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**Feasibility Study of a Long Duration Balloon Flight  
with  
NASA/GSFC and Soviet Space Agency  
Gamma Ray Spectrometers**

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(NASA-CR-192934) FEASIBILITY STUDY  
OF A LONG DURATION BALLOON FLIGHT  
WITH NASA/GSFC AND SOVIET SPACE  
AGENCY GAMMA RAY SPECTROMETERS  
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**Antarctic Balloon Study  
December 1989**

This is the report of a feasibility study of conducting a joint NASA/GSFC and Soviet Space Agency long duration balloon flight at the Antarctic in January 1993. The objective of the mission is the verification and calibration of gamma ray and neutron remote sensing instruments which can be used to obtain geochemical maps of the surface of planetary bodies. The gamma ray instruments in question are the GRAD and the Soviet Phobos prototype. The neutron detectors are supplied by Los Alamos National Laboratory and the Soviet Phobos prototype. These are to be carried aboard a gondola that supplies the data and supplies the power for the period of up to two weeks.

**Payload System Design**

Figure 1 gives the system design including all that is required for the gondola except for ballast. Table 1 is a list of the system weight, telemetry rate, and power. Below are discussed in more detail the components of the system

TABLE 1: Payload Resource Budget

	weight lbs	telemetry bps	power watts
GRAD w=322+168 p=10+78+60	490	1310	148
Soviet Gamma Ray w=18 p=65.5+11.8	18	41	77
Soviet Neutron w=26 p=17.6+4.2	26	1	22
Los Alamos Neutron w=70+ p=65.4+3.2	70	164	69
Soil System w=600+85 (no auger)	685	na	na
General Payload w=350+80+250 +90+40+150+10+50+60 p=83+22.2+41	1080	2	146
NSBF (SIP) w=350 + ballast	350+	na	na
TOTALS	2719+	1518	462

## Gondola

The gondola consists of a simple rectangular framework approximately 5' x 7' x 8' high. The central focus of the gondola is to house an array of instruments around a soil hopper, provide a power system and a data recording, archival and retrieval system. To this end the main components are the hopper system, a gondola rotator and pointing system, battery packs with solar panels, the NCAR provided SIP, hermetic container(s) housing a CAMAC crate with computer, two optical disc recorders and the necessary instrument electronics. The complement of instruments consists of the Gamma Ray Advanced Detector (GRAD) and associated GRAD electronics, a Los Alamos National Laboratory instrument and two instruments provided by the Soviet Space Agency. Figure 2 illustrates this payload concept.

Past experience with balloon gondolas has led to a simple framework of 2" square aluminum tubing (with 1/8" walls) bolted together at the corners with welded corner fittings. The gondola dimensions can readily be changed by simply cutting new lengths of tubing. With square tubing or angle it is easy to add additional cross members to support the various pieces of hardware. The rotator will sit atop pyramid framing linking the four corners of the gondola. Linkages at these points will be made using standard spherical bearing swivel bolts at all corners. Solar panels will be mounted on the 5x8 side of the gondola and can be stacked, accordion fashion, before launch. After lift off the panels can be deployed and hang below the gondola. This allows ample adjustment in the sizing of the solar panel but will probably mean non-reusable panels after landing. Skids are also proposed on the two 7x8 sides of the gondola. In all probability the payload will end up laying on one of these two faces. If the payload should decide to pick the improbable face a few good men should be able to tip the payload onto its skids

Each of the instruments should be mounted captively with a simple one point pin release. The smaller instruments, such as the Soviet detectors and the LANL, may be plate mounted. A channel will capture one edge of the instrument plate with positive locking provided by a quick release locking pin on the remaining edge. This scheme should provide quick hardware release. The harness must also be removed and if the recovery crew has ample time the twist-lock connectors should pose no problem. In the event that time is not available, heavy duty cable cutters shall be used to cut free all of the prime retrievable hardware. The GRAD because of its significant size shall have a framework built that permits loading from one end only. The hopper will provide one end stop and again the other end will be a one point pin release. Figure 3 illustrates this mounting conceptually.

The hermetic container will have to dissipate a considerable amount of power (see below). This shall be accomplished by conductively coupling the container to the lower hopper. The gondola framework/hopper and soil mass will act as a thermal sink during the mission. The lower hopper will have an unobstructed view of the earth and shall act as a radiator for added power dissipation. Further work shall be required to prove the feasibility of this scheme. The hermetic container(s) can be produced quite simply by rolling aluminum plate and welding on end flanges with hinged o-ring sealed doors. If access to the optical disc drives is required for quick data retrieval the doors can quickly be opened with a battery powered socket-wrench driver or speed wrench. Again the disc drives will employ the same mounting technique as used for the instruments.

## ***Soil Handling***

The instruments require a view of the soil sample varying from  $2\pi$  ster to a 60 degree solid angle. The optical depth in all cases is assumed to be 25 cm. Considering the above requirements a hopper with an equilateral triangle cross section is proposed that is 60 cm on a side and 60 cm deep. Total soil volume would be  $9.4 \times 10^4$  cc and with a soil density of 2.3 gm/cc this means a total soil weight of 215.1Kg (474 Lb) . The soil would reside in this hopper for 5 days during the instrument measurement period. The soil will be transferred to a second hopper of similar dimension ( it need not be triangular in cross section at this time ) while the instrument background signals are recorded, again a nominal 5 day period. Transfer from the upper to the lower hopper will be by a simply hinged, spring-loaded trap door actuated through pyros on command from the ground. The contents of the lower hopper can be released in total by a door of similar design upon ground command or the contents may be released in a controlled fashion to serve as ballast and assist in maintaining a nominal balloon altitude. This may be accomplished in a number of ways. For coarser soil dumps, on the order of 100 lbs. the lower hopper would be partitioned into 5 compartments each holding approximately 100 lbs. of soil. Each of these compartments would be individually dumped, again using a simple pyro actuated door as is proposed for the upper hopper. An auger system driven by a DC motor can provide precise release of the soil. A small commercially available auger as would be used for gravel handling is proposed if extremely fine control is needed. At this time we do not see a need for precise control.

Figure 4 shows where the estimated CG is located for a number of possible soil and ballast conditions during the flight: (1) Ballast in, soil top hopper; (2) Ballast out, soil top hopper; (3) Ballast out, soil bottom hopper; (4) Ballast out, soil out.

## ***Payload Electrical System***

The payload electrical system consists of the power system, the the command and data system, and the telemetry system. Figure 5 is a block diagram of the Payload Power system and the Data and Control System. Figure 6 shows the assignments for the CAMAC crate slots. The total power required is 595 watts including estimated power supply inefficiencies of 80%. We now discuss the particulars of the electrical system.

## ***Payload Power System***

The power system needs to be able to supply about 600 watts of continuous power. This requires 100 square feet of the NSBF solar power system arrays, approximately 8 of the 3 feet by 4 feet panels. These would be mounted on one side of the gondola and deployed after the balloon is at float altitude. A solar pointing rotator would be used to keep the panels pointing at the sun. Three battery system modules would be required. Each delivers 200 watts of continuous load for 11 hours without recharge.

## ***Payload Data System***

The payload data system (PDS) is a unified command, telemetry and data archiving package for the complete complement of scientific instruments as well as the neutron thermalization soil system and supporting gondola subsystems.

This payload complement requires minimal autonomous control functions. The few required are limited to energy, temperature and ballast management.

Since this particular configuration of instruments may not be available for a reflight, the data can be regarded as truly priceless. To ensure a successful mission, the PDS implements multiple means of data 'survival'. The primary level of data survivability are the on-board optical disks. This subsystem records the data simultaneously on two Write Once Read Many (WORM) optical disk drives. The WORM drives provide adequate storage capacity for this long duration mission, yet unlike tape drives, impose no performance penalty for the infrequent (order of minutes) recording of small data files. The drives selected are specifically designed and manufactured for high reliability avionics applications. The secondary level of data survivability is the high speed telemetry playback that is activated whenever the NSBF aircraft can accomplish an underflight. The data, read from either of the optical disk drives, will automatically begin transmission at the endpoint of the last underflight. The playback rate will be a compromise between rf link reliability and the need to dump large quantities of data within a nominal one hour contact. Finally, as is common practice, the integrated data is transmitted in realtime and is available to any ground station within range. Conventional receiver/tape recorder systems will do. With the NSBF aircraft and at least one other ground station (at US and USSR bases), coverage may be obtained over substantial arcs of the Antarctic continent.

