Small Explorer Class Library

LONG DURATION BALLOON OPPORTUNITIES

General Information

All scientific groups proposing long duration balloon missions can obtain more detailed information by requesting the **National Scientific Balloon Facility (NSBF) Long Duration Balloon (LDB) Flight Application** package or electronically accessing it at "http://www.nsbf.nasa.gov/docs.html". All science groups requesting Long Duration Balloon (LDB) support should be prepared to submit a LDB Flight Application immediately upon selection as a mission or approximately two years in advance of the requested support. The advance application for LDB flights is due to the long lead time required for operational planning, logistics, and interfaces with associated support organizations. A full list of acronyms is found at the end of this document, just before the appendix.

Systems Description

Balloon Vehicle

No proposals will be considered beyond the demonstrated capabilities for the 29.47 MCF (million cubic foot) volume zero-pressure balloon and the 59.84 MCF zero-pressure balloon. No options for use of other existing balloon designs will be considered in response to this announcement.

Zero-Pressure Balloons

The zero-pressure balloon carries the scientific instrument to a density altitude that is determined by the total mass of the system (suspended mass + balloon mass) divided by the fully inflated balloon volume. The balloon is only partially filled at time of launch and expands to its full volume as the balloon approaches its float altitude. NASA currently uses helium as the lifting gas. The zero-pressure balloon has openings to the atmosphere, called vent ducts, to release the excess gas, called free-lift, which provides the lifting force during ascent. The balloon continues to float at the density altitude until there is a change in the radiation environment, such as sunrise/sunset, upwelling earth flux, etc. At sunset the gas cools, the volume decreases, and the balloon can descend (~30-50 k-ft) to a lower equilibrium altitude based on atmospheric lapse rates and radiation environment. Altitude can be maintained by reducing the total system mass through release of ballast, which nominally amounts to ~8 percent/day. Zero-Pressure Balloon flights are thereby limited by the total available mass that can be used as ballast.

29.47 MCF Balloon Vehicle Specifications:

The 29.47 MCF zero-pressure balloon has a demonstrated capability on twenty-seven LDB flights flown since 1987.

- Balloon Volume: 29.47×10^6 ft^3
- Inflated Height: 335 ft
- Inflated Diameter: 424 ft
- Gas Barrier: 0.8 mil LDPE
- Number Caps: 2
- Balloon Mass: 3600 lbs
- Float Altitude: 118 to 130 k-ft

New Extreme Altitude 59.84 MCF Balloon Vehicle Specifications:

In August 2002, NASA successfully flight demonstrated an extreme altitude 59.84 MCF zero-pressure balloon, which supports a suspended payload weight of 1200 lbs to an altitude of 161 k-ft (1 mb). This balloon does not have a demonstrated LDB capability, but since it offers a higher altitude regime than what has typically been flown before, NASA will consider proposals requesting the capability this size balloon has to offer. Although the 59.84 MCF has a demonstrated capability, it has only been for a short duration flight of just over twenty hours and may require additional qualification testing for the LDB operational mode.

- Balloon Volume: 59.84×10^6 ft^3
- Inflated Height: 429 ft
- Inflated Diameter: 534 ft
- Gas Barrier: 0.4 mil LDPE
- Number Caps: 2
- Balloon Mass: 2751 lbs
- Float Altitude: 157 to 161 k-ft

Future Capability

A new capability, called Ultra Long Duration Ballooning (ULDB) is under development by the NASA Balloon Program. Although ULDB will NOT be available to support the missions proposed under this AO, it is expected that the potential mission enhancements that ULDB has to offer will generate some questions. ULDB will utilize superpressure balloons by using a radical new design and new material that will give the balloon vehicle an extended capability. These balloon vehicles are presently under development and their incorporation into the NASA operational Balloon Flight Program cannot be guaranteed. Therefore, they will not be offered for this announcement.

