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AEROSPACE PAYLOAD SUPPORT SYSTEMS

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"This Technical Report has been reviewed and is approved for publication"

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report describes engineering support systems developed under Contract No. F19628-81-C-0029 for sounding rocket and shuttle payloads. Contract efforts included the mechanical and electrical design, fabrication, integration, testing and launch support of a variety of payloads and related ground support equipment. Specific work areas included: payload structures, component packaging, deployment and eject mechanisms, diagnostic instrumentation, in-flight sequencing, power systems and control consoles.

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ILLUSTRATIONS

1.0 INTRODUCTION

Summarized in this report is the work effort performed under Contract No. F19628-81-C-0029 from 15 February 1981 to 7 May 1987. This contract was a continuation and extension of efforts initiated under five previous contracts - i.e., AF19(628)-4361, F19628-67-C-0223, F19628-70-C-0194, AF19628-73-C-0152 and F19628-76-C-0152. The accomplishments of the previous five contracts can be found in References 1 through 9 of this report.

The next section defines the specific projects funded on the contract and addresses the unique aspects of the payloads. Section 3.0 describes developments on typical payload sub-systems applicable to many of the projects. Integration and testing are discussed in the final section.

2.0 PROJECTS

A total of 26 projects were funded during the term of the contract and the level of effort ranged from total project coordination to providing individual modules or sub-systems to be integrated into payloads. The following sections describe projects in the sounding rocket payload and shuttle payload categories. Table 1 presents a project summary indicating the final disposition or status. Contract personnel participate in conceptual design, technical coordination, final design, design review meetings, assembly, wiring, testing, launch support and data evaluation.

TABLE 1

PROJECT SUMMARY

PROJECT	PROGRAM	SECTION	STATUS
A24.609-3	MSMP TEM	2.1.1	LAUNCHED 5/27/82
A30.175	FWIF	2.1.2	LAUNCHED 11/7/81
A30.276	FWIF	2.1.2	LAUNCHED 4/12/83
A30.579	HIRAM	2.1.2	SCHEDULED 10/87
A10.901-2	SPE	2.1.3	LAUNCHED 10/26/81
A10.901-3	SPE	2.1.3	ASSIGNED TO COLDR
A10.901-4	SPE	2.1.3	ASSIGNED TO COLDR
A25.609-4	MSMP HPTEM	2.1.4	DELIVERED 9/9/83
A25.609-5	MSMP HPTEM	2.1.4	DELIVERED 9/9/83
A13.277	TRACER	2.1.5	LAUNCHED 6/29/82
A20.123-1	BIME	2.1.6	LAUNCHED 9/8/82
A20.123-2	BIME	2.1.6	LAUNCHED 9/13/82
A31.200	SES	2.1.7	LAUNCHED 3/18/83
A11.074	STATE	2.1.8	LAUNCHED 6/15/83
A20.327-1	IMS	2.1.9	LAUNCHED 11/14/83
A20.327-2	IMS	2.1.9	LAUNCHED 10/31/83
A21.426	PIIE	2.1.10	LAUNCHED 3/14/85
A19.250-1	BERT	2.1.11	LAUNCHED 6/14/85
A21.628	POLAR ARCS	2.1.12	LAUNCHED 2/26/85
A24.570	EXCEDE III	2.1.13	PRELIMINARY DESIGN
A24.602	BEAR I	2.1.14	DESIGN COMPLETE
A12.629	COLDR	2.1.15	DESIGN COMPLETE
AFGL-804A	SETS I	2.2.1	LAUNCHED
	CLEOS	2.2.2	CANCELLED
AFGL-305	LAIRTS	2.2.3	CANCELLED
AFGL-806	IMPS	2.2.4	PRELIMINARY DESIGN

2.1 Sounding Rocket Projects

Typical sounding rocket payload support systems provided by this contract include: power distribution, flight batteries, structures, in-flight timing, mechanisms, diagnostic instrumentation and ground support equipment. These systems are customized for each application and incorporated into the overall package and wiring harness. Related tasks involve electrical and mechanical integration of experiments, telemetry systems, and other payload support modules such as ancillary experiment packages, attitude control systems and recovery systems. A summary of launches during the contract period are included in Table 2.

2.1.1 Multi Spectral Measurements Program - TEM (A24.609-3)

The Multi Spectral Measurements Program (MSMP) was begun during the previous contract. Payload details on the results of the first two launches in the Target Engine Measurements (TEM) phase of the program are described in Reference 9. The objective of the program was to measure burn characteristics of a target engine in the upper atmosphere. Northeastern University was responsible for the mechanical and electrical integration of the sensor section which was launched from a common ARIES vehicle with the target engine. At approximately 90km altitude the sensor module and the target engine module were separated and individually controlled on different trajectories.

TABLE 2

LAUNCH SUMMARY

PROJECT	PROGRAM	LAUNCH VEHICLE	LAUNCH SITE	LAUNCH DATE
A24.609-3	MSMP TEM	ARIES	WSMR	5/27/82
A30.175	FWIF	SERGEANT	PFRR	11/7/81
A30.276	FWIF	SERGEANT	PFRR	4/7/83
A10.901-2	SPE	PAIUTE TOMAHAWK	PFRR	10/26/81
A13.277	TRACER	TAURUS ORION	WFF	6/29/82
A20.123-1	BIME	SONDA III	NRR	9/8/82
A20.123-2	BIME	SONDA III	NRR	9/13/82
A31.200	SES	ASTROBEE F	WSMR	3/1/83
A11.074	STATE	NIKE HYDAC	PFRR	6/15/83
A20.327-1	IMS	SONDA III	WFF	11/14/83
A20.327-2	IMS	SONDA III	WFF	10/31/83
A21.426	PIIE	BLACK BRANT IX	GRN	3/14/85
A19.250-1	BERT	BLACK BRANT VII	WSMR	6/14/85
A21.628	POLAR ARCS	BLACK BRANT IX	GRN	2/26/85
AFGL-804A	SETS I	SHUTTLE	KSC	6/82

LAUNCH SITES:

GRN - SONDRESTROM, GREENLAND
KSC - KENNEDY SPACE CENTER, FLORIDA
NRR - NATAL ROCKET RANGE, BRAZIL
PFRR - POKER FLAT RESEARCH RANGE, ALASKA
WFF - WALLOPS FLIGHT FACILITY, VIRGINIA

Mechanical and electrical design modifications to the TEM-3 (A24.609-3) sensor module were completed early in the contract period followed by integration tests at Air Force Geophysics Laboratory (AFGL) and environmental tests at Acton Environmental Testing Corporation (AETC). The payload was shipped to White Sands Missile Range (WSMR) in April 1982 and prelaunch tests, including tracker alignment tests at Physical Science Laboratory (PSL), were conducted from 3 May to 17 May culminating in a full flight simulation on the Aries launch pad. A tracker problem was resolved, clean room operations were completed and the payload was returned to the pad on 25 May. After the 11 1/2-hour countdown, TEM-3 was launched successfully on 27 May at 0947 MDT and recovered the same day. The only anomaly was a malfunction of the cover mechanism on the spatial radiometer which impeded the closing and latching of the left instrument door. This problem was not detrimental to the data and the sensor module was recovered in good condition, except for the instrument door which was lost during re-entry.

2.1.2 Field Widened Interferometer (A30.175 & A30.276) High Resolution Infrared Auroral Measurement (A30.579)

The Field Widened Interferometer (FWIF) program, later designated as High Resolution Infrared Auroral Measurements (HIRAM), is a long term program started in November 1977 with 3 previous launches and recoveries from Poker Flat Research Range (PFRR) and 1 previous launch and recovery from the White Sands Missile Range (WSMR). The 17-inch diameter support module, serviced by this contractor, has been modified several times to support changing experiment requirements. Payload details and the scope of responsibilities are described in reference 9.

Recertification tests were completed in October 1981, followed by pre-launch checkout at PFRR. After 37 evenings of active count, waiting for suitable auroral and weather conditions, A30.175 was finally launched on November 7, 1981 completing the fifth successful launch and recovery of the FWIF (or HIRAM) payload.

The instrument was modified to include an optical baffle at the front end to extend the active window period. After a successful integration and recertification test at AFGL, A30.276 was shipped to PFRR during February 1983. The payload was counted for 24 evenings leading to a sixth successful launch and recovery on April 12, 1983.

The launch criteria for the HIRAM program was increased to more stringent auroral levels and payload A30.576 was returned to PFRR in January 1986. After counting for 70 evenings with no suitable conditions the payload was dismantled and returned to AFGL on April 12, 1986.

HIRAM, A30.579, was returned to PFRR in early February 1987 for another attempt at a launch. Again after 32 evenings of counting, the payload was dismantled and returned to AFGL because of insufficient scientific conditions on April 4, 1987.

2.1.3 Solar Proton Event (A10.901-2, A10.901-3, A10.90_-4)

The Solar Proton Event (SPE) payloads consisted of a forward looking quadrapole mass spectrometer, a gerdian condenser and a retarding potential analyzer packaged in a 12-inch diameter payload. Details of the payloads and results of the initial launch and recovery (A10.901-1) from PFRR are described in Reference 9. The recovered payload was refurbished and designated as A10.901-3.

Recertification was completed in July 1981 and payloads A10.901-2 and A10.901-3 were shipped to PFRR. Travel to support the SPE program occurred during the following periods:

5 August 81 to 19 August 81

13 October 81 to 29 October 81

18 March 82 to 7 April 82

2 October 82 to 3 November 82

Field operations consisted of preparing for launch with a full crew and reducing the personnel when the payloads were flight ready and mated to the launch vehicles. On 26 October 1981 payload A10.901-2 was launched and recovered the following day. All systems functioned normally and data was received from the mass spectrometer, ancillary experiments and support systems. The recovered payload was refurbished and designated as A10.901-4 in subsequent SPE field operations; however, suitable launch criteria were not attained and no further launches occurred. Both payloads were returned to Northeastern and stored until 1986 when they were reassigned to the COLDR program, described in Section 2.1.15.

2.1.4 Multi Spectral Measurements Program - HPEM (A25.609-4 and A25.609-5)

The MSMP High Performance Target Enginer Measurements (HPTEM) was a follow-on to the previously described TEM program. Two launches were scheduled from Vandenberg AFB, on a 3-stage launch vehicle, using the recovered TEM sensor and target engine modules. A preliminary mechanical design modification was completed in July 1983 to shorten the sensor module and incorporate other weight reduction measures. Program priorities were altered and the HPTEM was cancelled. Sensor modules and related ground support equipment were delivered to AFGL on 9 September 1983.

2.1.5 Tracer (A13.277)

The Tracer payload, A13.277, was designed to examine and characterize emissions at specific wavelengths and measure critical neutral atmospheric parameters simultaneously. The telemetry consists of a single link FM/FM system at 2279.5 MHz modulated by seventeen subcarrier oscillators. The experiments consist of a Tri-channel Radiometer, an Atomic Oxygen Detector, a Nitric Oxide

Detector, a Solar Aspect Sensor, three Photometers (Nitric Oxide Detector, a Solar Aspect Sensor, three Photometers (Nitric Oxide, Ozone and 5577°A), a DC Probe, a Magnetometer and a Midas Gyro Platform.

Tracking was accomplished by installing a C-band radar transponder in the telemetry section. This payload was very similar to the Aeronomy payload from the Auroral Dynamics series and also has a 10-inch diameter "Falling Sphere" experiment with telemetry being handled by personnel from Oklahoma State University. The transmission frequency for the sphere is at 2251.5 MHz.

The launch vehicle was a Taurus Orion which incorporated an In-flight-Ignition-System (IFIS) for the Orion motor. This system was designed and built by Northeastern in a twelve to fourteen inch transition section.

The payload was successfully launched from Wallops Flight Center, Virginia on 29 June 1982. All telemetry and tracking systems performed well without any problems. The Tri-channel radiometer instrument did not release its cover and its adjacent photometers saturated. All other experiments performed as expected.

2.1.6 Brazil Ionospheric Modification Experiments (A20.123-1 and A20.123-2

An international program, designated Brazil Ionospheric Modification Experiments (BIME), was designed to create and investigate artifical ionospheric irregularities. Experiments consisting of ground based, aircraft and rocket measurements were conducted from Natal Rocket Range (NRR), Brazil. Two rockets were launched in each effort. The first carried a 250# explosive release, pulsed plasma probes and positive ion D.C. probes. These probes measured the background ionosphere, and particularly the F-region ledge gradient. The probe outputs were monitored in real time so that the explosive could be detonated near the ledge using a command receiver in the rocket payload. The instrumented payload, (Sonda III) with an ion mass spectrometer and pulsed plasma probes was targeted to penetrate the ionospheric hole approximately ten minutes after the release when irregularities presumably will have had enough time to form.