The PDS hardware shall consist of a low power CMOS IBM-AT compatible computer designed and packaged for harsh industrial factory type environments. The computer will interface to the instrumentation, except for the GRAD instrument, through CAMAC I/O modules while normal payload monitoring and control will be interfaced through I/O cards located in the computer's backplane. There is a significant reduction in power consumption by placing low power I/O cards directly in the computer to handle the routine housekeeping and preserving the CAMAC crate for the specialized instrumentation interfaces.

In the case of the GRAD instrument the computer will acquire the instruments data directly from the GRAD'S NIM data modules by means of two RS-232 serial communication lines. This makes the GRAD instrument a closed system that can be checked out and calibrated by the University of Florida and then integrated onto the payload without the exchange of any specialized interfaces.

With the exception of the telemetry interface all computer and CAMAC modules will be off-the-shelf items. The telemetry interface concept will be borrowed directly from a recent sounding rocket program. In that instrument an interface card was developed that would buffer data from a computer parallel port and interface to a standard PCM telemetry system. Two such systems would be used with one providing for a slow TM system to handle routine health and safety data while a second PCM would provide a high speed data dump during aircraft underflight.

The application program will be written in a mix of Microsoft FORTRAN and C code using purchased Kinetic Systems low level drivers to access I/O from the CAMAC crate. When ever possible SPRL special purpose support software for specific CAMAC modules will be ported to the IBM flight computer. But many of the specialized CAMAC modules that we do not have subroutines for will require the coding of new upper level calling routines.

Once configured for flight the PDS will support the following interfaces:

- SIP ascii serial command input
- low rate PCM telemetry to SIP
- high rate PCM telemetry to SIP
- GPSS ascii position data from SIP

2 serial links to GRAD  
GPIB CAMAC interface

prom disk for flight program and operating system storage  
SCSI interface for optical disk  
instrument power switching  
instrument housekeeping monitors  
payload temperature, current, and voltage monitors  
soil system mechanism control

When the PDS is configured for ground operation and development it will also support a user keyboard and monitor, winchester and floppy disk, and a printer.

### **Instrument Requirements**

The weight, power and data rate for each of the four instruments are given in Table 1.

#### *Grad:*

The GRAD will be supplied by GSFC and the University of Florida. The detector must be refurbished. The GRAD will supply the computer system with data along 2 RS-232 lines.

#### *Soviet gamma ray and neutron detectors*

The data interface from the gamma ray detector will be through two CAMAC-based multi-channel analyzers. Therefore, the Soviet AMA-21 MCA will not be required. The data interface from the neutron detector will be through a six-channel CAMAC counter/timer, effectively bypassing the Phobos data circuitry. Both instruments will be supplied with analog telemetry channels and provision is made for contact-closure commands for power and mode selection. It must be noted that the Soviet instruments are designed for positive-ground operation and that the balloon will employ a negative-ground power system. This should not present a problem as the primaries of the Soviet instruments are electrically isolated from chassis, but it is recommended that operation with this polarity be verified. Mating connectors (to the gondola data system) will be supplied to the Soviets, who will then fabricate and test the interconnect cabling for their instruments. Data system software sufficient to operate the two Soviet instruments will be developed by the gondola contractor.

#### *Los Alamos National Laboratory neutron instruments*

The tasks are to design and fabricate the instrument. The PMTs will be encapsulated with high voltage power supply and preamps by gondola contractor. The instrument will then be assembled and tested at LANL using a CAMAC crate on loan from NASA/GSFC. Data system obtained and software development by gondola contractor.

### **Telemetry Budget**

The proposed telemetry budget is based on the following; a) 10 minute integration period, b) 200 events-per-sec average rate, c) 1000 events-per-sec peak rate. Though the events should be distributed over more than one binning interval in the histogram, with the information available, we have chosen a sufficiently large word size to accommodate the peak event rate in one bin. The science telemetry output for each instrument is listed in Table 2:

Table 2: Science Telemetry Allocation

	histogram		# chan	scaler		bits intg
	width	max cnts		max cnts	# chan	
GRAD	16k	24bits	2			786,432
Soviet						
Gamma R.	512	24bits	2	24bits	6	24,720
Neut. Flux				24bits	6	144
L.A.N.L.						
Neut. Flux	1k	24bits	4	24bits	4	98,400

Based on the above assumptions regarding science telemetry needs, the following telemetry system parameters can be derived:

- a) total bits per integration period: 909,648,
- b) the realtime channel rate: 1,516 bits sec<sup>-1</sup>,
- c) the mission storage requirements: 16,373,664 bytes day<sup>-1</sup>.

The housekeeping telemetry budget is also based on a 10 minute sampling interval and has been approximated at 1.5 bits sec<sup>-1</sup>.

The Antarctic Payload will have two command paths and three telemetry paths. The telemetry paths are the normal realtime telemetry, high speed data dump, and the ARGOS health and status.

The realtime telemetry will be sent at all times and can be received by any ground station in the balloon's line of sight or by an aircraft under flight. This set of data will be built into a 10 minute packet which will contain all status, house keeping, and instrument data. The realtime data packet is a direct copy of the data record that is written on the optical disk (WORM). If the data rate of the PCM stack is high enough then this data packet may be transmitted multiple times within a single 10 minute integration period.

The high speed data dump will occur from a separate 1 megabit PCM stack. A command from the ground station (generally on board the aircraft) will give the starting point of the data dump and, optionally, the end point to the on-board data system computer which will transfer data from the optical disk to the PCM stack.

The third data path will transmit a brief payload status through the ARGOS satellite system. Because of the extremely low data rate of the ARGOS and the intermittent nature of the data link the on-board computer will limit itself to 4 bytes of status information. Each data bit will correspond to a particular condition being "OK". For example if the GRAD high voltage is within a defined minimum or maximum limit then the "OK" will be active. The status bits will be defined to indicate temperatures, currents, and monitor voltages for each instrument and the data system.

The general format for the real time data record will be a series of fixed length fields. The computer will integrate data for a 10 minute time period after which it will build a telemetry data packet. A copy of the data packet will be stored on the optical disk while an exact copy will be sent out over real time telemetry as many times as the telemetry bandwidth will permit.

The two command paths to the data system are a serial command and a relay closure from the NSBF/SIP. The relay command will be used as a redundant command for such things as turning on instruments, firing pyros, and activating recovery aids that can be used even if the data system is powered down.

Payload commands are generally sent to the payload computer from the SIP through a multidrop serial communication bus. The Payload computer then decodes and executes the command. Because the SIP includes a series of command relays, they will be used as redundant commands in case that a command fails through the normal command path. Most SIP commands are expected to be a momentary relay closure which will either set or reset a latching relay.

## **National Scientific Balloon Facility (NSBF)**

### *Instrumentation Requirements*

The NSBF Standard Instrument Package (SIP) is 17.4 cubic feet and weighs 350 lbs. Its principal function is to monitor the balloon functions, limited instrument status and balloon command functions. It has its own power system independent of the experiments. The SIP will provide a central processor unit (CPU) and an ARGOS beacon and GPSS receiver for location of payload. An ARGOS Local User Terminal provides low rate command uplink. A VHF beacon and L-band PCM system for line of sight transmission. An altitude transducer, externally mounted solar panel and ballast hopper and feed control complete the package.

The CPU has the function of ballast control, monitoring, and command. The presence of the CPU allows RS232 interface modules to be used at various locations on the payload.

### *Launch and Recovery*

It is assumed that the NSBF will provide the appropriate balloon to lift 2700 pounds plus ballast to 100,000 feet. NSBF will also handle the launch operations and requirements. The NSBF will handle recovery through the use of the aircraft available to them. Given the limited data base on balloon flights in Antarctica and the nature of the terrain, they feel the chance is slim of a long duration balloon flight payload recovery. In any event they will not allow water landings. Since they are in control of the cut down, any movement toward water will trigger a cut down on land.

