATIONS CONTROL CENTER (MSOCC)

The MSOCC provides ground system control of the satellite during the first phase (45 days) of the SIRIO mission. The team from CONSIGLIO NAZIONALE DELLE RICERCHE is responsible for satellite control with the assistance of the NASA support group responsible for providing the necessary data and information for decision-making. MSOCC provides orbital and attitude computations and satellite control support to the mission.

STDN GROUND STATIONS

Five STDN stations, directly connected with MSOCC, send commands to the satellite, receive telemetry data from the satellite, and perform ranging functions as directed by MSOCC or SIOCC.

SAN MARCO GROUND STATION

The San Marco ground station is the first station to receive telemetry data from the satellite after its separation from the launch vehicle. SIRIO personnel at the San Marco station provide information on the satellite's operational status to the SIRIO operations team at MSOCC via voice and teletype links.

SIRIO ITALIAN OPERATIONS CONTROL CENTER (SIOCC)

The SIOCC, located in Fucino, controls the main functions and performance of the satellite and is the major data-collection center for SIRIO operations.

The SIOCC receives the telemetry data from the VHF or SHF antennas. The VHF link is used mainly during periods of shadow or during attitude and orbit maneuvers. The SHF link is normally used for performing the SHF experiment, and the VHF antenna is always used for commanding operations.

The decommutation and processing of the telemetry signal provides data for monitoring satellite health and attitude. The SIOCC main computer also handles the SHF data collected by the SHF ground station during the experiment, and provides the first data processing to the experimenters. The attitude and ranging data are transmitted by dedicated data line to the CNUCE computing center in Pisa. Some telemetry data are also transmitted to the SHF ground station at Lario for monitoring the operational status of the satellite while performing the SHF experiment.

SHF EXPERIMENT GROUND STATIONS AND DATA LOGGING

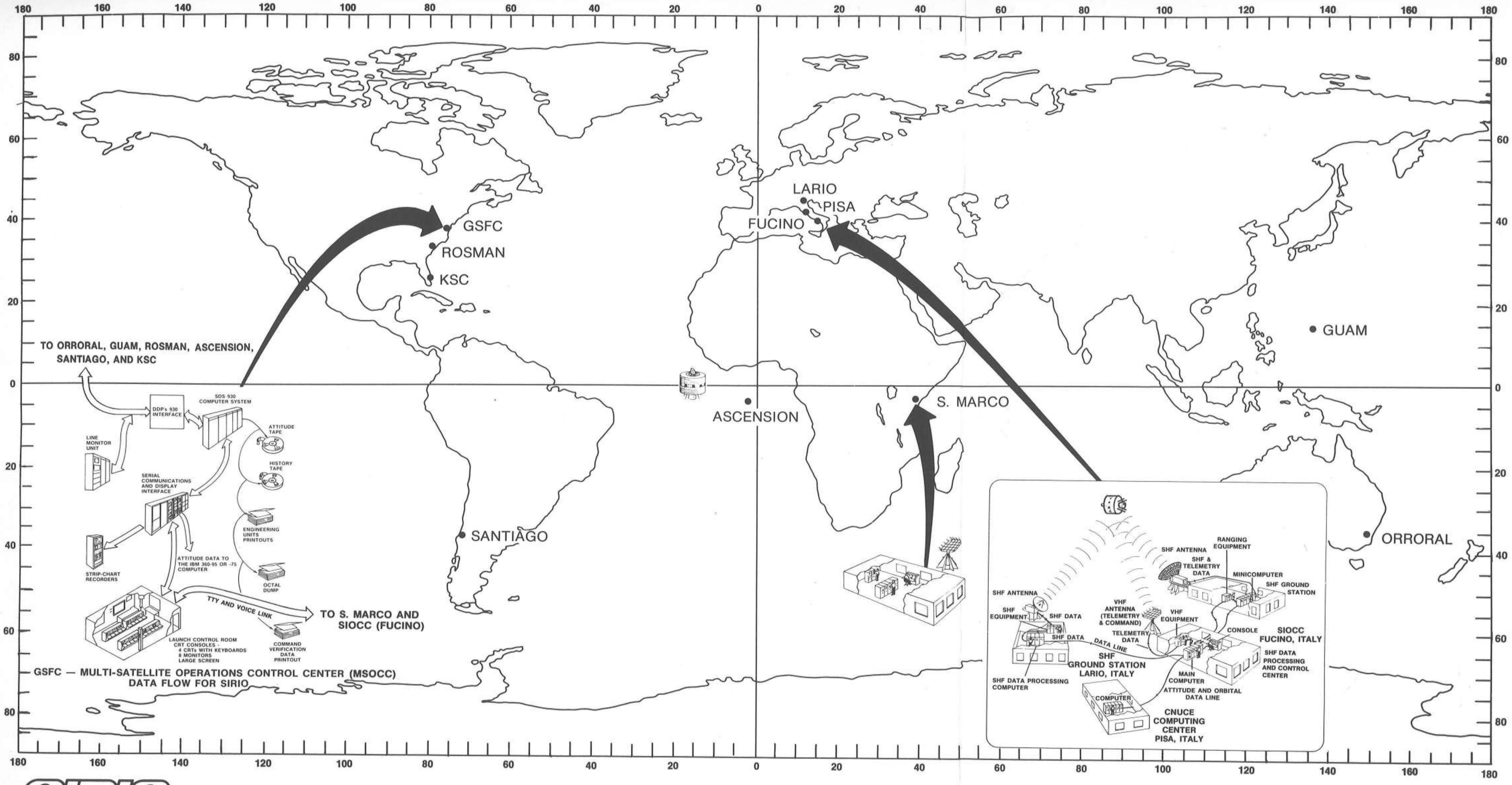
The main SHF experiment ground stations are located at the TELESPAZIO facilities in Fucino and Lario (on the Lake of Como) in Italy. Both stations are equipped with 17-meter (51-foot) diameter SHF antennas operating at 12 to 18 GHz. Ground equipment collects rainfall data from pluviometers located near the SHF ground stations at Fucino and Lario and evaluates SHF carrier parameters, such as signal attenuation. A dedicated minicomputer in Fucino collects these data and transmits them to the main computer for processing. In the Lario station, the same computer handles both operations, because no commanding and ranging functions are performed.

Furthermore, the Fucino station is equipped with SHF ranging facilities that provide range data to the main computer, together with the SHF antenna tracking data.

ORBIT AND ATTITUDE DETERMINATION AND CONTROL

The ranging, tracking, and attitude data files are stored in the SIOCC main computer, and are transmitted, as required, in the proper format to CNUCE in Pisa at which there are larger computer facilities.

A flight-dynamics system (FDS) consisting of many large programs is in operation at CNUCE. The FDS permits processing of attitude and R&RR data for determining satellite attitude and orbit, respectively. This makes it possible to control the position of the satellite in orbit and to determine the maneuvers necessary to compensate for the effects of gravitational perturbing forces in order to maintain the satellite in the proper operating position.



SIRIO CONSIGLIO NAZIONALE DELLE RICERCHE