Details of instrumented payloads A20.123-1 and A20.123-2 integrated by Northeastern University are presented in Table 3 along with a payload profile drawing in Figure 1. In addition to the standard integration and environmental test on both payloads, a structural load test and a spin test were conducted due to the unique payload configuration dictated by the Brazilian built SONDA III launch vehicle.

TABLE 3

BIME PAYLOAD DATA

PAYLOAD CONFIGURATION

WEIGHT: 68 kg
DIAMETER: 9-INCHES (12-INCH TO 9-INCH TRANSITION AFT)
LENGTH: 88-INCHES

SCIENTIFIC EXPERIMENTS --- (SUPPLIERS)

MASS SPECTROMETER (AFGL-LID)
PULSED PLASMA PROBES (NRL)

SUPPORT SYSTEMS --- (SUPPLIERS)

3 AXIS MAGNETOMETER (N.U.)

RF SYSTEMS

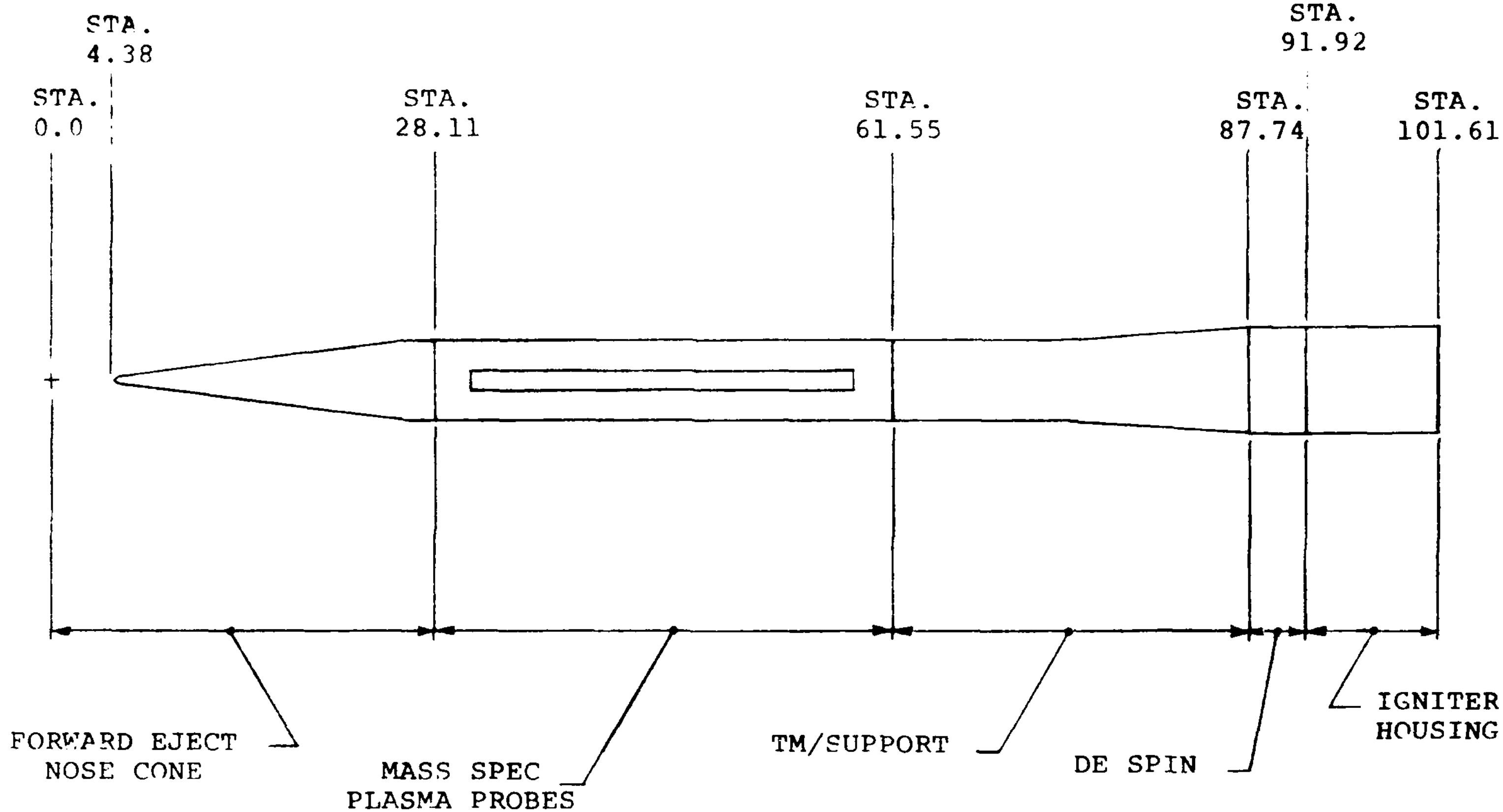
PCM TELEMETRY LINK: 2259.5MHz, 221.184KBPS, Bi0-L
BEACON TRANSPONDER: C-BAND, SINGLE PULSE
RANGING RECEIVER: 430MHz, TRADAT

PAYLOAD TIMING

N.U. MODEL #2840 - REDUNDANT TIMERS

MECHANISMS

DOOR EJECT - 2 DOORS
NOSECONE RELEASE - MASS SPECTROMETER
SEPARATION - PAYLOAD/VEHICLE
PROBE DEPLOY - PULSED PLASMA PROBES
DESPIN - YO/YO RELEASE



BIME

PROFILE DRAWING

Figure 1

Personnel left for NRR on 17 August 1982 and completed pre-launch checks and installation of range cables. The launch window opened on 6 September and the first pair of payloads were launched two days later. The explosive release occurred on schedule and the A20.123-1 payload was launched ten minutes later, at 1852 hrs. All systems functioned normally and useful data was received from the instruments, even though the payload did not hit the ionospheric hole created by the detonation. Criteria for the second launch sequence was altered to attempt traversing the hole during the up-leg of the trajectory, rather than the down-leg. On 13 September, payload A20.123-2 was launched 6-minutes after a successful detonation. Support systems functioned properly; however, the mass spectrometer failed and no useful data was obtained.

2.1.7 Sensor Ejection System (A31.200)

Details of the Sensor Ejection System (SES) payload are presented in Table 4. The objective of the SES Program was to demonstrate the feasibility of ejecting multiple sensors from a payload and obtaining scientific data. Contents of the four ejectables and related payload sensors were classified. Support and telemetry systems were packaged in the ojive.

Design reviews and preliminary payload tests were conducted at AFGL and the Applied Physics Laboratory (APL) of Johns Hopkins University. System integration tests were

TABLE 4

SES PAYLOAD DATA

PAYLOAD CONFIGURATION

WEIGHT: 272 kg
DIAMETER: 17 - INCHES
LENGTH: 152 - INCHES

SCIENTIFIC EXPERIMENTS --- (SUPPLIERS)

4 EJECTED MODULES (APL - JHU)
4 PAYLOAD SENSORS (APL - JHU)

SUPPORT SYSTEMS --- (SUPPLIERS)

ATTITUDE CONTROL SYSTEM (SVC)
RCOVERY SYSTEM (BAL)
DESPIN SEPARATION SECTION (PSL)

RF SYSTEMS

PCM TELEMETRY LINK: 2279.5MHZ,2 WATT,20,480 BPS,NRZ-S
PCM TELEMETRY LINK: 2251.5MHz,5 WATT, 1.0 MBPS, NRZ-S
BEACON TRANSPONDER: C-BAND, DOUBLE PULSE

PAYLOAD TIMING

MECHANISMS

DOOR EJECT - 4 DOORS
CANISTER EJECT - 4 MODULES

at AFGL during January 1983, followed by shock and vibration at Acton. Field operations at WSMR began in early February and the payload was mated to the Astrobee F vehicle on 20 February. The first launch attempt was aborted due to problems with range ground stations. At 0915 hrs MST on 28 February the launch was accomplished and all systems performed flawlessly. The payload was recovered the following day in excellent condition.

2.1.8 STATE (A11.074)

The STATE payload, A11.074, a revised version of the Tracer/Aeronomy payload described in section 2.1.5 was rescheduled for launch at PFRR, Alaska during early June 1983. The experiment was to be flown in conjunction with a series of small probes on Super Arcas vehicles.

The main payload had a PCM/FM/FM telemetry system at 2259.5 MHz with twelve subcarrier oscillators. The second link was on board a 10-inch sphere at 2269.5 MHz as a PCM/FM/FM telemeter consisting of three subcarrier oscillators in support of the sphere accelerometer system. Tracking of the main payload was accomplished by use of the TRADAT ranging system at 547 MHz and an S-band radar transponder. Tracking of the sphere was accomplished by use of a C-band radar transponder.

The STATE payload completed its integration and vibration testing successfully on May 20, 1983. The payload and personnel arrived at the PFRR on June 6, 1983. The launch window was opened on June 13, 1983. The vehicle was successfully launched at 2151 hours on June 15, 1983, and followed an azimuth of 355^{o} with a launch elevation of 84^{o} to an apogee of 131.46km. The telemetry, tracking and ranging systems all performed as expected with LOS occurring at T + 437 seconds. The only failure was in the measurement of Atomic Oxygen. This was carried on IRIG Channel 17 and telemetry indicated failure at lift off.

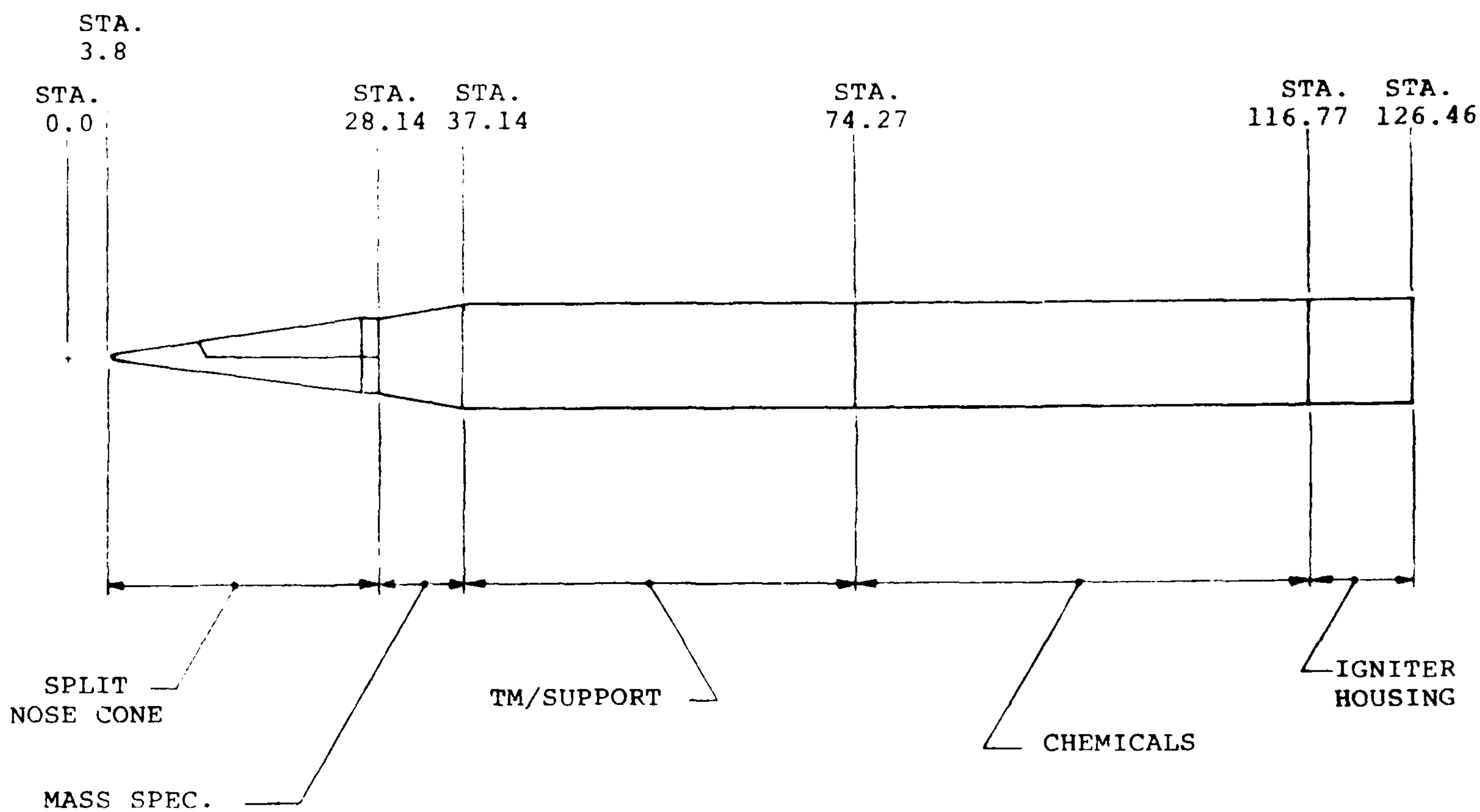
2.1.9 Ionospheric Modification Studies (A20.327-1, A20.327-2)

Ionospheric Modification Studies (IMS) was another international program conducted with Brazil, and was similar to the BIME program conducted at NRR in 1981 (Reference Section 2.1.6). One significant difference was that the instrumented IMS payloads included the chemical packages, whereas in the BIME program the instrumented payload was launched into the F-region altered by a detonation from a separate vehicle. The purpose of the program was to develop ionospheric modification technology, create F-region disturbances, measure their structure, composition and dynamics and simultaneously measure the effects on satellite transmissions and ground-based reflections from the artificially created irregularities.

