An Overview of the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) Mission

D. N. Baker, G. M. Mason, O. Figueroa, G. Colon, J. G. Watzin, and R. M. Aleman

Abstract—**The scientific objective of the NASA Small-class Explorer Mission SAMPEX are summarized. A brief history of the Small Explorer program is provided along with a description of the SAMPEX project development and structure. The spacecraft and scientific instrument configuration is presented. The orbit of SAMPEX has an altitude of 520 by 670 km and an 82° inclination. Maximum possible power is provided by articulated solar arrays that point continuously toward the sun. Highly sensitive science instruments point generally toward the local zenith, especially over the terrestrial poles, in order to measure optimally the galactic and solar cosmic ray flux. Energetic magnetospheric particle precipitation is monitored at lower geomagnetic latitudes. The spacecraft uses several innovative approaches including an optical fiber bus, powerful onboard computers, and large solid state memories (instead of tape recorders). Spacecraft communication and data acquisition are discussed and the space- and ground-segment data flows are summarized. A mission lifetime of 3 years is sought with the goal of extending data acquisition over an even longer portion of the 11-year solar activity cycle.**

I. INTRODUCTION

RECOGNIZING the advantages of small, quick-turnaround projects, NASA's Office of Space Science and Applications recently initiated a program at the NASA Goddard Space Flight Center in Greenbelt, MD, called the Small Explorer Program, or SMEX. SMEX is intended to support disciplines traditionally served by NASA's longstanding Explorer Program, which include astrophysics, space physics and upper atmospheric science. An important aspect of SMEX is that one principal investigator (PI) proposes a complete mission and its experiments. The idea is to have one team responsible for the entire mission and all instruments. The team usually includes scientists at a variety of institutions who have worked together closely in the past. The result is an efficient, highly cohesive research effort [1].

The original SMEX announcement of opportunity was released on May 17, 1988, with proposals due by September 30, 1988. The announcement articulated the following goals:

> "The Small-class Explorer Program seeks to conduct scientific research of modest programmatic scope which can be launched within three years of selection. The program intends to provide a continuing opportunity for quickly implemented flights of small free-flyers to conduct focused investigations which complement major missions, prove new scientific concepts, or make significant contributions to space science in other ways. It is the goal of the program to obtain flight frequency of at least one flight per year."

The cost per mission was to be limited, on average, to $30 million (1988 dollars) which includes both the instruments and the spacecraft but excludes launch services and mission operations costs beyond the first 30 days after launch.

The first SMEX mission is the Solar, Anomalous, and Magnetospheric Particle Explorer, or SAMPEX. SAMPEX measures energetic electrons as well as ion composition of particle populations from ~0.4 MeV/nucleon to hundreds of MeV/nucleon from a zenith-oriented satellite in near-polar orbit. SAMPEX was successfully launched from NASA's Western Test Range (Lompoc, CA) at 1419 UT on July 3, 1992. A photograph of SAMPEX in its final configuration is shown in Fig. 1. This paper summarizes the scientific and technical aspects of the overall SAMPEX mission.

II. SCIENCE OVERVIEW

The SAMPEX payload combines some of the most sensitive particle sensors ever flown in space. It studies the energy, composition, and charge states of particles from supernova explosions in the distant reaches of the galaxy, from the heart of solar flares, and from the depths of nearby interstellar space. It also monitors closely the magnetospheric particle populations which plunge occasionally into the middle atmosphere of the Earth, thereby ionizing neutral gases and altering the atmospheric chemistry. A key part of SAMPEX is to use the magnetic field of the Earth as an essential component of the measurement strategy. The Earth's field is used as a giant magnetic spectrometer to separate different energies and charge states of particles as SAMPEX executes its near-polar orbit.

In the energy range below ~50 MeV/nucleon, there are at least six elements (He, C, N, O, Ne, and Ar) whose energy spectra show large increases in flux above the quiet-time galactic cosmic ray spectrum during the solar activity

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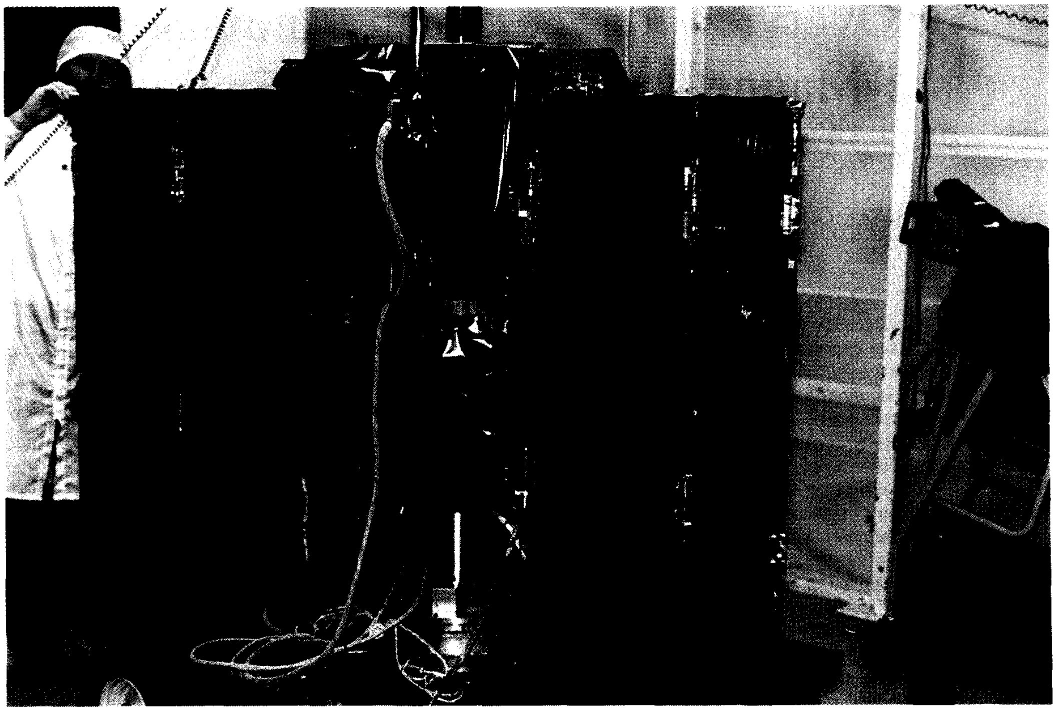