## **Payload Recovery Systems**

### *Land recovery*

We have investigated various quick-release schemes for critical subassemblies that will allow rapid recovery of the data system enclosure, followed by the instruments in the event that the total payload is unrecoverable. We are planning on the availability of GPSS data from the payload and the NSBF aircraft to facilitate rapid location and recovery of the payload.

Because of the difficulty of spotting a downed payload some type of visual aid will be incorporated into its basic design. Below are a list of ideas that could be incorporated into the structure of the gondola itself or as a package that's dropped from a spotter plane at the time of the balloon cutdown.

\* Strobe lights. The human eye will spot moving or flashing objects long before it will ever spot a stationary one. A strobe light that contrast with its background should be very easy to add and will require only a small amount of power to operate. Strobe lights can be mounted on all faces of the gondola so as to be visible no matter what the landing orientation of the gondola is. Strobe lights could be used in pairs (e.g. red and green) to facilitate daytime spotting.

\* Dye marker. A concentrated water soluble dye, rodimine or floriscene, such as used by divers could be dropped by the payload a hundred feet before landing. This would create a large florescent green or violet spot about the size of a football field. The drop altitude could be obtained by a sonar distance measuring device similar (and available from) to what is used on Polaroid instant cameras. A small pyro charge could be used to aid in dispersing the dye. Blowing snow in small amounts may even aid in the dispersion of the dye into an even larger area for visual spotting.

\* Radio Beacon. An omnidirectional beacon such as used to find tagged animals or aircraft emergency locator transmitters could be mounted on the gondola. Personnel with Antarctic experience say that UHF devices don't work very well down there. They use HF and VHF devices when they use any at all. If we use a beacon then we must also provide a finder on the airplane. Mounting the antenna could be a problem.

\* Signal Balloon. Once on the ground the gondola could release a small tethered signal balloon that would hold aloft a corner cube reflector and maybe a strobe light. The balloon itself could be metalized mylar so as to reflect a radio signal

\* Corner cube reflectors could be built into the structure of the gondola itself.

\* VORTAC & OMB. An aircraft navigation VORTAC or omnidirectional beacon could be mounted on the gondola. The aircraft would already have the required finder built in. However, the cost and complexity of such a device are unknown.

\* Smoke bombs. It is possible to leave the command system powered up once the balloon lands. If the antennas survive impact then a command could be received that would light off a smoke bomb to aid in visual spotting. The sensibility of lighting a fire near a downed payload that still contains precious data needs to be investigated.

### *Water Recovery*

Flotation has been addressed as desirable in the event that the payload should come down in water. To float a payload of approximately 2500 lbs dry weight would require a water displacement of 40 cu ft. The total empty volume of hermetic containers, upper and lower hopper (assuming that they could be made watertight), SIP container and GRAD are approximately 20 cu ft. An additional 20 cu ft ( two 1.5' dia. cylinders x 7' long ) would be required for neutral buoyancy . Our experience has been that the NSBF procedures prevent or minimize such an occurrence to the point that flotation would be a costly proposition.

### **Ground Support Systems**

The payload requires a moderate amount of payload specific ground support systems to support the development, integration, calibration, and launch support tasks. In order to take advantage of the New Mexico State Physical Sciences Lab (PSL) designed telemetry decommutation board, the payload GSE will be built around a i386 based pc compatible computer. The system will support command file generation, data archiving, realtime

display of housekeeping functions, near-realtime display of instrument data and will support off-line display of instrument data in greater detail.

The GSE system for the Antarctic balloon is illustrated schematically in Figure 7. It will be required to perform various job functions at various places such as during the development phase of the gondola while at U of M, Instrument Integration and testing, preflight at McMurdo, balloon under flight, and post flight. Below is a short list of GSE requirements during each phase:

#### Development and Test

- \* Provide power
- \* Gondola computer interface
- \* Data transfer
- \* Real time data display
- \* Command Interface
- \* SIP simulator

#### Qualification Test at GSFC with SIP and McMurdo preflight

- \* Provide Power
- \* Real time data display
- \* Telemetry interface
- \* Command interface
- \* Data printing
- \* Data logging
- \* Data playback

#### Aircraft Under Flight

- \* Telemetry Interface
- \* Real time data display
- \* Data logging
- \* Data playback

#### Post Flight

- \* Data dump of optical disk
- \* Data playback
- \* Data printing
- \* Low level data analysis
- \* Data transfer

### *Development*

In all probability the SIP from PSL will not be made available until after all of the instruments have been integrated onto the payload. And even then only during qualification testing. This means that the GSE must be able to simulate the SIP's telemetry timing and command signals during the development phase of the gondola and on to integration of the payload instrumentation. The GSE must be able to act as a dumb terminal for the balloon's on board computer. It also must provide a real time display of the balloon data. This data would be obtained by simulating the SIP's PCM telemetry channel. The GSE must be able to transfer data gathered from the balloon payload to SPRL's mainframe computer network. The GSE has to be able to provide power to the payload. This is no simple task! The Payload requires a total of 595 watts of power into 3 power busses. During flight each power bus would be serviced by its own solar array and battery. The GSE should have the capability of pre-charging the payload batteries.

### *Qualification Test at GSFC and McMurdo Preflight:*

While at GSFC (or NSBF in Texas) and McMurdo the GSE has to perform most of the functions that were required during development. The exception is that there will be no need for networking or for simulation of the SIP. The SIP will now acquire data from the balloon computer and relay it as telemetry. The GSE must now decom the payload data from a bi-phase telemetry signal.

The power at McMurdo is provided by diesel generators. This power is of questionable quality. To prevent the GSE computer from crashing the GSE should be provided with an uninterruptable power supply. The UPS need not provide power to the payload because it will have its own storage batteries. The GSE will have to precharge the payload batteries.

### *Aircraft Under Flight*

During under flight it is assumed the PSL will provide the telemetry receivers and antennas required to receive data from the balloon. It is also assumed that PSL will provide a coax line with bi-phase telemetry signals to our GSE. Our GSE will then be required to display the normal housekeeping data that is normally telemetered by the balloon. It will also be required to provide storage and readback capability for the balloon's optical disk data dump.

The GSE unit will have it's own avionic quality optical disk similar to the units mounted on the balloon payload. The optical disk will become the storage media for the balloon's data dump. In the case that only the optical disk unit can be recovered from the payload then the optical disk drive on the GSE will be used to transfer data from the flight disk.

Due to aircraft vibration the hard disk within the GSE computer may be unusable. For this reason the computers hard disk should be removed, or at least disconnected, from the GSE. The GSE's operating system and control program will be loaded from either its floppy drive or a solid state disk.

During flight the GSE will be operated on aircraft power. If the aircraft does not provide 110v AC then what ever power is provided will be used to charge the batteries on the uninterruptable power supply which in turn will provide 110v AC power to the GSE's computer.

After the flight the GSE will be used to readback the balloon's dumped data and to perform low level processing and display of the data. It shall also provide hardcopy output of the data.

### *Post Flight*

After the flight the GSE will make multiple copies of the flight data disk. The media for these copies will be either optical disk and/or cartridge magnetic tape. Once the GSE is returned to SPRL the data from the copied media will be transferred along SPRL's computer network onto standard 6250 magnetic tape for final distribution.

The GSE itself will be capable of providing low level analysis and display of balloon data for those who are too eager to wait until the hardware makes the return trip to U.S.

### *Computer Software*

The computer software will be written with common off the shelf development tools. No obscure operating systems or languages on this project. Presently envisioned (but not limited to) software written in Pascal or C operating under multi-tasking OS2.

The general instrument display program will be a series of multiple menus and pop up screens where each screen will display either instrument or balloon data in either text or color graphics. The top of all screens will contain a fixed field of screens that can be selected (similar to what you would see on a Macintosh). If an instrument data screen is presently displayed and an error is detected by the computer in the health and safety screen then the button for the health and safety screen will turn from its normal color to red. If its an urgent error then the button would flash red and the computer will make a beeping sound.

Selection from screen to screen will be performed either by a keyboard entry or by selection with a light pen. The light pen will become useful in the aircraft under flight. Vibration and bouncing around may make keyboard entry somewhat difficult.