Each of the SONDA III payloads house a positive/negative ion mass spectrometer, housekeeping support and two chemical release modules. The chemicals contained in the modules are Sulfur Hexafluoride (SF_6) and Samarium (Sm) for flight A20.327-1, and Trifluoromethyl-Bromide, CF_3Br and Samarium for flight A20.327-2. Figure 2 is a profile drawing of the payloads including the location of the chemical canisters.

A unique aspect of these payloads was an up-leg command link incorporated to initiate release of the chemical modules at prescribed altitudes. The WFF system was utilized which included pre-programmed control and direct commands from the ground transmitter. In this application real time altitude data was fed to the computer which was programmed to transmit commands for chemical releases during the up-leg of the trajectory. Altitude data displays were used to manually transmit commands for releases after apogee. Other payload systems are described in Table 5.

Integration and environmental tests were conducted at AFGL and Acton during September 1983 and field operations began at WFF on 19 October. During all pre-launch chcks simulators were used in place of the chemical modules for safety considerations, and extensive tests of the remote command system were conducted since the command transmitter was not accessible during integration. Payload A20.327-2 was launch at 0530 local time, on 31 October and a problem



IMS

PROFILE DRAWING

Figure 2

TABLE 5

IMS PAYLOAD DATA

PAYLOAD CONFIGURATION

WEIGHT: 149 kg
DIAMETER: 12-INCHES(12-INCH TO 9-INCH TRANSITION FWD)
LENGTH: 113-INCHES

SCIENTIFIC EXPERIMENTS --- (SUPPLIERS)

ION MASS SPECTROMETER (AFGL LID)

SUPPORT SYSTEMS --- (SUPPLIERS)

3 AXIS MAGNETOMETERS (N.U.)

RF SYSTEMS

PCM TELEMETRY LINK: 2251.5 MHZ, 5 WATTS NOM. 9600 BPS NRZ-S
BEACON TRANSPONDER: C-BAND, DOUBLE PULSE
COMMAND RECEIVER: C.E. ELECTRONICS @ 412 MHz

PAYLOAD TIMING

N.U. MODEL #2480 - REDUNDANT TIMERS
COMMAND CONTROLLER

MECHANISMS

NOSECONE RELEASE - MASS SPECTROMETER

developed with the SONDA III launch vehicle. The first-stage functioned normally; however, the second-stage burned for only six seconds rather than the designated 15 seconds. The payload reached an apogee of only 25 kilometers and no useful data was received. Data indicated all systems operated as predicted through second-stage ignition and there was no apparent reason for the failure.

The second launch, payload A20.327-1, occurred at 0515 local time on 14 November. Again the first stage performed as predicted but the second-stage failed to ignite and the payload reached an apogee of only 15 kilometers. Monitors indicated a normal separation of the first-stage and a firing pulse to the second-stage at the designated time.

2.1.10 Polar Ionospheric Irregularities Experiment (A21.426)

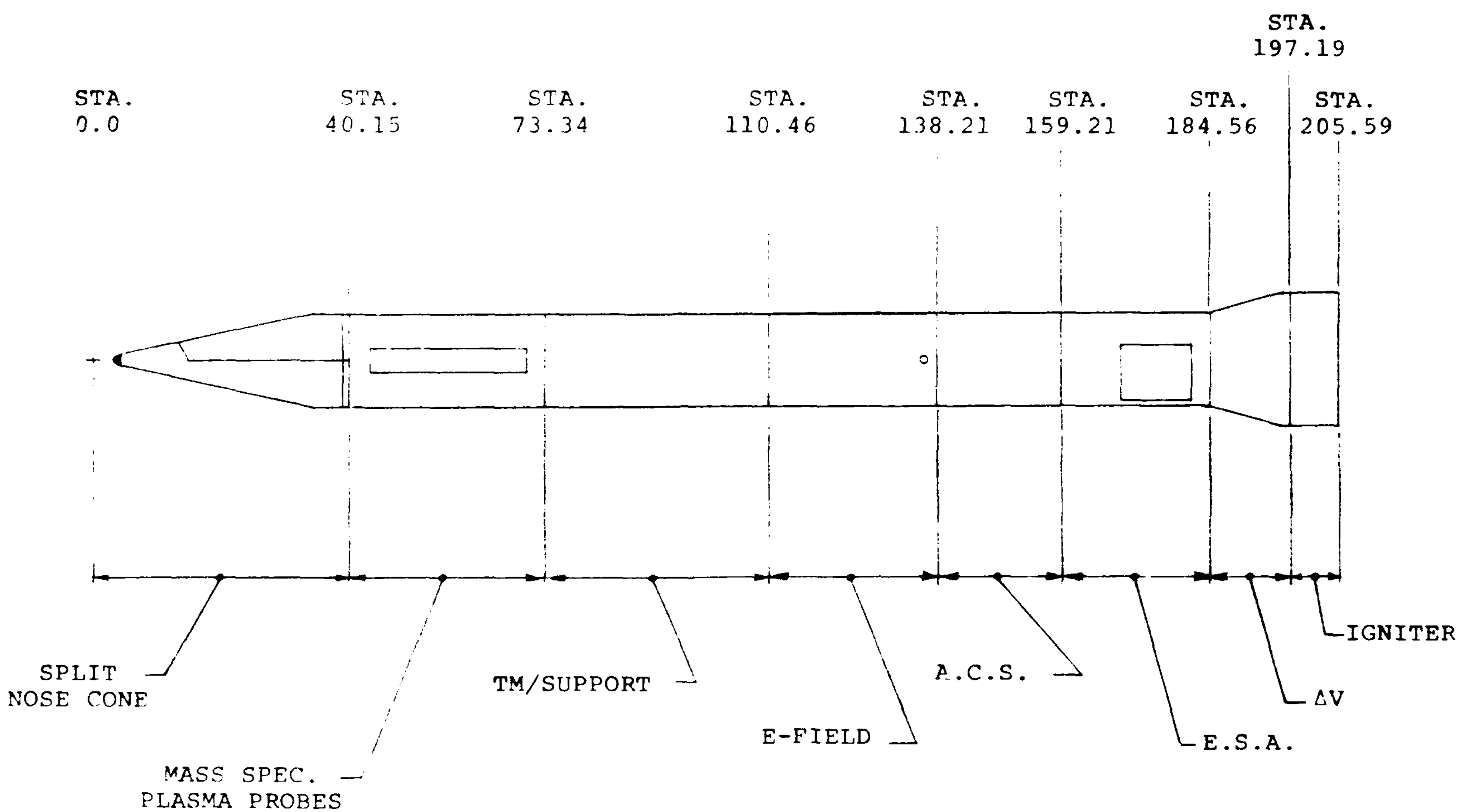
The objective of the Polar Ionospheric Irregularities Experiment (PIIE) program was to launch an instrumented payload from Sondrestrom, Greenland, during a polar cap disturbance in conjunction with an overpass of the HiLat satellite. Simultaneous measurements were performed by the AFGL KC-135 Airborne Ionospheric Observatory (AIO), by the Sondrestrom radar and by ground-based optical and polarimeter measurements. Prior to the launch of A21.426 a separate vehicle carried a 114 kg chemical canister which was detonated in the ionosphere from a ground command. The configuration and technical data for the instrumented payload are presented in Figure 3 and Table 6 respectively.

Typical system tests were conducted during January 1985 and personnel left for Sondrestrom on 22 February. Several problems with the payload and ground control lines were encountered and resolved prior to the all up test on 8 March. This was the first program conducted at the temporary facility at Sondrestrom. Countdowns were carried out each evening from 9 to 13 March, but weather conditions and lack of auroral activity precluded a launch. Finally, on 14 March at 2035 hours local time, A21.426 was launched, approximately 8 minutes after the successful detonation of the chemical canister. Auroral conditions were ideal and the payload flew through the aurora on both up and down legs of the trajectory. All systems functioned as predicted and the project scientist described the results as beyond expectations.

2.1.11 Beam Emission Rocket Technology (A19.250-1)

BERT-I, Beam Emission Rocket Technology I, was a single sounding rocket program for beam studies.

The primary objectives were to determine the extent and cause of spacecraft charging created by the ejection of charged particle beams from space vehicles, and to test the operation of a system designed to automatically discharge space vehicles. Additional objectives were the study of the characteristics and radiation of ejected charged particle



PIIE

PROFILE DRAWING

Figure 3

TABLE 6

PIIE PAYLOAD DATA

PAYLOAD CONFIGURATION

WEIGHT: 152 kg
DIAMETER: 12 INCHES (12-INCH TO 17-INCH TRANSITION AFT)
LENGTH: 193-INCHES

SCIENTIFIC EXPERIMENTS --- (SUPPLIERS)

MASS SPECTROMETER (AFGL-LID)
E. FIELD PROBES 3 AXIS (GOODARD - CORNELL)
PULSED PLASMA PROBES (NRL)
ELECTRO STATIC ANALYZER (TRICON)
E.S.A CORRELATOR (SUSSEX)

SUPPORT SYSTEMS --- (SUPPLIERS)

ATTITUDE CONTROL SYSTEM (SPACE VECTOR CORP.)
2 AXIS MAGNETOMETER (N.U.)

RF SYSTEMS

PCM TELEMETRY LINK: 2279.5 MHZ, 5 WATTS 258.048 KBPS, NRZ-S
FM TELEMETRY LINK: 2251.5 MHz, 10 WATTS, 16 CHANNELS
BEACON TRANSPONDER: C-BAND, DOUBLE PULSE
RANGING RECEIVER: 550 MHz, TRADAT