Ballooncraft (Gondola)

SIP (Support Instrument Package) Configurations:

There are two SIP configurations. One incorporates a TDRSS/HF command and telemetry system that is used in Antarctica. The other configuration uses TDRSS/INMARSAT-C for all other areas of operation. Both configurations incorporate Argos LEO satellite relay systems for low data rates (i.e. housekeeping status, etc.) INMARSAT-C, TDRSS, and Argos are over-the-horizon (OTH) telemetry systems. HF is a limited OTH command telemetry system. Communication between the science instrument and the SIP is via RS-232. Scientists desiring higher return data telemetry rates than those offered by the current SIP systems have the option of providing their own telemetry systems, provided it passes compatibility testing with the SIP and flight control systems. However, all science commands sent to the payload must be routed through the NASA/NSBF Operation Control Center (OCC) or Remote Operations Control Center (ROCC) to the SIP, which in turn passes all science commands on to the instrument via the SIP-Science Instrument interface.

[Note: Each SIP is configured to provide onboard data storage of all science data. This data can be played back through TDRSS for post record recovery in order to mitigate losses due to TDRSS outages (i.e. zones of satellite exclusion, etc.). Scientists planning to incorporate their own data telemetry systems are strongly encouraged to incorporate a playback mode of the data archived in their onboard storage in order to alleviate possible problems that may otherwise be encountered by relying solely upon payload recovery to get all the data.]

NASA is currently in the process of qualifying an Iridium flight modem for use as a replacement for the INMARSAT-C transceiver and HF command receiver, now currently flown on SIPs. It is anticipated that once this qualification is completed, all SIPs will be of the same configuration, no matter where flown; namely, TDRSS/Iridium. At this time, there is expected to be little or no cost deltas between the current configurations and that of TDRSS/Iridium. Anticipated completion of qualification and reconfiguration is expected to be completed one year from release of this SMEX FY03 AO. Initial Iridium configurations will accommodate 2400 baud operation with greater flexibility of scheduling command/data links to/from the payload. Proposers should base their requirements on the current SIP configuration as described elsewhere herein, but when the SIP Iridium becomes available users will be offered the full range of capabilities provided by this enhancement.

Polar Configuration (McMurdo, Antarctica):

The TDRSS/HF SIP configuration will allow regional HF commands to be transmitted from McMurdo, Antarctica as a backup during periods of TDRSS ZOE should the trajectory take the flight toward the pole. The TDRSS/HF SIP configuration also allows TDRSS commands to be sent from the NSBF at Palestine, Texas via NASA's TDRSS network. TDRSS uplink commanding and downlink data is only available at the NSBF Operations Control Center (OCC). Science users can send requests for transmitting their commands through TDRSS from either their home institutions or while in the field in Antarctica. This is accomplished by having pre-defined commands sent from their science GSE computer at the NSBF, which in turn is interfaced to the OCC GSE computer. Or in some cases, science commands can be configured in the OCC GSE computer's command configuration tables, which can be executed pending notification to operations personnel who are monitoring these systems on a 24 X 7 basis.

Return telemetry is provided via TDRSS and Argos. TDRSS return telemetry is 6 kbps (omni antenna) or 100 kbps (high gain antenna) on a near-continuous basis. NASA is in the process of completing qualification of the TDRSS HGA for use with LDB SIP systems. Conversion of LDB SIPs to incorporate TDRSS HGAs is scheduled for years FY04 and FY05. A science dedicated Argos Platform Transmitter Terminal (PTT) is offered which transmits 32 bytes every 60 seconds. Argos data is only available during periods of co-visibility with LEO satellites, which varies between 90 and 300 cumulative minutes per day, depending upon the latitude of the balloon. Argos only offers a return data link. There is no ability to send commands through Argos. While within line-of-sight (LOS) of the launch facility, science data can be acquired via L/S-Band telemetry links for higher data rates. Maximum LOS return telemetry rate at the ground station is 333 kbps Bi-phase. In addition to the aforementioned near "real-time" telemetry, science data is stored onboard SIP hard drives for recovery after flight termination. LOS commands are offered through UHF. Detailed information is available via the aforementioned LDB Flight Application documentation.

