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DYNAMICS EXPLORER SPACECRAFT AND GROUND OPERATIONS SYSTEMS

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Abstract. The Dynamics Explorer program of NASA is designed to study the coupling of energy, electric currents, electric fields, and plasmas between the atmosphere, ionosphere, and the magnetosphere. The program is composed of two well instrumented polar orbiting satellites and ground operations and data handling systems which have been designed to acquire, process, and make readily available to the scientists of the program the data sets necessary for analysis to accomplish the science objectives. These systems are described with emphasis placed on the relationship of the two instrumented spacecraft and the ground systems to their roles in meeting the program requirements. In addition, the characteristics of the orbits selected are specified.

1. Requirements and Program Elements

The Dynamics Explorer program of the National Aeronautics and Space Administration (NASA) has been developed to investigate the strong interactive processes coupling the hot, tenuous, convecting plasmas of the magnetosphere and the cooler, denser plasmas and gases co-rotating in the earth's upper atmosphere, ionosphere, and plasmasphere.

To accomplish these investigations, the program must fulfill at least the following four measurement requirements that have not been included in previous programs:

(1) Three-component measurements of dc electric fields with global coverage.

(2) Three-component measurements of the velocity vector of the neutral winds in the upper ionosphere.

(3) Comprehensive measurements of vector magnetic fields, plasmas, suprathermal particle distribution functions, neutral gas parameters, characteristic light emissions, and plasma waves, simultaneously with the measurements of electric fields and neutral wind velocities.

(4) Frequent measurements of the field and plasma parameters simultaneously at two altitudes on or near common magnetic field flux tubes.

The measurement requirements, in turn, lead to the four basic elements of the program:

- instrument complement to meet specific science objectives,
- dual satellites in polar orbits,
- science investigation-oriented operations,

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– interactive ground data system.

The first element assures the acquisition of the data sets that the scientists associated with the program will use in their analyses to accomplish the objectives. Two new instruments along with instruments evolved from previous programs will provide a comprehensive set of measurements for assessing atmosphere-ionosphere-magnetosphere couplings.

The second element provides accommodations for the instrument in orbits which allow the instruments access to the significant regions of the near space environment, and especially the capability of measurements at two altitudes on or near common magnetic field flux tubes.

As the orbits of the two spacecraft rotate in local time, precess and decay throughout the mission, different science investigations will become possible. To take full advantage of the simultaneous observational opportunities that will exist using both spacecraft, their operations will be closely coordinated to achieve data sets for the resolution of specific scientific questions, which is the essential third element. Coordination of operations with those of various ground observatories, rocket flights, and other satellites will add to the data base for many of the scientific investigations.

Current problems in space plasma physics require extensive measurements of the plasma characteristics for their solution. For processing and making available to the scientists multiparameter data sets derived from a number of instruments, the Dynamics Explorer project will use the Atmosphere Explorer ground data system, expanded and upgraded to an interactive ground data system with enhanced graphics capabilities, the fourth element.

These four elements will be described in more detail with emphasis placed on the relationships of these spacecraft and ground systems to their roles in meeting the program requirements.

2. Instrument Overview

The instrument complement for both spacecraft is listed in Tables I and II. The instruments fall into five categories related to the measurements listed in the overview article [1]: thermal ions, thermal neutral particles, suprathermal particles, fields, and optical remote sensing. In addition, the VLF transmitter located at Siple, Antarctica, is a required ground based instrument.

The two instruments utilizing new techniques for scientific satellites are the Spin-Scan Auroral Imager and the Fabry-Perot Interferometer, both optical remote sensing instruments. The remaining instruments are primarily derived from the International Sun Earth Explorer (ISEE) program [2] and the Atmosphere Explorer (AE) program [3]. The Plasma Wave Instrument on the high altitude mission contains a special receiver for the controlled and naturally occurring wave-particle interaction investigations. The Low Altitude Plasma Instrument resides on a single-axis scan platform which will be used primarily to adjust the detector array to the inclination of the magnetic field. Each instrument is described in detail in other articles in this issue.

TABLE I

Instruments for the high altitude mission (DE-A)

Instrument	Acronym	Instrumentation	Measurement	Investigator
Magnetometer	MAG-A	Three axis fluxgate	Vector magnetic field	M. Sugiura
Plasma wave instrument	PWI	Variety of antennas and receivers	Electromagnetic waves Electrostatic waves DC Electric fields	S. Shawhan
Spin scan auroral imager	SAI	Three scanning photometers	Visual and UV global auroral images	L. Frank
Retarding ion mass spectrometer	RIMS	Retarding potential analyzer with mass spectrometer	Thermal ion density, temperature bulk velocity. Ion composition	C. Chappell
High altitude plasma instrument	HAPI	Five electrostatic analyzers	Ion and electron fluxes to 30 keV	J. Burch
Energetic ion mass spectrometer	EICS	Energetic ion mass spectrometer	Ion composition to 17 keV	E. Shelley

TABLE II

Instruments for the low altitude mission (DE-B)

Instrument	Acronym	Instrumentation	Measurement	Investigator
Magnetometer	MAG-B	Three axis fluxgate	Vector magnetic field	M. Sugiura
Vector electric field instrument	VEFI	Triaxial double probes	Vector electric field Variational electric field	N. Maynard
Neutral atmosphere composition spectrometer	NACS	Quadrapole mass spectrometer	Neutral composition and density	G. Carignan
Wind and temperature spectrometer	WATS	Retarding potential quadrupole mass spectrometer	Vertical, zonal and meridional components of neutral wind	N. Spencer
Fabry-Perot interferometer	FPI	Flat plate interferometer with zenith angle scan	Drift and temperature of neutral and ionic atomic oxygen	P. Hays
Ion drift meter	IDM	Collimated ion trap with segmented collectors	Components of ion drift normal to spacecraft velocity	R. Heelis
Retarding potential analyzer	RPA	Retarding potential analyzer	Thermal ion density, temperature, irregularities. Ram component of ion drift	W. Hanson
Langmuir probe	LANG	Cylindrical electrostatic probes	Electron temperature and density, ion density, irregularities	L. Brace
Low altitude plasma instrument	LAPI	15 electrostatic analyzers and two Geiger counters	Ion and electron distributions to 30 keV. High energy monitors	J. Winningham

