Columbia Scientific Balloon Facility

LONG-DURATION BALLOONING

LDB SUPPORT FOR SCIENCE

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1 LDB SUPPORT OVERVIEW

1.1 LAUNCH LOCATIONS

Long-Duration Balloon (LDB) missions are currently supported for launches from McMurdo, Antarctica; Wanaka, New Zealand; Alice Springs, Australia; and Kiruna, Sweden.

1.1.1 MCMURDO, ANTARCTICA

Launches are conducted from William's Field, located about seven miles from McMurdo Station on the Ross Ice Shelf. Since 1996, the launch site has been operated exclusively as a field camp to support scientific balloon operations. Launch site position is on or about 77.86 degrees south latitude and 167.13 degrees east longitude near sea level. A single circumpolar flight trajectory is nominally 9 to 12 days, traveling to the west, and typically bounded between 73 to 82 degrees south latitude for balloon float altitudes of 115,000 to 130,000 feet. For mission planning purposes, logistics requirements are quite stringent; therefore experiment, payload, and ground support equipment must be flight ready prior to departure from the United States. Logistics, housing, meals, and other on-site support is provided by the NSF (National Science Foundation) who has responsibility for management of U.S.-sponsored polar programs in Antarctica.

Launch operations are normally conducted from about December 5 through January 10 each year. However, due to end-of-season logistics, experimenters should plan to be flight ready by 5 December so that the flight can be conducted with minimum risk of interfering with other NSF logistics support requirements. Approval for launch after January 1 through January 10 is with NSF concurrence and can be driven based upon other polar projects being supported. Flights may remain aloft as late as January 21 but recovery assets become scarcer near the end of the season. Experimenters hoping for two circumpolar trajectories should plan to be flight ready absolutely no later than December 5 to allow sufficient time to conduct an 18 to 21 day flight mission, allow for launch delays, and be accommodating within the NSF logistics support schedule for termination and recovery.

CSBF support personnel normally begin arriving at McMurdo Station around November 1 each year (pending camp readiness reported by NSF). Science personnel may arrive earlier if required to insure their flight readiness date. This scheduling will be coordinated by the CSBF Campaign Manager. Typical departure dates from Antarctica run no later than around January 20 to 30 to ensure complete departure of equipment and personnel before the NSF's "winter-over" operations begin.

Shipping of all CSBF equipment in support of each year's campaign is no later than the end of August to allow time for equipment to arrive at Port Hueneme, California for on-forward ocean shipment to New Zealand and then to McMurdo by air. This includes experiments, ground station equipment, flight equipment, and all final shipments required for flight support the following November. Although CSBF helps arrange for the shipping carrier from Palestine to Port Hueneme, experimenters are expected to provide proper shipping containers and perform their own packing prior to shipment. CSBF ships heavy items such as balloons and helium to McMurdo one year in advance, so special balloon configuration requirements must be identified early enough to be built and shipped. This typically means that special balloon requirements must be identified and approved no later than May 1 for operations which require them to be used two summer seasons hence to allow sufficient time for special engineering considerations, construction, and shipment to Port Hueneme, California prior to on-forwarding to Antarctica.

Because shipment of equipment is due out by the end of August, pre-deployment integration in Palestine must be concluded by the middle of August each year. Following this integration and compatibility testing, a Mission Readiness Review (MRR) is conducted by a board appointed and chaired by the Wallops Flight Facility Balloon Program Office prior to shipment to assess the readiness of both the experimenter and the CSBF. Scheduling and special support required for the pre-deployment integration will be jointly worked out between the experimenter and CSBF once the flight request is reviewed. It should be understood that all equipment is shipped directly from the CSBF to Port Hueneme following pre-deployment integration. No configuration changes to the science experiment (including flight software) or the CSBF support systems are allowed following integration without approval from the Mission Readiness Review (MRR) technical panel.

Pertinent details as to thermal environment and configuration, balloon performance, mechanical configuration, telemetry support, and ground support will be reviewed following receipt of the LDB Flight Application Form.

1.1.2 KIRUNA, SWEDEN

Kiruna is located about 67.86 degrees north latitude and 20.43 degrees east longitude. Launch operations are normally conducted between May 15 and July 10 of each year. Flight trajectory is to the west bounded between 60 and 70 degrees north latitude for a 5- to 10-day mission and then terminated over Alaska or Canada. Float altitudes of 115,000 to 130,000 feet can be expected. Whenever Russian overflight permission is received, flight durations will be considerably longer.

Pre-deployment integration in Palestine will normally be concluded by March 1. An MRR will be conducted at Palestine following integration and compatibility testing to assess readiness prior to shipping of equipment to Kiruna. The primary surface shipment will leave Palestine no later than the first week in March. Scheduling and special support required for the pre-deployment integration will be jointly worked out between the experimenter and CSBF once the flight request is reviewed. It should be understood that all equipment is shipped directly from the CSBF to Kiruna following pre-deployment integration. The CSBF Campaign Manager will coordinate final shipping from Palestine to Kiruna. No configuration changes to the science experiment or the CSBF support systems are allowed following integration unless approved by the MRR technical panel.

Pertinent details as to thermal environment and configuration, balloon performance, mechanical configuration, telemetry support, and ground support will be reviewed following receipt of the LDB Flight Application Form.

1.1.3 WANAKA, NEW ZEALAND

Wanaka is located about -44.72 degrees south latitude and 169.24 degrees west longitude. Launch operations are currently conducted between February 15 (flight ready by April 1) and April 30 of each year. Flight trajectory is to the east and allowed to circumnavigate the globe on ultra-long duration balloons (Super Pressure Balloons). Float altitudes of 100,000 to 110,000 feet can be expected.

Pre-deployment integration in Palestine will normally be concluded by the first of December (during November). An MRR will be conducted in Palestine following integration and compatibility testing to assess readiness prior to shipping equipment to Wanaka. Scheduling and special support required for the pre-deployment integration will be jointly worked out between the experimenter and CSBF once the flight request is reviewed. It should be understood that all equipment is shipped directly from the CSBF to Wanaka following pre-deployment integration. The CSBF Campaign Manager will coordinate final shipping from Palestine to Wanaka. No configuration changes to the science experiment or the CSBF support systems are allowed following integration unless approved by the MRR technical panel.

Pertinent details as to thermal environment and configuration, balloon performance, mechanical configuration, telemetry support, and ground support will be reviewed following receipt of the LDB Flight Application Form.

1.1.4 ALICE SPRINGS, AUSTRALIA

Alice Springs is located about 23.82 degrees south latitude and 133.88 degrees west longitude. Launch operations are normally conducted between November 1 (flight ready by December 1) and January 20 of each year. Flight trajectory is to the west. Circumglobal routes have not been approved as of this writing. Float altitudes of 100,000 to 130,000 feet can be expected.

Pre-deployment integration in Palestine will be normally concluded by the first of September (during August). An MRR will be conducted at Palestine following integration and compatibility testing to assess readiness prior to shipping equipment to Alice Springs. Scheduling and special support required for the pre-deployment integration will be jointly worked out between the experimenter and CSBF once the flight request is reviewed. It should be understood that all equipment is shipped directly from the CSBF to Alice Springs following pre-deployment integration. The CSBF Campaign Manager will coordinate final shipping from Palestine to Alice Springs. No configuration changes to the science experiment or the CSBF support systems are allowed following integration unless approved by the MRR technical panel. **Any changes must be identified and approved by BPO**

Pertinent details as to thermal environment and configuration, balloon performance, mechanical configuration, telemetry support, and ground support will be reviewed following receipt of the LDB Flight Application Form.

1.2 SIP CONFIGURATION

Every SIP (Support Instrumentation Package) has a similar architecture based on COMM1 (default TDRSS–Tracking and Data Relay Satellite System) and COMM2 (default Iridium) flight telemetry systems. The TDRSS and Iridium functions supported by COMM1 and COMM2 are redundant; however, there is a single TDRSS transceiver shared between the two COMM systems. Each COMM system has its own flight computer which supports RS232 communications with forward and return telemetry to the science user. Each COMM system is powered from its own separate power bus (two separate photovoltaic power systems are flown for each SIP). Sections 3 and 4 provide information concerning the science port interfaces to COMM1 and COMM2. The following explanation of various subsystems is provided to assist with planning telemetry (TM) support requirements.

Experimenters are required to use both COMM1 and COMM2 low-rate science ports primarily for commanding redundancy. If the TDRSS link is unavailable, then the Iridium link can be used and vice-versa, otherwise there will be no command path once the payload is out of line-of-sight (LOS). The Iridium Pilot Broadband Service may also be used as a redundant command link; however, the commanding implementation must be completed by science.

1.2.1 IRIDIUM (SBD, DIALUP, AND PILOT)

Iridium provides global forward and return telemetry with the balloon via a network of low earth-orbiting (LEO) satellites. Commands (forward TM) can be sent from both the OCC in Palestine and during testing from the ROCC at the launch site. Data (return TM) is received at the OCC and can be verified from the ROCC. Data is usually received within a few minutes of transmission from the balloon depending upon the load of network traffic and the selected Iridium modem mode: short burst data (SBD) or dialup (see Sections 1.2.1.1 and 1.2.1.2).

Science return telemetry and forward command data is accessed via Iridium through the SIP’s COMM1 or COMM2 science ports (high- and low-rate interfaces when in dialup mode, or just the low-rate interface in SBD mode). Science users do not have direct control over the flight Iridium terminals. All science data written to the COMM1 or COMM2 science low-rate ports are also logged on internal storage for the duration of the flight mission, which is recovered only after flight termination and physical recovery of the science payload (see Section 3). Note that the communication link speed is independent of the science high- or low-rate port baud rate, and each modem may be in one of two modes with differing link throughputs: SBD or dialup.

1.2.1.1 SHORT-BURST DATA (SBD) MODE

Iridium SBD mode is a packetized system and return data throughput is one 255-byte packet every 15 minutes when the flight Iridium terminal is logged into the Iridium network. The latest science data packet passed to the LDB SIP central processing unit (CPU) prior to transmission will be sent. Aggregate return telemetry via COMM1 or COMM2 is approximately 1020 bytes of data every hour in this mode.

1.2.1.2 DIALUP MODE

Iridium dialup mode can also be used for near real-time TM at the rate of up to 2 Kbps; however, only one Iridium modem may use dialup mode between the two COMM systems at one time. The data throughput is highly variable and dependent on the connection quality with the Iridium network. In most cases, the dial-up mode will stay connected for up to an hour. This mode is typically used when there are TDRSS outages. In dialup mode, data from both the low- and high-rate ports is sent through the Iridium dialup link.