Fig. 1. Photo of SAMPEX spacecraft in final launch configuration.

minimum. This "anomalous" cosmic ray (ACR) component is generally believed to represent neutral interstellar particles that drift into our solar system (i.e., the heliosphere), become ionized by solar wind interactions or solar ultraviolet radiation, and are then accelerated [2]. This model predicts that the ACR particles should be singly ionized, an assertion for which there is now supportive evidence [2]. SAMPEX makes direct measurements of the charge state of He, N, O, and Ne by using the Earth's magnetic field as a charge-state spectrometer. By using sophisticated numerical trajectory calculations for each incident particle, the ACR fluxes are organized according to magnetic cutoff rigidity. This allows SAMPEX to distinguish between a number of possible charge states. If the ACR particles turn out to be singly ionized, then this component represents a direct sample of the local interstellar medium.

Considering more impulsive particle phenomena, solar flares frequently inject large populations of energetic heavy ions into the interplanetary medium. The elemental and isotopic composition of these particles provide crucial information about the history of solar system material and about solar flare acceleration and propagation processes. High sensitivity spectrometers on SAMPEX have 10–100 times more collecting power than previous instruments. The number of electrons stripped from solar energetic particle ions within the sun's atmosphere is determined by plasma conditions at the acceleration site; thus, detailed determinations of the individual ionic species can be derived, in principle, from the charge state distribution measured far from the sun.

Within the Earth's magnetosphere itself, observations at geosynchronous orbit (6.6 Earth radii, R_E) have shown that relativistic ($\gtrsim$1 MeV) electron intensities can increase by orders of magnitude for periods of several days and then return to background levels. These enhancements inside the magnetosphere are related to the presence of recurrent high-speed solar wind streams outside in the interplanetary medium, and show a strong solar cycle (11-year) dependence. Numerical modeling shows that when these electrons precipitate they can cause large energy depositions at 40–60 km altitude in the atmosphere, dominating other ionization sources at these heights. Precipitating relativistic electrons may lead to substantial long-term increases in the levels of odd nitrogen compounds (NOx) in the middle atmosphere with an attendant impact on local ozone levels via the reactions $NO + O_3 \rightarrow NO_2 + O_2$, and $NO_2 + O \rightarrow NO + O_2$. Thus, relativistic electrons may provide a mechanism for coupling the 11-year solar activity cycle into the middle and lower atmosphere [3]. It is therefore a critical problem to determine the actual intensity and spatial extent of relativistic electron precipitation, vital information that SAMPEX will provide.

Galactic cosmic rays are a directly accessible sample of matter from outside the solar system. A spectrometer on SAMPEX carries out measurements of the isotopic composition of this sample of high energy matter, which contains a record of the nuclear history of cosmic rays. Cosmic ray isotope observations have dramatically altered thinking about both cosmic ray origin and propagation. As an example, prior measurements have shown that ^{22}Ne is more than a factor of 3 times more abundant in cosmic ray source material than in the solar system. The abundances of ^{25}Mg, ^{26}Mg, ^{29}Si, and ^{30}Si are all enhanced by a factor of $\sim$1.5. The exposure obtained on SAMPEX will make it possible to extend the search for isotopic differences between galactic and solar cosmic ray material to many other key elements.

III. Spacecraft Configuration

The broad range of inquiries described briefly above can only be addressed using experimental measurements obtained on a low-altitude, near-polar orbiting spacecraft. The SAMPEX mission uses a spacecraft developed by the SMEX Project at the Goddard Space Flight Center. The spacecraft is required to provide the total support (power, data, thermal, structural, etc.) to four separate scientific instruments and their associated data processing unit. The spacecraft has been designed as a single string system. A system design was selected that uses proven design concepts and flight qualified or readily available hardware wherever possible. A Performance Assurance program with minimum paperwork, best exerimenter judgment, and extensive bench testing has been implemented for the SAMPEX instrument payload. Within this resource-constrained package, there are many innovations including powerful onboard processors, optical fiber busses, solid state memory units, and a highly integrated mechanical design.

The SAMPEX spacecraft was designed to support a minimum mission duration of 1 year, with a mission goal of 3 or more years. Because the four-stage Scout launch vehicle could loft a very limited weight for this mission (<372 pounds), the spacecraft systems were primarily designed in a single-string architecture. The SAMPEX mechanical system basically consists of a primary structure, a deployable solar array system, and a yo-yo despin system. SAMPEX is built up of machined aluminum plates which form a box-like structure that houses all of the spacecraft components (see Fig. 2). An adapter ring on the bottom provides the interface to the Scout 200-E adapter on the fourth stage of the Scout launch vehicle. SAMPEX was designed to fit within the Scout 34-inch diameter heatshield.

The deployable solar arrays are configured in two symmetric wings. The arrays deployed by a damped spring system which prevented the motion from imparting any severe loads on the structure. The arrays consist of four panels, associated deployment mechanisms, position monitors, cabling, gallium arsenide solar cells, and cover glass. The solar array panels are fabricated from aluminum honeycomb and have solar cells bonded to them. Each array has two coarse sun sensors mounted on the upper and lower extreme corners.

The power subsystem is a Direct Energy Transfer system providing an unregulated +28 V direct current bus. Power is generated during the sunlight periods from the solar array paddles and stored in a nickel cadmium battery. Power is drawn solely from the batteries during eclipse periods. A shunt regulator is provided to dissipate excess array power. See Fig. 3 for electrical and power system details.