3. Spacecraft Systems

3.1. GENERAL DESCRIPTION

The Dynamics Explorer spacecraft are modified versions of the AE-C, -D and -E spacecraft, and are being built by the Astro Electronics Division of RCA in Princeton, New Jersey. Considerable modifications were required to accommodate the variety of booms and antennas related to the instrumentation and to provide an electromagnetically clean environment for the various wave and field measurements.

The two spacecraft (DE-A and DE-B) will be launched in a stacked configuration on a Delta 3913 launch vehicle with a TE-364-14 third stage, as shown in Figure 1. The required coplanar polar orbits are achieved by first inserting the stack into the DE-B orbit of 305 km by 1300 km using the first two stages, and separating the B spacecraft. After

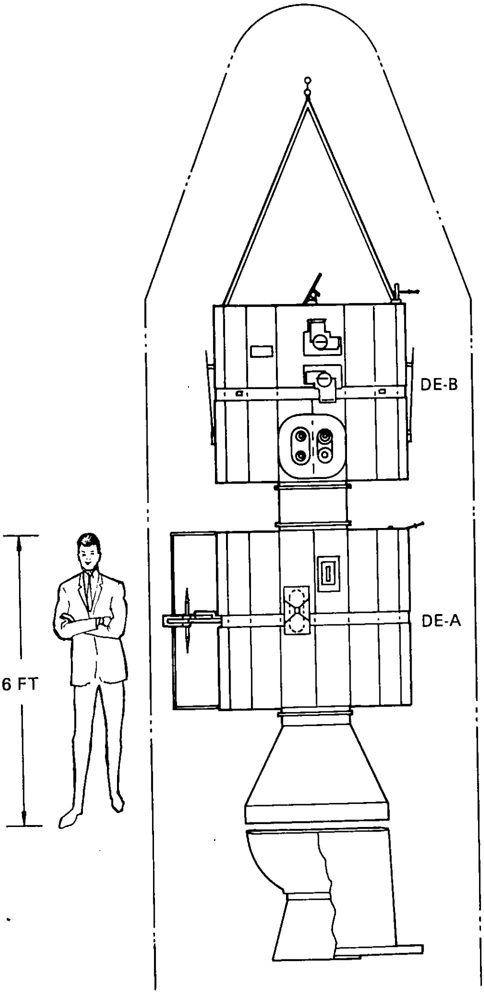

Fig. 1. Dynamics Explorer stacked launch configuration.

activating the spin table on the third stage, this solid rocket then lifts the DE-A spacecraft into its highly elliptical orbit.

The general form of each spacecraft is a short (1 m) polygon with a diameter of about 1.4 m as illustrated in the frontispiece (artist's conception). Internally, a central column supports two parallel integral baseplates which provide mounting surfaces for the instruments and spacecraft subsystems. The basic structure is enclosed with panels and end plates which support the solar cells and thermal-control devices. Two adjacent sides of the polygon are combined into one flat surface to facilitate mounting those instruments on DE-B which require orientation in the direction of motion. The system design and moments of inertia ratios locate the spin axis coincident with the polygon axis. The weights of the A and B spacecraft are 409 and 403 kg respectively.

3.2. INSTRUMENT ACCOMMODATIONS

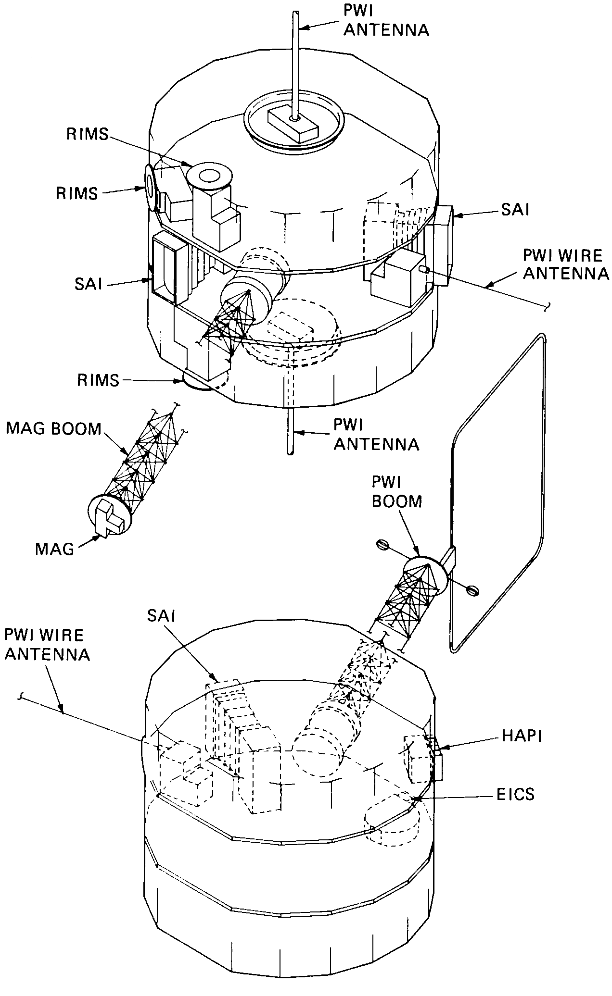

Fig. 2a. Isometric drawing of DE-A.