1.2.1.3 PILOT

Iridium Pilot uses the same global network described above; however, it presents an Ethernet interface with Transmission Control Protocol/Internet Protocol (TCP/IP) and/or User Datagram Protocol (UDP)-based data flow. Data originating from the payload (return TM) are sent through the Pilot access point in the same manner as a standard internet connection. Data sent to the payload (commands/ forward TM) must address the Pilot’s external IP address at a specific pre-arranged port number. Port forwarding rules then route data to the corresponding internal IP address and internal port based on the external port provided. The highest achievable throughput may burst up to 128 Kbps; however, average observed throughput is between 80 and 100 Kbps.

1.2.2 TDRSS

Nominal TDRSS support for LDB offers 6-Kbps return telemetry continuously (high- and low-rate science interfaces) using an omni-directional antenna. If requested, the SIP optionally records science data onto its flight computer hard drives when using the omni antenna. These hard drives are only recovered at the end of the flight.

A higher data rate TDRSS capability is also available. A high-gain antenna (HGA) can be included allowing science to transmit up to approximately 92 Kbps using a 115,200-baud serial interface. This is detailed further in Section 3.

The OCC in Palestine is the only location from which TDRSS science data and commanding is accessed during the flight. Support is available in the field to verify TDRSS return and forward TM using a special test set; however, this does not allow for science access to TDRSS TM and commanding other than when working around the payload in close proximity during pre-flight preparations.

1.2.3 SCIENCE STACK

A science stack which provides analog and digital return telemetry and discrete command outputs can be made available. Refer to Section 4 for more information. This stack is accessed by either the COMM1 or COMM2 telemetry links (one at a time).

NOTE

Experimenters are STRONGLY encouraged to use the science stack option primarily for verifying minimal status information and ON/OFF/RESET of experiment functions independently of science instrument.

1.2.4 LINE OF SIGHT RETURN TELEMETRY

An L-Band or S-Band telemetry transmitter can be made available for science use for monitoring data while within line-of-sight (LOS) of the launch site. Serial isolation to this transmitter is required. The experimenter is responsible for any encoding the signal may require (e.g. bi-phase, NRZ-M, etc) as well as setting of proper signal levels into the transmitter (contact the CSBF for information concerning proper signal level settings).

1.2.5 LDB GROUND STATIONS

The ROCC (Remote Operations Control Center - launch site) and OCC (Palestine) provide similar capabilities. The science GSE computer to LDB GSE computer interface (Section 3) is the same for both the ROCC and OCC configurations. The ROCC is used at both the Antarctica and the mid-latitude launch sites. The ROCC is the primary CSBF control center during launch, after the balloon reaches float altitude, and prior to it leaving the launch site telemetry coverage range. Operational control is then handed over to the OCC at Palestine.

The OCC in Palestine is the only point of interface for the experimenter requiring TDRSS support. TDRSS return telemetry and forward commanding are available only at the OCC. Additionally, Iridium SBD and dialup data and commanding are also available at the OCC. Iridium Pilot data may be accessed from any location with internet service. The experimenter should plan to have his/her GSE located at the OCC.

2 SCIENCE-TO-GROUND COMPUTER INTERFACE SPECIFICATIONS

Three RS232-C ports are provided to science for interfacing with the Palestine OCC ground control computer (see section 2.1 for baud rates): one COMM1/COMM2 return telemetry downlink, a command uplink port, and a TDRSS Direct return telemetry downlink. TDRSS Direct is optional based on science requirements that need the TDRSS high-gain antenna. Return telemetry consists of science flight computer data routed through COMM1 or COMM2 science interfaces: low rate (TDRSS/Iridium SBD) and high rate (TDRSS/Iridium dialup). The ground support computer will monitor the science command uplink port for science commands routed through COMM1 or COMM2 via Iridium (SBD/dialup), TDRSS forward, or LOS links.

A standard Ethernet RJ45 port is provided with internet connectivity to facilitate remote desktop connections to science, or command and data connectivity through the Iridium Pilot system if present.

The ground support computer operator controls all access to all communication links. The ground support computer operator can disable access to any uplink at any time. The scientist will specify what link he or she wishes to use to transmit to the balloon. Scientists will receive an error message if their selected link is disabled. If the link is not disabled and a request-to-send packet is received from science, the data will be re-packetized and sent through the desired link (LOS, Iridium SBD/dialup uplink, or TDRSS forward). Command uplink and data downlink through the Iridium Pilot is managed by science through the internet connection (RJ45 port).

2.1 PHYSICAL INTERFACE

2.1.1 DOWNLINK (RETURN TM)

2.1.1.1 PORT 1 (COMM1/COMM2)

115,200 Baud, 8 data bits, 1 stop bit, no parity, standard RS232-C DB9 DTE

NOTE
This interface does not use CTS or DTR. It is two wires using only TX and GND; no hardware handshaking.

2.1.1.2 PORT 2 (TDRSS DIRECT)

115,200 Baud, 8 data bits, 1 stop bit, no parity, standard RS232-C DB9 DTE

NOTE
This interface does not use CTS or DTR. It is two wires using only TX and GND; no hardware handshaking.

2.1.2 COMMAND UPLINK PORT

2400 Baud, 8 data bits, 1 stop bit, no parity, standard RS232-C DB9 DTE

NOTE
This interface does not use CTS or DTR. It is three wires using only TX, RX, and GND; no hardware handshaking.

2.1.3 INTERNET AND IRIDIUM PILOT

Standard RJ45 Ethernet connection

2.2 COMMAND UPLINK

2.2.1 REQUEST-TO-SEND PACKETS

2.2.1.1 REQUIRED FORMATS

Table 1 – Request-to-Send Packet Format

BYTE	DESCRIPTION
1	Start Byte: ascii.dle (ascii.dle = 10$_H$)
2	Link Routing: 0,1,2 Byte 2 specifies the link routing: 0$_H$ Selects LOS as the link 1$_H$ Selects TDRSS as the link 2$_H$ Selects Iridium as the link
3	Routing address: 9,C Byte 3 specifies the routing address: 9$_H$ Selects Science Interface COMM1 C$_H$ Selects Science Interface COMM2
4	Length: Up to 20, must be a multiple of 2
4	Length: Up to 255 (extended commanding - see below)
5-?	Data Length: Even number up to 20 (numbers 21 and above can be odd)
?+1	Stop Byte: ascii.etx (ascii.etx = 3$_H$)

2.2.1.2 VALID COMBINATIONS OF BYTES 2 AND 3

Table 2 – Combinations of Bytes 2 and 3

BYTE 2 (LINK SELECTION)	BYTE 3 (ROUTING ADDRESS)
0 (LOS)	9$_H$=COMM1 C$_H$=COMM2
1 (TDRSS)	9
2 (IRIDIUM)	C

2.2.2 DATA ADDRESSED TO COMM SCIENCE COMMAND INTERFACE PORT (ROUTING ADDRESS 9$_H$ AND C$_H$)

On the ground, science command data will be re-packetized two bytes at a time for data lengths 20 bytes or less. Once received by the LDB flight computer on board, the data will be re-packetized and will be sent to the onboard science interface port (two bytes at a time) in the format specified by Section 3, *Science to LDB Flight Computer Interface Specifications*. For data lengths greater than 20 bytes, the science command data will be sent as one contiguous packet with start and stop bits (again, see Section 3).

2.2.3 ACCESSING THE SCIENCE DISCRETE COMMAND DECK

Science can access the science discrete command deck directly through a web interface. A description of the capabilities of the science discrete command deck is given in Section 4.

2.2.4 ACKNOWLEDGEMENT PACKET FORMAT

In all cases after a packet is received by the ground support computer, an acknowledgment packet will be sent to science to indicate whether or not the commands were transmitted.

Byte 1: Sync byte 1 = FA$_H$
Byte 2: Sync byte 2 = F3$_H$
Byte 3: Acknowledgment Byte = 00$_H$
or = 0A$_H$
or = 0B$_H$
or = 0C$_H$
(00$_H$, commands transmitted)
(0A$_H$, 0B$_H$, 0C$_H$, 0D$_H$ commands not transmitted)

An acknowledgment byte of hex A, B, or C indicates that the ground support computer did not send the command packet. Any of the following errors can cause this to occur.

2.2.4.1 ERROR CODES

0A$_H$	GSE operator disabled science from sending commands
0B$_H$	Routing address does not match the selected link
0C$_H$	The link selected was not enabled
0D$_H$	All other cases

An acknowledgment byte of 00$_H$ indicates that the commands were sent. This does not mean that the science payload received the commands. Science must monitor their own telemetry data to determine whether or not their equipment received and responded to their commands. All command packets received by the ground support computer will be time-tagged and logged along with their transmission status.

NOTE
It is possible that if more than two bytes are sent, the payload (SIP) may not receive them all in rare cases of dropouts in a particular RF link.

2.2.5 IRIDIUM PILOT UPLINK

Iridium Pilot uplink data is sent by science through the RJ45 port as TCP(preferred) or UDP data packets. This data is not logged by the SIP and must be encoded, decoded, and managed by the science flight computer. Data sent to the payload (commands/forward TM) must address the Pilot's external IP address at a specific pre-arranged port number. Port forwarding rules then route data to the corresponding internal IP address and internal port based on the external port provided. The Pilot system has 15 port forwarding rules available; however, CSBF systems may use some of the available rules. Science should discuss the number of rules they require with CSBF to ensure availability.

A firewall white-list is enabled for connections through Iridium Pilot. Firewall rules must be submitted in advance for each science ground station which requires access to the payload while in flight.

2.3 DOWNLINK

Science telemetry data will be time-tagged and logged, re-packetized, and sent to science via the science telemetry interface port. The following summarizes the various packet formats in which science telemetry data will be sent to science.

2.3.1 LOS - COMM1

Byte 1: Sync 1 = FA$_{\text{H}}$
Byte 2: Sync 2 = FA$_{\text{H}}$
Byte 3: Origin byte
  Lower nibble:
    Bits 0…2: (0$_{\text{H}}$ - Science Housekeeping Deck or 1$_{\text{H}}$ - Low-Rate Science Port)
    Bit 3: (0$_{\text{H}}$ - COMM1 or 1$_{\text{H}}$ - COMM2)
  Upper nibble: Is zeroed out by LDB computer
Byte 4: 0 (not used, zero inserted)
Byte 5: Length of data (MSB)
Byte 6: Length of data (LSB)
Byte 7-N Data (1… length)
Byte N+1: Checksum (Σ bytes 3-N)

Bytes 5 and 6 tell how many bytes follow from Byte 7 to Byte 7+N.