Mid-Latitude Configuration (Fairbanks, Alaska & Karlsborg, Sweden):

The TDRSS/INMARSAT-C SIP configuration is the principle configuration for flights launched from Fairbanks or Karlsborg. Refer to the aforementioned discussion for TDRSS telemetry rates. INMARSAT-C return telemetry is transmitted at the rate of 256 bytes every 15 minutes. INMARSAT-C allows for commanding from either the launch site or the NSBF at Palestine, Texas. Same as with the polar configuration SIP, Argos data and LOS data/command systems are available on the mid-latitude configuration SIP. Detailed information is available via the aforementioned LDB Flight Application documentation.

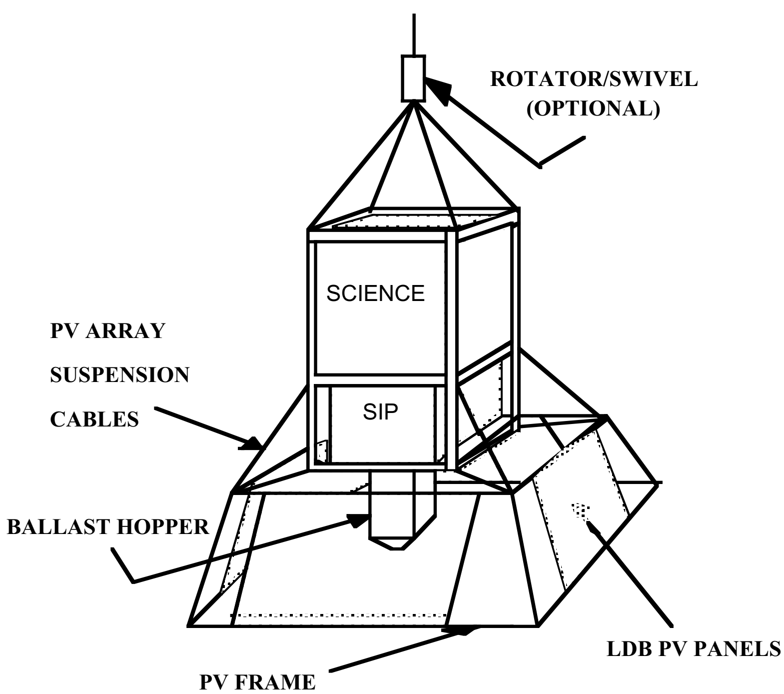
Gondola Configuration:

Balloon gondolas (payloads) vary depending upon the experimenter's needs. The following drawing is a simple example (excluding science power photovoltaic array) for purposes of illustrating what a typical configuration would include. The

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

The LDB PV array is a four-sided array. Because the LDB PV systems support mission-critical safety requirements, they are configured in this manner even when a sun-pointing rotator is flown. 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. Factors impacting placement of all PV (science and LDB) panels include thermal, shading, and illumination considerations. Generally, heat sensitive components are never placed behind PV panels because extreme heat is radiated off the back of the panels.

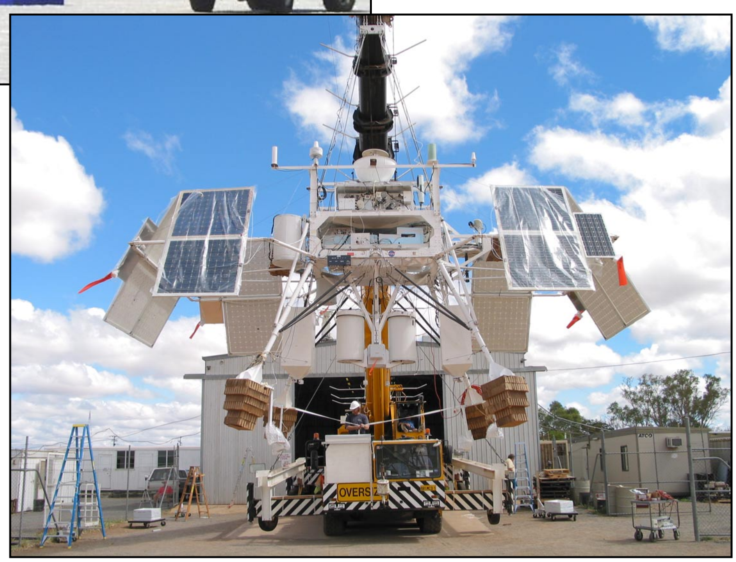
A rotator or free swivel, either of which are optional on LDB flights from Fairbanks and McMurdo, must include electrical slip rings to accommodate the SIP's serial communications lines going to the Balloon Control electronics package above the gondola. Eight slip rings are required but it is recommended that spares be included.