The wide diversity of instrument requirements with respect to pointing directions and fields-of-view constrained the mechanical configurations of both spacecraft. Figure 2a shows the physical layout of DE-A isometrically; Figure 2b identifies the pointing direction of each sensor with respect to the $+X$ spacecraft axis. The requirement for long wire antennas on DE-A for electric field measurements dictates that the spacecraft be spin stabilized. Therefore, those instruments requiring angular scanning are distributed about the perimeter of the spacecraft according to field-of-view constraints. The three photometers of the Spin-scan Auroral Imager are separated by about 120° to allow sequential scanning of the earth. The $\pm Z$ axis tubular antennas are mounted directly on the spacecraft Z axis to eliminate the effects of centrifugal force on the antennas. To minimize interfering fields from the spacecraft, the Magnetometer and remaining plasma wave antennas are mounted on six meter Astromast booms which are phased 90° from the wire antennas to balance the moments of inertia.

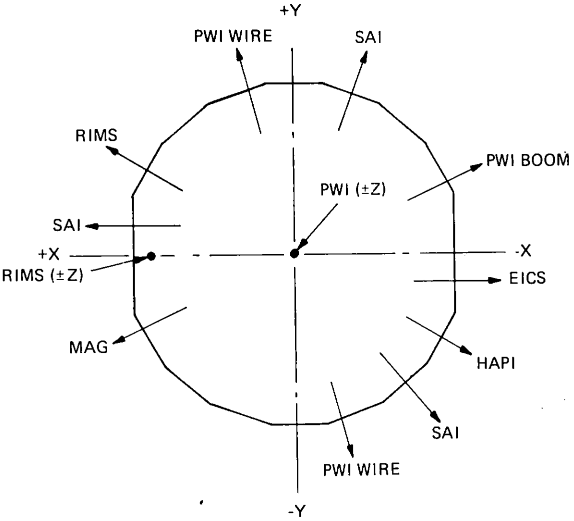

Fig. 2b. Sensor Directions on DE-A.

Since DE-B contains no wire antennas but has four instruments which require alignment nearly along the spacecraft velocity vector and one instrument which requires a fixed earth reference orientation, the attitude is maintained in a nadir pointing (one revolution per orbit) mode. As shown in Figure 3a these instruments are clustered on the $+X$ axis, which is aligned with the velocity vector at perigee and apogee and offset by a maximum of 4° over the remainder of the orbit due to its ellipticity. The Fabry-Perot Interferometer is tilted 15° toward the Earth in the normal orientation of the spacecraft (Figure 3b) so that its optics can scan the altitude region ahead of and below the spacecraft. The Low Altitude Plasma Instrument is mounted on a single axis scan platform on the $+Z$ axis, with the detectors projected away from the spacecraft body so that they scan in the X–Y plane. This scan platform accommodation leads to the $\pm Z$ axis tubular antennas of the Vector Electric Field Instrument being located near the

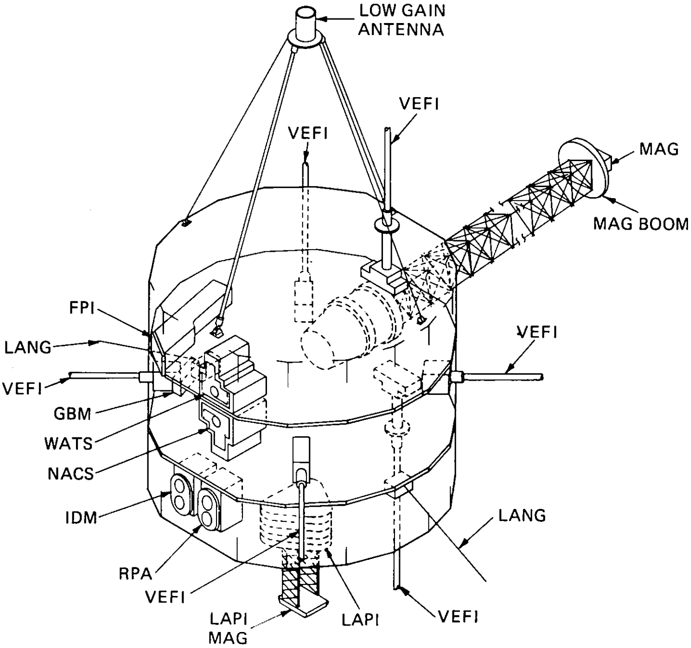

Fig. 3a. Isometric drawing of DE-B. GBM is the galactic background monitor.

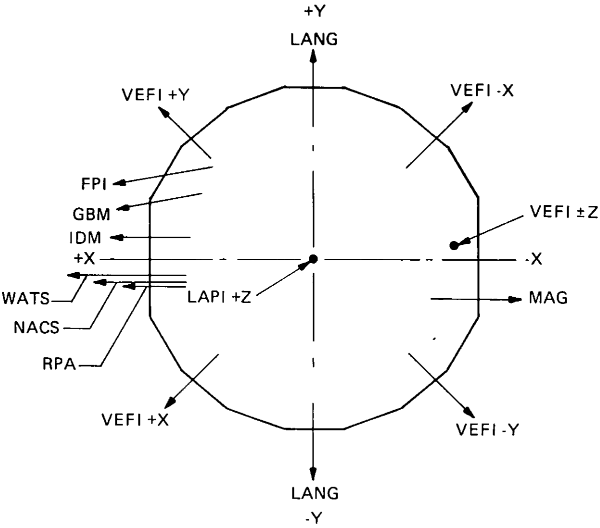

Fig. 3b. Sensor Directions on DE-B.

periphery of the spacecraft. The remaining orthogonal antennas are oriented 45° to the spacecraft X and Y axes to allow field-of-view clearances for the $+X$ directed sensors. The wake region along the $-X$ axis is used for the six meter Astromast to mount the Magnetometer sensors. In addition to the 1 RPO mode, DE-B has a slow spin calibration mode. The spin rate is limited by the centrifugal force on the offset ±Z axis tubular antennas to about 1 revolution per minute.