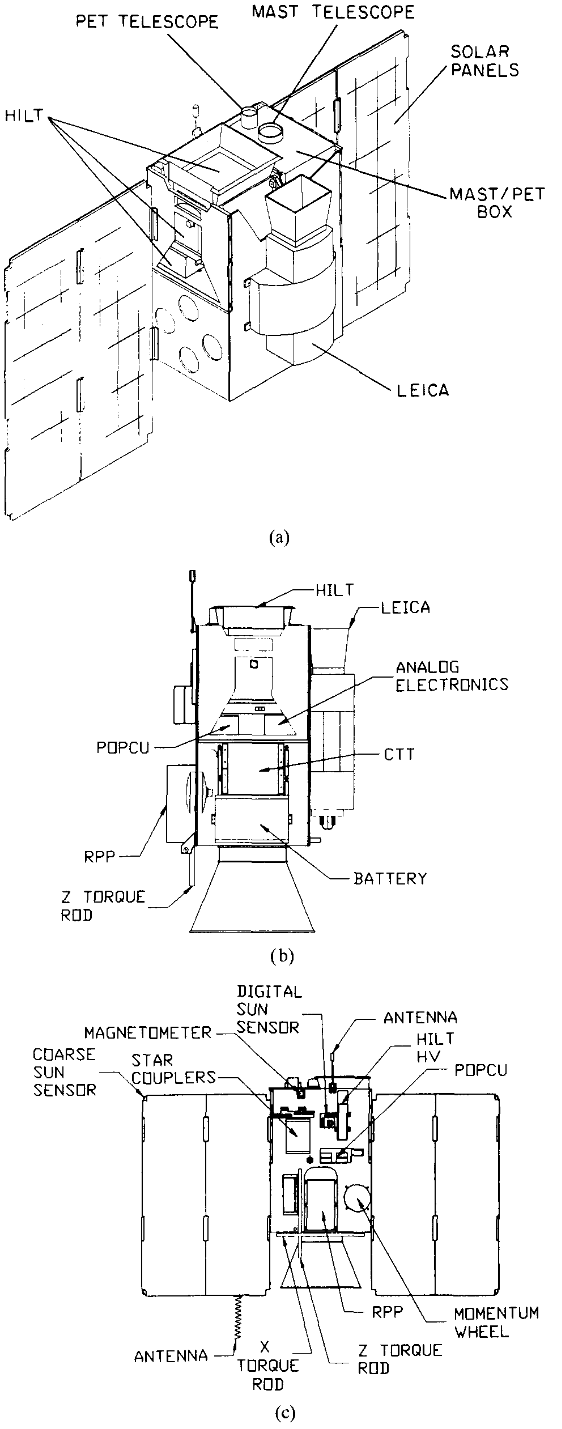
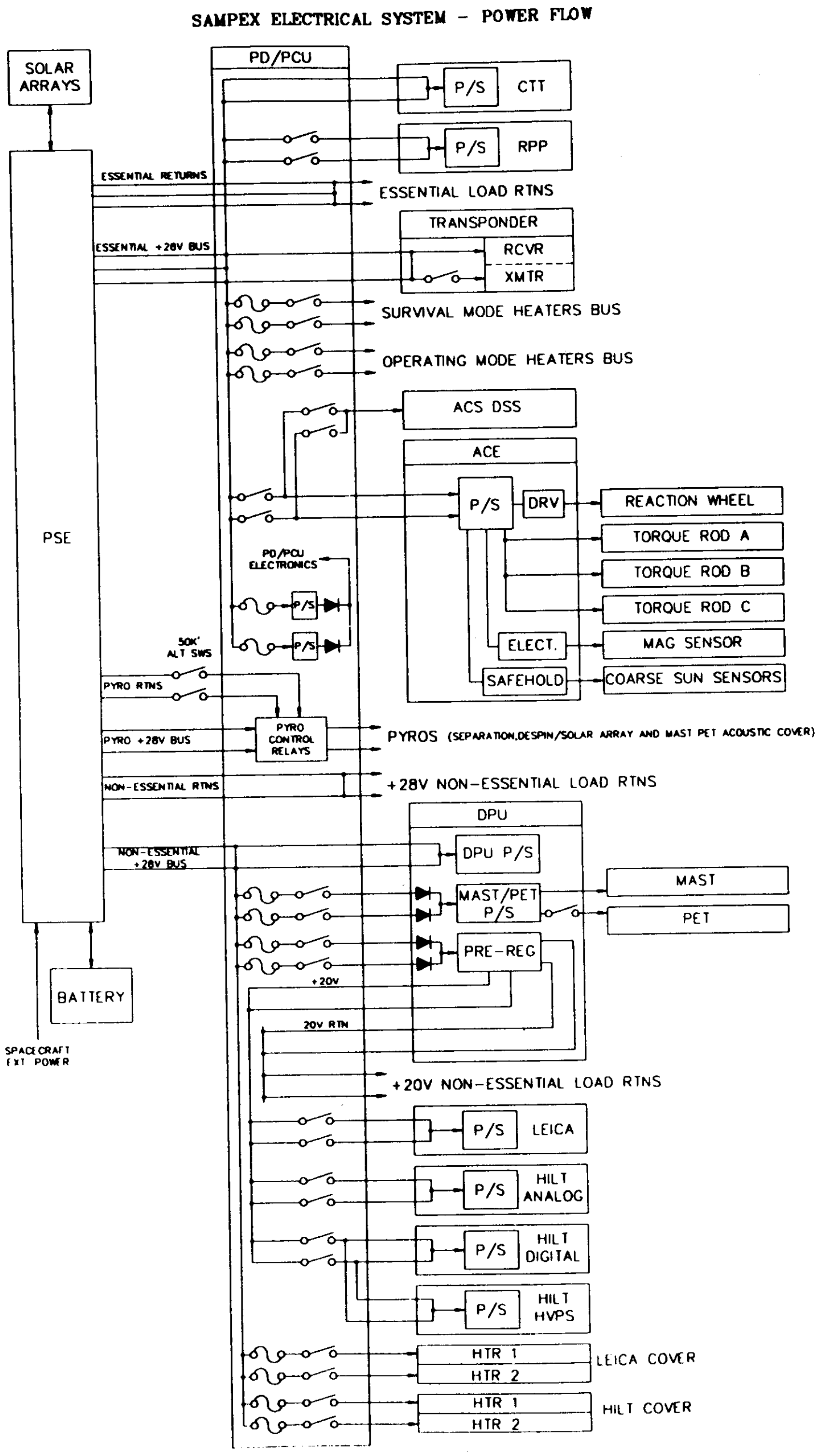