PAYLOAD TIMING

N.U. MODEL #2840 - REDUNDANT TIMERS

MECHANISMS

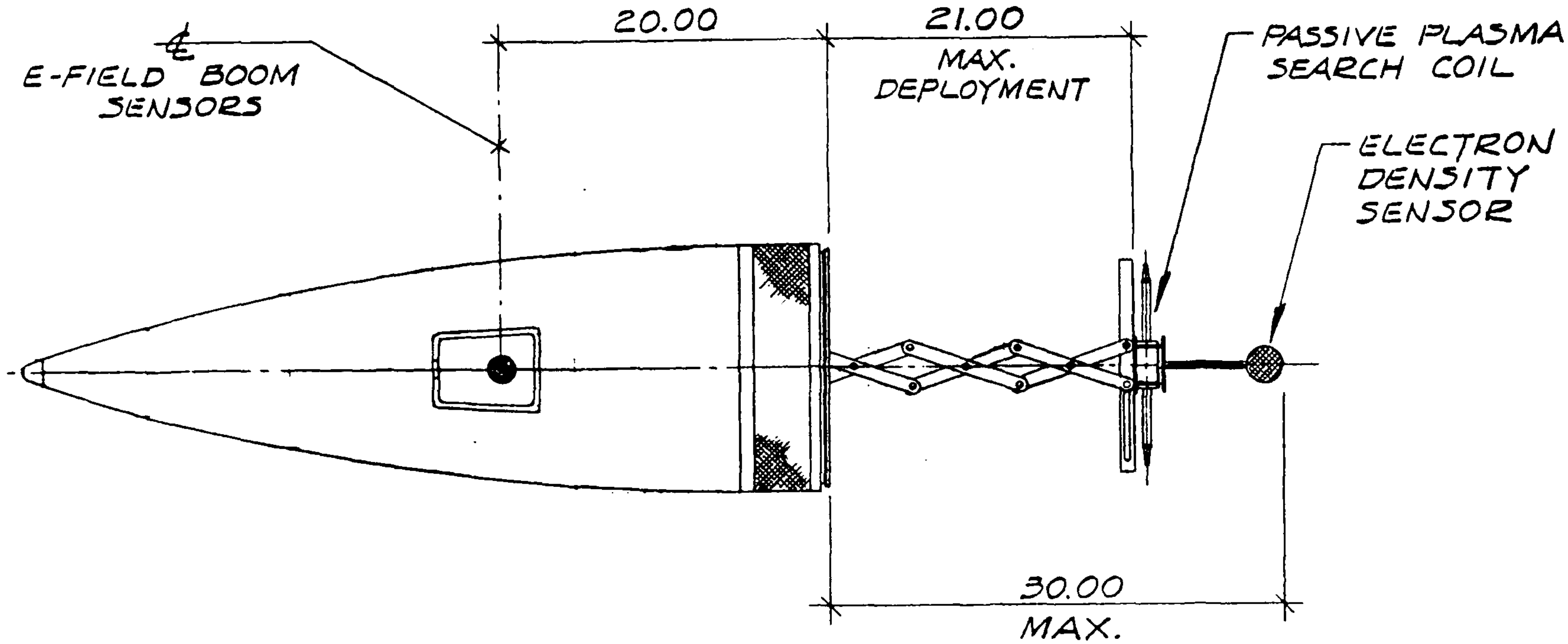
DOOR EJECT - 5 DOORS
NOSECONE RELEASE - MASS SPECTROMETER
ANTENNA DEPLOY - 3 PAIRS
SEPARATION - PAYLOAD/VEHICLE
PROBE DEPLOY - PULSED PLASMA PROBES
DELTA VELOCITY - CANISTER

beams. Several different beam systems were used to eject positive and negative charged particles of a wide dynamic range of current and energies. On-board instrumentation measured the transient and steady state vehicle potential, beam characteristics, the energy and density distribution of plasma surrounding the craft, and particle return current.

The beam system, comprised of an electron source and two ion sources, and the related diagnostic instrumentation were packaged in four cylindrical, 17-inch diameter segments. An ejectable nosecone experiment and support system was incorporated to measure magnetic and electric field effects, isolated from the primary payload. This section was called the "ERNIE" module and was a separately funded program.

Figure 4 depicts the nosecone configuration with the aft sensors deployed. The jack mechanism, at the separation plane was designed specifically for the application to deploy the two sensors 21-inches from the nosecone base. A direct current motor was incorporated to drive a jackscrew that elevated the multi-segment extension system, which was fabricated using all non-metallic materials.

Several configurations were contemplated during the early phases of the BERT program and several experiments and support systems were eliminated due to weight constraints. Table 7 provides details of both the BERT and ERNIE payload segments. In addition to the usual system tests at AFGL and



ERNIE

PROFILE DRAWING

Figure 4

TABLE 7

BERT/ERNIE PAYLOAD DATA

PAYLOAD CONFIGURATION

WEIGHT: 400 kg
DIAMETER: 17 INCHES
LENGTH: 221 INCHES

SCIENTIFIC EXPERIMENTS --- (SUPPLIERS)

ELECTRON SOURCE (HUGHES)	[B]
ION SOURCE (TRI-CON ASSOCIATES)	[B]
MULTIPLE ION SOURCE (KIMBALL)	[B]
MASS SPECTROMETER (AFGL-LID)	[B]
ELECTROSTATIC ANALYZER (TRI-CON)	[B]
2 FARADAY CUPS (TRI-CON)	[B]
2 PHOTOMETERS (PHOTOMETRICS	[B]
4 HIGH IMPEDANCE PROBES (TRI-CON)	[B]
INTERSEGMENT VOLTMETER (TRI-CON)	[B]
2 E-FIELD PROBES (SYSTEMS UNLIMITED/WEITZMAN)	[E]
SEARCH COIL (AFGL-PHG)	[E]

SUPPORT SYSTEMS --- (SUPPLIERS)

VIDEO CAMERS (PHOTOMETRICS)	[B]
3 AXIS MAGNETOMETER (N.U.)	[E]

RF SYSTEMS

PCM TELEMETRY LINK: 2251.5MHz,10 WATT,192KBPS,NRZ-S [B]
FM TELEMETRY LINK: 2279.5MHZ, 5 WATT(16 CHANNELS) [E]
BEACON TRANSPONDER: C-BAND, DOUBLE PULSE [B]

PAYLOAD TIMING

NU MODEL 2480-REDUNDANT TIMERS IN EACH SEGMENT	[B][E]
EXPERIMENT PROGRAMMER (TRI-CON)	[B]

MECHANISMS

DOOR EJECT	- 7 DOORS [B], 2 DOORS [E]	
NOSECONE RELEASE	- ERNIE [B]	
ANTENNA DEPLOY	- 2 ANTENNAS	[E]
PROBE DEPLOY	- 2 BOOMS	[B]
JACKSCREW	-	[E]

[B] - BERT SEGMENT
[E] - ERNIE SEGMENT

Acton an extensive vacuum test was conducted at the large chamber at the Johnson Space Center. Contract personnel defined chamber interfaces and coordinated the tests in which the two payload sections were individually suspended in the chamber. After a week of preparation, five days of vacuum tests were completed with many combinations of beams and plasma, and with various payload orientations. The magnetic characteristics of the ERNIE payload segment were also defined during a week of testing at the Goddard Space Flight Center facility.

Field operations began at WSMR on 3 June3 1985, leading to a launch from the 350-Tower on 14 June. All systems functioned normally during boost, separation and deployment until T + 103 seconds, which was the initialization of the experiment programmer. This programmer was independent of the flight timers and was provided by the experimenter to cycle beam and measurement parameters during the flight. Initial analysis of the flight data indicated anomalies in the PCM encoder and the experiment program at T + 103 seconds, apparently related in some way to charge or plasma produced from the operation of the guns. Extensive reconstruction of the PCM data yielded a significant amount of useful data and confirmed that the experiment program did malfunction. The data obtained during the system vacuum test complemented the limited flight data and the program was deemed successful by the BERT-I post-flight review team.

2.1.12 Polar Acceleration Regions and Convection Study (A21.628)

The Polar Acceleration Regions and Convection Study (Polar Arcs) program, a joint Air Force/NASA effort, was a follow-on to the 1985 PIIE program. Several experiments, including an ejectable nosecone daughter module, were added to the original PIIE configuration and the scope of the program was expanded to include a total of 5 launches. The experiments and other details of the mother module are described in Table 8. One requirement was to deploy one of the sensors, a soft particle spectrometer, to a position 10-inches from the payload skin. A slide mechanism was developed utilizing deployment springs and a restraint cable actuated by a pyrotechnic cutter. A profile drawing of the mother module is presented in Figure 5.

Integration tests, including deployment of the spectrometer at various spin rates, were conducted at AFGL followed by shock and vibration at Action Environmental Testing Corporation. Personnel traveled to Sondrestrom, Greenland on 4 February 1987 and the A21.628 payload was mated to the Black Brant vehicle on 17 February. Launch criteria of quiet magnetic conditions and polar cap auroras were not attained during the first nine nights of countdown. The chemical payload in this program included three separate releases and was successfully launched on 26 February at approximately 2040 hours local time. Instrumented payload, A21.628, followed at 2049 hours and traversed both the

TABLE 8

POLAR ARCS PAYLOAD DATA

PAYLOAD CONFIGURATION (MOTHER & DAUGHTER MODULES)

WEIGHT: 250 KG
DIAMETER: 12-INCHES (17-INCH TO 12-INCH ADAPTER AFT)
LENGTH: 215 INCHES

SCIENTIFIC EXPERIMENTS --- (SUPPLIERS)

ION MASS SPECTROMETER (AFGL-LID)
PULSED PLASMA PROBES (NAVAL RESEARCH LABORATORY)
SOFT PARTICLE SPECTROMETER (SOUTHWEST RESEARCH INC.)
E-FIELD ANTENNAS-3 PAIRS (SYSTEMS UNLIMITED)
AC MAGMETOMETER (DANISH SPACE RESEARCH INSTITUTE)

SUPPORT SYSTEMS --- (SUPPLIERS)

DAUGHTER MODULE-NOSECONE (OKLAHOMA STATE UNIVERSITY)
ATTITUDE CONTROL SYSTEM (SPACE VECTOR CORP.)

RF SYSTEMS

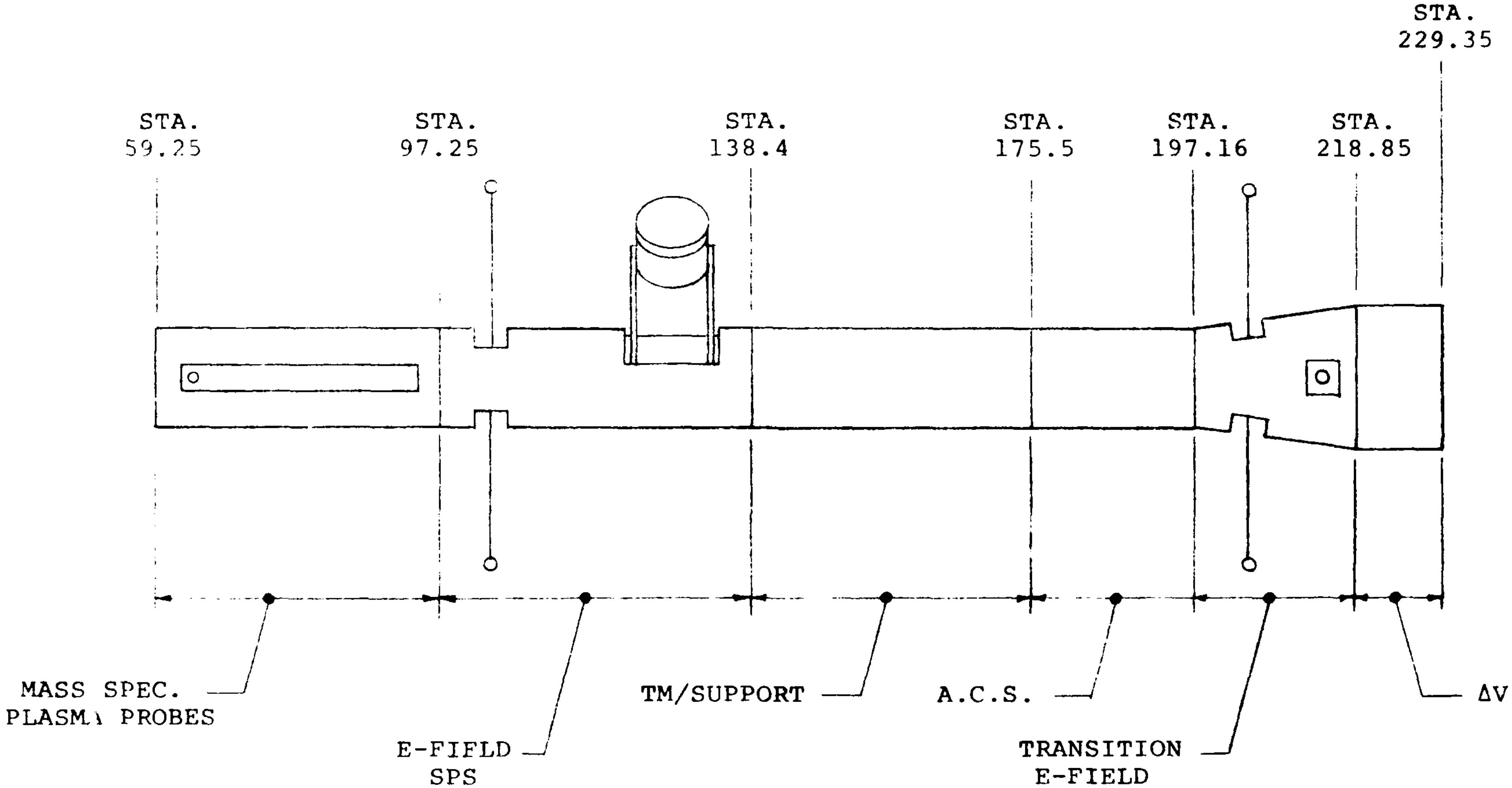
PCM TELEMETRY LINK: 2279.5MHZ, 5 WATT, 300 KBPS
FM TELEMETRY LINK: 2251.5MHZ, 10 WATT, 14 CHANNELS
BEACON TRANSPONDER: C-BAND, DOUBLE PULSE

PAYLOAD TIMING

NU MODEL 2480-REDUNDANT TIMERS

MECHANISMS

DOOR EJECT	- 10 DOORS
NOSECONE RELEASE	- DAUGHTER MODULE
ANTENNA DEPLOY	- 3 PAIRS
SEPARATION	- VEHICLE/PAYLOAD
PROBE DEPLOY	- AC MAG. & SPECTROMETER
DELTA VELOCITY	- CANISTER



POLAR ARCS

PROFILE DRAWING

Figure 5

aurora and the barium cloud. The only anomaly was an apparent deployment problem with the AC Magnetometer, located at the payload/vehicle separation plane.