A sun-pointing rotator may be required to support larger power requirements. If a rotator is not provided by the experimenter, the Balloon Program Office will provide one at the time of final integration with NASA support systems. All gondola configurations require consultation with, and concurrence by the NASA Balloon Program Office.

Although the above figure is used to convey a typical configuration for purposes of explanation, as the following photographs show, balloon payload geometries can vary depending upon unique instrument requirements.

BOOMERANG – Williams Field, Antarctica



NIGHTGLOW – Alice Springs, Australia

LDB Ground Stations

The ROCC (Remote Operations Control Center - launch site) and OCC (Operations Control Center - Palestine, TX) provide similar capabilities. The Science GSE Computer to LDB GSE Computer interface is the same for both the ROCC and OCC. After the balloon reaches float altitude, and prior to it leaving the launch site LOS TM range, Operations Control is handed over to the OCC at Palestine. For Antarctica operations, the ROCC maintains local Argos data monitoring and local HF command functions for the duration of the flight. For all other launch sites, the ROCC operations may be turned off upon transfer of control to the OCC, depending upon specific mission requirements. Scientists have the option of establishing their own Science GSE at their home institution; however, all commands must be routed through the ROCC and/or the OCC.

The OCC in Palestine is the only point of interface for the experimenter requiring SIP TDRSS support. In addition, mid-latitude data from Argos and INMARSAT-C is also available at the OCC. INMARSAT-C commands can be sent from the OCC for any region of flight operation. Even if planning to use the higher data rates offered by TDRSS as their primary return data link, science users are strongly encouraged to take advantage of the data and command support capabilities offered by INMARSAT-C.

The ROCC supports pre-launch testing of all data/command links as well as support of LOS data and command channels. For Antarctica operations, an Argos Local User Terminal receives direct satellite relay of Argos data when the payload and launch site ROCC are co-visible to over-passing NOAA satellites, which average 8 to 10 minutes of co-visibility about every 90 minutes. Antarctica HF commanding is maintained through the ROCC for the duration of the flight. Global INMARSAT-C command and data capability is supported at the ROCC for mid-latitude configured SIPs, but normally, this function is transferred to the OCC as the flight moves downrange. Pre-launch TDRSS data flow and command verification testing is supported at the ROCC via the TURFTS (TDRSS User RF Test Set) at all launch sites. The TURFTS does not operate within the TDRSS network; rather, it is designed as a direct receive and transmit test set for the purpose of performing open link testing in order to not burden TDRSS network and satellite assets while performing ground payload tests. Detailed information is available via the aforementioned LDB Flight Application documentation.

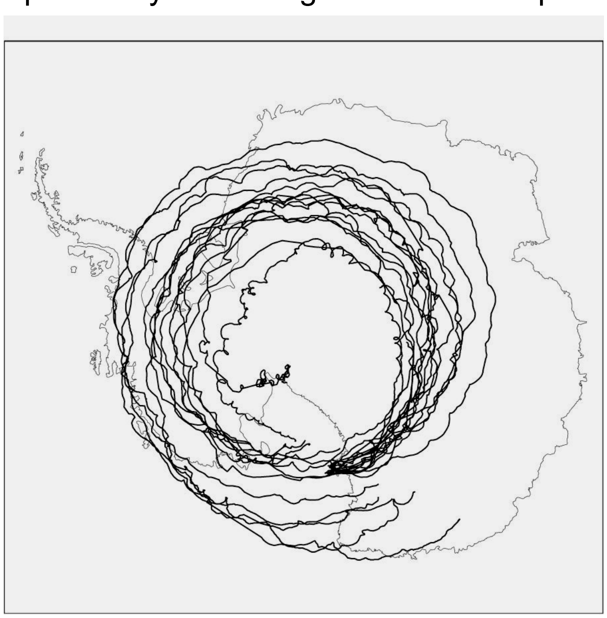
Launch Sites, Flight Windows and Trajectories