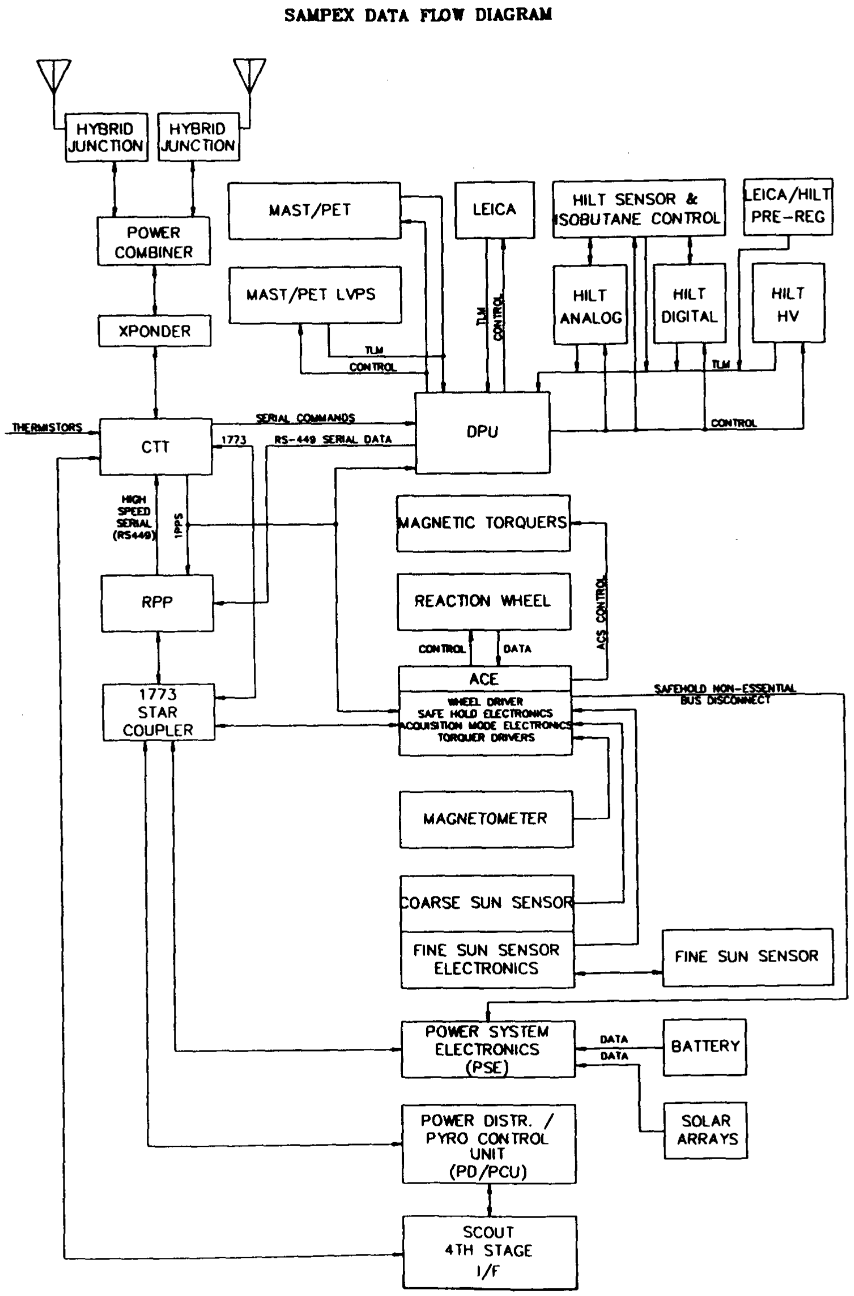
Fig. 2. Mechanical design of the SAMPEX spacecraft and physical layout: (a) Scientific instruments; (b) Side view of subsystems; (c) Back view of subsystem layout.

The power subsystem supplies power to the spacecraft via three busses: the essential bus, the nonessential bus, and the pyrotechnic bus. The essential bus provides continuous power to spacecraft functions including the data system, the telemetry transponder, the heaters, the attitude control system, and the power distribution electronics. The nonessential bus provides power to the spacecraft instruments. The pyrotechnic bus provides unprotected battery power to fire the pyrotechnic devices. All three busses are routed to the power distribu-



(a)

Fig. 3. Electrical layout and (b) data flow within the SAMPEX spacecraft.



(b)

Fig. 3. *(Continued)*

tion unit for switching and fusing (where appropriate). The power subsystem includes an isolation relay to disconnect the nonessential bus in the event that the spacecraft is drawing excessive current, the battery is in undervoltage, or when the spacecraft goes into safehold. With the exception of the shunt drivers, all power subsystem electronics are designed in a single string, nonredundant configuration. The Power Distribution/Pyro Control Unit (PD/PCU) provide primary power distribution and fusing to other spacecraft subsystems, and control and power to the spacecraft's separation and deployment pyrotechnic devices.