2.3.2 LOS - COMM2

Byte 1: Sync 1 = FA$_{\text{H}}$
Byte 2: Sync 2 = FB$_{\text{H}}$
Byte 3: Origin byte
  Lower nibble:
    Bits 0…2: (0$_{\text{H}}$ - Science Housekeeping Deck or 1$_{\text{H}}$ - Low-Rate Science Port)
    Bit 3: (0$_{\text{H}}$ - COMM1 or 1$_{\text{H}}$ - COMM2)
  Upper nibble: Is zeroed out by LDB computer
Byte 4: 0 (not used, zero inserted)
Byte 5: Length of data (MSB)
Byte 6: Length of data (LSB)
Byte 7-N Data (1…length)
Byte N+1: Checksum (Σ bytes 3-N)

Bytes 5 and 6 tell how many bytes follow from Byte 7 to Byte 7+N.

2.3.3 IRIDIUM

Byte 1: Sync 1 = FA$_{\text{H}}$
Byte 2: Sync 2 = FD$_{\text{H}}$
Byte 3: Origin byte
  Lower nibble:
    Bits 0…2: (0$_{\text{H}}$ - Science Housekeeping Deck, 1$_{\text{H}}$ - Low-Rate Science Port, 2$_{\text{H}}$ - High-Rate Science Port)
    Bit 3: (0$_{\text{H}}$ - COMM1 or 1$_{\text{H}}$ - COMM2)
  Upper nibble: Is zeroed out by LDB computer
Byte 4: 0 (not used, zero inserted)

Byte 5: Length of data (MSB)
Byte 6: Length of data (LSB)
Byte 7-N Data (1…length)
Byte N+1: Checksum (Σ bytes 3-N)

Bytes 5 and 6 tell how many bytes follow from Byte 7 to Byte 7+N.

2.3.4 TDRSS

Byte 1: Sync 1 = FA$_H$
Byte 2: Sync 2 = FF$_H$
Byte 3: Origin byte
  Lower nibble:
    Bits 0…2: (0$_H$ - Housekeeping Deck, 1$_H$ - Low-Rate Science Port, 2$_H$ - High-Rate Science Port)
    Bit 3: (0$_H$ - COMM1 or 1$_H$ - COMM2)
  Upper nibble: Is zeroed out by LDB computer
Byte 4: 0 (not used, zero inserted)
Byte 5: Length of data (MSB)
Byte 6: Length of data (LSB)
Byte 7-N Data (1…length)
Byte N+1: Checksum (Σ bytes 3-N)

Bytes 5 and 6 tell how many bytes follow from Byte 7 to Byte 7+N.

2.3.5 TDRSS DIRECT DATA

The TDRSS Direct interface is an RS-232 port as described in Section 3. Data transmitted to the SIP TDRSS Direct port will be received from the TDRSS Direct GSE serial port. There is no error checking, timing, or error correction included.

2.3.6 IRIDIUM PILOT DOWNLINK

Iridium Pilot downlink data is received by science through the RJ45 port as TCP or UDP data packets. This data is not logged by the LDB ground station and must be encoded, decoded, and managed by science.

3 SCIENCE TO LDB FLIGHT COMPUTER INTERFACE SPECIFICATIONS

3.1 SCIENCE COMM PORTS

This section describes the interface to the low rate, high rate, and TDRSS Direct science interfaces. A low-rate science support interface (RS232) is available on each communication link computer (COMM1 and COMM2) simultaneously. Either of these serial lines can handle low-rate science data to be included in the downlink, uplink commands addressed to the science experiment, and SIP data (GPS position, GPS time, and MKS pressure if requested by the science). Science low-rate data need not be the same through COMM1/COMM2 if science chooses increased data downlink over redundancy.

3.1.1 PHYSICAL INTERFACES

3.1.1.1 LOW-RATE SCIENCE PORTS (COMM1 AND COMM2)

1200 baud, 8 data bits, 1 stop bit, no parity, standard RS232-C DB9 DTE

NOTE
This interface does not use CTS or DTR. It is three wires using only TX, RX, and GND; no hardware handshaking.

3.1.1.2 HIGH-RATE SCIENCE PORTS (COMM1 & COMM2)

115200 baud (configurable), 8 data bits, 1 stop bit, no parity, standard RS232-C DB9 DTE

NOTE
This interface does not use CTS or DTR. It is two wires using only TX and GND; no hardware handshaking.

3.1.1.3 TDRSS DIRECT SCIENCE PORT

115200 baud, 8 data bits, 1 stop bit, no parity, standard RS232-C DB9 DTE

NOTE
This interface does not use CTS or DTR. It is two wires using only TX and GND; no hardware handshaking.

3.1.1.4 IRIDIUM PILOT

CAT5E cable terminated with a non-shielded RJ45 connector (T568B termination)

3.1.1.5 PHYSICAL INTERFACE CONNECTION EXAMPLES FOR SCIENCE

a) Five Science Ports

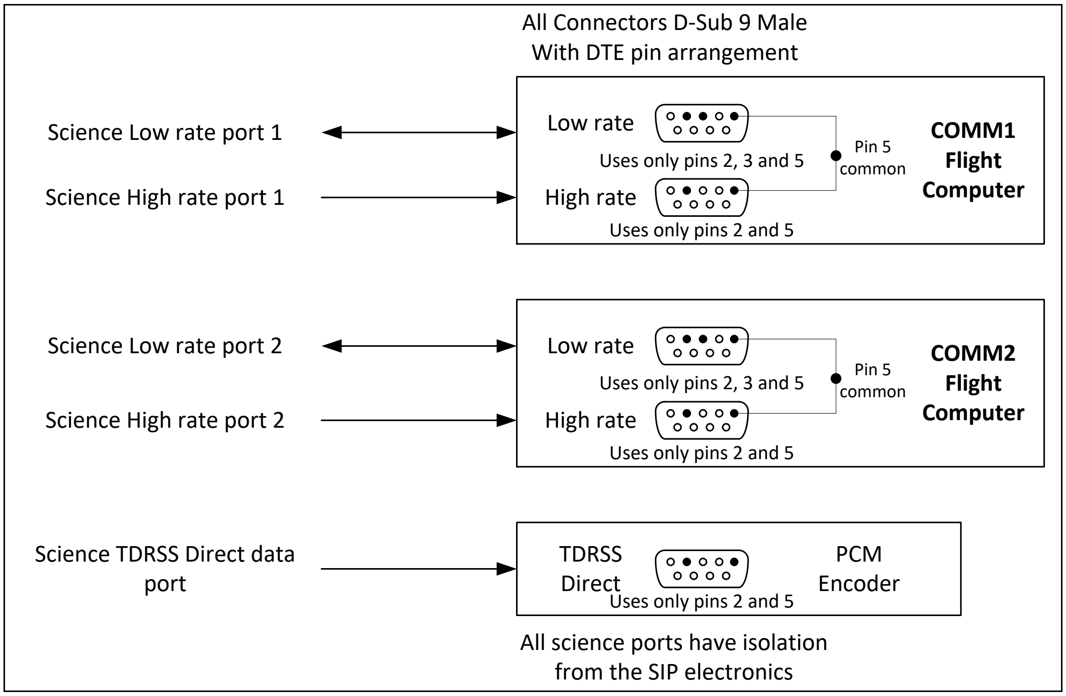


Figure 1 – Physical interface example for five science ports

b) Four Science Ports

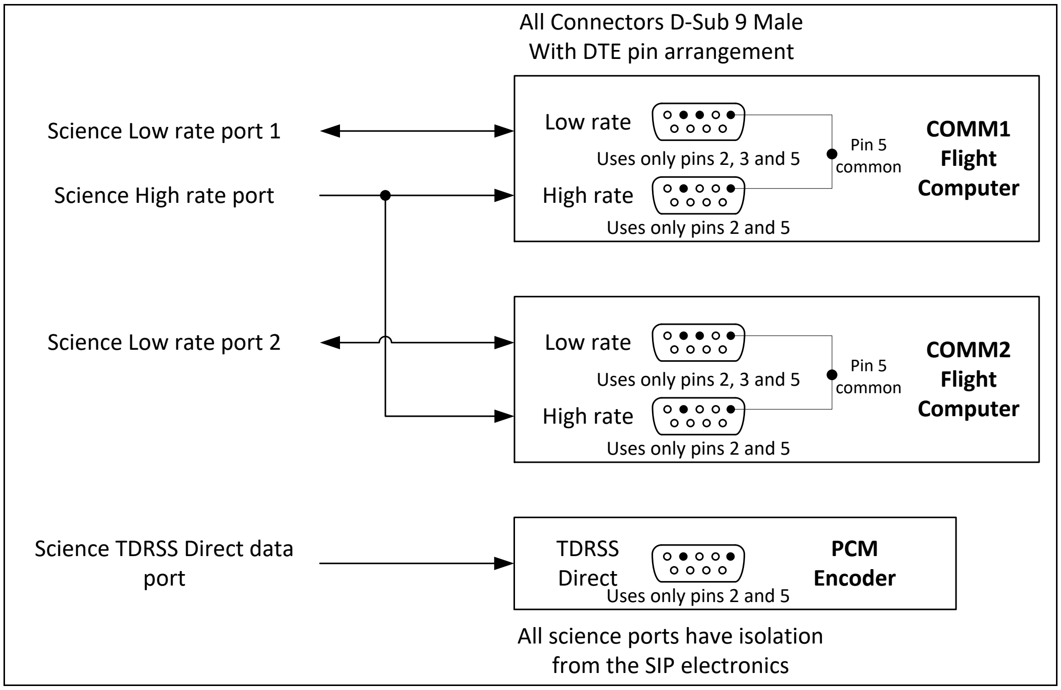


Figure 2 – Physical interface example for four science ports

c) Three Science Ports:

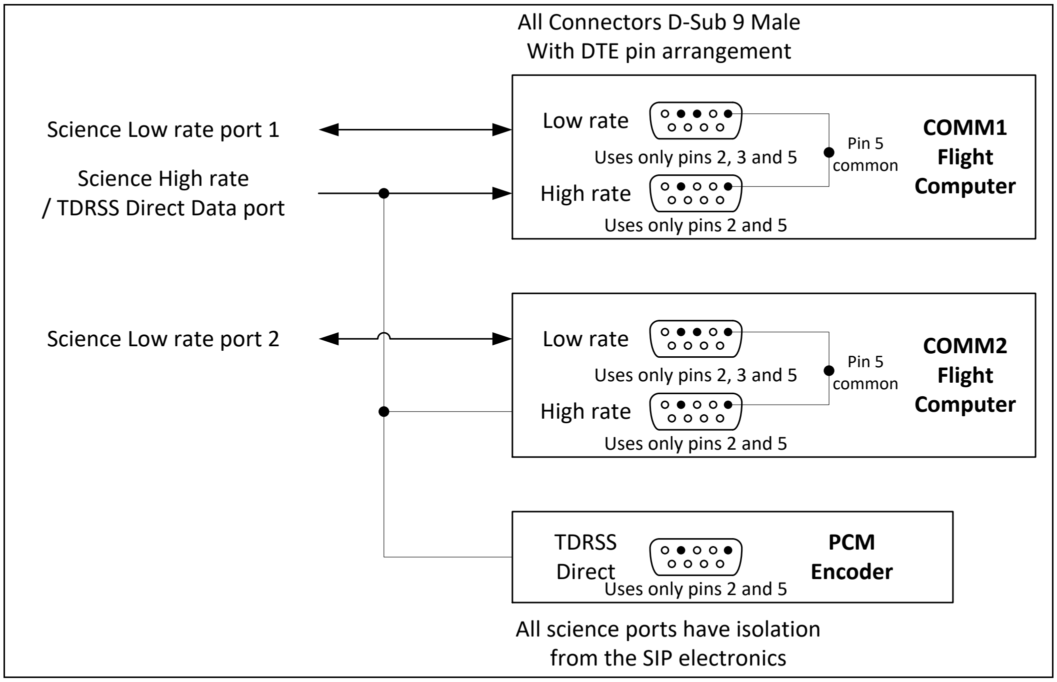


Figure 3 – Physical interface example for three science ports

3.1.2 SOFTWARE INTERFACE

3.1.2.1 LOW-RATE SCIENCE PORT

Because the low-rate science port is a more complicated interface, it will be implemented using a message protocol. The format of a message is:

ascii.dle, ID Byte, optional data bytes, ascii.etx

Where: ascii.dle = 10_H
ascii.etx = 3

The message protocol will follow in more detail.

3.1.2.2 HIGH-RATE SCIENCE PORT

The high-rate science port will transmit all data in 2041-byte packets. There is no format requirement like that required for the low-rate port (e.g. ascii.dle, ascii.etx). Science must ensure that the average bit rate does not exceed the currently selected communication link speed: Iridium dialup at up to 2 Kbps, TDRSS with omni antenna at up to 6 Kbps, or TDRSS with high-gain antenna at up to 75 Kbps.

CAUTION

NO ERROR CHECKING OR SYNCHRONIZATION WILL BE PROVIDED. EXPERIMENTERS NEED TO DO THEIR OWN ENCODING TO PROVIDE FOR THE ABOVE OPERATIONS.

3.1.2.3 TDRSS DIRECT SCIENCE PORT

The TDRSS Direct science port does not log data presented to it. There is no format requirement as with the low-rate port (e.g. ascii.dle, ascii.etx). Science must ensure that the average bit rate to the TDRSS Direct science port is not greater than 92 Kbps.

CAUTION

NO ERROR CHECKING OR SYNCHRONIZATION WILL BE PROVIDED. EXPERIMENTERS NEED TO DO THEIR OWN ENCODING TO PROVIDE FOR THE ABOVE OPERATIONS.

3.1.3 LOW-RATE SCIENCE INTERFACE MESSAGES FROM LDB COMM CPU TO SCIENCE

3.1.3.1 GPS POSITION (ID BYTE = 10_H)

The format of the GPS Position message is:

ascii.dle, 10_H, longitude, latitude, altitude, satellite status, ascii.etx

Where: *Longitude*, *latitude*, and *altitude* are 4-byte ***IEEE std 754*** single-precision real-format numbers. Longitude and latitude are in degrees. *Altitude* is in meters.

Satellite status is a byte with the following format:

Table 3 – Satellite status byte format

BIT	ITEM	TYPE	VALUE	DEFINITION
0-2	Dimension	UINT8	3	2D
			4	3D
3	Auto / Manual	UINT8	0	Auto
			1	Manual
4-7	Satellites in view	UINT8	-	nSVs

An example of a real number will be generated to show the byte order.

```
LSB                  MSB

109    120    238    191    =    -1.86305E00
```

LSB (109) is sent first and MSB (191) is sent last.

The bytes are packed to form a single precision real format number as follows:

```
   MSB                                        LSB
  1|0 1 1 1 1 1 1  1|1 1 0 1 1 1 0   0 1 1 1 1 0 0 0   0 1 1 0 1 1 0 1
A  |       B        |                    C
```

A: Sign bit 1=negative 0=positive

B: Exponent Represented using Excess Notation;
(8 bit represented above) - 127 = Actual Exponent

e.g. 01111111 (127) - 127 = 0;
10000000 (128) - 127 = 1;
10000001 (129) - 127 = 2, etc.

C: Mantissa Only the fractional part of the mantissa is given above.
All data is *normalized with the "Phantom Bit"* 1 as *given.*

$\Sigma 2^{(-N)}$ = Fractional mantissa

Where N = 1,2,4,5,6,9,10,11,12,17,18,20,21,23 for above example reading the bits from left to right under part C

$\therefore$ (Phantom Bit).(Fractional Mantissa) X 2^0 = -1.86305E00

If exponent had been E02, then:
(Phantom Bit).(Fractional Mantissa) X 2^2 = -7.4522

A zero exponent combined with a zero mantissa represents zero: *if the mantissa is nonzero, it is taken as a non-normalized number*.

Sign notation is negative for west longitudes and south latitudes.

3.1.3.2 GPS TIME (ID BYTE = 11_H)

The format of the GPS Time message is:

ascii.dle, 11_H*, GPS time of week, GPS week number, GPS/UTC time offset, CPU time, ascii.etx*

Where: GPS time of week represents the number of seconds since Sunday at 12:00 AM. The GPS week number is referenced from week number 1 starting January 6, 1980. GPS/UTC time offset should be subtracted from the GPS time to obtain UTC time. If GPS time of week is < 0 then the current GPS time is not known. The GPS time is updated in the LDB COMM CPU every 5 seconds when the GPS receiver is not doing position fixes and every 5 seconds when the GPS receiver is doing position fixes (this is a function of the GPS receiver itself). GPS time of week and GPS/UTC offset are 4 byte real numbers. GPS week number is a 2-byte integer. CPU time is seconds from midnight today synchronized to GPS time when status 1 > 3, status 2 is 0, and CPU time is more than 60 seconds off.

NOTE
This time should not be used for exact timekeeping purposes.

3.1.3.3 MKS PRESSURE ALTITUDE (ID BYTE = 12_H)

The format of the MKS Pressure Altitude message is:

ascii.dle, 12_H*, MKS High, MKS Mid, MKS Lo, ascii.etx*

MKS pressure altitude is two bytes where the MSB is transmitted first. The LDB Payload Engineer will provide, upon request, the switch points to be used so you will know which sensor (Hi, Mid, or Lo) to use while in its "active" linear range. MKS sensors are defined here as:

MKS High = high altitude sensor (0 to 10 torr)

MKS Mid = mid altitude sensor (0 to 100 torr)
MKS Lo = low altitude sensor (0 to 1000 torr)

3.1.3.4 MKS ALGORITHMS

MKS pressure is derived from a linear equation of the type $y = mx + b$ (where x = number of counts given in each two-byte packet and y = pressure in millibars. The m and b variables for this equation must be obtained from the LDB Payload Engineer as it is dependent upon each set of sensors and their calibration coefficients. Pressure Altitude is expressed in terms of Standard Atmosphere.

Let Z = Natural Log (pressure)

$$\begin{aligned}\text{Altitude in feet} = \; & 156776.89 + \\ & -25410.089 * Z + \\ & 462.44626 * Z^2 + \\ & 130.61746 * Z^3 + \\ & -20.0116288 * Z^4\end{aligned}$$

3.1.3.5 REQUEST SCIENCE DATA (ID BYTE = 13_H)

The format of the Request Science Data message is:

ascii.dle, 13_H, *ascii.etx*

This message informs the science interface that the LDB COMM computer is ready to accept a message packet from the science interface. The COMM computer will repeat this message at science transmission opportunities when its LDB science buffer is empty (the most recent science data passed over to the LDB flight computer is what gets transmitted when the LDB science buffer is empty); however, all science data requested by the LDB flight computer is logged onto the LDB hard disk drive whether it gets transmitted or not. Presently, the LDB flight computer polls the science port for new data every 30 seconds.

3.1.3.6 SCIENCE COMMAND (ID BYTE = 14_H)

The format of the Science Command message is:

ascii.dle, 14_H, *length, data, ascii.etx*

This message relays data addressed to the science package from the GSE systems. The *length* is the number of bytes of data passed to the science which is always two based on the LDB command format if the packet size was 20 or less from the ground. If more than two bytes were sent from the GSE, then it is possible that some bytes do not pass error checking and therefore are not passed to the science interface. If the command message sent was more than 20 bytes, the entire packet will be sent contiguously. The *data* is the data bytes passed to the science.

3.1.4 SCIENCE MESSAGE TO THE LDB COMM COMPUTER

3.1.4.1 REQUEST GPS POSITION (ID BYTE = 50_H)

The format of the Request GPS Position message is:

ascii.dle, 50_H, *ascii.etx*

This message requests the LDB COMM computer to send a GPS position message.

3.1.4.2 REQUEST GPS TIME (ID BYTE = 51_H)

The format of the Request GPS Time message is:

ascii.dle, 51_H, *ascii.etx*

This message requests the LDB COMM computer to send a GPS time message.

3.1.4.3 REQUEST MKS ALTITUDE (ID BYTE = 52_H)

The format of the Request MKS Altitude message is:

ascii.dle, 52_H, *ascii.etx*

This message requests the LDB COMM computer to send a MKS Altitude message.