The radiation environments for the spacecraft have been evaluated for a mid-1981 launch utilizing minimum drag orbit parameters, the radiation dosage models developed by E. Stassinopoulos of the Goddard Space Flight Space Center and RCA's UNIDOSE program. The resulting dosage versus shielding curves were then utilized to develop component shielding requirements consistent with a mission design life of greater than 1–1/2 yr and with weight constraints.

3.3. POWER

The basic power source for each spacecraft is the solar cell array mounted on the sides and end panels. The solar array charges two six ampere-hour nickel-cadmium batteries. These batteries provide electric power during the launch phase, in eclipse and as a supplement to the array during peak loads. Solar array generated power is conditioned to provide an unregulated negative polarity load bus, a regulated −24.5 V instrument bus and a pulse load bus. The polarity was selected to permit a negative potential for the solar array which achieves the stability of the satellite potential against the natural plasma medium necessary for thermal charged particle measurements.

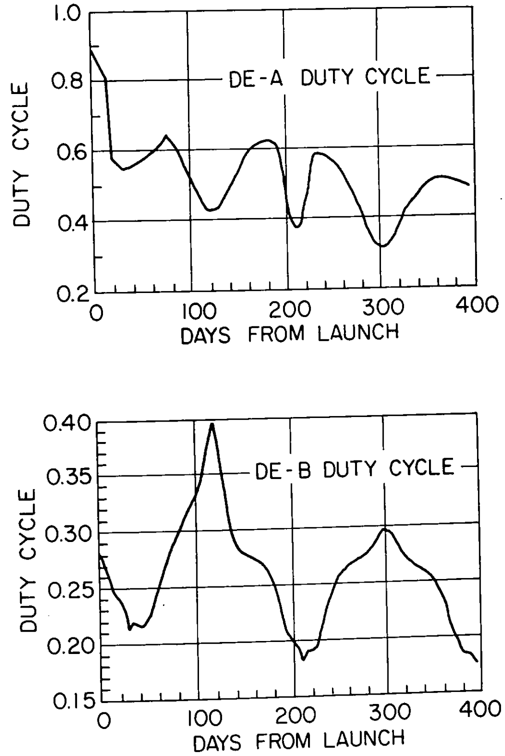

Fig. 4. Average duty cycles for DE-A and B based on energy balance per orbit.

Computer simulations of the power system performance taking into account the orbit and sun angle history, solar-array output power and degradation, and the depth of battery discharge/charge current magnitude were conducted to determine the nominal instrument duty cycle as a function of the time of year after launch. The results of this analysis indicate the available yearly average instrument 'on' time for DE-A is about 50% with a minimum of 35%, and, for DE-B, a yearly average of about 25% with a minimum of 18%. Figure 4 shows the computed available science instrument duty cycle for the first 400 d after launch for each spacecraft.

3.4. THERMAL CONTROL

The spacecraft thermal control approach combines passive (paints and insulation) and active (thermal louvers and heaters) systems to attain thermal balance in orbit within the design objective of 0 to + 25 °C for both spacecraft. The design is somewhat different for each spacecraft since the three-axis stabilized DE-B can be maneuvered using magnetic torquing coils to reorient one end of the spacecraft away from the sun at all times. That end of the DE-B spacecraft contains four thermal louvers each activated by a bimetallic actuator to provide a thermal interface to deep space. A spacecraft inversion maneuver, to be executed every six months, inverts the Y axis of the spacecraft; as a result, the Fabry-Perot Interferometer will unavoidably be tilted 15° away from the earth for six months out of every year.

In contrast, the large moment-of-inertia created by the two wire antennas, the two six meter booms and a 10 RPM spin rate makes a 180 deg yaw maneuver impractical for DE-A. Therefore, six thermal louvers have been placed behind the solar array on each end of the spacecraft to provide active thermal control independent of solar aspect.

3.5. COMMUNICATION/COMMAND AND DATA HANDLING

A simplified block diagram of the DE spacecraft communication and data handling system is shown in Figure 5. Each spacecraft utilizes a pulse code modulation data

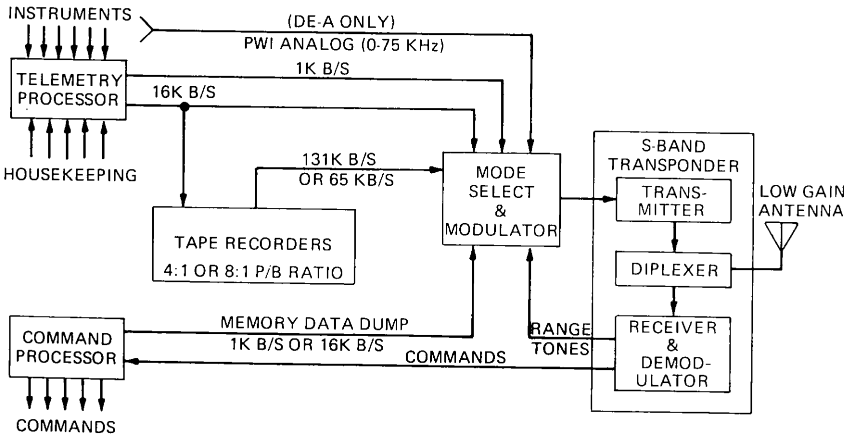

Fig. 5. Block diagram of the DE communication and data handling system.