The Balloon Program is currently prepared to support LDB missions from McMurdo, Antarctica; Fairbanks, Alaska; and Karlsborg, Sweden. Only McMurdo and Fairbanks have a proven LDB circumnavigation flight history. Semi global missions launched from Karlsborg may be proposed and the NASA Balloon Program will make every effort to accommodate them. However, only flights from

Karlsborg to western Canada can be offered with reasonable certainty for avoidance of restricted regions of overflight. Additionally, any circumglobal flights in the Northern Hemisphere at middle to high latitudes will require an overflight agreement with Russia. Therefore, any LDB flights from Fairbanks will require this agreement. While one does not exist at the present time, an agreement for cooperative ballooning and overflight is being vigorously pursued between the U.S. and Russia. U.S. officials are optimistic that an agreement will be established in the near future. Additionally, various options for southern hemisphere flights from Australia and Brazil are being pursued at this time. Due to the current uncertainties with establishment of routine missions involving circumglobal flights launched from Fairbanks and Australia or Brazil, proposers should demonstrate that their minimum requirements can be achieved by being launched from McMurdo, Antarctica and/or Karlsborg, Sweden to Canada.

McMurdo, Antarctica:

Launches are conducted from Williams Field located about seven miles from McMurdo on the Ross Ice Shelf. The launch site will be operated exclusively as a field camp to support balloon operations. Launch site position is on or about 77.86 degrees South Latitude and 167.13 Degrees East Longitude and 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 (See Figure below.) 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 currently provided by NSF (National Science Foundation) who has responsibility for management of U.S. sponsored polar programs in Antarctica.



Composite of all Antarctica LDB trajectories over the past 12 years showing variation in track (excluding FY03 trajectories). Durations varied between 4 to 32 days. All flights launched between December 12 and January 10.

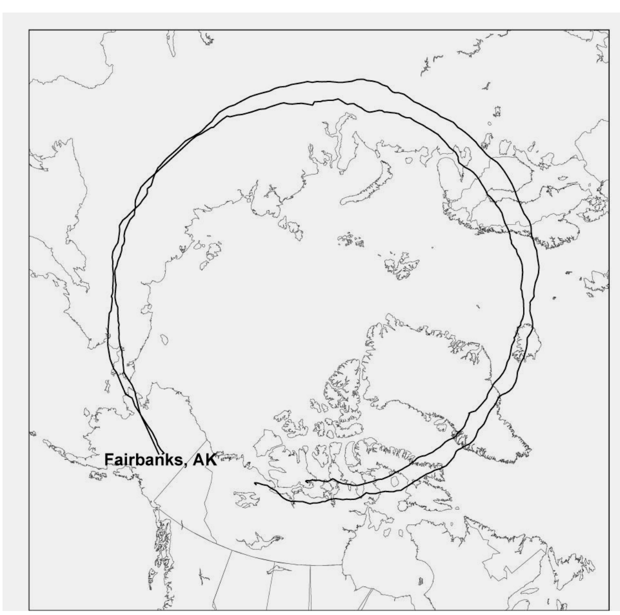
Launch operations are normally conducted from about 1 December through 10 January each year and flights may remain aloft as late as 21 January.

One LDB mission has demonstrated a two-circumpolar trajectory lasting 32 days duration. Experimenters desirous of being considered for a flight that includes two or more circumpolar trajectories should develop plans for mitigating the additional risk associated with such missions. For such missions, minimum mission success criteria should be less than one circumpolar (~14 day) mission. They should also plan to be flight ready by 1 December in order to allow sufficient time to conduct a longer mission, allow for launch delays, and account for logistics support from National Science Foundation in recovering the payload.

Although every attempt will be made to recover the payload in the same year it's flown, proposers should not base their requirements upon this due to the high probability that payloads cannot be recovered late in the season due to logistical limitations. In cases where a payload cannot be recovered in the same year flown, attempts at recovery will be made the following year. In such cases, onboard data storage hard drives can usually be recovered the same year flown, depending upon the difficulty of access to the payload.