3.1.4.4 SCIENCE DATA (ID BYTE = 53_H)

The format of the Science Data message is:

ascii.dle, 53_H, *data length*, *data*, *ascii.etx*

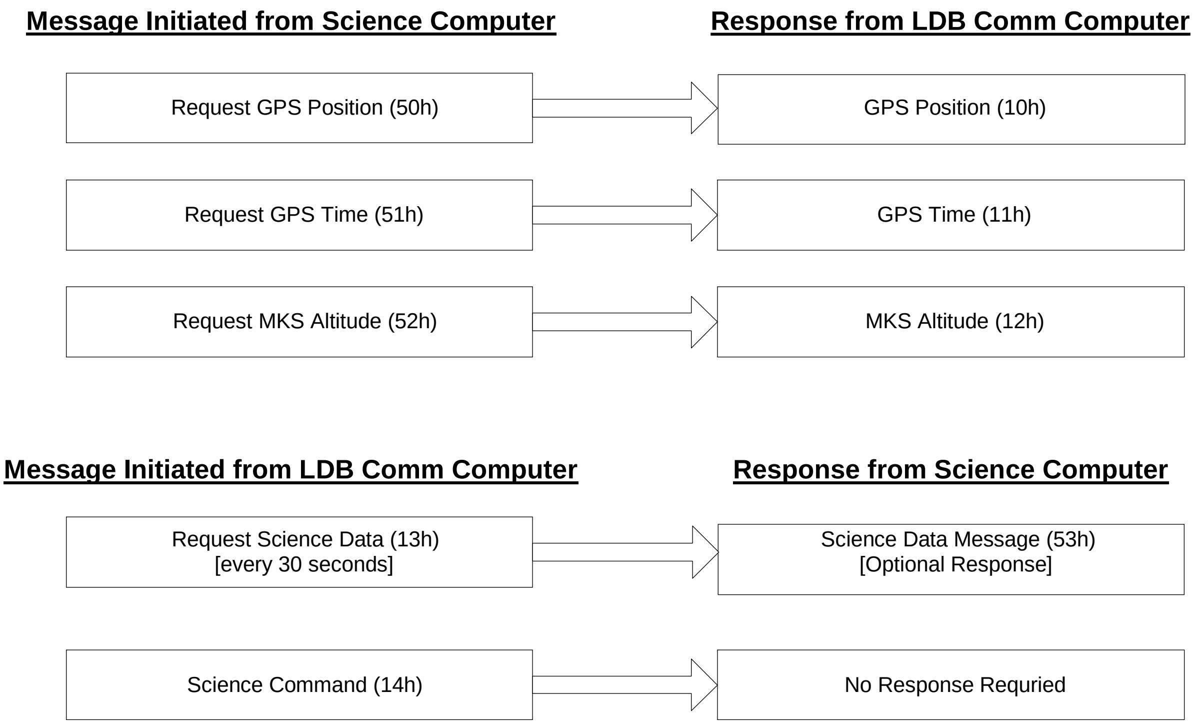
This message contains the data which the LDB COMM computer is to transmit to the ground and log in the low-rate science data log. This message must be in response to a Request Science Data message.

Where: *Data length* is a byte whose value must be between 1 and 255.
Data is length bytes of data which will be transmitted and stored on board.

CAUTION

IF A NEW PACKET IS NOT TRANSMITTED TO THE SCIENCE LOW-RATE PORT, THEN THE LAST PACKET RECEIVED BY THE SIP FLIGHT COMPUTER IS WHAT WILL BE DOWN-LINKED.

3.1.5 LOW-RATE SCIENCE INTERFACE MESSAGE EXAMPLES



4 Science Stack

A science stack option is available which provides:

- 32 Analog channels return telemetry (12-bit resolution)
- 32 Digital channels return telemetry
- 28 Open-collector command outputs (200-mA maximum @ 50 volts @ 100 milliseconds).
- 2 Optional diode clamp command returns (to be used if suppression diode is not available on science relay operating on open collector outputs)
- 1 Timed open collector command output (200-mA maximum @ 50 volts)
- 5-Volt reference

One science stack provides the above listed functions which can be accessed by either COMM1 or COMM2. The science stack is an option used by those experimenters with simple telemetry support requirements and who do not wish to incorporate their own flight data and command processing computer with which to integrate to the COMM science interfaces. The science stack can also be used for redundant commanding and/or housekeeping in addition to the COMM science interfaces.

The science stack is interrogated by the LDB flight computers (COMM1 or COMM2) and return telemetry is brought down on the selected COMM link (configured before launch and is typically the link which offers the highest data rate or best command link, but is selectable). Commands from the respective COMM system are routed accordingly to the science stack upon recognition of the proper stack address and command decode for the individual open collector outputs. This is all managed by the LDB system and the experimenter only has to be concerned with proper hardware integration to the science stack. (Please reference Section 2, *Science-to-Ground Computer Interface Specifications*.)

4.1 Science Stack Decks

4.1.1 Science Housekeeping/Command Deck

The housekeeping/command deck of the science stack consists of an individual connector for commands (discrete and timed), analog telemetry, and digital statuses. Specifications for utilizing the housekeeping/command deck are listed below.

4.1.1.1 Hex Addresses for Commands

Table 4 – Science discrete command deck hex addresses for commands

Output	Hex Address
1	09
2	0A
3	0B
4	0C
5	0D
6	0E
7	0F
8	11
9	12
10	13
11	14
12	15
13	16
14	17
15	21
16	22
17	23
18	24
19	25
20	26
21	27
22	41
23	42
24	43
25	44
26	45
27	46

OUTPUT	HEX ADDRESS
28	47

4.1.1.2 PHYSICAL INTERFACE: COMMAND DB-37P CONNECTOR (SIDE CONNECTOR)

(Science provides 37S.)

Table 5 – Physical interface for DB-37P connector

PIN	DESCRIPTION
1 through 28	Outputs 1 through 28
29	Clamp (Cmd1 - Cmd14; not used if transient suppressor diode is on relay)
30	Digital ground
31	Clamp (Cmd15 - Cmd28; not used if transient suppressor diode is on relay)
32	Digital ground
33	Timed Command Output
34	Digital ground
35	Clamp (not used if transient suppressor diode is on relay)
36	Digital ground
37	Digital ground

4.1.1.3 PHYSICAL INTERFACE: ANALOG DB-37P CONNECTOR (LEFT CONNECTOR)

(Science provides 37S.)

Table 6 – Physical interface for DB-37P connector

PIN	DESCRIPTION
1 through 32	Analog inputs (0 to 5 Vdc
33 through 36	Analog grounds (signal return)
37	5-V Reference (buffered through LT 1078)

4.1.1.4 PHYSICAL INTERFACE: DIGITAL STATUS DB-37P CONNECTOR (RIGHT CONNECTOR)

(Science provides 37S.)

Table 7 – Physical interface for DB-37P connector

PIN	DESCRIPTION
1 through 32	Digital inputs (input on 74HC375 - threshold is 1.5 Vdc
33 through 37	Digital grounds (signal return)

4.1.2 PHYSICAL AND POWER INTERFACE SPECIFICATIONS: DB-9S CONNECTOR

(Science provides 9P.)

The experimenter is responsible for accommodation of mounting the science stack as well as providing power to the stack. The science stack is serially isolated from the SIP via serial isolator built into the stack's power deck. CSBF will provide the cable going from the SIP to the science stack.

4.1.2.1 POWER

Provide 16 to 31-Vdc at 50 mA (maximum current).

Table 8 – Physical interface for DB-9P connector

PIN	DESCRIPTION
1	Power
6	Ground

4.1.2.2 MOUNTING

See the dimensioned drawing in Figure 4. Mounting height may vary depending on science and CSBF requirements due to the number of decks present in the science stack. A typical science stack consists of two decks plus a cover (0.564 in.): a 0.564-in. height power deck and a 0.562-in. height housekeeping/command deck, for an overall height of about 1.7-in. total.

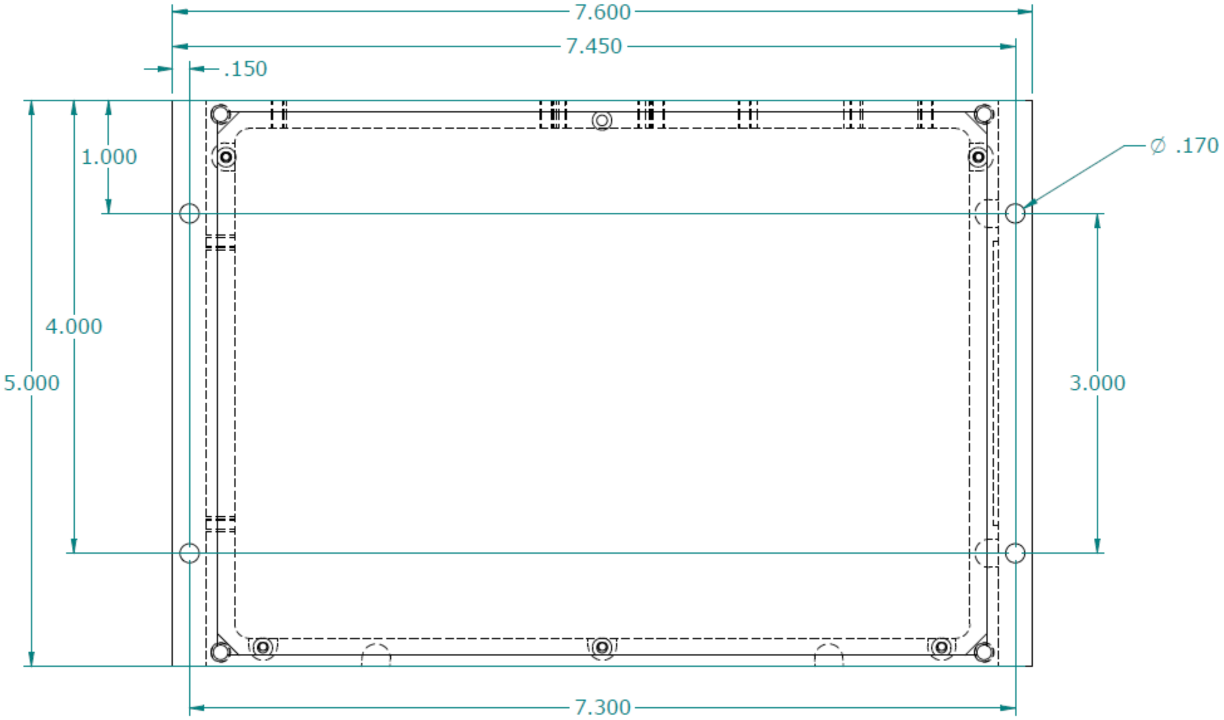
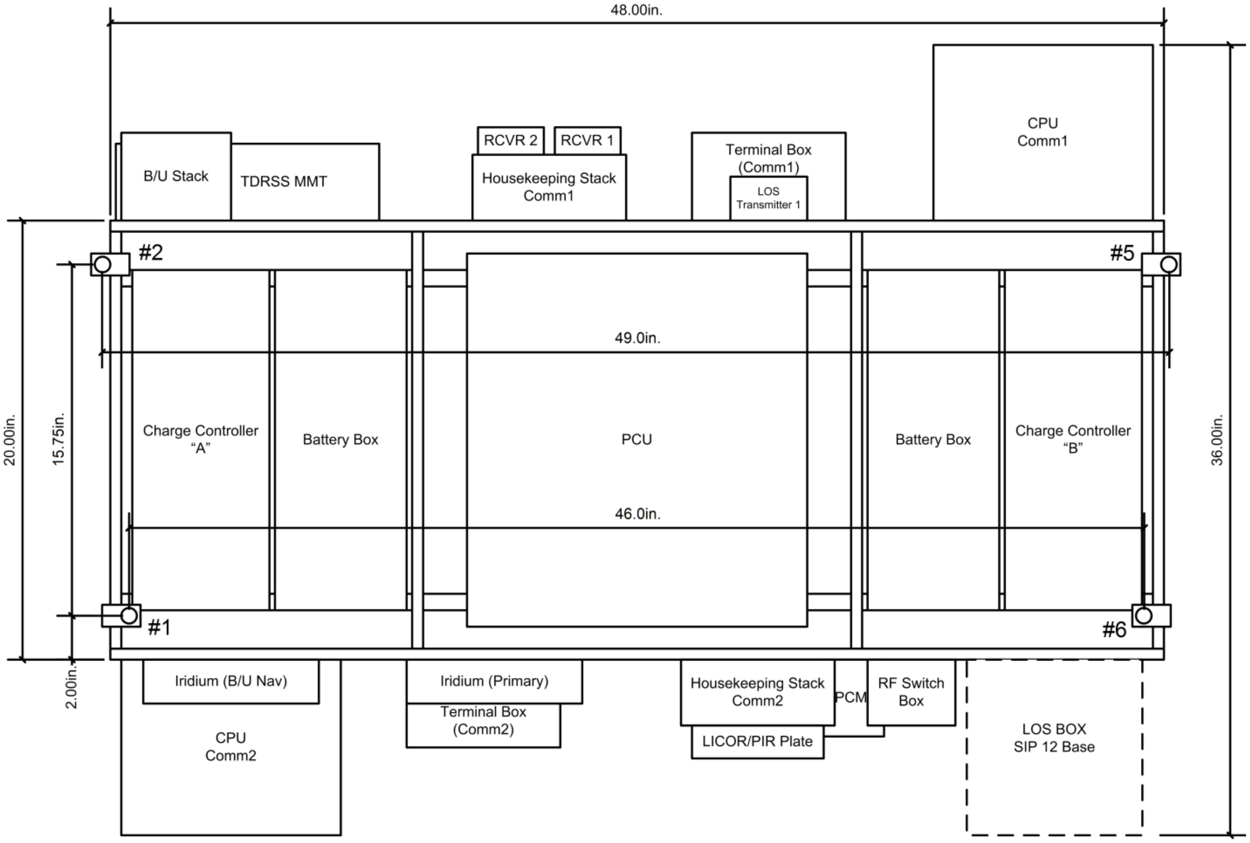