system with 128–8 bit words at a main frame rate of 16 frames per second and subcommutation rates of 4 and 8 s. The primary data rate is 16 384 bits per second. In addition a 1024 bit per second data stream containing a subset of the primary mission data is utilized for monitoring instrument and spacecraft housekeeping information and attitude data, and for command verification. Command memory management is supported by inserting command memory data into either data stream. Two tape recorders each having a capacity of 2.4×10^8 bits are included in each spacecraft allowing four hours of recording on each unit. The recorded primary data rate is played back through telemetry to the NASA tracking and data acquisition sites at a speed ratio of 8 : 1. A playback to record ratio of 4 : 1 is also provided for additional operational flexibility. Unique to the DE-A spacecraft is a 650 Hz to 75 kHz analog channel for the Plasma Wave Instrument which directly modulates the telemetry carrier.

The command system provides 512 relay drive and logic level control commands which are transmitted to the spacecraft at a 1000 bits per second rate. Time delays up to 72 h can be programmed for remote execution of commands with time increments as small as 4 s. Using this command memory capability and the ample tape recorder capacity, science instrument operations may be programmed for specific orbital locations many orbits in advance without intervening ground station contacts. The prime operational mode for each spacecraft will utilize this stored command capability.

An S-band transponder combines command reception, ranging, and telemetry transmission on each spacecraft. Appropriate premodulation processors and mode selection circuitry are provided to configure the spacecraft to the desired telemetry mode. The DE-A utilizes a biconical dipole linearly polarized antenna which provides a toroidal antenna pattern and is mounted on a deployable mast to accommodate the stacked launch configuration. The DE-B utilizes a bifilar helix circularly polarized antenna mounted on a guyed bipod support to provide a broad toroidal pattern.

3.6. ATTITUDE CONTROL SYSTEM

The DE-A spacecraft is spin stabilized at 10 ±0.1 RPM with the spin axis antiparallel to the orbit normal and maintained to ± 1 deg. The attitude of the spacecraft is measured by V-mounted body horizon scanners. These horizon scanners, sensitive to the 14–16 μ (CO_2) band, will measure the earth horizon crossing envelope relative to the local vertical within ±0.2 deg. Additional attitude information and horizon scanner calibration data are provided by sun sensors to an accuracy of ±0.25 deg. The output of the horizon sensors is used to generate a nadir sync signal. Spacecraft orientation and spin rate will be maintained by air-core magnetic coils that are pulsed at the appropriate times to interact with the earth's magnetic field to provide required control torques. Nutation damping is provided by a liquid-filled loop damper. Damping of pitch disturbances resulting from non-rigid behavior of the wire antennas and the spacecraft core is provided by a second liquid-filled loop damper.

The DE-B spacecraft uses a rotating wheel momentum bias system for stabilization and control. A momentum bias of 30.73 newton-meter-sec. provides inertial stiffness of the spacecraft pitch (Z) axis, and magnetic torquing is used to maintain this axis to within

1 degree of the orbit normal. Rotation about this axis is controlled using earth horizon sensors to point the yaw (*Y*) axis to within 1 degree of parallel or anti-parallel to the nadir (or zenith). Ground commands may select other orientations about the pitch axis in 0.35 deg increments. The spacecraft can also be operated in a slow scan mode (1 RPM) in support of the science mission. Infrared momentum wheel-mounted horizon scanners and body-mounted solar aspect sensors will provide spacecraft attitude sensing to within 0.2 to 0.3 deg in each axis. The earth crossing envelope relative to the local vertical will be measured also by the horizon sensors to ±0.2 deg. Additional calibration information will be supplied from sun sensors accurate to ±0.12 deg. Passive and active damping will control spacecraft nutational oscillations induced by vehicle separation, aerodynamic drag, and other disturbing forces.

Attitude data telemetered from each spacecraft are stripped, formatted and transmitted to the IBM 360/95 Multi-Satellite Attitude Production System computer at the Goddard Space Flight Center (GSFC) for processing. There, the spacecraft attitude sensor data are combined with previously computed orbit ephemeris and sensor calibration data and processed to provide definitive attitude information with a 3-sigma accuracy of 0.4 deg for all three axes on DE-A and 0.7 deg in roll and yaw, and 0.5 deg in pitch for DE-B. Data are processed on an orbit by orbit basis and accumulated for a full day before being transferred to the Science Data Processing System at the GSFC for use in the science investigations.

3.7. Electromagnetic compatibility (emc)

The diversity of the instrumentation necessary to make the required science measurements posed significant problems with respect to the electromagnetic compatibility of the spacecraft and instruments and electrostatic control. The AE spacecraft, from which the DE spacecraft evolved, was significantly less constrained in this area due to the absence of fields instrumentation and the higher electron density in their low orbits. Therefore, a set of requirements more stringent than those imposed on the AE spacecraft and instruments (which were essentially MIL-specification) was developed.

Several of the spacecraft subsystems, as well as instruments on both DE-A and DE-B, employ motor driven components which generate significant interference beyong the normal, passive background environment of the spacecraft. Since there is no acceptable way to shield the dc magnetic fields generated by these devices, it is necessary to mount the magnetometer sensors away from the spacecraft on six meter booms. Magnetic testing has verified that the magnetometers are unaffected by spacecraft and/or instrument magnetic fields.

To control the variation of electric potentials on the surface of the spacecraft, it is important to insure that the external potential of the spacecraft be as uniform as possible. A 'bare area criterion' was developed which dictated that conducting material, at spacecraft structure potential, be exposed to the ambient plasma in as uniform a distribution as possible over the spacecraft surface, thereby attempting to approximate an equipotential surface. This uniformity was achieved to within a factor of two among the solar array facets on DE-A. Bypass resistors are used in parallel with the solar array isolation diodes to minimize the potential differences among solar array strings due to shadows on the array from the spacecraft appendages.