### **Schedule**

Figure 8 is a proposed schedule of activities to meet a January 1993 launch from McMurdo. FY90 consists of payload design, data system design and fabrication and software development; FY91 concludes design and starts payload fabrication, test and integration; FY92 consists of qualification at GSFC (of NSBF) and shipment to Antarctica; FY93 consists of launch operations.

## Cost

The estimated budget is outlined in Table 3. The tasks to be done are as follows:

1. Payload system design
2. Mechanical design and interface control
3. Electrical power system and interface control
4. Gondola design and fabrication
5. Hoppers and mechanisms for soil system
6. Mechanical GSE
7. Thermal control and thermal GSE - if required
8. Coordination with NSBF regarding;  
    Batteries, Solar Arrays, CIP, VHF & UHF Beacons  
    ARGOS Beacon and Local User Terminal
9. Amplifier design and fabrication and potting of the PMTs for the LANL neutron inst.
10. On-board data system for the instruments, data archiving, and telemetry
11. Payload harness fabrication
12. Payload GSE
13. Payload testing, calibration, and qualification
14. Launch and Recovery operations support

The required number of man months to accomplish the listed tasks by engineers, technicians, and programmers is given. These are based on the experience SPRL has from previous balloon projects, ground based observatory projects and sounding rocket projects. The hardware cost estimate is based on the amount spent by SPRL fabricating a similar gondola on a previous program, and current prices. Software is utilized from other programs, written new, and purchased. The principal costs under travel are in support of the field tests and launch operation. Finally there are costs of the subcontracts to U. Florida, and LANL for the instrument specific tasks at those institutions. These numbers are unknown at this time; however, estimates from the principals are given in brackets.

Table 3. Budget (Burdened)

I. LABOR (estimate man months)

	Area	Eng	Tech	Software	Notes
1	System Design	3	1	0	
2	Mechanical	2	1	0	
3	Electrical Pwr. Sys.	1	1.5	0	
4	Gondola	1	2	0	
5	Hopper Mechanism	1	2 + 1*	0	*test
6	MGSE	0	0	0	
7	Thermal	0.5	0	0	analysis
8	Coord. with NSBF	0.5	0	0	
9	Instruments	0.5	4	0	Pot PMT, HV, Pad,
10.	Data System	1	1	4.5	
11	Harness	1	2	0	
12	EGSE	1	1	4.5	
13	Integration, Test, Qual	7	7	0	
14	Launch Support	2	2	0	
	TOTAL	21.5	25.5	9.0	
		@7.0k	@5k	@6k	
		150.5k	+127.5k	+54.0k	= \$332.0k

II. PROGRAM MANAGEMENT

Management	2 @ 12k = 24		
Secretarial	3 @ 3.6k = 10.8k		
		Total	= \$ 34.8k

III. HARDWARE COSTS

Item 4	Gondola	8.3	
5	Mechanisms	7.0	
6	MGSE	1.0	
9	Instruments	5.0	
10	Data System	61.6	
11	Harness	12.0	
12	EGSE	<u>52.8</u>	
		Total	= \$147.7k

IV. SOFTWARE COST

Microsoft 'C' and Fortran; Operating System; Misc.	Total	= \$ 1.5k
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V. TRAVEL

1 trip to USSR	5k	
5 trips (2 person/2 day @\$700/trip/person)	7k	
U of Florida, LANL, NASA/GSFC, NSBF/Texas		
Field support		
Qual test @ GSFC: 2 persons, 3 weeks, truck	12k	
Shipping to New Zealand 2600 Lbs @ 3.13/lb	16k	
Field staff to Los Angles (2 persons Det to LA)	2k	
Launch support 2 persons Per diem 2 mm	<u>14k</u>	
	Total	= \$ 56.0k

GRAND TOTAL = \$572,000

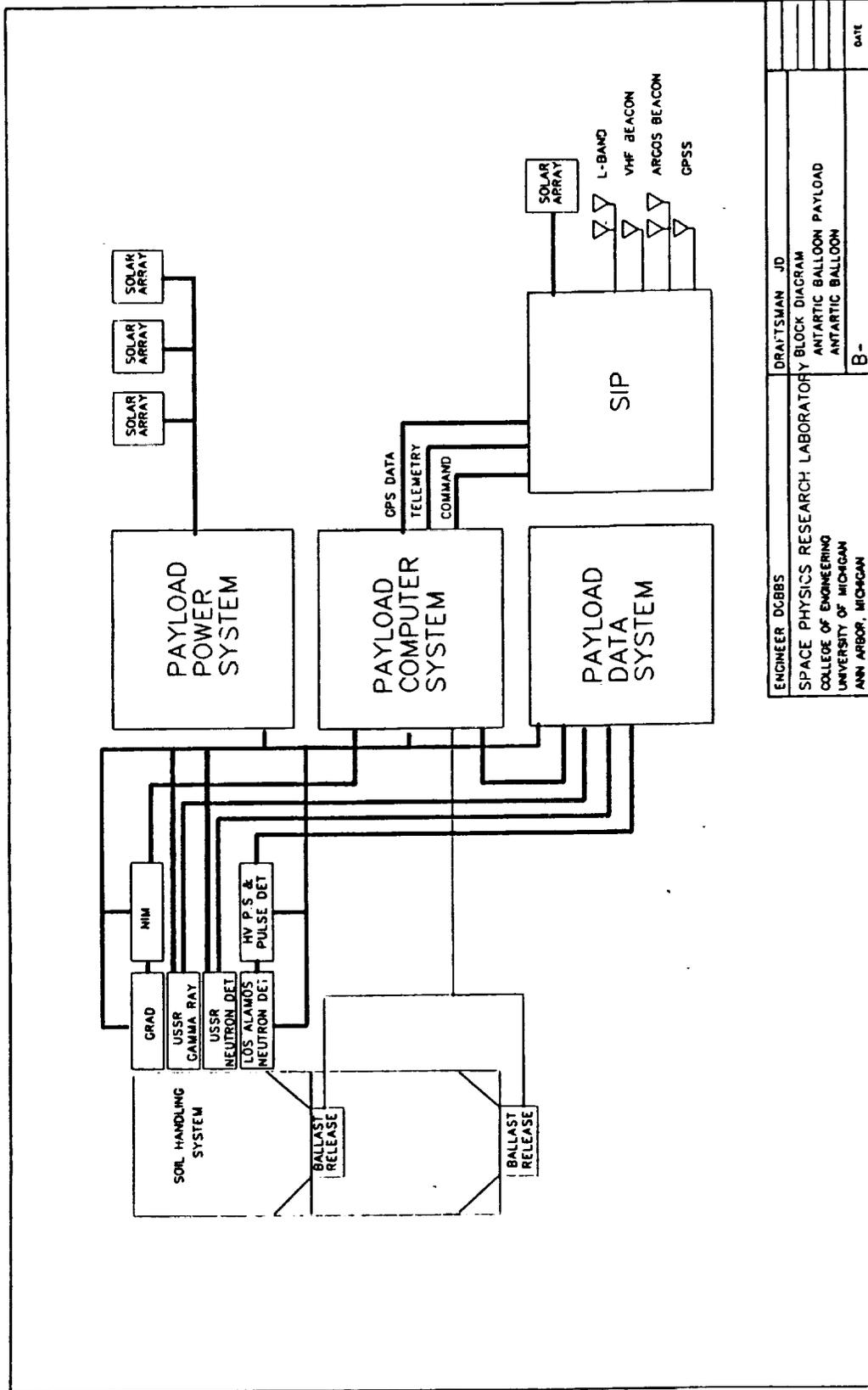
VI. INSTRUMENTS:

University of Florida (GRAD detector)	\$(299k)
Los Alamos Nat'l Lab. (Neutron Detector)	\$(50k in FY 91)

Budget by fiscal year in 1989 dollars

Category	FY90	FY91	FY92	FY93
A.	\$109.0k	\$169.0k	\$ 30.0k	\$ 24.0k
B.	12.6k	12.6k	3.3k	6.3k
C.	119.4k	28.3k		
D.	1.5k			
E.	8.0k	4.0k	28.0k	16.0k
F.				
TOTAL	<u>\$250.5k</u>	<u>\$213.9k</u>	<u>\$ 61.3k</u>	<u>\$ 46.3k</u>