2.1.13 EXCEDE III (A24.570)

EXCEDE III is proposed as a follow-on to the EXCEDE SPECTRAL program conducted from PFRR in 1978. The prime objective for the EXCEDE III flight is to obtain spatial/temporal measurements of the infrared, visible and optical emissions without interference from outgassing or beam-plasma interactions. EXCEDE III will use a single rocket to carry two payloads to an apogee of 130 kilometers. One payload, the gun module, will carry four electron guns operating at about 3 kilovolts and with a total current of about 40 amperes. The gun module will also carry cameras, an electrostatic analyzer, and other diagnostic instrumentation. The second payload, the remote sensor module, will carry a variety of sensors which will cover the spectral range from 0.13 to 20 micrometers. These instruments will include an infrared interferometer, an infrared spatial circular variable filter spectrometer, an infrared spatial radiometer, ultraviolet and visible spectrometers, scanning filter photometers, video cameras and an atomic oxygen resonance fluorescence experiment.

This contractor was originally assigned both the gun module (gun sensor and gun sections) and the remote sensor module. Later the tasks were divided among several contractors and Northeastern was assigned the gun module in total and timing responsibilities only for the remote sensor module. At the end of this contract period a preliminary design of the gun sensor section and a conceptual design of the gun package were delivered to AFGL. Interface requirements for redundant controllers in the remote sensor module were also defined.

2.1.14 Beam Experiments Aboard Rockets (A24.602)

The Beam Experiments Aboard Rockets I (BEAR-1) project is the initial phase of a program of beam experiments in space.

The objective is to demonstrate the operation of a neutral particle beam (NBA) accelerator in exoatmospheric near-earth space, and to monitor the accelerator's performance in, and the interaction of the particle beam with, the local space environment. The 44-inch diameter Aries payload will include instrumentation to measure accelerator performance and beam characteristics.

A 148-inch long section will house the accelerator components, including the ion injector, RF accelerator and neutralizer used to generate the NPB. Instrumentation to determine the effects of beam interaction with the local environment will be packaged in the beam diagnostic section, aft of the accelerator. The beam will pass through the center of the diagnostic section. Los Alamos National Laboratory (LANL) has primary responsibility for these two sections with Northeastern assisting in aerospace design areas and providing flight batteries. Another cylindrical section, forward of the accelerator, includes physics experiments, telemetry systems and support components. Details of the telemetry/physics (TP) section are presented in Table 9. Four langmuir probes are included in the complement of physics experiments and packaged in beam diagnostic section.

Payload design had to consider an extended vacuum chamber test and the hostile environment anticipated during beam firing. Experience with the BERT program (Section 2.1.11) and the related vacuum test was beneficial in developing a design plan. In the data area redundant telemetry transmitters and on-board tape recorders were incorporated with parallel lines for critical data. Also grounding, shielding and isolation techniques were investigated for this environment, and precautions such as optical isolation, double shielding and the use of special cables were incorporated. Also, the module was packaged so

TABLE 9

BEAR T/P SECTION DATA

PAYLOAD CONFIGURATION

WEIGHT: 152 kg
DIAMETER: 44 INCHES
LENGTH: 36-INCHES

SCIENTIFIC EXPERIMENTS --- (SUPPLIERS)

ELECTROSTATIC ANALYZER (SCIENCE APPLICATIONS CORP.)
HIGH IMPEDANCE VOLTMETER PROBE (NRL/WENTWORTH)
2 PLASMA WAVE RECEIVERS (NRL/WEITZMAN)
4 LANGMUIR PROBES (NRL, HOUSED IN BD SECTION)

SUPPORT SYSTEMS --- (SUPPLIERS)

2 FLIGHT RECORDERS (N.U.)
3 AXIS MAGNETOMETER (N.U.)

RF SYSTEMS

PCM TELEMETRY LINK:	2269.5 MHZ, 5 WATT, 320 KBPS
	2241.5 MHZ, 5 WATT, ACCEL/BD
	2279.5 MHZ, 5 WATT, ACCEL/BD
FM TELEMETRY LINK:	2251.5 MHZ, 5 WATT, PWR WIDEBAND
VIDEO TELEMETRY LINK:	2215.5 MHZ, 10 WATT
BEACON TRANSPONDER:	C-BAND, DOUBLE PULSE

PAYLOAD TIMING

N.U. APCAM, REDUNDANT CONTROLLERS
RAYMOND ENGINEERING, MECHANICAL TIMER

MECHANISMS

DOOR EJECT	- 4 DOOR
ANTENNA DEPLOY	- 2 PWR, 4 LP
SEPARATION	- PAYLOAD/VEHICLE, BD SKIN
PROBE DEPLOY	- HIV, CCIG
SENSOR EJECT	- 2 PWR, HIV

that cell components not directly related to instruments requiring doors were located on the bottom side of the instrumentation deck where an RF shield is maintained.

BEAR I is designated as the first payload to utilize the controller system described in Section 3.3. Redundant controllers are included to provide pre-launch, as-well-as all in-flight commands. Also included is a pyrotechnic actuated mechanical timer to provide down-leg functions. The mechanical timer is dictated by the anticipated hostile environment during beam firing that could upset the sequence of the electronic controllers. One second before the beam ON command the mechanical timer is started and it is programmed to initiate the beam OFF command, and the ejection of the three extended sensors so that they do not interfere with recovery operations.

Preliminary and critical design reviews were held at Air Force Weapons Laboratory (AFWL) during January 1986 and June 1986, respectively. At the end of this contract the electrical and mechanical design are complete and some of the sub-systems have been fabricated. Schedule dates are indefinite at this time, but wiring of the harness will be completed followed by a test of the TP section then a full payload integration at AFGL. A vacuum chamber test, tentatively at AFWL, is anticipated prior to the launch at WSMR.

2.1.15 Conductivity of Lower D-Region (A12.629)

Payloads formerly identified as part of the SPE program (Section 2.1.3) were reassigned to the Conductivity of Lower D-Region (COLDR) program late in the contract period. The concept of COLDR is different from the traditional sounding rocket payload in that prime data collection will occur during descent through the D-region. A large parachute will be deployed near apogee to decelerate the payload and allow a longer period of time at lower altitudes. In addition to collecting data in this altitude range, the COLDR payloads will be used to evaluate the flight scenario for future instrument designs.

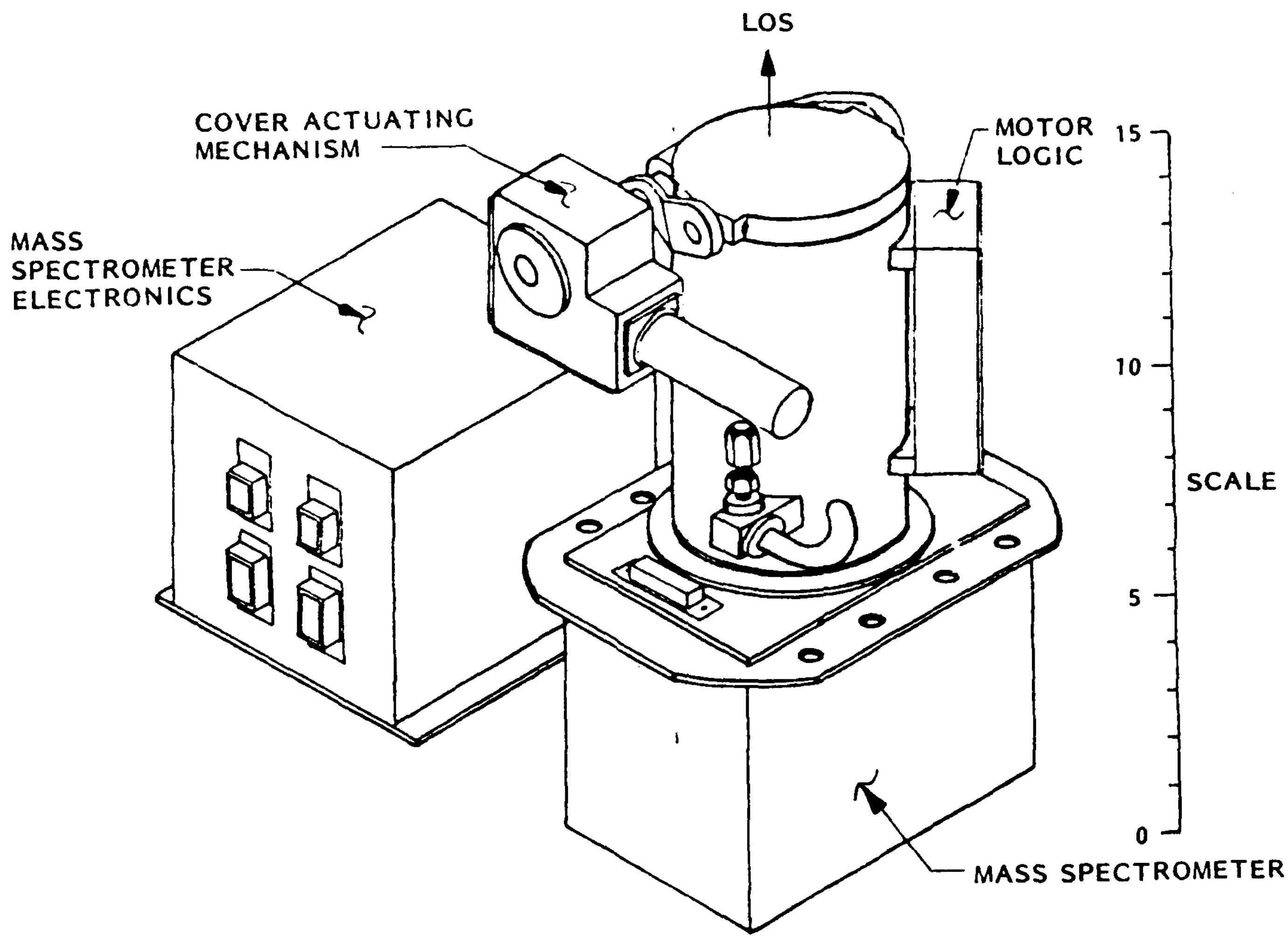
Modifications to the SPE payloads included elimination of the attitude control and ancillary experiment sections and repackaging the telemetry and support sections. Also, the part of the mass spectrometer/nosecone section was reconfigured with a grid system to allow diffusion of SF_6 gas in the area of the mass spectrometer orifice. This entailed packaging of a cylinder and valves for the SF_6; increasing the length of the cylindrical section aft of the nosecone; and a redesign of the mass spectrometer cap pull mechanism. Design modifications are complete and the first launch, designated A12.629, is scheduled at WFF on August 10, 1987. Initially an aircraft recovery of the payload was contemplated, but not currently planned for the August launch.

2.2 Shuttle Projects

The second category of projects are those related to space shuttle experiments aboard the NASA-Space Transportation System (STS). These projects can be further delineated into primary payloads in the shuttle orbiter cargo bay; subsatellites of the orbiter; and self-contained get-away-special (GAS) payloads. Analogous to the sounding rocket payloads, shuttle support systems were customized for each task. Unique to the shuttle application was the critical selection and qualification of components and materials.

2.2.1 Secondary Experiments Test Set I (AFGL-804A)

Secondary Experiments Test Set I (SETS-I) was a primary payload on a pallet in the shuttle bay, comprised of 4 active and one passive experiment. Lockheed Missile and Space Company (LMSC) was the payload integrator. This contractor was introduced to the program after the preliminary design was complete, and tasked with eliminating the pyrotechnic devices normally used to eject the mass spectrometer cover. The mass spectrometer was designated as experiment AFGL-804A on the SETS-I pallet. A mechanism was designed using a direct current motor and control circuit to open and close the cover without the use of pyrotechnic devices. The system was designed compatable with the pallet interface and featured redundant control circuits and current limiting to protect the motor. Figure 6 depicts the



SETS-1
MASS SPECTROMETER SYSTEM
Figure 6

mass spectrometer, cover actuating mechanism, motor logic box and the mass spectrometer electronics box. Northeastern personnel presented the design at LMSC, Sunnyvale, in August 1981 as part of SETS-I design review.