AC fields are considerably more difficult to minimize. Sources of potentially interfering ac fields are contained close to the source and away from the sensitive external antennas of the fields instruments to the extent that was practical. Operating frequencies for sources such as power converters were chosen to minimize interference. A design for separating the power, signal and chassis grounds was developed to minimize multiple ground paths, thereby controlling currents flowing in the spacecraft structure. Exceptions to this design were treated on a case by case basis. In addition, a detailed harness shielding design was implemented to shield radiated electric fields and to minimize radiating current loops.

Finally, care was taken to decouple the solar array from the spacecraft generated noise. Specifically, the solar array connections are filtered and a solar array disconnect switch is included to allow for short periods of operation solely on the internal batteries. Solar array bypass diodes are included to minimize the efficiency of the solar array as a radiating antenna, and the array was backwired where possible or compensation loops were used externally. All gaps and instrument apertures are sealed with RF gaskets and the solar cell tabs are painted with an insulator to prevent exposed potentials from contacting the ambient plasma. To further reduce the spacecraft interference levels, three of the Plasma Wave Instrument sensors are mounted on a six meter boom.

Since sources of electromagnetic interference cannot be entirely eliminated from the instruments and spacecraft subsystems, a detailed, conducted emissions test was carried out during spacecraft integration. During this test, ac signals on spacecraft grounds, power lines, and certain other cables were spectrally analyzed in conjunction with a careful analysis of instrument data for a wide variety of operating modes. The results of this test provided a clear indication of the residual sources of electromagnetic interference. These data provided a basis for modifications to the spacecraft harness during integration intended to minimize these sources, as well as a 'road map' to aid in the identification of interference sources found during the traditional electromagnetic compatibility testing of the integrated spacecraft.

TABLE III

Orbit parameters

	High altitude spacecraft	Low altitude spacecraft
Apogee, km	24 875[a]	1300
Perigee, km	675	305
Inclination, deg	90	90
Orbital period, min	440	101
Local time of initial perigee, hr	14.0	02.0
Latitude of initial perigee, deg	80 S	25 S
Rate of change of latitude of perigee, deg/day	−0.298	−3.34
Lifetime, months, nominal	$\rangle$36	25.7

[a] 4.9 R_E geocentric.

4. Orbit Characteristics

Many of the criteria which influenced the selection of the orbits of the spacecraft are specified in the preceding article [1]. After extensive trade-off studies the orbital parameters in Table III were selected.

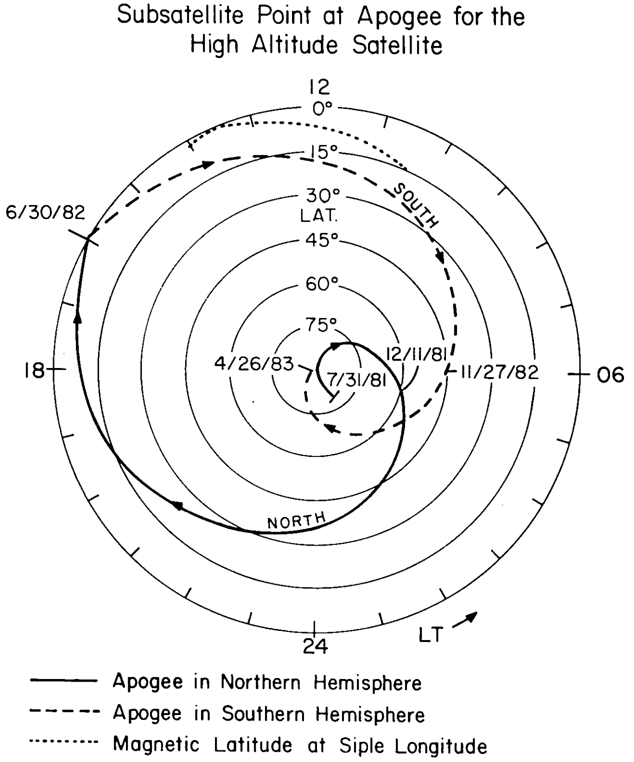

Fig. 6. Locus of apogee as a function of time in local time, latitude coordinates for DE-A. The orbit plane is defined by a line through an apogee position and the pole.

The apogee and perigee histories as a function of latitude and local time are displayed in Figures 6 and 7 for the high and low altitude spacecraft, respectively. These show that apogee of the high altitude spacecraft will pass over the north pole one month after launch and swing through the pre-midnight hours at fairly low latitudes. It will cross the equator during the afternoon and pass through the morning hours at mid-southern latitudes. However, the magnetic latitude of apogee, when on the Siple, Antarctica, meridian, will be about 12° north of the geographic latitude, so that magnetically it will remain near-equatorial well into the morning hours. Apogee will reach high southern latitudes during the southern winter of 1983.