The on-orbit average output power of the system is 102 W with no solar array shadowing and minimum solar intensity at end-of-mission life. During the launch phase, with the spacecraft launched into a full sun orbit, the power system was capable of supplying 200 Wh of energy. This

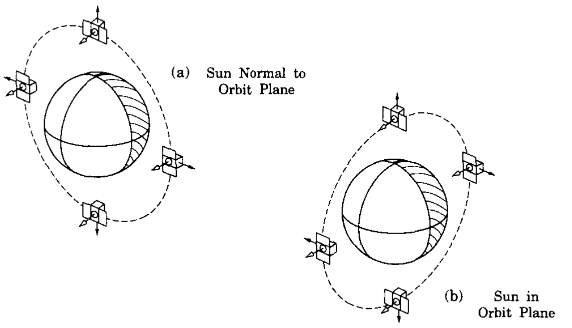


Fig. 4. The pointing strategy for the SAMPEX spacecraft in two illustrative orbit planes.

is based on a 9 Ah battery and an 80% battery depth of discharge.

The Attitude Control Subsystem (ACS) is designed as a solar-pointed/momentum-bias system. The SAMPEX spacecraft points at the sun while it rotates about the sunline once per orbit in order to position the instrument lines-of-sight in the zenith direction when overflying the poles. Pointing requirements for the selected experiments are met by choosing sensor, torquers, and system configurations from a standard set of electronics, sensors, and actuators. The ACS system utilizes one momentum wheel and three electromagnetic torque rods to orient the experiment viewing axis. Pointing ranges within ±15° of vertical over the poles. Attitude knowledge accuracy computed onboard the spacecraft is better than 2° (3 sigma). The pointing strategy for SAMPEX is to point the pitch axis (i.e., the normal to the solar panels) directly at the Sun. Then the yaw axis (parallel to the detector bore sights) rotates about the pitch axis once per spacecraft orbit. The spacecraft views north over the north pole, south over the south pole, and parallel to the equator during the equatorial plane crossings (see Fig. 4).

An Attitude Control Electronics (ACE) box which contains signal conditioning electronics and an independent analog safehold mode controls the ACS sensor and hardware discussed previously. The onboard data system performs closed loop real-time attitude determination and control processing. Three-axis attitude determination is provided by comparing the local measured sun vector and magnetic field vector with an on-board ephemeris model. Digital control of the spacecraft attitude is completed by sending appropriate command signals across the spacecraft data bus to the actuators.

The Thermal subsystem maintains internal SAMPEX temperatures between $-10°$ and 50°C. These temperatures are controlled by selected surface-finish application, regulating conduction paths, passive thermal control elements, and thermostatically controlled heaters.

The SAMPEX antenna system is composed of two quadrifilar helices, two 90° hybrid junctions, and a power divider. These omnidirectional antennas are located on the top and on the bottom of the spacecraft. The top antenna is a half-turn quadrifilar with a 150° beamwidth. The bottom antenna is a three-turn quadrifilar with a 210° beamwidth. Each antenna is fed with a 90° hybrid junction to create the proper phasing between elements. A power divider feeds each hybrid junction with a signal of equal amplitude and phase. This system is designed to operate over a 2025–2300 MHz frequency range. The Communications subsystem consists of a near-Earth S-band transponder operating in full duplex mode, providing reception of uplinked commands, transmission of telemetry data, and support of tracking by the designated ground station. The command data rate is 2 kb/s. The telemetry output signal from the transmitter is modulated onto the carrier to produce the downlink signal. The transmitter modulation bandwidth is 10 MHz and its output power is 5 W. The transponder interfaces with the antennas and the Command and Data Handling (C&DH) subsystem.

The SAMPEX C&DH functions are performed by the Small Explorer Data System (SEDS). The SEDS provides on-board computers that can be programmed to perform mission unique functions as required and provides autonomous operations of the spacecraft when it is not in contact with the ground. The SEDS is responsible for the command and data handling functions of the SAMPEX spacecraft (see Fig. 5). The SEDS provides data collection from the different subsystems and instruments, stores the data, processes it, and sends it to the ground. The data system uses solid-state memory instead of conventional tape recorders to record spacecraft telemetry data when the spacecraft is not in contact with the ground. Data transmitted from SEDS to the ground is formatted as a "Packet Telemetry" stream in accordance with the Consultative Committee for Space Data Systems (CCSDS) and Goddard Space Flight Center standards. The SEDS is comprised of three main components:

1) The Recorder/Processor/Packetizer (RPP) provides storage for 26.5 Mbytes of data, packetizes commands and telemetry, and is used as a general purpose processor. The RPP supports overall spacecraft control functions and specific requirements such as attitude control. The RPP generates the telemetry data stream for transmission to the ground.
2) The Command Telemetry Terminal (CTT) connects the SEDS to the transponder, provides uplink command processing, downlink telemetry encoding, time code management, local telemetry acquisition and command distribution, housekeeping, attitude determination, and system monitoring functions. The CTT can control some of the spacecraft functions if the RPP fails.
3) The Military Standard (MIL-STD) 1773 data bus connects SEDS components to the attitude control and power subsystems. The MIL-STD-1773 bus in the implementation of the MIL-STD-1553 military avionics protocol. The 1773 bus uses optical fiber links for a high throughput and low-mass spacecraft harness. It also is a nonconductor so it cannot introduce electronic or radio frequency interference into the system. This fiber optics approach provides spaceflight experience for a new generation of high data rate busses.