Testing of the individual experiments for SETS included vibration, shock, thermal, vacuum, thermal-vacuum and RF interference. All tests on 804A flight and space units were conducted during October and November 1981 and the mass spectrometer was integrated into the SETS-I pallet at LMSC in January 1982. A cover motor simulator was fabricated since the cover on the flight mass spectrometer could not be exercised during integration checks. The simulator was connected directly to the motor logic box and confirmed command and monitor signals from the SETS-1 harness during functional tests. Limit switches and mechanical stops were included to allow the simulator motor to operate through the current limit and monitor signal conditioning circuits.

After integration, AFGL and LMSC personnel handled the pallet during shuttle operations at Kennedy Space Center, leading to a successful launch and recovery.

2.2.2 Cloud Lidar Experiment On Shuttle

Get Away Special (GAS) payloads on shuttles are self-contained experiments which are accommodated on a space available basis. The GAS configuration provides a cylindrical enclosure with an experiment mounting plate and a motor driven cover. Standard containers are either five cubic feet (200# payload capacity) or 2 1/2 cubic feet (100# payload capacity). Each experimenter must provide power, heating and data handling within his own GAS container.

The Cloud Lidar Experiment on Shuttle (CLEOS) experiment utilized two adjacent five cubic foot GAS cylinders. The scientific objective was to measure the wave dynamics using a solid state laser to excite the resonance fluorescence line of sodium. Design of payload packaging, wiring harnesses, power systems and control techniques were in process when the program was postponed indefinitely.

2.2.3 Lairts (AFGL-305)

Lairts was a complex infra-red, measuring experiment designed for shuttle. The system included a large, cryogen cooled vacuum vessel, several support experiments, and an on-board three-axis pointing system. Northeastern was tasked with defining the control requirements, preparing the system performance specification, and developing a control system for the pointing sequence as-well-as the experiments and telemetry system. A real-time feedback mode and an interface to the mission specialist were also required.

Concepts developed for the sounding rocket payload controller (Section 3.3) were used as the basic building blocks for this application. Shuttle qualified components and packaging configurations were investigated and several special interface boards were contemplated using the basic modular, controller busboard system.

Funding constraints in FY85 dictated that a lower cost sounding rocket payload option be considered, possibly using a Polaris booster. This did not impede controller design since the shuttle package was more complex than the sounding rocket application and required only deletion of some interface modules and software modifications. Interfaces to the five major systems were identified, for either payload option, and a paper design was in process when the program was cancelled due to further budget problems.

2.2.4 Interactions Measurement Payload for Shuttle (AFGL-306)

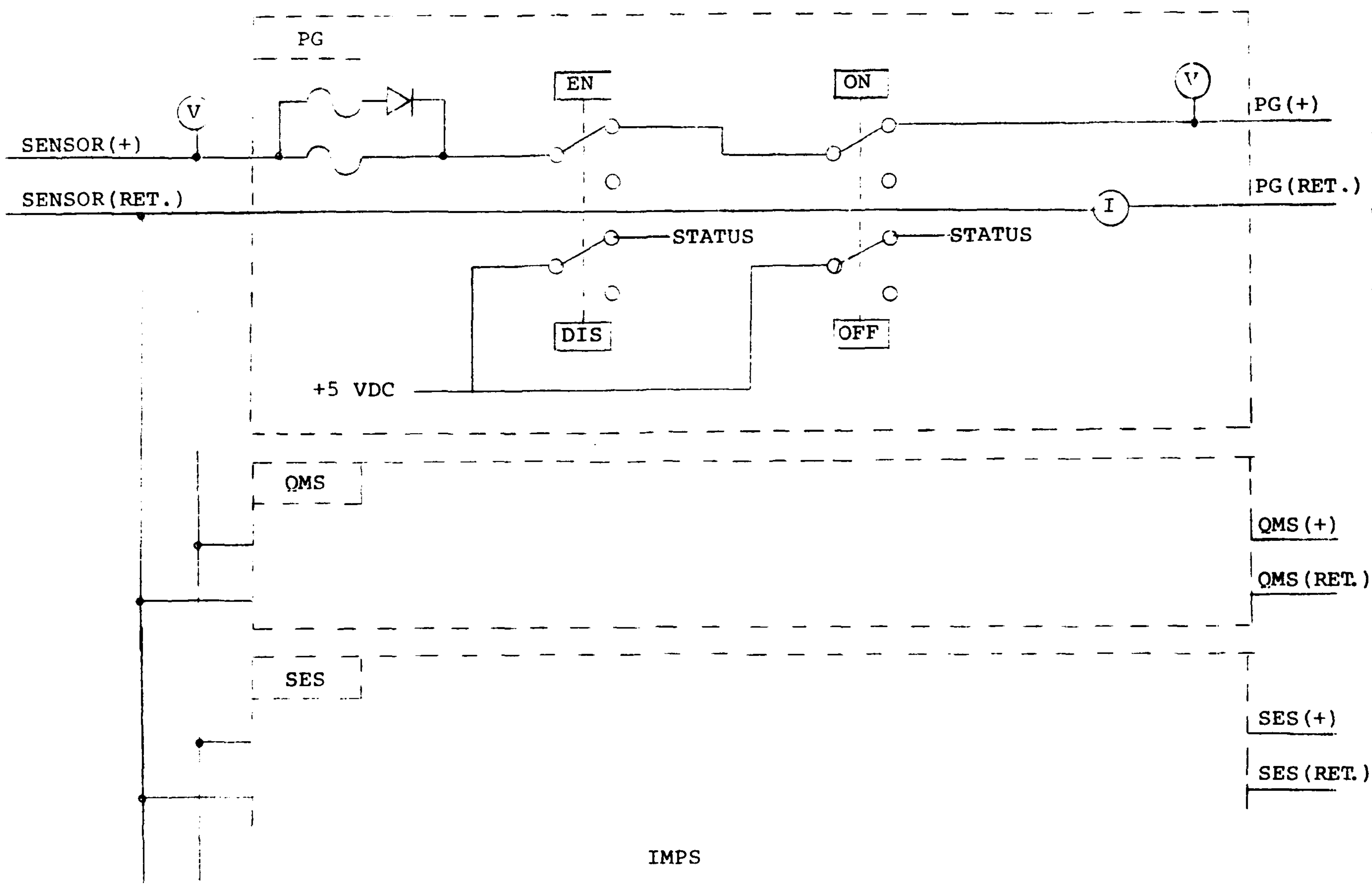
The carrier system for the Interactions Measurement Payload for Shuttle (IMPS) payload, will be SPAS (Shuttle Pallet Satellite). The Jet Propulsion Laboratory (JPL) has developed an Adaption kit (Ak) to extend the basic SPAS accommodations in order to meet payload objectives during both sortie (attached) and subsatellite (detached) operations. The Ak enhances the SPAS capabilities by providing data storage, power distribution and additional battery power with a minimum of hardware modification to the SPAS. There are four primary engineering investigations on IMPS and a group of instruments defined as Environmental Interactions Monitors (EIM). The statement of work to this contract is to define the wiring harness for EIM and to provide the required power distribution and control functions. Initial efforts on the program involved becoming familiar with the applicable JPL documents; the SPAS carrier configuration and standard interfaces; and the environmental, EMC, safety, reliability and quality assurance requirements. An enclosure, defined as the EIM Interface System (EIS) will house the power and control systems as-well-as the telemetry and timing circuits for EIM. The following is a list of the EIM experiments including the subgroup of plasma and fields sensors:

PG	PRESSURE GAUGE	
QMS	QUADRUPOLE MASS SPECTROMETER	
ESA	ELECTROSTATIC ANALYZERS	
DIFP	DIFFERENTIAL ION FLUX PROBE	
SES	SUPRATHERMAL ELECTRON SENSOR	
PAF	PLASMA AND FIELDS	
	PFE	PLASMA FIELDS ELECTRONICS
	PFI	PLASMA FIELDS INTERFACE
	PP	PLASMA PROBES
	SCM	SEARCH COIL MAGNETOMETER
	EFA	E-FIELD ANTENNAS
	LP	LANGMUIR PROBE
	MAG	FLUXGATE MAGNETOMETER

Contract personnel participated in several instrument PDR's and two working group meetings at AFGL. A proposed power distribution system and an EIS enclosure design were presented at the EIM/EIS preliminary design review in May 1986. Figure 7 is a typical power system featuring two interrupts for each sensor; independent fusing; and monitor circuits for relay status, current, voltage and power ON. The EIS enclosure was a bolt-together construction and an expandable printed-circuit board layout with individual power and signal interface connectors for each experifment. After the PDR a list of materials and components was compiled and sent to JPL for comments and/or approval. Card guides and DC/DC converters remain open items. The launch date, and other program milestones, remain indefinite because of the shuttle program hold.

2.2.5 <u>Visual Photometric Experiment (AFGL-501)</u>

The Visual Photometric Experiment (VIPER) payload is packaged in a GAS cylinder similar to that described in Section 2.2.2. The scientific objective of the program is to measure the diffuse zodiacal light and galactic emission with a high sensitivity photometer and low light level television system as a precursor to the large aperture infrared experiments to be flown. The instruments are a visual radiometer, a low light television camera (LLTV) and a film camera. A VHS recorder will be flown to collect the TV data.



IMPS

EIS POWER SYSTEM

Figure 7

This contract provided the battery system and packaging for the encoder, controller and electronic boxes. Fabrication and preliminary tests are complete and a PDR and CDR were held at AFGL. The payload is awaiting reactivation of the shuttle program to define a schedule.

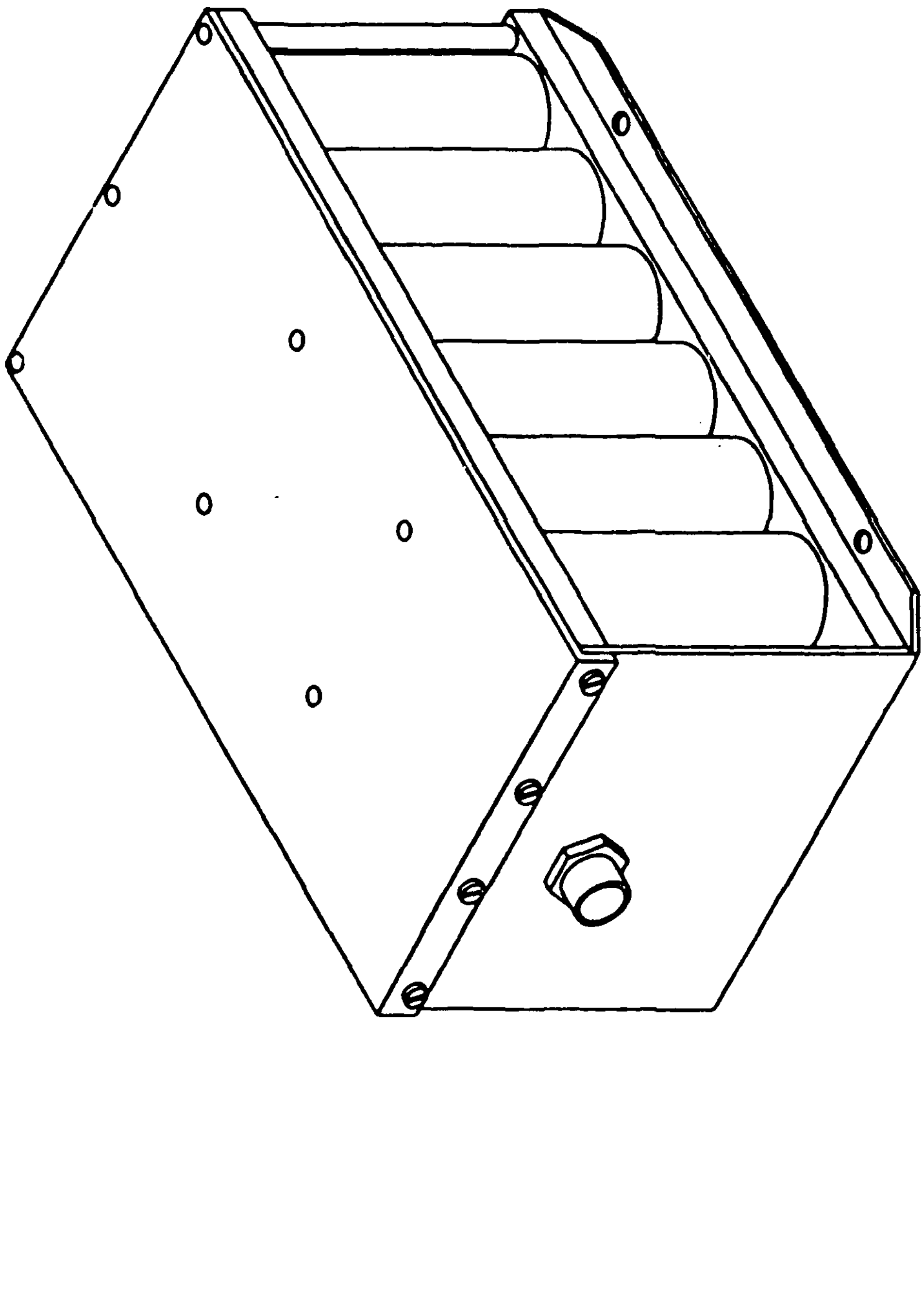
3.0 SUPPORT SYSTEMS

Many of the subsystem categories included in this section have been discussed in previous reports and specific payload discussions herein. Advances, modifications, new applications and results of investigations during the 16 February 81 to 5 May 87 period are presented here. Some investigations are related to specific programs, others were funded directly by AFGL in-house-work-unit (IHWU) funds.