The rate of change of latitude of perigee of the low-altitude spacecraft will be over 10 times that of the high altitude spacecraft, so that a pole-to-pole latitude scan of perigee will require less than 2 months. For neutral atmospheric measurements orbital sectors below 500 km near the noon-midnight meridian over the northern polar region will occur

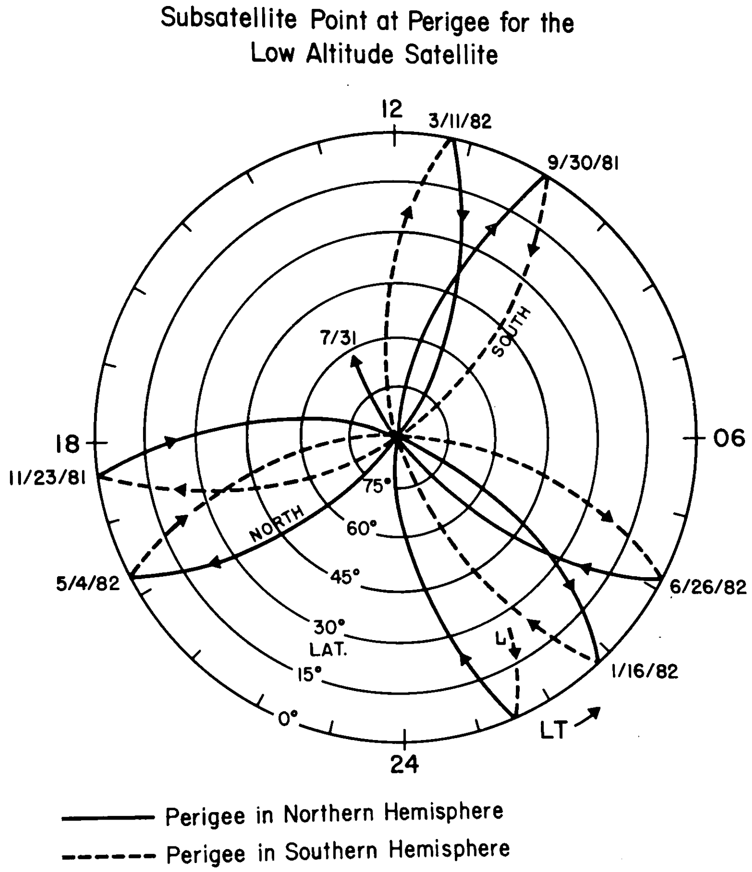

Fig. 7. Locus of perigee as a function of time in local time, latitude coordinates for DE-B. The orbit plane is defined by a line through a perigee position and the pole.

at the beginning of the mission. Nearly dawn-dusk orbital sectors in the same region will occur during northern winter.

During the first month after launch, limited science data will be acquired. This period will be utilized to acquire proper spacecraft attitude, activate instruments, deploy booms and antennas, and verify operational procedures. At the beginning of science operations, emphasis will be placed on northern polar phenomena, since the apogee of DE-A as well as perigee of DE-B will be over the north pole, allowing neutral particle measurements in this region while monitoring global auroral emission patterns.

5. Operations

Two basic mission characteristics have dictated the need to establish procedures for detailed operations planning: operations for each spacecraft will be power constrained, and instrument operations will continuously change over the life of the mission as the primary science investigations change.

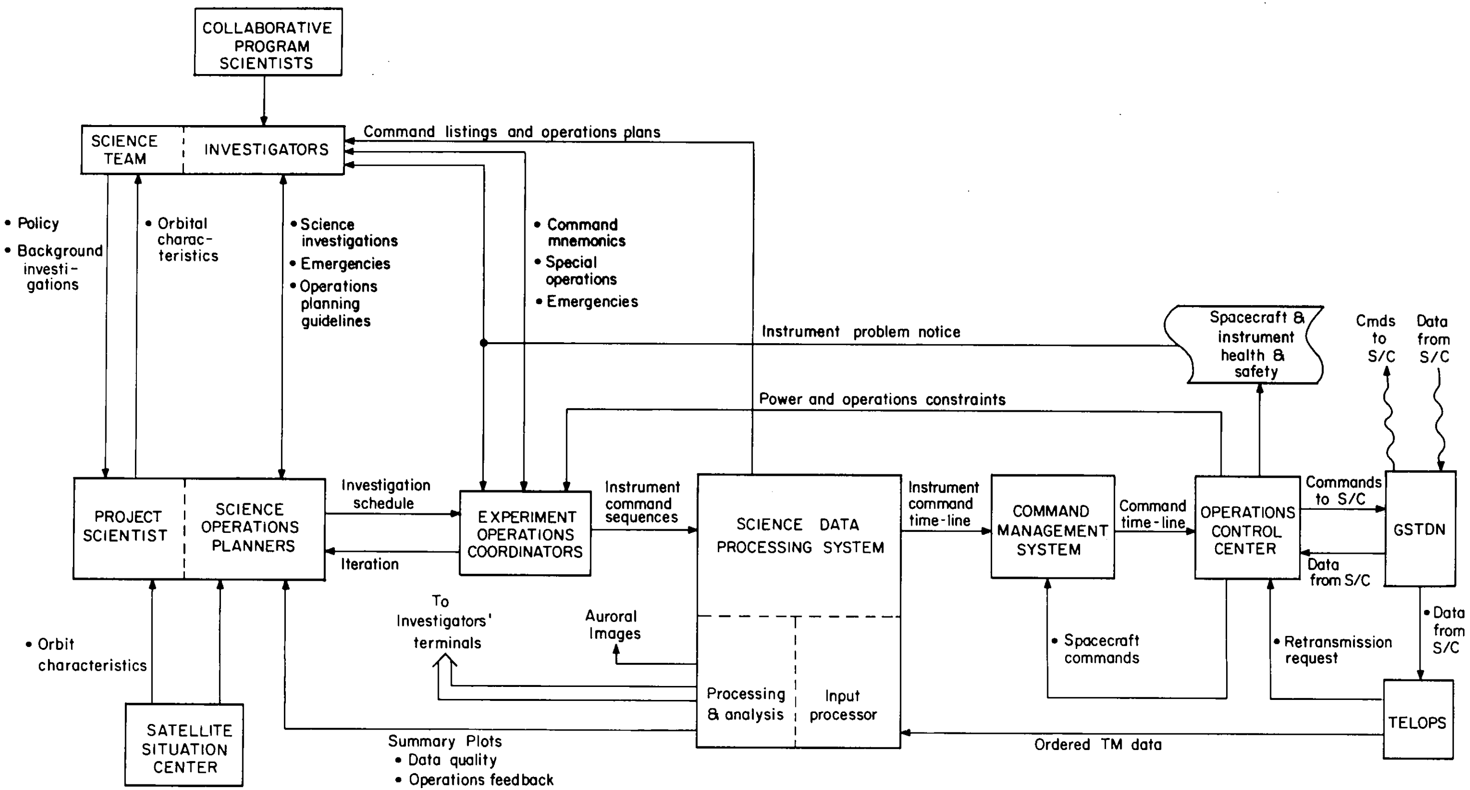

Fig. 8. Operations planning and data flow schematic.