These components are used for command reception, telemetry transmission and tracking. The SAMPEX operating radio

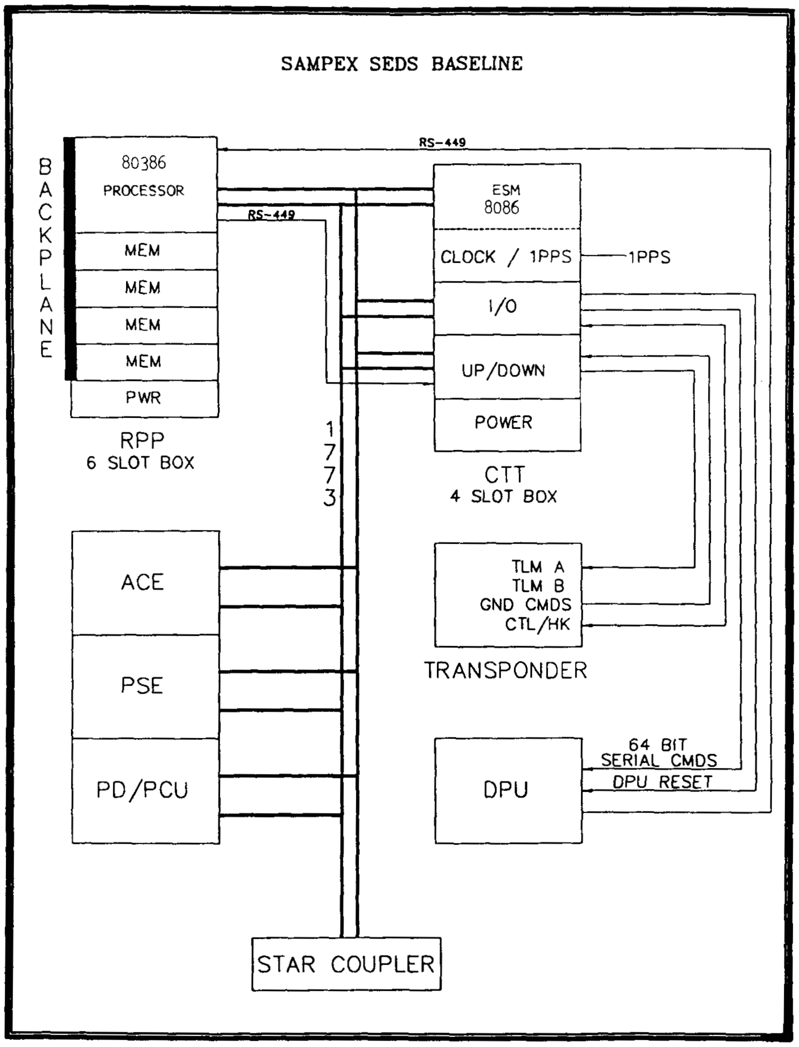


Fig. 5. The Small Explorer Data System (SEDS) functional diagram for the SAMPEX spacecraft.

frequency modes are high- and low-rate modes. Both modes consist of coherent tracking, which provides two-way Doppler and range data, simultaneously with telemetry and command.

The Data Processing Unit (DPU) is responsible for overall control of the science payload [4]. It serves as the interface between the science instruments and the spacecraft. The DPU controls sensor high-voltage power supplies and isobutane regulation based on status feedback from the sensor electronics, and it performs instrument housekeeping functions. It also is responsible for packetizing instrument data and passing these formatted data to the spacecraft.

IV. Instrument Complement

The instruments on the SAMPEX spacecraft are the Low Energy Ion Composition Analyzer (LEICA), the Heavy Ion Large Telescope (HILT), the Mass Spectrometer Telescope (MAST), and the Proton/Electron Telescope (PET).

A. Low Energy Ion Composition Analyzer (LEICA)

The LEICA instrument is a time-of-flight mass spectrometer that identifies incident ion mass and energy by simultaneously measuring the time-of-flight and residual kinetic energy of particles that enter the telescope and stop in an array of four solid state detectors. The time-of-flight is determined by START and STOP pulses from chevron microchannel plate (MCP) assemblies that detect secondary electrons emitted from the entrance foil and a foil in front of the solid state detector, respectively, when the ion passes through them. These secondary electrons are accelerated to approximately 1 KV and deflected onto the MCP's by electrostatic mirrors. The measured energy and velocity are combined to yield the mass of the ion and the energy per nucleon. Details of the LEICA instrument are presented by Mason *et al.* [5].

TABLE I
SAMPEX SCIENTIFIC INSTRUMENTS

Energy Range for:	LEICA	HILT	MAST	PET
Electrons	—	—	—	0.4–30 MeV
H	0.76–6.1	—	—	18–250 MeV
He	0.45–6.1	4.3–38	7–20	18–350 MeV/nuc
C	0.44–11.4	7.2–160	14–210	34–120 MeV/nuc
Si	0.33–5.5	9.6–177	21–330	54–195 MeV/nuc
Fe	0.21–3.1	11.0–90	27–450	70–270 MeV/nuc
Charge range for elements	1–25	2–28	2–28	1–2 1–28*
Charge range for isotopes	2–16	2	2–28	1–2 1–10*
Geometry factor (cm^{2}sr)	0.8	60	7–14	0.3–1.6
Field of Viw (deg, full angle)	24 x 20	68 x 68	101	58
Mass (kg)	7.4	22.8	8.8	(incl. with MAST)
Power (W)	4.9	5.6	5.3	(incl. with MAST)
Telemetry (kbps)	1.3	0.9	1.4	0.5

*commandable low-gain mode

B. Heavy Ion Large Telescope (HILT)

The HILT sensor is designed to measure heavy ions from He to Fe in the energy range from 8 to 220 MeV/nucleon for oxygen, covering the medium-energy solar energetic ions, the galactic cosmic rays, and the range of maximum intensity of the anomalous cosmic ray component. The sensor consists of a three-element ion drift chamber with two thin multilayer entrance windows followed by an array of 16 solid state detectors and a scintillation counter with photodiodes. The HILT instrument uses a flow-through isobutane system for the drift chamber. The fluid isobutane tank in SAMPEX is located with its longitudinal axis on the spin axis of the payload. The tank is 40.6 cm long by 24.1 cm in diameter with a volume of 1.5×10^4 cm^3. At launch the tank was approximately 90% filled with isobutane fluid. The isobutane storage tank is a major component of the SAMPEX spacecraft as shown in Fig. 2 (see also Klecker *et al.* [6]).