Figure 4 – Science stack dimensions

5 MECHANICAL

5.1 SIP MOUNTING REQUIREMENTS

The SIP is normally mounted by the top four outside mounting holes having 17/32-in. clearance. For most gondolas, this has been accomplished by suspending the SIP from the gondola structure. Electrical and thermal isolation between the SIP and SIP thermal shield is required with respect to the gondola. Holes #1, #2, #5, and #6 are used for mounting the SIP to the gondola. Note that the mounting blocks (for holes #1, #2, #5, and #6) may be oriented pointing inward (46.0-in. wide) or pointing outward (49.0-in. wide). The Figure 5 shows an example of each; however, the flight implementation will be one or the other. 46.0-in. wide mounting of the SIP is only available while mounting the SIP in suspension. Cases which require the SIP to “sit” on a gondola frame or shelf require 49.0-in. wide mounting holes.



Suspension Mounting: 46.0" x 15.75" (inside) or 49.0" x 15.75" (outside)
Base Mounting 49.0" x 12.5" (outside)

Figure 5 – SIP Mounting hole locations

Clearance must be provided to accommodate the SIP thermal shield as shown in Figure 6 (an additional three inches on the top side as well). Access to all four sides after mounting to the gondola is an **absolute** requirement. The SIP thermal shield must not be blocked by any structure on any of the four sides to facilitate heat transfer away from the SIP.

Normally, CSBF will attach ballast onto the gondola structure, not the SIP frame. Again, special cases where you may require having the SIP “sit” on a gondola frame or shelf will have to be given special consideration.

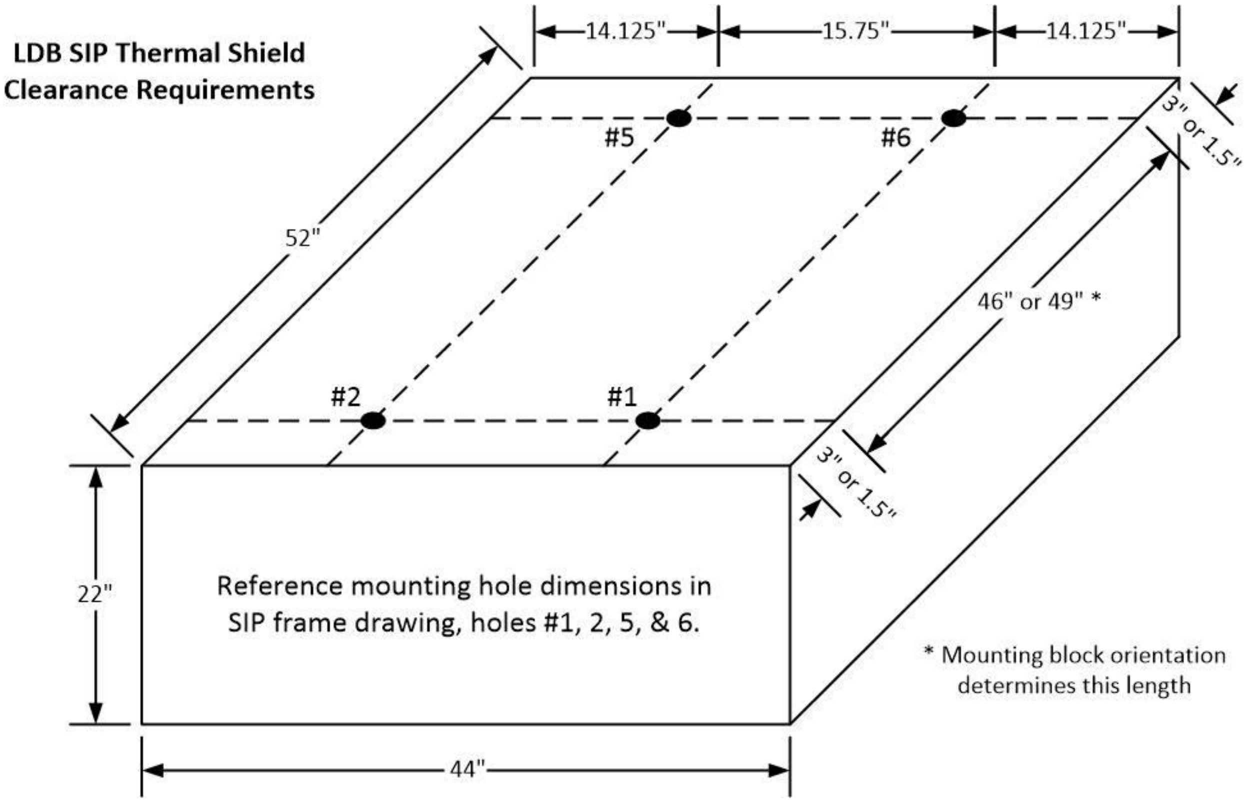


Figure 6 – LDB SIP Thermal shield requirements

5.2 LDB WEIGHTS

The weights shown in Table 9 are provided for estimating total gondola weights, stress analysis, etc. These weights will vary depending upon specific upper antenna boom requirements, photovoltaic (PV) array size requirements, antenna cable lengths, etc.

Table 9 – LDB weights for estimating gondola weight

ITEM	WEIGHT (LBS.)
Sip and thermal shield[1]	200
Ballast hopper and ballast valves[3]	23
LDB Solar array and batteries[3] *Batteries* *PV Panels* *Support frame* *Various sensors and antennas*	200
Upper antenna boom / antennas / cabling[3]	50
High-gain antenna	25
Iridium Pilot	28

---

[1] *Will vary depending on launch location*

5.3 GONDOLA CONFIGURATION

A simplified block diagram view as shown in Figure 7 illustrates a typical configuration (excluding science PV array).

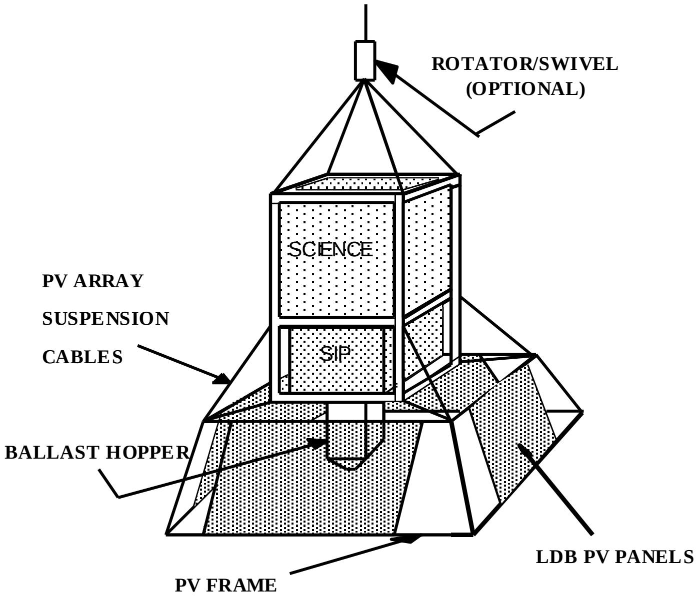


Figure 7 – Typical gondola configuration

The SIP and suspended LDB PV array are thermally and electrically isolated from the science gondola frame.

The optional rotator or free swivel must include electrical slip rings to accommodate the SIP’s serial communications lines going to the terminate electronics package. Although eight slip rings are required (SPB flights require 20 slip rings), it is recommended that spares be included. Further slip ring wiring information is included in section 5.5.2.

The LDB PV array is normally a four-sided array, even with rotators being flown, to assure operation in the event of rotator failure. Special configurations that differ from the basic concept shown in Figure 7 above require consultation with CSBF prior to completing the final configuration definition. Factors influencing LDB PV array size include gondola height, science PV array structure, and other factors impacting shading on the PV array. No shading of the PV array is allowed for any angle of the gondola with respect to the sun at any elevation. Other factors impacting placement of all PV panels (science and LDB) include thermal consideration such that no vulnerable components are placed directly to the backside of a PV panel.

Please refer to the document *Structural Requirements and Recommendations for Balloon Gondola Design* (OM-220-10-H) for further information on SIP protection and thermal considerations. This document can be downloaded from the CSBF website: http://www.csbf.nasa.gov/docs.html.