/USER/DOBROW/SOVIET\_BALLOON/PAYLOAD\_BLOCK\_2.DRW 88 DEC 89 08:02 last update: 88 DEC 89 08:01



ENGINEER DCBBS	DRAFTSMAN JD
SPACE PHYSICS RESEARCH LABORATORY	ANTARCTIC BALLOON PAYLOAD
COLLEGE OF ENGINEERING	ANTARCTIC BALLOON
UNIVERSITY OF MICHIGAN	B-
ANN ARBOR, MICHIGAN	DATE

1 1/2" X 11" R C D L

4 1/2" X 11"

FIGURE 1

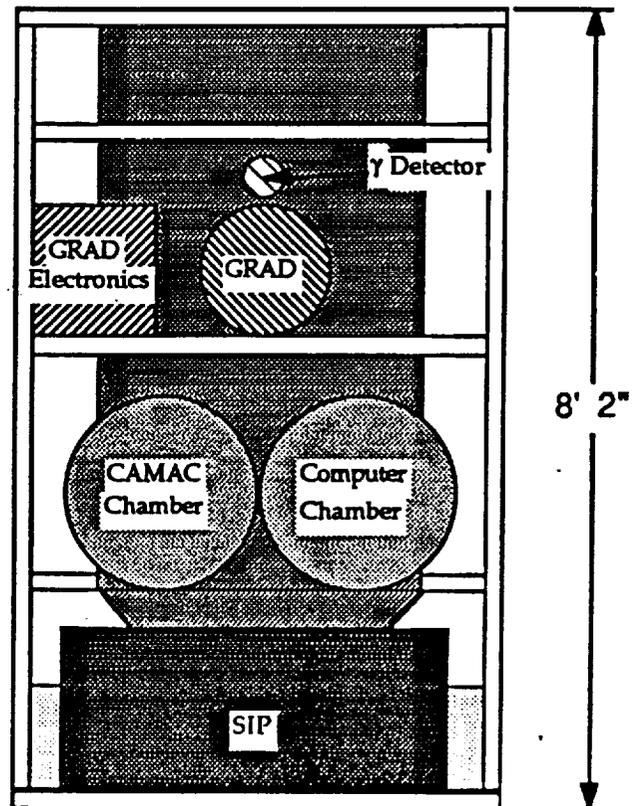
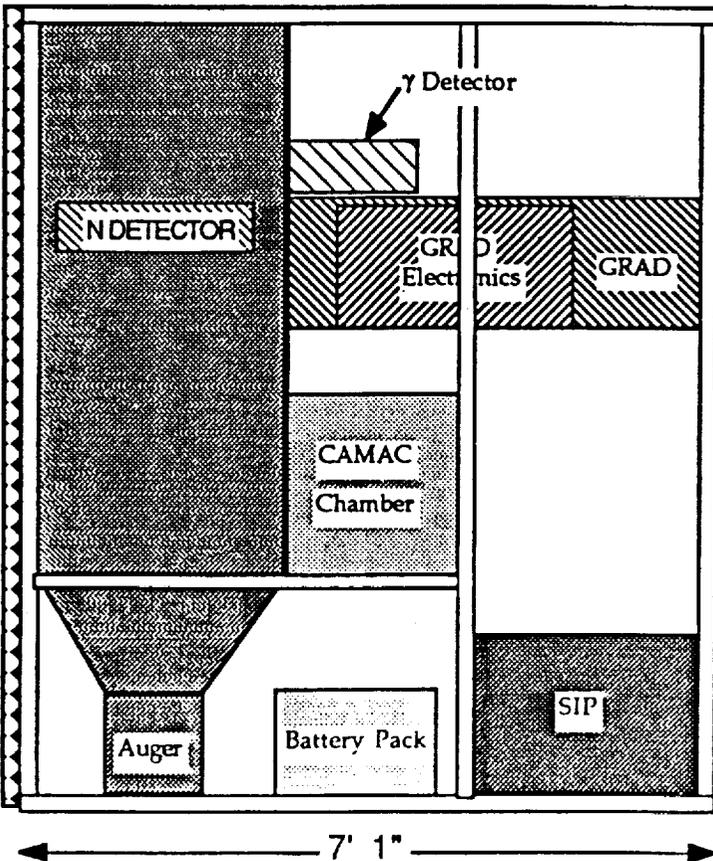
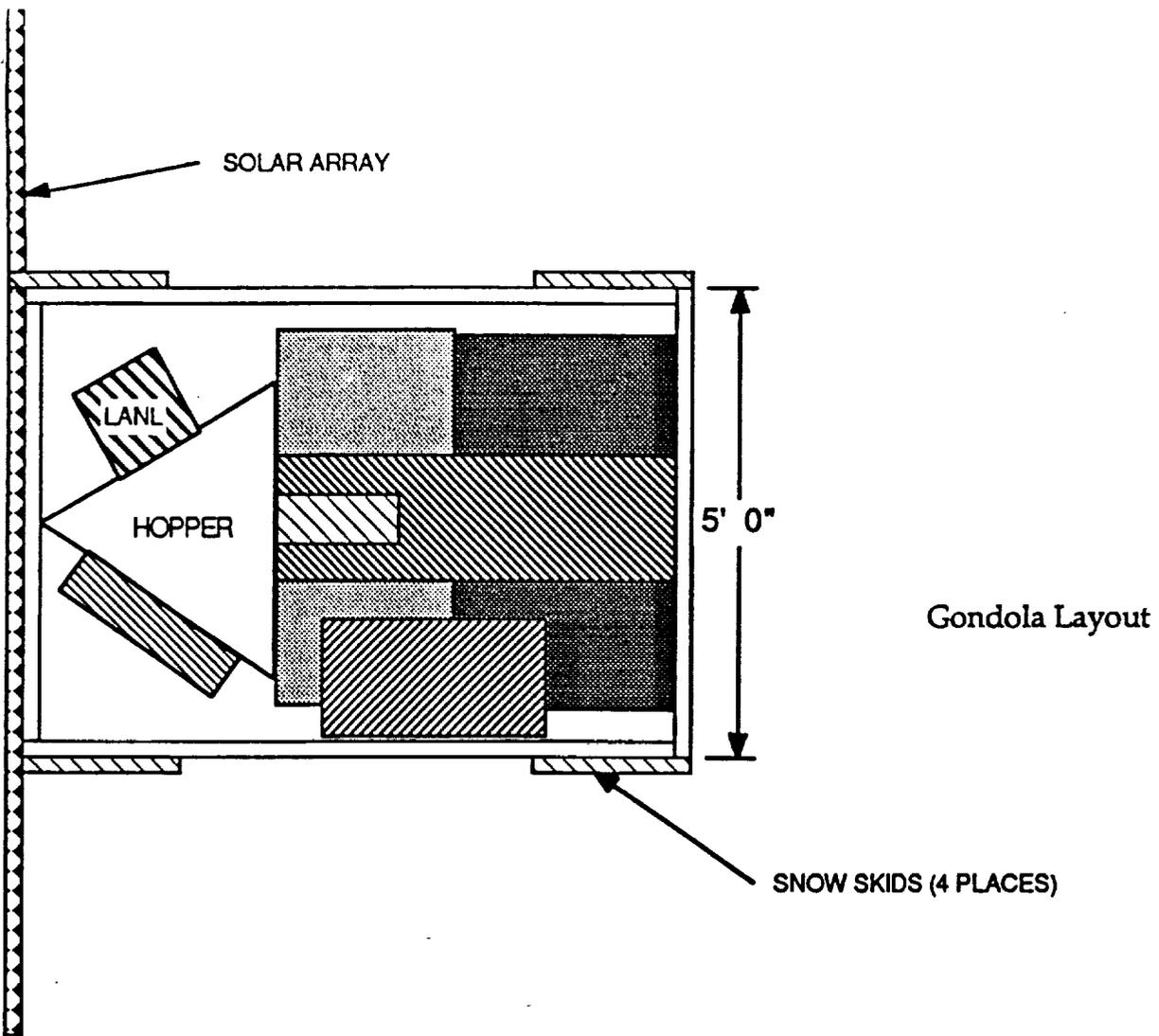
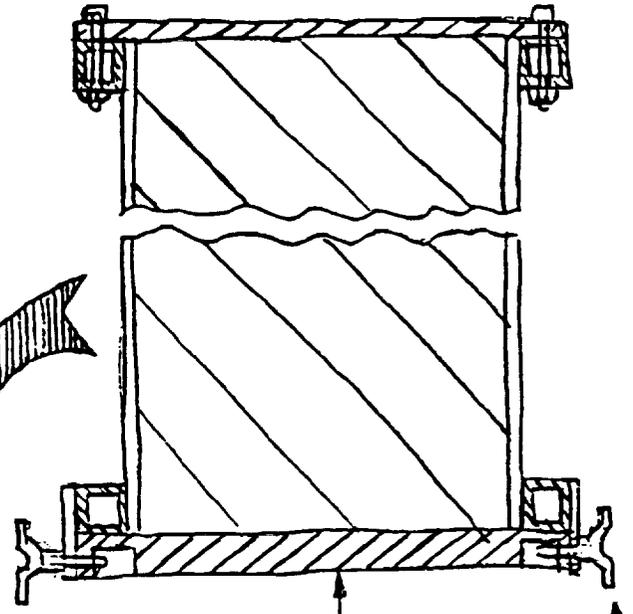
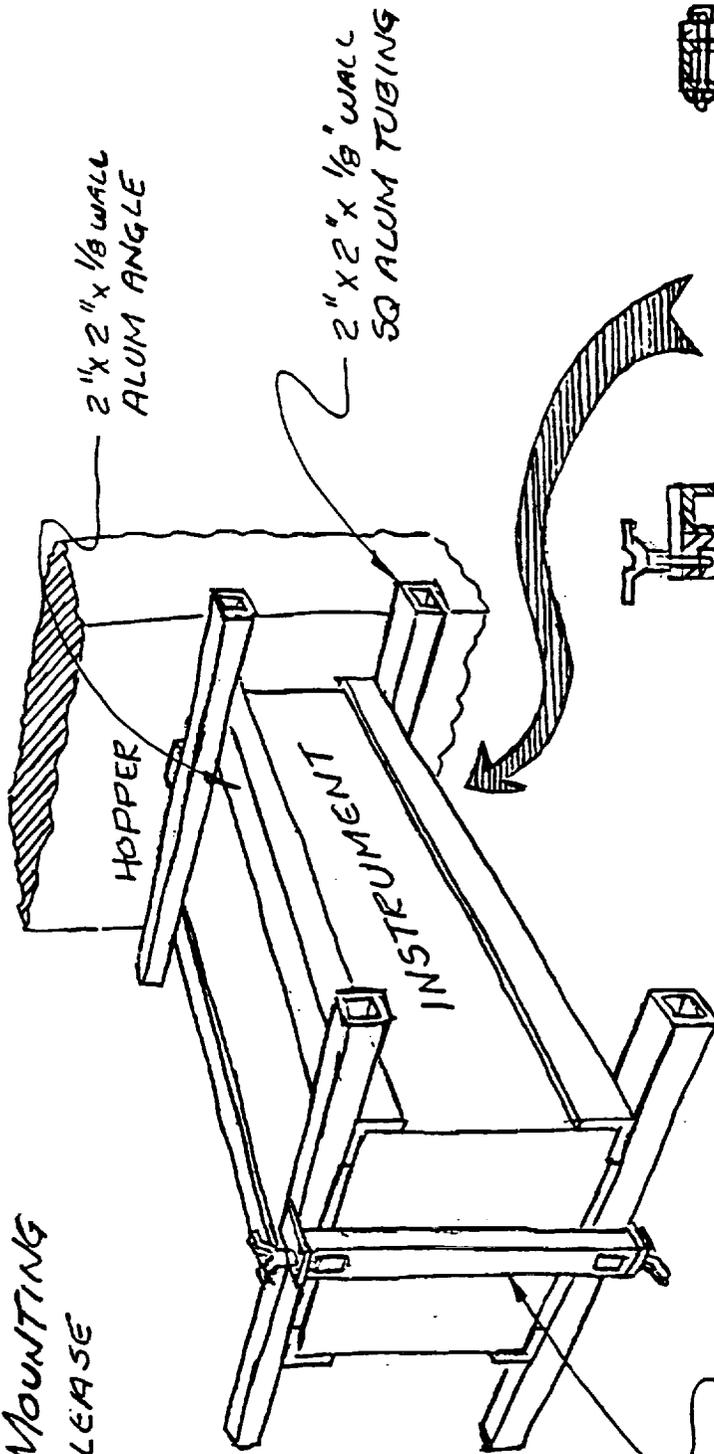