C. Mass Spectrometer Telescope (MAST)

MAST (see Cook *et al.* [7]) is designed to measure the isotopic composition of elements from Li ($Z = 3$) to Ni ($Z = 28$) in the range from approximately 10 MeV/nucleon to several hundred MeV/nucleon. MAST consists of a combination of surface barrier and lithium-drifted solid-state detectors (11 total). Combined matrix detector positions determine the particle trajectories, allowing accurate corrections to be made for the pathlength variation with angle and detector response nonuniformities. Although optimized for isotopic analysis of the elements Li to Ni, MAST also performs measurements of stopping He isotopes from approximately 7 to 20 MeV/nucleon. In addition, MAST analyzes particles that penetrate the entire stack, providing differential energy spectra of the more abundant elements to well beyond the endpoint energy for stopping particles, and integral flux measurements at higher energies. A priority system ensures that the most interesting events are selected for readout, with stopping $Z \geq 3$ events given the highest priority. However, because MAST is assigned a high telemetry data rate, the pulse heights from essentially all stopping $Z \geq 3$ nuclei can be transmitted, even in very large flares.

D. Proton/Electron Telescope (PET)

The PET system is designed to complement MAST by measuring the energy spectra and relative composition of protons (18 to 250 MeV) and helium nuclei (18 to 350 MeV/nuclei) of solar, interplanetary, and galactic origins, and the energy spectra of solar flare and precipitating electrons from approximately 0.4 to $\sim$30 MeV. The instrument measures both trapped and precipitating energetic particles in different parts of the SAMPEX orbit. It also has the capability to look at manmade particle populations such as positrons which are emitted by nuclear reactors that have flown previously in low-Earth orbit. The PET system can also duplicate and extend some measurement capabilities of MAST by providing energy spectra and elemental composition of nuclei from Li through Fe using a commandable high-gain mode. It provides some isotopic information on nuclei from H to Ne. Details of the PET sensor system are provided by Cook *et al.* [8]. Table I summarizes the SAMPEX instrument characteristics and Fig. 6 shows the connectivity of the instruments and subsystems.

V. INFORMATION ACQUISITION AND OPERATIONAL DATA FLOW

The SAMPEX spacecraft is operated through the Project Operations Control Center (POCC) located at Goddard Space Flight Center. The mission operation activity is manned 24 hours a day, 7 days a week. The data are transmitted to the ground twice per day through the Wallops Flight Facility. The data are transmitted as a series of CCSDS transfer frames. Commanding is performed once per day. Command data are also CCSDS compliant. (Notably, SAMPEX is the first NASA mission to fully exercise the CCSDS data system recommendations for packetized command and telemetry.) Spacecraft planning and scheduling determine the spacecraft

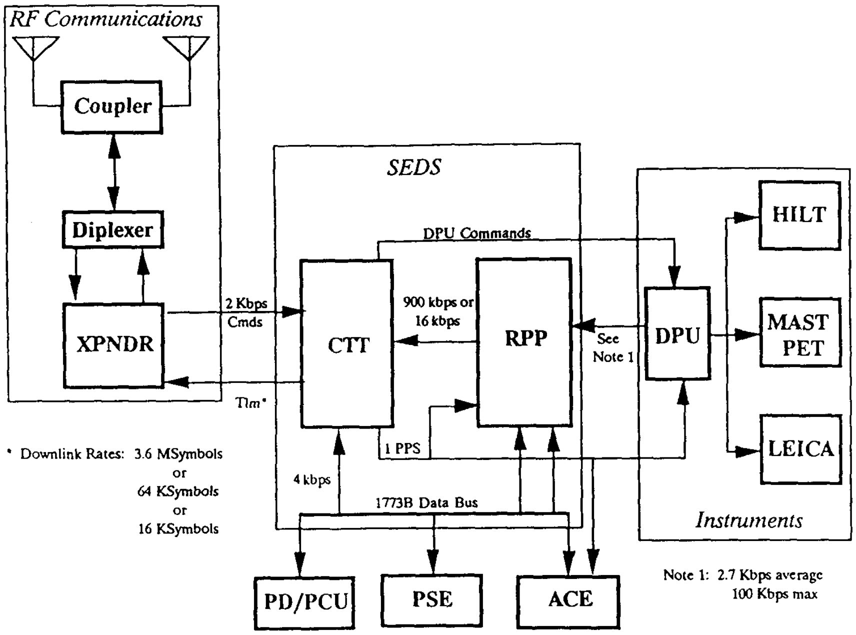


Fig. 6. The science instrument and major subsystem connectivity for the SAMPEX spacecraft.

operations and the coordination of ground system elements to ensure successful science data collection. Science operations for the SAMPEX mission can be described as routine (as opposed to missions which have a campaign or an interactive style of operations). There is no daily interaction between instrument representatives and the spacecraft, and instrument command functions for routine operations are performed by the onboard Data Processing Unit. The DPU is responsible for overall control of the science payload and controls the data acquisition from each instrument and packetizes science data for recording by the Small Explorer Data System. Instrument calibrations are performed on a periodic (~monthly) basis. Requests for special operations originate from instrument representatives and are transmitted to the Flight Operations Team using the University of Maryland Science Operations Center (UMSOC) as intermediary. The UMSOC is the primary point of contact between Flight Operations and the experimenters. Requests for special operations are transmitted to the Operations Team by means of the NASA Science Internet or by means of fax transmission.