Fairbanks, Alaska:

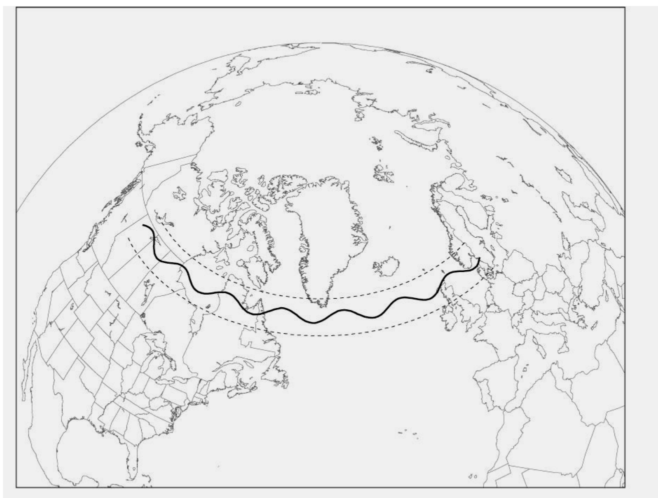
Fairbanks is located about 64.67 Degrees North Latitude and 147.07 Degrees West Longitude. Launch operations are normally conducted between 1 June and 10 July. Flight trajectory is to the west with a single circumglobal route bounded between 60 degrees and 70 degrees north latitude for a 9 to 12 day mission that is terminated over Canada. Depending upon available ballast and diurnal altitude stability requirements, there may be opportunity to allow the flight to go on past Alaska and over Russia a second time, with recovery either in Russia or Sweden. Average float altitudes of approximately 115,000 feet can be expected with diurnal variations of +/-10,000 feet.



Composite of Fairbanks LDB trajectories launched on June 23, 1997 and June 29, 1998. Both flights around 12.6 days duration.

Karlsborg, Sweden:

Karlsborg is located at 58.5 degrees North Latitude and 14.5 degrees East Longitude. Launch operations are normally conducted between 10 June and 20 July. Flight trajectory is to the west with a semi global trajectory bounded between 54 degrees and 64 degrees North Latitude for a 5-7 day mission that is terminated in western Canada. Float altitudes of 120,000 to 130,000 feet can be expected during the day with significant excursions of 15,000 to 20,000 during the night. Occasional descents to approximately 90,000-ft. altitude during nighttime periods may be experienced due to storms.



Nominal predicted Karlsborg to Canada trajectory showing +/- 5 degree latitude variation. Nominal 7 day duration.

Launch & Flight Operations

LDB Weights:

The following weight information is provided for determining total gondola weight stress analysis for structural loads, etc. These weights will vary depending upon specific configurations for antennas, PV arrays, antenna cable lengths, etc.

-Sip and Thermal Shield	380 lbs.
-Ballast Hopper / Load Cell / Ballast Valves	23 lbs.
-LDB Solar array	130 lbs.
-PV Panels	
-Support Frame	
-Various Sensors & Antennas	
-Upper Antenna Boom / Antennas / Cabling	40 lbs.
-Rotator (if required)	200 lbs.
-Line-of-sight Batteries	60 lbs.

Maximum LDB Allowable Science Weights For 29.47 MCF Zero Pressure Balloons	
Antarctica	**4000 lbs.**
Fairbanks, Alaska	**3500 lbs.**
Karlsborg, Sweden	**3000 lbs.**