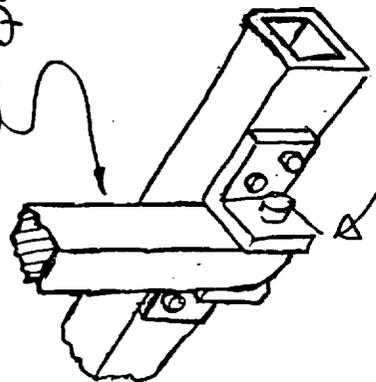
FIGURE 2

INSTRUMENT MOUNTING  
WITH QUICK RELEASE



QUICK RELEASE TIE BAR

QUICK RELEASE PIN  
2 REQ'D?  
OR



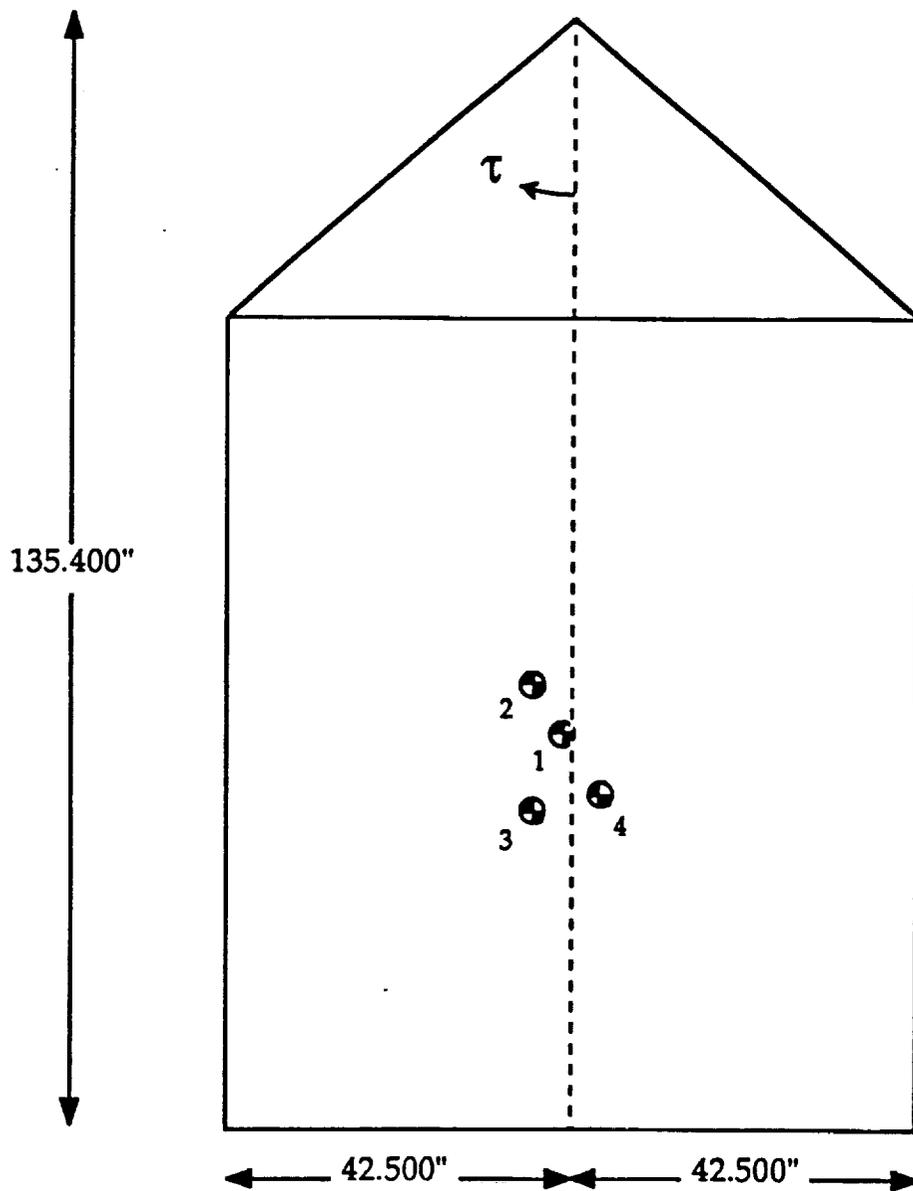
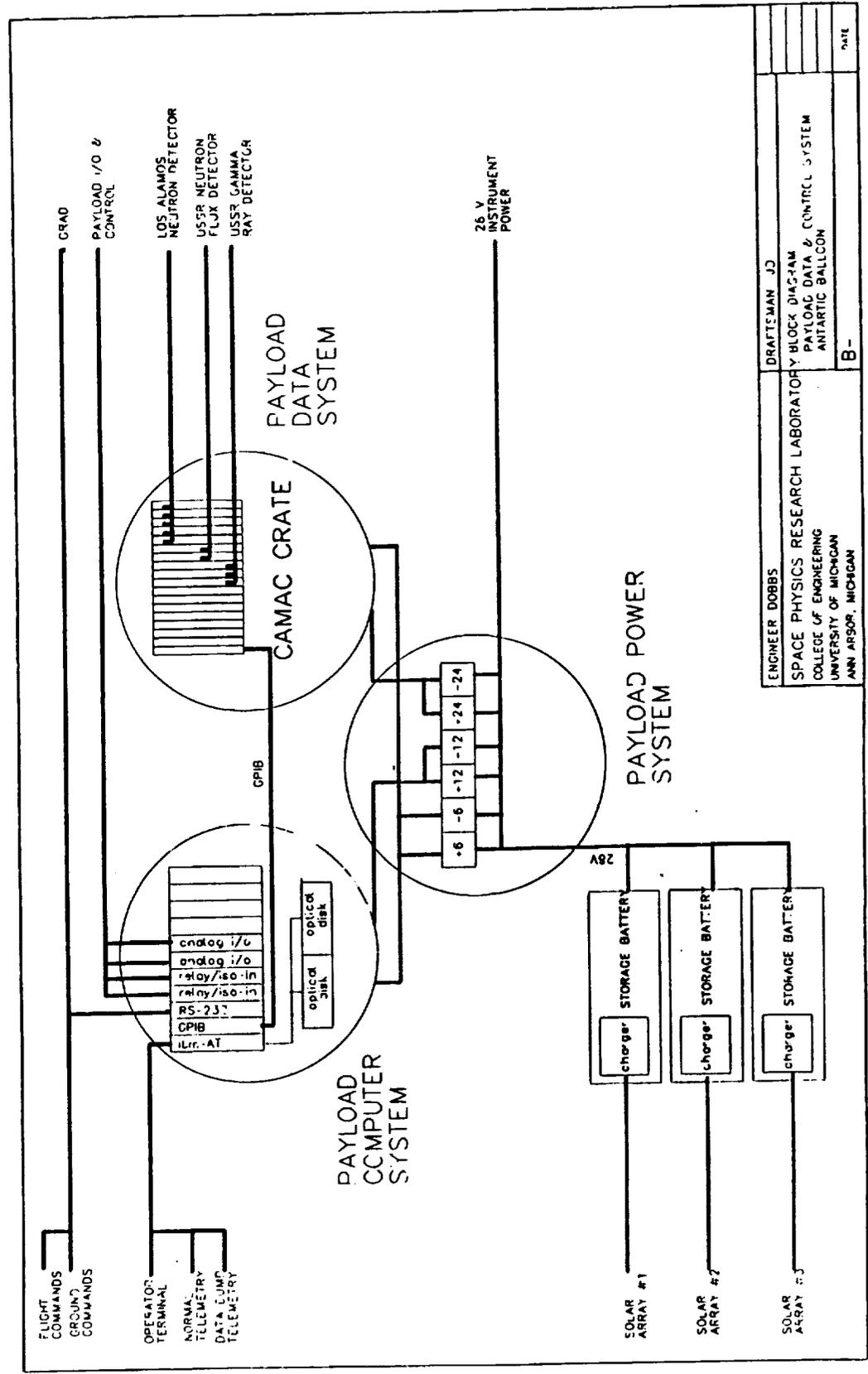


FIGURE 4: Gondola Center of Gravity Locations

/USER/DOOMBOW/SOVIET\_BALLOON/DATA\_SYSTEM\_2.DRW 06 DEC 89 08:51 last update 06 DEC 89 08:50



ENGINEER DOBBS	DRAFTSMAN JD	DATE
SPACE PHYSICS RESEARCH LABORATORY		
PAYLOAD DATA & CONTROL SYSTEM		
ANTARCTIC BALLOON		
B-		
UNIVERSITY OF MICHIGAN		
ANN ARBOR, MICHIGAN		