Figure 8 illustrates the operations planning and data flow at the GSFC. At its meetings, the Science Team, composed of the investigators [1], establishes the operations policies, primary science investigations and operations priorities. These investigations emphasize the regions of special importance for the period, such as the auroral acceleration region, Siple operations, neutral wind data regions for neutral models, etc., with instrument clusters, modes of operations, and operations priorities. The Project Scientist and lead investigator for each investigation interpret these plans for the Science Operations Planner, who also receives special investigations from individual investigators. These planning activities are assisted by the Satellite Situation Center of the National Space Science Data Center, which determines conjunctions between spacecraft and with ground facilities based on predicted orbit data, satellite movement through regions of space defined by simple models, and orbital characteristics useful for planning. The Science Operations Planner merges the science investigation plans and the special investigations, such as overflights with collaborating facilities, rocket campaigns, other spacecraft conjunctions, etc., with the predicted orbital characteristics and produces daily investigation schedules, utilizing the operations priorities.

The Experiment Operations Coordinators analyze the daily investigation time lines in detail for inconsistencies with spacecraft and ground operation constraints and then convert them to instrument command sequences. In preparation for this task, they develop the command mnemonics pertaining to the various operational modes of the instruments with the instrumenters based on the requirements of the investigations. The Experiment Operations Coordinators access software in the Science Data Processing System (SDPS) to compile the instrument command sequences, which are accessible for review on remote terminals at the investigators' facilities. Thus, the investigators can submit suggestions for modifications to the operations plans for the next operations period. Planning is performed in half-weekly intervals about 10 to 12 days in advance. For very special situations, such as unusual geophysical events or emergencies, this planning sequence can be greatly accelerated.

After the instrument command sequences are merged with the spacecraft commands in the command management system, the operations plans are reviewed in the Operations Control Center in light of the spacecraft status. Should any spacecraft systems or ground facilities be unable to support the plans, the Experiment Operations Coordinator office is notified and the operations priorities are utilized again to reconcile the differences. The Operations Control Center transmits the command sequences to the spacecraft through the Ground Spaceflight Tracking and Data Network (GSTDN) stations.

6. Data Acquisition and Processing

Telemetry from both spacecraft will be received by the GSTDN ground station network where it is formatted into blocks for transmission over high speed data lines to the GSFC. As data are acquired through the GSTDN, the Operations Control Center monitors the status of spacecraft subsystems and engineering parameters from the instrumenters –

a first order health and safety monitor. The telemetered data are captured and stored in the Telemetry On-Line Processing System (TELOPS), a computer controlled mass storage, which also inverts the spacecraft tape recorded data to the normal sequence and performs data quality checks. Retransmission of data can be requested through the Operations Control Center. Data are transferred to the input processor of the SDPS in 24 hour batches [4]. The input processor performs additional quality checks, attaches Universal Time to the data, and strips out attitude data for transmission to the attitude determination computers.

The SDPS is a central computer facility composed of a Xerox Sigma-9 accessed by several types of graphics terminals at the investigators' facilities [4]. The Sigma-9 provides seven functions to the user community: (1) access to the telemetry data bases, (2) the creation of summary plots, which are common time-scale plots of data from the instruments, (3) processing of the data to create Mission Analysis Files (MAFs), a data base of processed data, (4) storage of and access to the MAFs, (5) interactive analysis, (6) creation of graphics displays, and (7) miscellaneous support functions. The facility will be augmented by an IBM 4341 analysis computer, designated the Mission Analysis Computer System (MACS), to provide vastly increased on-line storage for the MAFs and a considerable improvement in computer power to support the interactive analysis.

The MAFs are the primary data base used by the Science Team for scientific interpretation. The data base management system allows for scanning a central directory via the terminals to initially sort and select data for scientific investigations. The selected data sets will then be accessed by the terminals and further analyzed interactively or, in some cases, transferred to a computer-assisted terminal for detailed analyses. The system is also designed to allow uninterrupted access to the Atmosphere Explorer data in the Sigma-9 computer during the Dynamics Explorer mission.

The summary plots are being developed for three purposes: (1) most importantly, for the identification and selection of time periods or events for detailed analysis, (2) as a first order quality check of data from the instruments, and (3) as feedback for operations planning. The plots will contain unverified data in geophysical units on common time scales from all but the auroral-imaging instrument. These plots on microfiche will be duplicated, then distributed to the investigators and other appropriate scientists. The auroral image data will be processed off-line at the University of Iowa and returned to the Sigma-9 for storage and the generation of microfilm plots for distribution.

The graphics display terminals (vector, grey scale, or color) and hard-copy units at each investigator's facilities are tailored to the specific needs of the individual investigator. Many of the terminals will be associated with minicomputers. Commonality in plot formats and mobility of programs between investigators' facilities are being stressed during software preparation.

Many of the data displays for analysis and for archival purposes will be recorded on 35-mm microfilm and on microfiche. For timely production, an Information International Incorporated FR-80 micrographics unit with grey scale and color capability has been obtained for the SDPS.

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