3.1 Power Systems

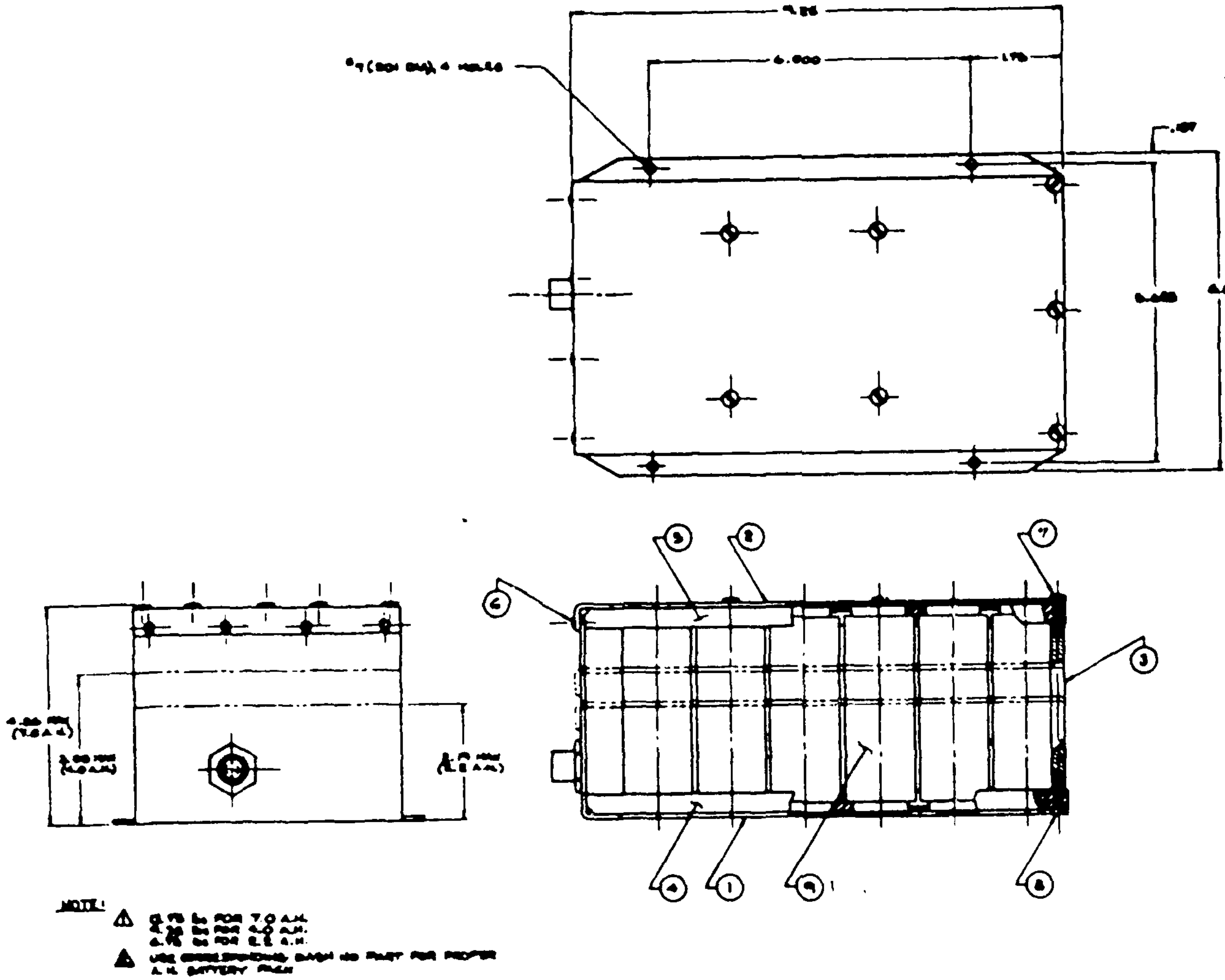
In general power systems consist of an internal/external latching relay and a 28.8 volt nicad battery pack with a power distribution system including in-flight control relays DC to DC converters and fuses where appropriate. Philosophically we prefer to use several smaller batteries rather than a large central battery. This approach allows for redundancy in critical systems; eliminates crosstalk inherent with common power supplies; reduces current carrying capacity of the distribution system; requires smaller charging currents; and improves reliability since a single battery problem will only impact a portion of the payload system. Thermal problems are also reduced with the multiple battery concept since the batteries can be distributed throughout the payload and in many cases located in close proximity to their respective loads. Engineers on the contract have kept pace with battery developments and technicians have conducted extensive evaluation and performance tests on a wide variety of batteries. Sealed nicad cells are most commonly used since they are efficient, have a long life expectancy and are easy to handle and package. Silver-zinc, silver-cadmium, lead-acid, gel-cell and lithium batteries have been used for special applications.

Continuing problems with purchased nicad battery packs and requirements for larger and specialized batteries led to an in-house assembly process early in the contract period. Initially the housings were similar to those of the manufactured, sealed packages. Scientific Report Number 3 of this contract "Nicad Battery Packages" describes the development and qualification of a family of standard 28.8-volt battery packs, using cylindrical nicad cells. Figures 8 and 9 illustrate the open frame design which is easy to assemble and test and provides improved thermal properties over enclosed/potted battery packs. The standard open frame packages are for 7.0, 4.0, 2.2 and 1.2 ampere-hour cells. The 9.6 volt (8 cell) pyro batteries remain enclosed packages. This packaging concept is easily adaptable for



OPEN FRAME BATTERY

Figure 8



ITEM NO	QTY REQD	PART OR IDENT NO	DESCRIPTION
10	2	[illegible]	INSULATOR, OPEN FRAME BATTERY PACK
9	1	D-[illegible]	WIRING SUB-ASSY, OPEN FRAME BATTERY PACK
8	7	STD	6-32 UNC x .75 LG FLATHEAD [illegible]
7	7	STD	8-32 UNC x .75 LG BINDERHEAD SCREW
6	4	STD	4-40 UNC x .[illegible] LG BINDERHEAD SCREW
5	1	C-[illegible]	TOP TRAY, OPEN FRAME BATTERY PACK
4	1	C-[illegible]	BOTTOM TRAY, OPEN FRAME BATTERY PACK
3	7	A-[illegible]	STAND-OFF, OPEN FRAME BATTERY PACK ▲
2	1	C-6057	COVER, OPEN FRAME BATTERY PACK
1	1	D-[illegible]	BASE MOUNT, OPEN FRAME BATTERY PACK ▲

LIST OF MATERIALS

ASSEMBLY

OPEN FRAME BATTERY PACK

Figure 9

non-standard applications. For example the BEAR program requires three higher voltage (greater than the 28.8 volt standard) and a multiple voltage battery which were readily accommodated.

3.2 Timers

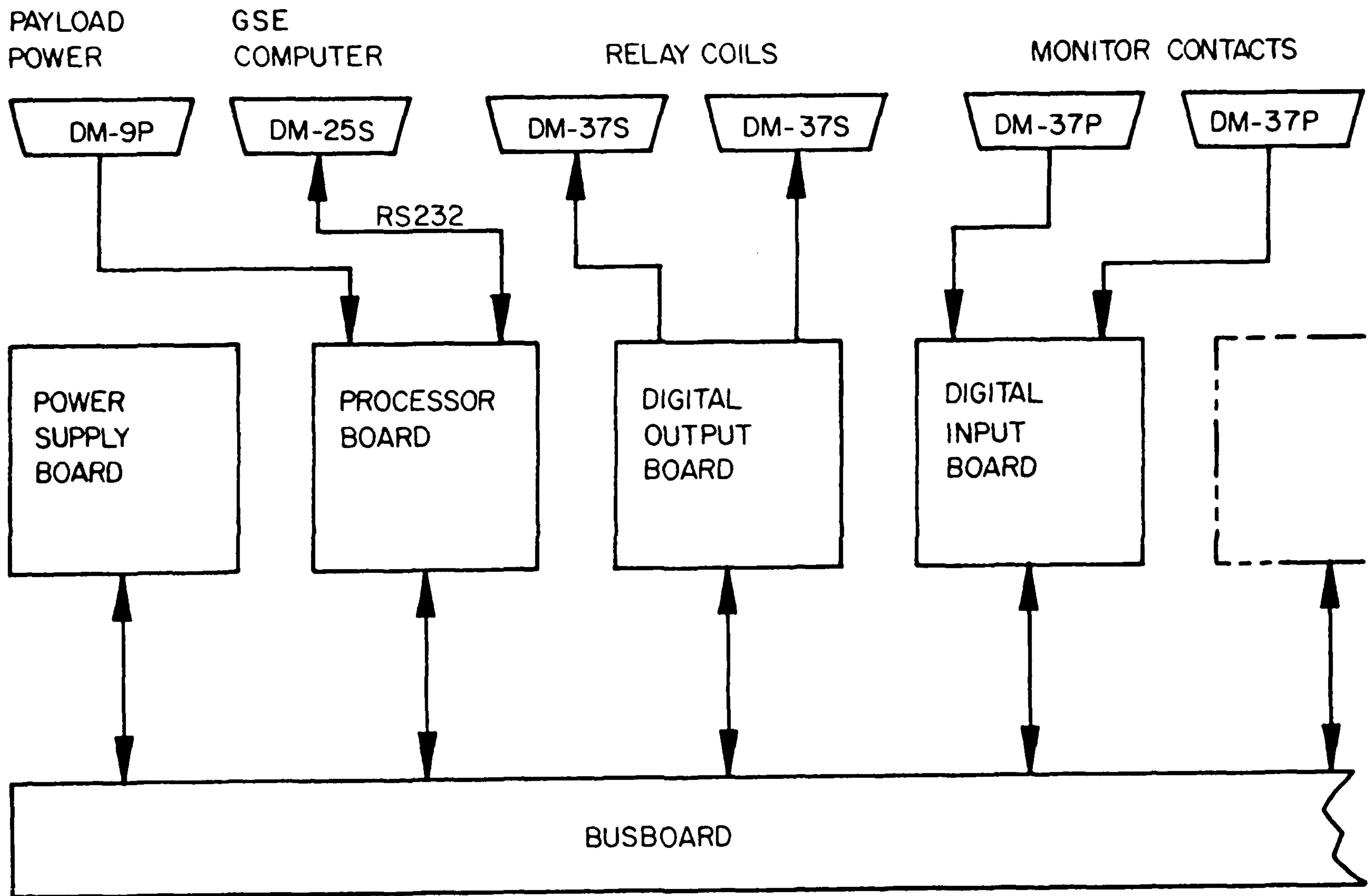
N.U. has incorporated a wide spectrum of devices to provide in-flight sequencing on sounding rockets. The Model 2480 digital timer (Ref. 10) was developed under the previous contract and has flown successfully on 18 sounding rocket payloads. Four printed circuit boards house the crystal clock oscillator and EPROM with related control circuits, as-well-as output relays which are selected and installed for the specific application. Limitations of the Model 2480 timer include a maximum of 16 output functions and the fact that an EPROM must be removed from the unit in order to change program parameters. Another related concern with larger and more complex payloads is the increased number of umbilical control lines required, and the corresponding increase in control console requirements. An expandable control unit was developed to provide both prelaunch and in-flight functions and to resolve both the timing capacity and umbilical problems. The controller is described in the next section.