LAST REV R C D L

FIGURE 5

USER/DOUGROW/SOVIET\_BALLOON/CAMAC\_BLOCK\_2.DRW 06 DEC 89 06:28 last update: 08 DEC 89 06:28

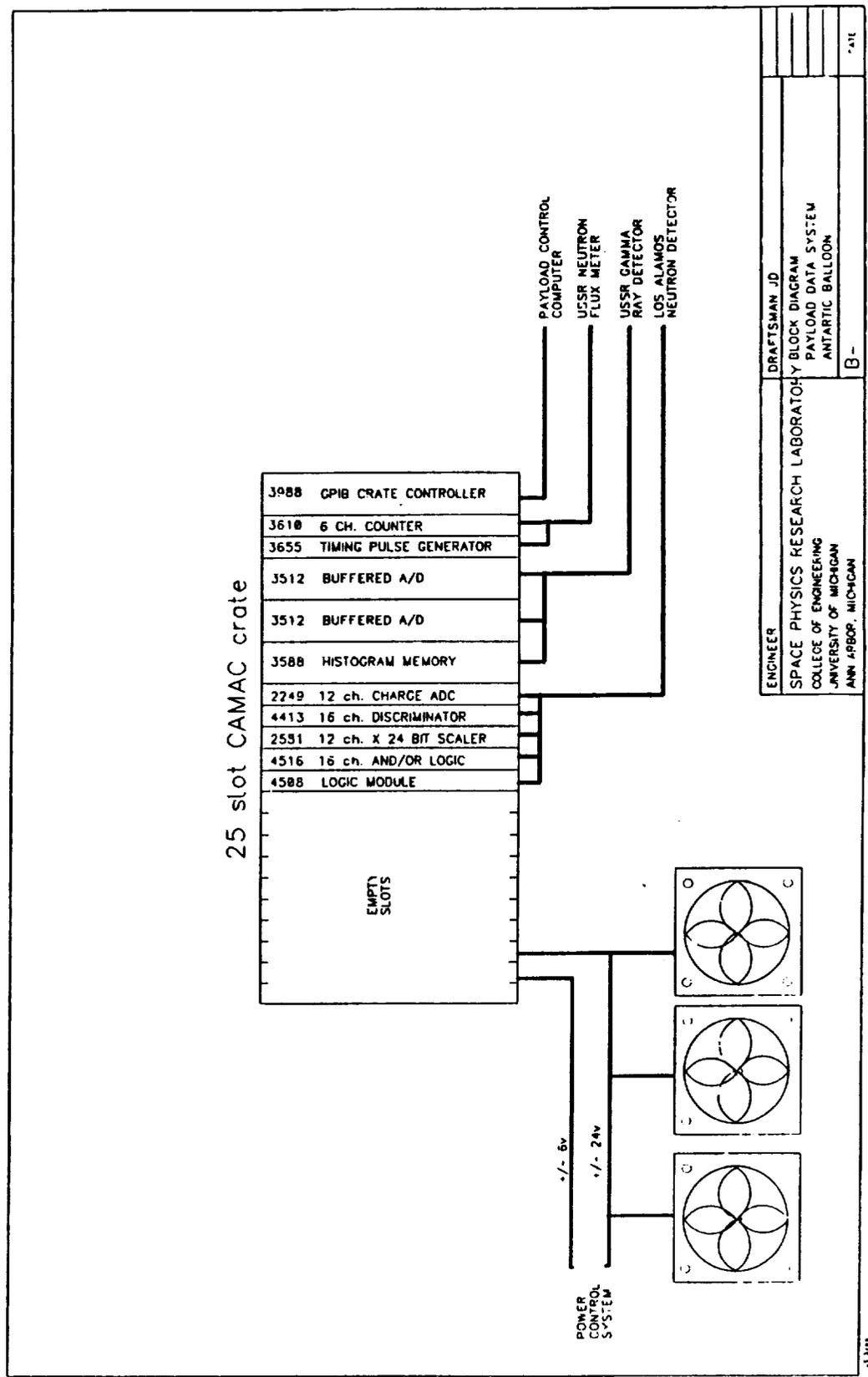


FIGURE 6

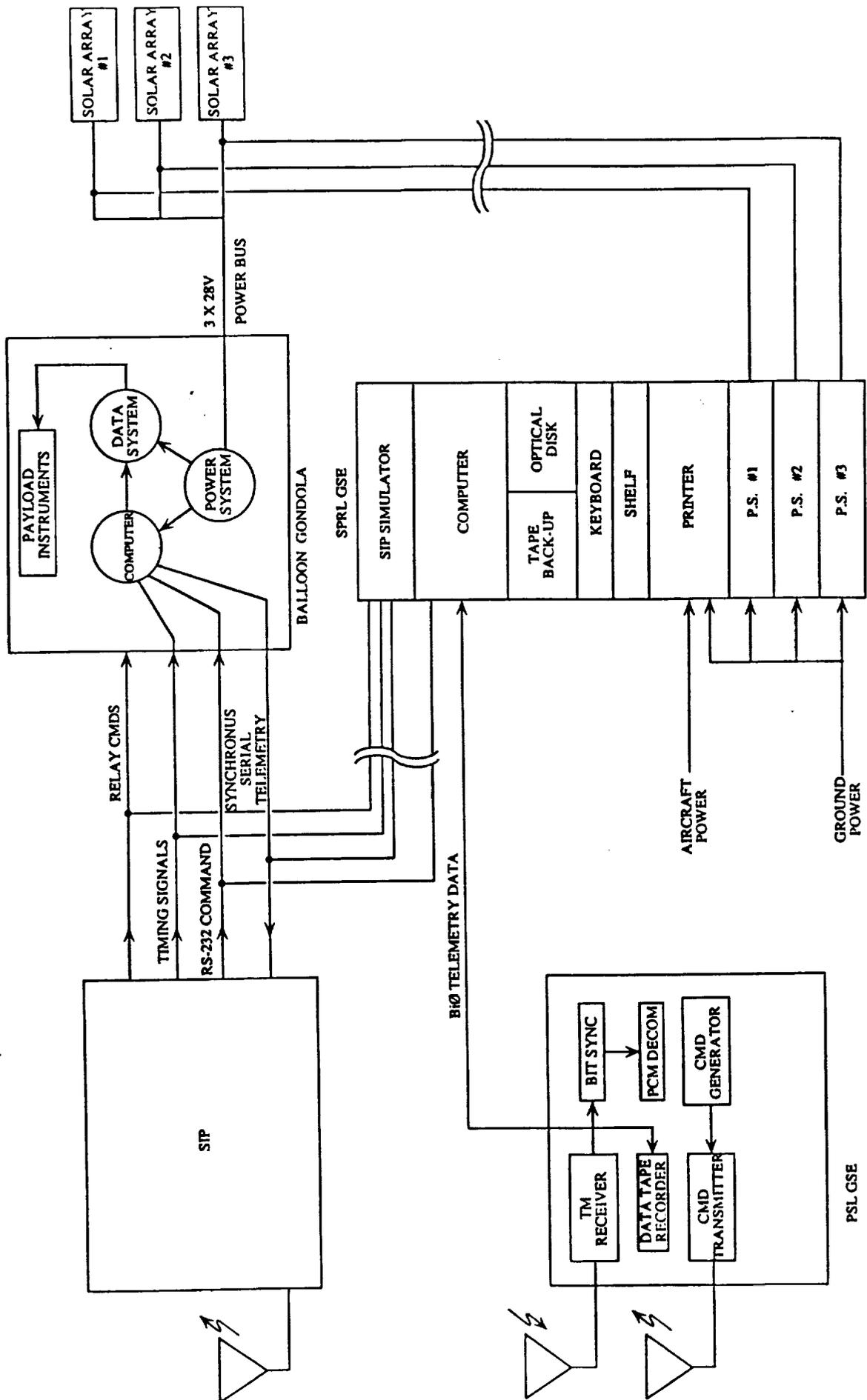


FIGURE 7

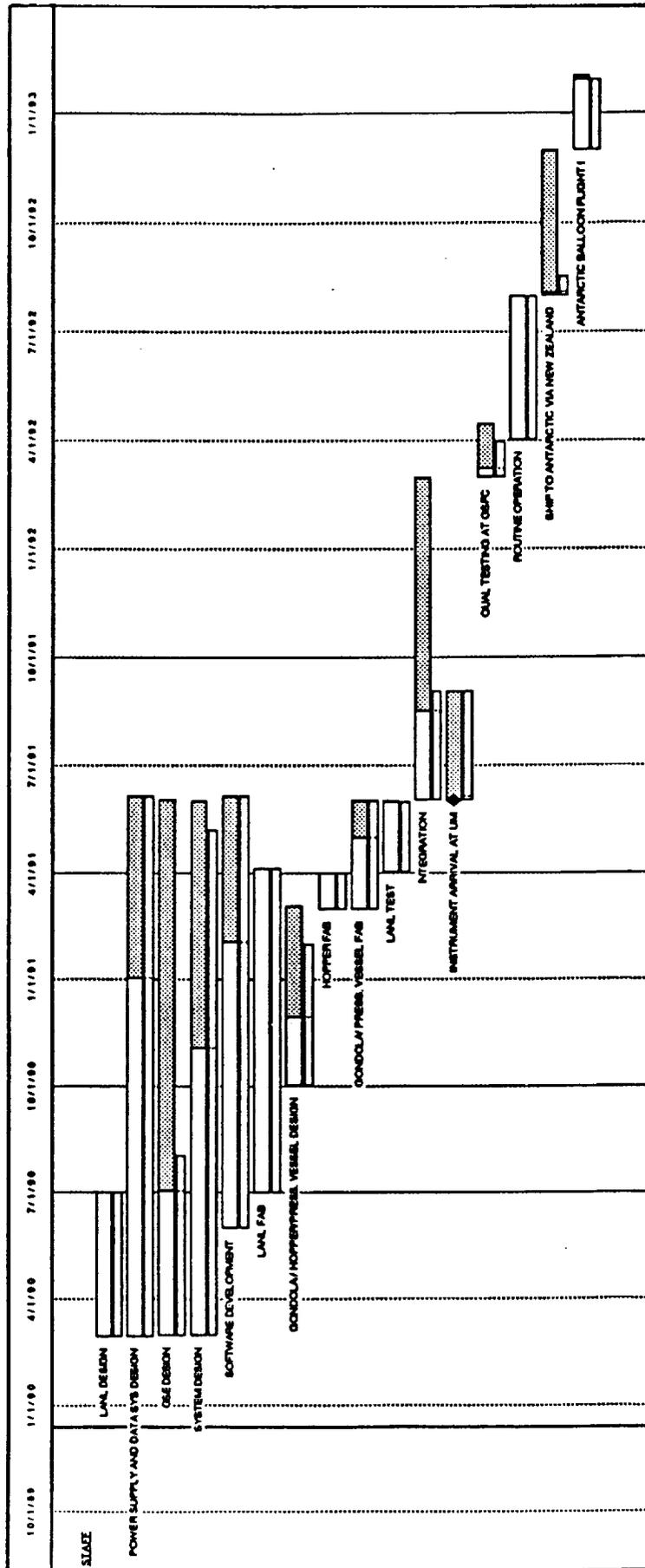


FIGURE 8