5.4 ANTENNAS

5.4.1 PLACEMENT

For an LDB flight, there are a number of required antennas that must be mounted on top of the gondola to provide minimum obscuration horizon-to-horizon for 360 degrees. Obviously, gondola suspension members will provide some obscuration; however, from experience this has been of little negative impact when the antennas are properly placed. Orientation of these top-mounted antennas may necessitate judicious placement depending upon the pointing requirements of any given experiment. A rule of thumb is to insure that placement is such so as to maximize visibility of the Iridium and TDRSS antennas to any point on the geostationary orbiting satellite arc as seen from the balloon. The GPS antennas must view polar orbiting satellites. If you don't provide a location for placement of the top antennas, CSBF will provide a boom to be attached to your gondola on which to mount these antennas. Antennas are electrically isolated from the gondola.

The number of antennas mounted at the top are:

- TDRSS: 1 (mid-latitude or Antarctica)
- Iridium: 3
- GPS: Up to 5 with HGA
- High-gain antenna - TDRSS (Optional)
- Iridium Pilot: 1+ (Optional)

Other antennas for LOS forward and return communications are mounted on the bottom of the LDB solar array.

5.4.2 ANTENNA DIMENSIONS

Antenna dimensions are as shown in Figure 8, Figure 9, and Figure 10.

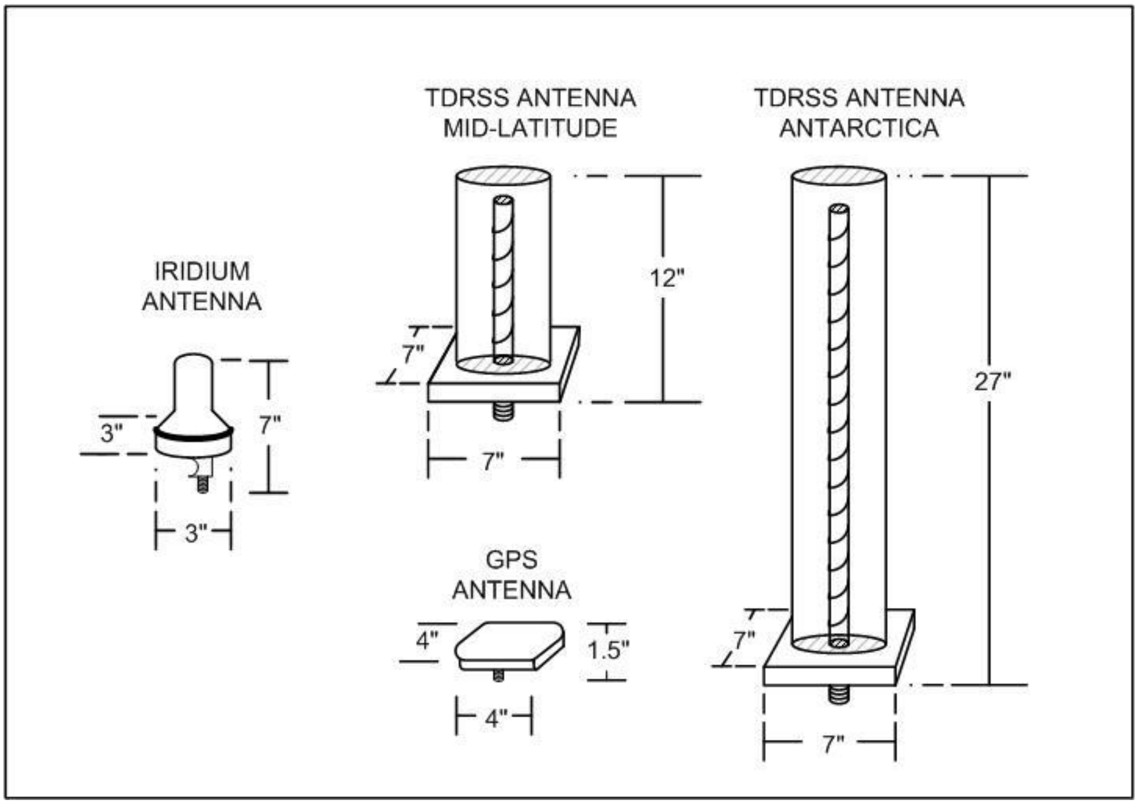


Figure 8 – LDB Antenna dimensions

Figure 9 – TDRSS high-gain antenna

HGA Dimensions

Diameter:	24.0 in.
Height:	16.0 in.
Weight:	25.0 lb.

Figure 10 – Iridium Pilot antenna

Pilot Dimensions

Diameter:	22.44 in.
Height:	7.87 in.
Weight:	28.0 lb.

5.4.3 ANTENNA SPECIFICATIONS

Table 10 – Antenna specifications

ANTENNA	LOCATION	FUNCTION	FREQUENCY (MHZ)	RF POWER	TYPE	CABLE	CONNECTOR TYPE
Iridium	Top	CMD/TM	TX/RX 1616.5 to 1626.5	7 Watts (peak)	OMNI RHCP	RG214	TNC-Female
Iridium Pilot	Top	TM	1616 to 1626.5	6 Watts (average)	RHCP	CAT5E	RJ-45 / Bulgin PX0728/S
TDRSS	Top	CMD/TM	2106.5 (RX) 2287.5 (TX)	5 Watts	Omni LHCP	Rigid Coax	N-Female
GPS	Top	RX/Nav	1575.42	N/A	RHCP	RG223	SMA
L-Band	Bottom	TX/LOS TM	1444.5 to 1525.5	2 Watts	¼ Vert.	RG214	N-Female
S-Band	Bottom	TX/LOS TM	2378.5 to 2387.5	5 Watts	¼ Vert.	RG214	N-Female
UHF	Bottom	RX/LOS CMD	429.5	1 Watt (during retransmit)	¼ Vert.	RG223	BNC

5.5 ROTATOR

The NASA Solar Pointing System (SPS), or rotator, is provided for use on LDB flights. The rotator is designed as an optional power system element to maintain maximum solar flux in conjunction with directional PV panels mounted to the gondola structure. The rotator uses a simple proportional-integral-derivative (PID) feedback system (Inner Velocity Loop [IVL], control law algorithm), an inertial rate sensor to measure angular velocity of the payload (primary method), and LICOR (pyrometer) sensors for pointed station-keeping. A back-up mode (estimated rate) is available that derives payload position using only the LICOR sensors. The rotator is required to maintain pointing accuracy to within +/- 10 degrees (98.5 % peak solar flux) and is intended for rough tracking of the sun for PV power—coarse azimuth pointer. Acquisition time for target settling (180 degrees) worse case is approximately 10 minutes. The rotator is designed to provide linear stability throughout the duration of the flight with a 6-dB gain margin and 30-degree phase margin. Both the upper and lower rotator universal joints provide 3-axis movement evenly distributing the load during azimuth rotation. The rotator is designed to autonomously track and maintain station keeping; manual and back-up services are available. Telemetry and commanding to and from the rotator is managed through the CSBF SIP and can be accessed or controlled both from LOS and OTH routing. Pointing services are initiated above 80,000 ft.

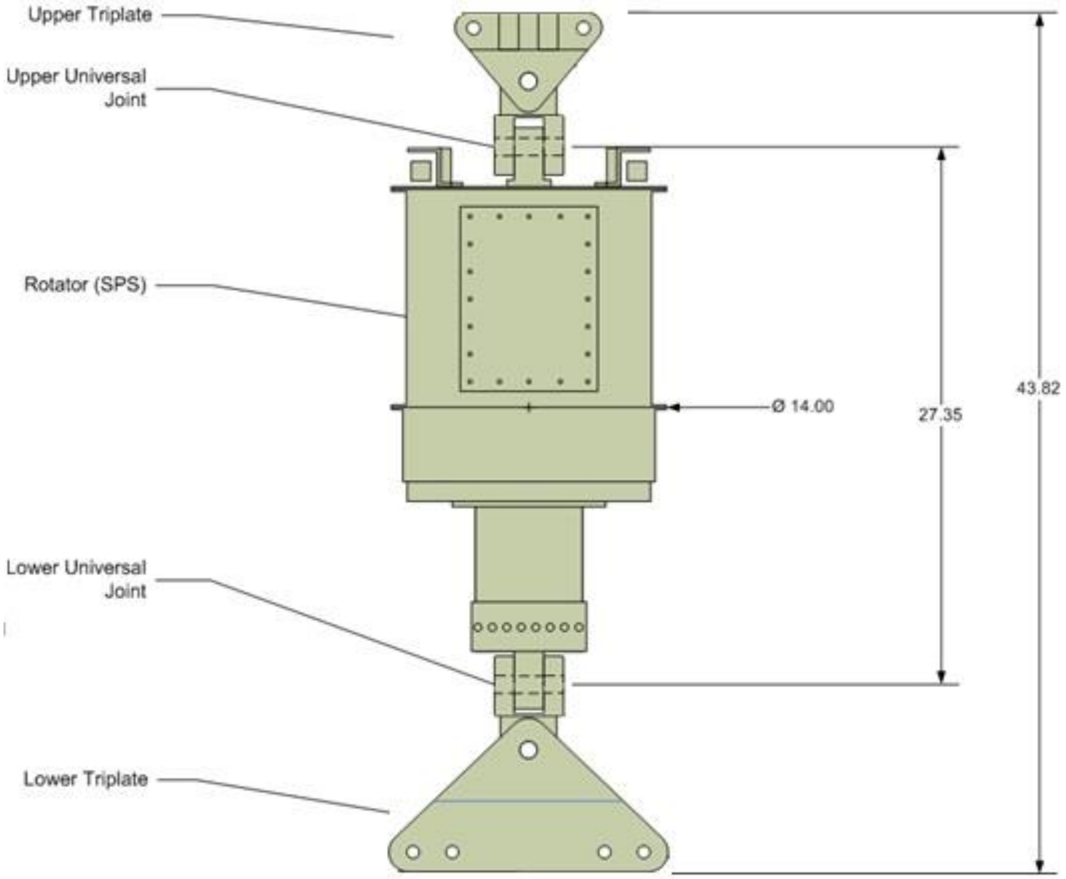


Figure 11 – Rotator dimensions

5.5.1 ROTATOR MASS SPECIFICATIONS

The following specifications are provided for estimating above gondola weights, stress analysis, etc.

- Weight (including universal joints and tri-plates): 145 lb.
- Diameter: 14 in.
- Height: 27.35 in. (pin to pin), 43.82 in. (overall)

5.5.2 ROTATOR SLIP RING INFORMATION

- Electro-Miniatures P/N 2424-00-20-3 or equivalent
- Two contacts per ring (~5 amps)
- Total of 20 rings, 16 wired with 7 shielded, twisted pairs of Teflon insulated 22-gauge wire, and 4 wired with Teflon insulated 16-gauge wire.