3.3 Controllers

Figure 10 is a block diagram of a modular controller with a busboard configuration, allowing expansion in 64-function increments. As indicated, the basic controller consists of four (4) printed circuit boards. The power supply board is shielded from the remaining boards and includes monitor circuits and a self-test feature at power-up. An 8751 microcontroller, crystal oscillator and 2718 EEPROM occupy the processor board. A pair of digital I/O boards provide 64 independent ground switching relay driver outputs and 64 digital monitor lines. Additional I/O boards can increase capacity and special function boards can be designed compatible with the bus system. Motor control, solenoid mechanisms and up-leg command interface boards are typical ancillary functions. Initial development was funded through an IHWU and the BEAR program will be first to use the controllers.

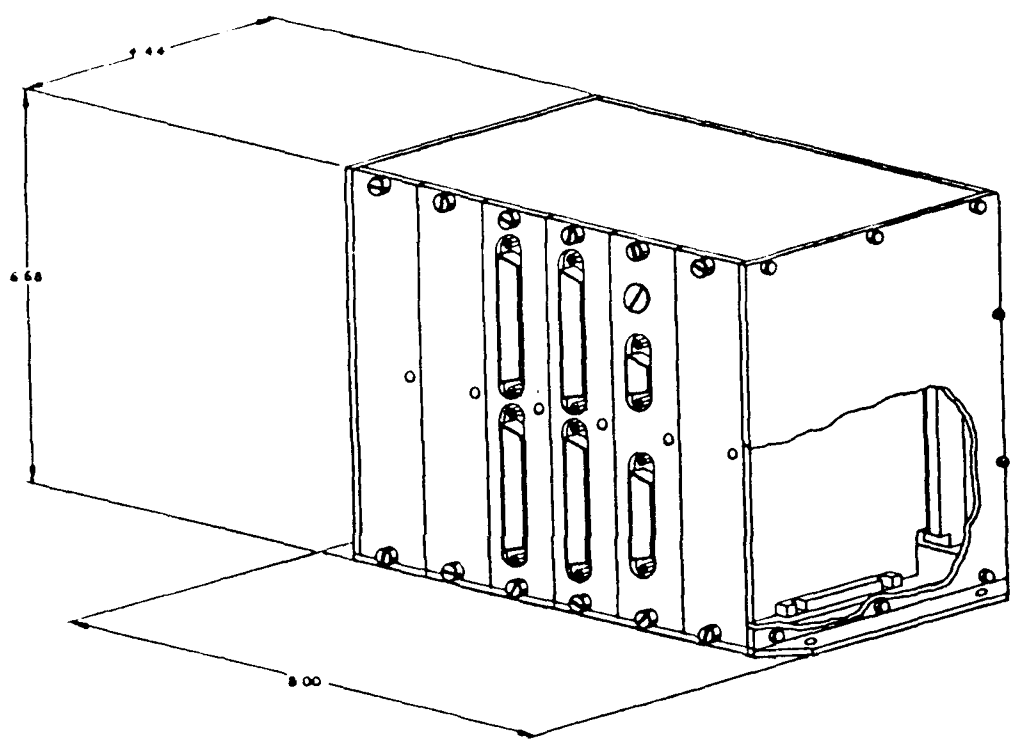
Busboards for four and six plug-in boards have been fabricated and a prototype was qualified to ARIES specifications. Figure 11 depicts a six position unit which weights approximately 2.6kg. The only GSE required is an RS232 interface to a dedicated interface unit and a desk top type computer terminal.

A presettable timer has a range of over an hour-and-a-half with a resolution of 0.1 seconds. Mission or test criteria are stored in an EEPROM programmed through the



SYSTEM BLOCK DIAGRAM
CONTROLLER

Figure 10



PAYLOAD CONTROLLER

Figure 11

system's RS-232 communications link. All controls and monitors pass through this link except Master Reset and Time Sync lines. On power-up or after Master Reset, the unit enters a self-test mode which insures the integrity of all critical functions before it is allowed to assume control of the payload. Any faults encountered in this mode are reported to the operator and the system is halted.

The controller has two main modes of operation: manual and automatic. In the manual mode, the internal timer is on hold and waits for instructions from the Ground Control Unit. The monitors coming into the unit are scanned continuously and any change in their status is reported. When the system is enabled for automatic operation, the timer is started and the pre-programmed payload functions are performed. The operator can access all payload support functions by name and views monitor data the same way. In launch countdown operations, it is possible to assume control of all functions at T-1 hour and perform all minus count operations automatically; the operator takes action only in case of a hold or abort.

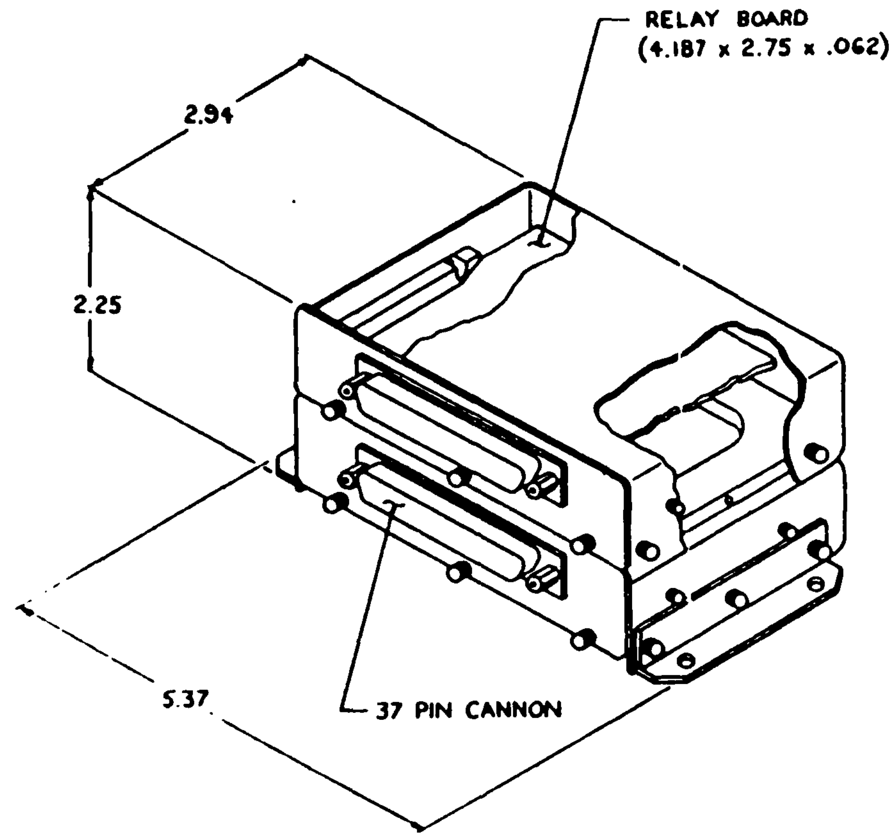
3.3.1 Relay Modules

A relay box concept, consisting of stacking modules with four different circuit board options, is used to interface the controllers to the timing functions. Relay boxes can be located at convenient locations in the payload to facilitate wiring. This concept allows the flexibility of providing independent relay contacts for each function and eliminates the need for individual umbilical control lines for relays. The modular concept allows stacking of up to four units. A dual stack is illustrated in Figure 12.

3.4 Diagnostic Instrumentation

Linear accelerometers, magnetometers, vibration accelerometers, pressure transducers and thermistors are routinely included in sounding rocket payloads by the integrating contractor. Northeastern is continuously monitoring developments with this instrumentation in the areas of interfacing requirements, test procedures and calibration methodology. Television camera systems (MSMP, BERT I, and EXCEDE) and film cameras (MSMP) are part of the diagnostic instrumentation requirements for some of the payloads.

In addition to the specific payload requirements, Northeastern was tasked with developing a vibration monitoring system to interface with a PCM encoder. System requirements were defined as a range of 0.1G to 30G with a frequency response of 0 to 5kHZ. Investigation led to a combination system of a triaxial vibration sensor and a single axis vibration sensor with compatable charge



MODULAR

CONTROL RELAY BOXES

Figure 12

amplifiers interfaced to a four-channel PCM encoder. Evaluation units were ordered; however, delivery problems were encountered and tests were not accomplished by the end of the contract period.

3.5 Mechanical Systems

On sounding rocket payloads mechanical design includes the overall payload structure, internal rack structure, mounting brackets, mechanisms and enclosures for various subsystems. Shuttle projects generally require only internal rack structures and enclosures. During the contract period, payloads ranging from 9-inches to 44-inches in diameter were designed and fabricated. Design quidelines also vary with the launch environment dictated by the flight sequence and the test specifications for the particular launch vehicle.

Unique aspects of the mechanical design usually involve the mechanisms required to expose sensors to the environment. These are either pyrotechnic actuated or motor driven mechanisms. Redundant actuators are used in all pyro activated mechanisms. This type of mechanism is relatively simple and can generally be adapted more readily than a motor driven system.

Previous payload motor drive systems (BERT I and MSMP on this contract) have utilized dual-armature motors with a single output shaft. This concept provides electrical redundancy, but the output shaft is a single failure point.

A differential drive system utilizing two independent motors each driving a bevel gear on a differential is being investigated for the EXCEDE payload. With both motors operating the output shaft will rotate at the same speed as the motors. In the event of a motor failure the output shaft will rotate at one-half speed with equivalent torque. Sufficient intervals must be allocated in the flight timeline to allow for this contingency. Motor driven mechanisms have the obvious advantage of being retractable and do not use expendable pyros. A listing of mechanisms is included on the individual payload sheets presented in Section 2.1 of this report.

3.6 Ground Support Equipment

Customized Ground Support Equipment (GSE) interfaces are required for each project. These include control consoles, battery servicing consoles, control cables and simulators for use in all phases of testing. In addition to the test cables used when the consoles are in close proximity to the payload, a cable distribution system must be coordinated with test and launch facilities where the payload is remote from the control center.

During the contract period a simplified modular control console concept was developed and battery charges were redesigned to accommodate a wide variety of high rate battery packs. Also, an expandable monitor panel was fabricated to provide visual indication of pyrotechnic functions and simulate the pyrotechnic bridgewire resistance. Other simulators were custom fabricated to meet unique payload requirements.

The inception of the payload controller has significantly reduced the magnitude and complexity of control consoles and control cables, since most control and monitoring is accomplished through the RS-232 link to the computer terminal. When the controller is used, only external power, battery charging and controller master reset functions require dedicated umbilical lines.

4.0 INTEGRATION AND TESTING

This contract was responsible for overall payload coordination in all sounding rocket programs described in Section 2.1. In the design phase, this entailed mechanical and electrical integration of scientific instruments, telemetry systems and other support modules. Northeastern personnel also participated in all phases of payload testing and contributed to the implementation of interface control documents, program schedules, test sequences and countdown procedures. The level of contractor involvement, with respect to integration and testing, on shuttle payloads varied with the scope of the project and the level of effort is described in the Shuttle projects Section of this report.

4.1 Component and Subsystem Testing

Functional tests of all components and subsystems are conducted at various stages of fabrication, and eventually in the flight configuration. These include batteries, timers, controllers, mechanisms, electronic boxes and diagnostic instrumentation. Environmental tests, at the qualification level are required for any new component or subsystem. Flight inits are tested to acceptance levels before installation in the payload. Applicable sequences and specifications for qualification and acceptance level tests are defined in AFGL manuals which are derived from MIL-STD-1540B(USAF) "Test Requirements for Space Vehicles".

Laboratory notebooks are utilized to record preliminary test results and a project test matrix is developed to document acceptance level-tests that evolve into system tests.

4.2 System Testing and Launch Support

The first step at the system level is a complete in-house test of all Northeastern support systems and related GSE. This includes power checks, timing cycles with simulators and operation of all diagnostic instrumentation. Next, the payload section is delivered to AFGL where scientific instruments are sequentially integrated, followed by the remaining payload sections. A flight simulation with all systems is then conducted followed by environmental tests of the system segment, generally consisting of shock and vibration to the specified levels. At this time the payload is prepared for shipment to the launch facility.

As indicated in the project sections of this report some special tests, at the system level, are dictated by the scientific criteria. These included: system vacuum (BERT and BEAR), magnetic compatability (ERNIE), EMI and EMC (SETS and IMPS) and spin balance (ERNIE and POLAR ARCS).

Launch site operations for sounding rocket payloads include verification of payload operation, installation of launcher and blockhouse cables and equipment, and range integration tests leading to the final countdown. Contract personnel did not participate in any shuttle launches during the reporting period.

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6.0 PERSONNEL

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