Science data are recorded onboard the spacecraft in the SEDS. The details of the data sampling and recording scheme are described by Mabry *et al.* [4]. Science data recording is cycled between two recorder partitions, each recording approximately 12 hours of data. The data are played back twice per day at the Wallops Flight Facility (WFF) Orbital Tracking Station. Playback data quality statistics from ground system elements can be compared to spacecraft telemetry to verify the quality of the downlink. Should the recorder dump quality be unacceptably low, WFF support on the following orbit is then scheduled. Next-orbit playback opportunities are expected to occur approximately 40% of the time. If the second contract does not exist, cannot be scheduled, or if the dump taken at the second Wallops support is still not of acceptable quality, the data partition onboard the spacecraft will be released and the data lost. WFF transfers the data stream to the Goddard Space Flight Center (GSFC). The Packet Processor (PACOR) interfaces with the ground station via the NASA Communications System, and records all incoming data. All data transfers to PACOR occur during real-time contacts with the spacecraft or by playback from the ground station (see Fig. 7).

PACOR performs level zero processing on the incoming telemetry, and extracts the science data. It transmits the science data sets to the UMSOC in 24-hour blocks. The following list outlines the basic functions performed by PACOR:

- Data capture
- Transfer frame extraction from NASCOM blocks
- Checking of cyclical redundancy code
- Separation of virtual channels, packet extraction and reassembly
- Logging of received playback transfer frames to magnetic media
- Grouping and time ordering of data sets
- Deletion of redundant data
- Quality and accounting data generation
- Store and forward prepared data sets to users via electronic transfer

Data are transmitted via electronic links between the ground station and the POCC, the ground station and PACOR, and PACOR and the UMSOC. The data are stored on analog tapes at the ground station and on optical disk (short term) and magnetic tape (long term) by PACOR. UMSOC distributes the science data to all the co-investigators (Langley Research

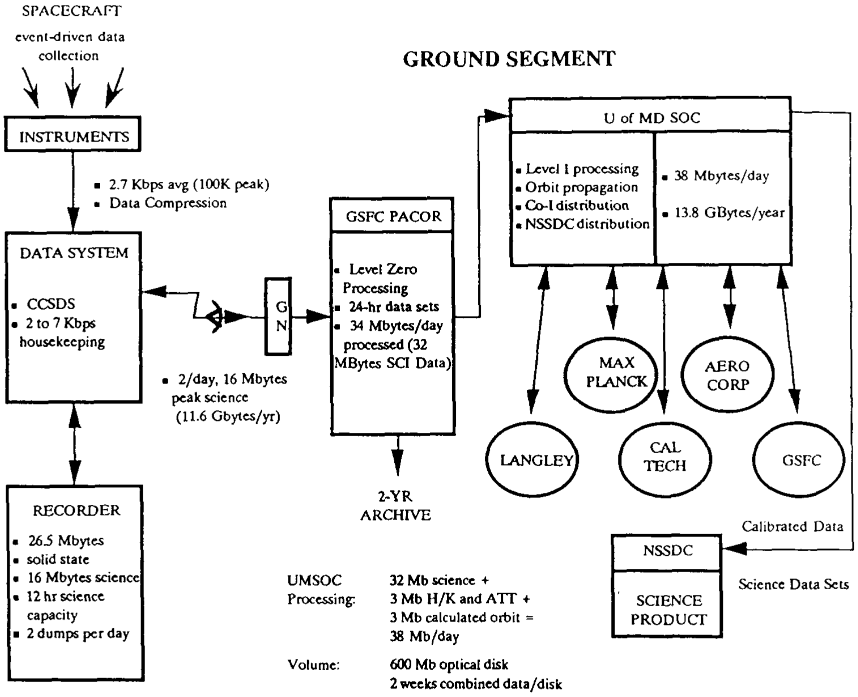


Fig. 7. The overall operational data flow from the SAMPEX spacecraft into the SMEX ground segment.

Center, Max Planck Institute, Caltech, Aerospace Corp, and Goddard Space Flight Center) and to the National Space Science Data Center (NSSDC).

WFF supports science data recorder dumps at 4, 16, and 900 Kbps downlink telemetry rate. The Deep Space Network sites only receive the 4 and 16 Kbps downlink telemetry rate. The Network anticipates station upgrades in 1993 which will allow for the 900 Kbps telemetry rate. The data are transmitted from the ground station to the POCC and PACOR on a 1.544 Mbps link. Level zero processed data are transmitted from PACOR to the UMSOC on a 56 Kbps link.

UMSOC delivers data to the instrument teams using a SAMPEX team standard which is called the tennis standard and is very compatible with the NASA/CCSDS packet standard used for the telemetry downlink and with the NASA/CCSDS Standard Formatted Data Unit. The instrument teams are encouraged to use the tennis standard for internal processing and for data returned to UMSOC for archiving and delivery to the NSSDC. The standard emphasizes self-documenting data structures and minimizes computer and operating system dependences. Monthly summary plots of the instrument performance and particle activity will be published in the U.S. Department of Commerce, National Oceanic and Atmospheric Administration publication, "Preliminary Report and Forecast of Solar Geophysical Data." During the 1-year period of proprietary data ownership, additional publications or data release will generally require the approval of the SAMPEX Science Working Group, with specific written approval provided by the SAMPEX Principal Investigator and the Project Scientist.

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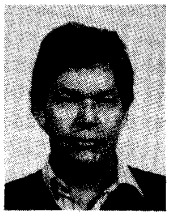

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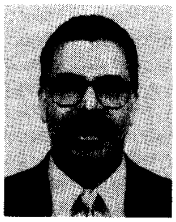

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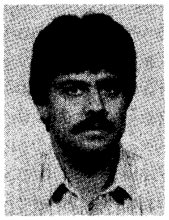
Throughout his career, Mr. Figueroa has received several awards for group achievements, outstanding performance and was awarded the NASA Outstanding Leadership medal in March 1993 for the management of the SMEX program during the successful development and launch of the Solar Anomalous and Magnetospheric particle EXplorer. He is a member of the International Academy of Astronautics.

G. Colon, photograph and biography not available at the time of publication.

J. G. Watzin, photograph and biography not available at the time of publication.



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