5.5.2.1 ROTATOR SLIP RING PHYSICAL INTERFACE: AMPHENOL PT06A-16-26P / PT02A-16-26S

(Connectors science provided or available from CSBF upon request.)

The connector terminated to the wires exiting the top of the slip ring assembly

- Amphenol PT06A-16-26P

The connector terminated to the wires exiting the bottom of the slip ring assembly (PT02A-16-26S only if cable and connector are properly secured and strain relieved).

- Amphenol PT01A-16-26S (panel mount)
- Amphenol PT02A-16-26S (in-line cable)

Table 11 – Physical interface for slip ring Amphenol connectors

PIN	DESCRIPTION
G through L	Signal
M through N	Flight train power (+28V)
P through R	Flight train power ground
S through c	Signal

5.5.3 REQUIRED SCIENCE PAYLOAD PROPERTIES

The following data is needed to prepare the balloon rotator for flight. This data is required as soon as possible, no later than at least two months prior to the hang test in Palestine.

- Estimated gondola weight–without ballast (lb.)
- Estimated gondola inertia (slug-ft.^{2})
- Gondola natural period (sec.)
- Desired ballast weight (lb.)
- Attachment method (direct, cables, etc.; include cable lengths, spacing, etc.; attach drawing if available)

- Operational parameters (e.g. night-time pointing–mid-latitudes only, maximum rotation rates)
- Desired pointing accuracy (+/- deg.) and interval (deg./sec.)

5.6 THERMAL

A thermal analysis is required for each LDB science payload. This analysis must be completed sufficiently in advance of final integration in Palestine to insure proper configurations are made prior to shipment to the field.

LDB project thermal analysis support is provided only for CSBF's equipment and systems. Experimenters need to have their own thermal analysis support in order to calculate their operating parameters within the chosen environment. Keep in mind that environmental flight conditions differ between Antarctic flights and mid-latitude flights.

The LDB project's thermal analyst will work with the experimenter's thermal analyst to resolve intra-system thermal coupling issues, etc. Due to the length of time to perform this analysis, it is important to establish the gondola configuration and mounting location for the SIP, solar arrays, and instruments as soon as possible. The outcome of the thermal analysis can result in changes to requirements for mounting locations and/or component surface coatings, thermal shields, etc.

5.7 LAUNCH VEHICLE REQUIREMENTS IN ANTARCTICA / SWEDEN

1) The height of the payload suspension point on the launch vehicle is fixed (normally) at 36 feet above the ground surface (39 feet for Kiruna).
2) A minimum ground clearance of 5 feet between the ground surface and the lowest point of the LDB payload is required. The lowest point of the hanging gondola is the antennae (5 feet); the bottom limit of the payload structure is 6 feet.
3) The combined height of the LDB SIP and the LDB omnidirectional solar panel array is approximately 6 feet. In Figure 7 on page 23, the SIP is shown in the diagram mounted externally at the base of the science gondola. Other mounting configurations for the SIP may be possible.
4) The shaded area shown in Figure 12 describes a plane which delimits acceptable and unacceptable payload geometry. Experience has shown that any payload element which extends above and to the left of this shaded area will strike the underside of the boom during the launch.

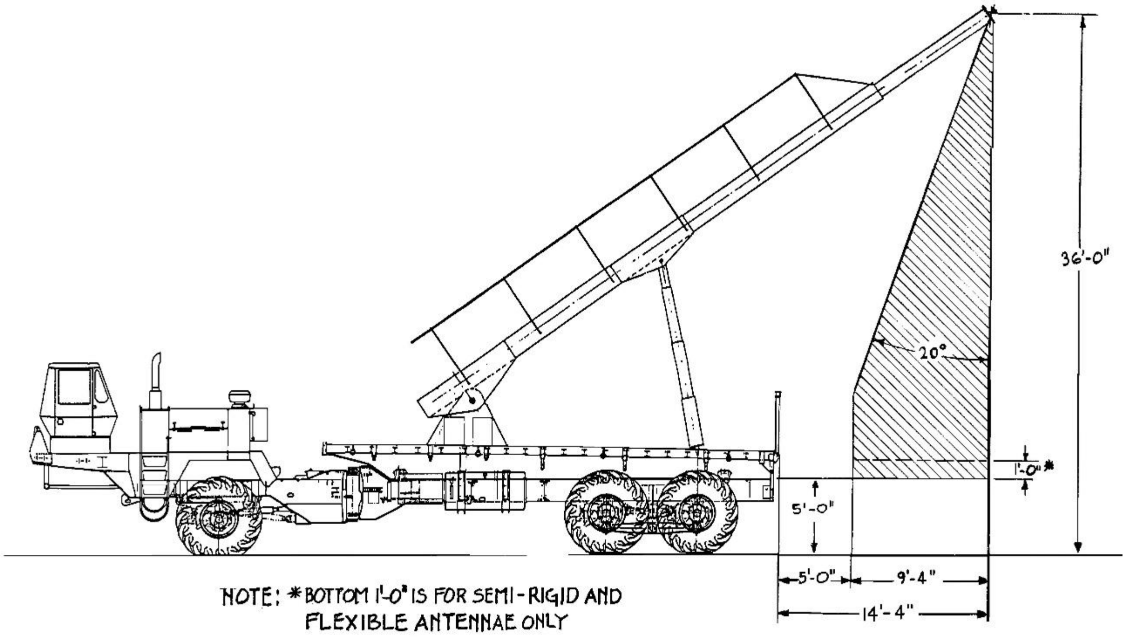


Figure 12 – Dimensions for "The Boss" launch vehicle (Antarctica)

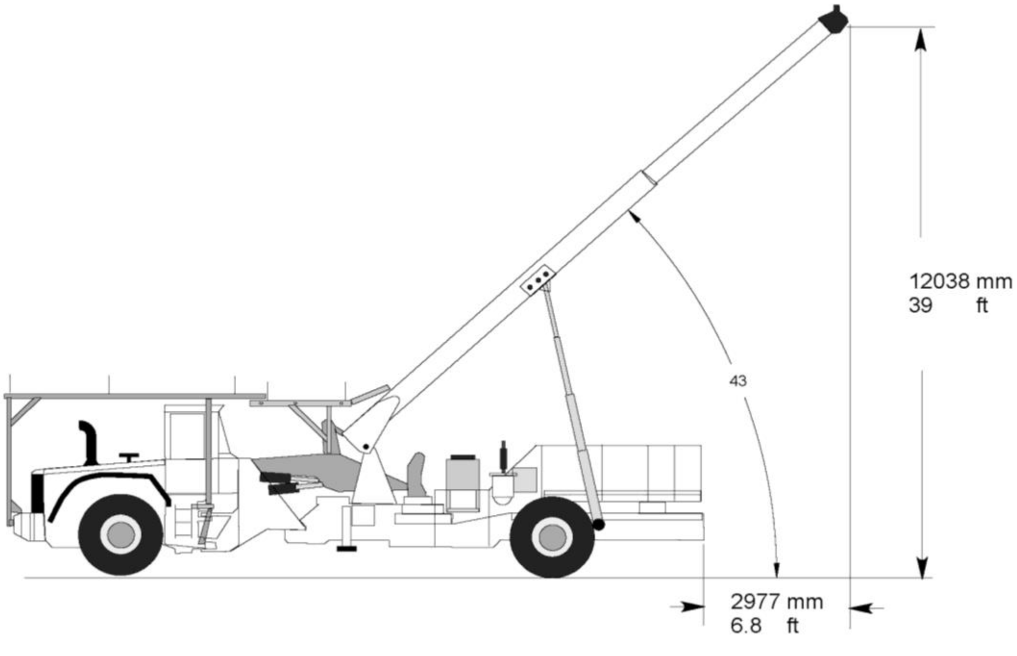


Figure 13 – Dimensions for the "Hercules" launch vehicle (Sweden)

5.8 RECOVERY REQUIREMENTS

5.8.1 ANTARCTICA

From a science, economical, and environmental standpoint, it is highly desirable to recover 100% of the payload. To date only one gondola has been recovered using the LC 130 aircraft (i.e. recovery planning should be based on *not* using an LC-130). This is largely due to accessibility of the aircraft (the LC 130) and surface conditions at or near the impact site.

Most recoveries are done using a Twin Otter or helicopter. Making use of the Twin Otter, each discipline must be aware of the usable space and configuration with this aircraft. The cargo door opening of the Twin Otter is 56.0-in. wide by 50.0-in. high. Two hundred pounds per square foot is the limitation of the cargo density. Because the Twin Otter cargo holding area tapers from fore to aft and other operations considerations, final coordination of the recovery package dimensions must be coordinated with the CSBF Campaign Manager. The Twin Otter can usually get off the snow surface with 2,200 pounds on board. This capacity diminishes with altitude and poor surface conditions.

The helicopters have a very limited inside cargo carrying capacity but can sling loads up to 1,800 pounds. As can be seen by the dimensions, several trips are required for a complete recovery. With this information, each science group should be building payloads such that they will break down into components that will fit inside the Twin Otter or helicopter. Weights are manageable by a limited ground crew. Various components must withstand extended periods of time exposed on the Antarctic surface waiting for a recovery to take place. ***Payloads built with a single source recovery aircraft in mind (i.e. LC 130 Hercules) run the risk of not getting recovered.***

5.8.2 GREENLAND

For Fairbanks or Kiruna-to-Canada trajectories, termination and recovery from Greenland is now planned only as a contingency in the event of an emergency. In the unlikely event of a Greenland termination, CSBF currently plans on using its own aircraft for the terminate portion of the operations. LC 130s operated by the New York Air National Guard (NYANG) may be available for recovery. Other options for recovery do exist, but at high cost. There are ski-equipped Twin Otters available in Canada and Iceland, but again are quite expensive to use for recovery. CSBF may be able to make use of the NYANG while they are positioned in Thule, Greenland supporting other NSF and military missions. However, due to the cost, using KBA Otters could be significantly less expensive that the NYANG. This means that if a recovery opportunity is missed while the NYANG are positioned in Greenland, the payload would need to rest on the ice sheet until they return to Greenland or until other arrangements can be made.

5.8.3 FAIRBANKS, ALICE SPRINGS, KIRUNA, AND WANAKA

Normally, recovery for mid-latitude type launches will be handled in much the same manner as currently done for conventional ballooning. Various helicopter and ground recovery assets will be used. Gondola design should take into account ease of recovery in remote locations which will generally require helicopter lifts.

6 CHANGE LOG

Table 3 – Change Log

CHANGE SUMMARY	REVISION	DATE
Updated science stack connector details	B	May 13, 2019