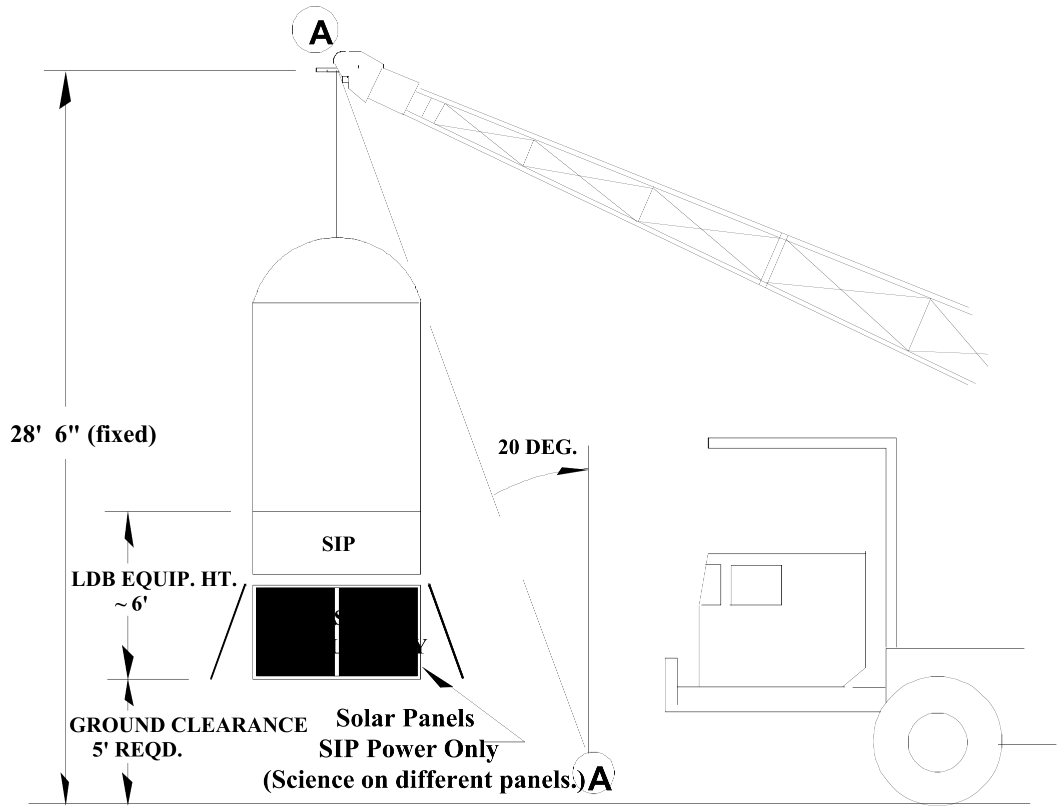
<u>Launch Vehicle Restrictions:</u>

There are some dimensional and geometric limitations for payloads on cranes normally used as launch vehicles at remote launch sites. These limits are illustrated in the accompanying diagram of an LDB payload suspended on a launch vehicle. The diagram should make the following points clear:

1.) The maximum height of the payload suspension point on the launch vehicle is typically 36 feet above the ground surface.

2.) A minimum ground clearance of 5 feet between the ground surface and the lowest point of the LDB payload is required.

- The combined height of the LDB Support Instrumentation Package (SIP) and the LDB omni directional solar panel array is approximately 6 feet. The SIP has been shown in the diagram mounted externally at the base of the science gondola. Other mounting configurations for the SIP may be possible.
- The line, marked "A-A", describes a plane, which defines acceptable and unacceptable payload geometry. Experience has shown that any payload element, which extends above and to the right of the “A-A” line, will likely strike the underside of the boom during the launch. Any requirements exceeding those mentioned above will need to be identified in the proposal. The costs associated with providing support beyond those listed above will have to be identified as additional costs in the proposal.



Termination and Recovery

The flight can be terminated by command or by on-board flight control systems. The flight can be terminated for any number of reasons such as a balloon vehicle problem, successful conclusion of the science mission, prevention of over-flight of inhospitable territory, etc. In many cases the payload is recovered with minimal damage and refurbishment costs. In some cases where the payload was terminated near the launch site, the payload has been able to be refurbished and re-flown.

The payload is suspended below a flat circular parachute, which is fully deployed below the balloon. At the time of termination, a command is sent which releases the parachute and payload from the balloon. (Opening shocks of up to 10 times the suspended mass must be accommodated for in the design. Additional details for structural design requirements can be found in the LDB Flight Application documents.) The payload and parachute then descend to the surface and impact with a terminal velocity of 20 ft/sec or less. Upon impact, the parachute is separated from the payload via command or automatic parachute release in order to minimize risk of damage to the payload due to dragging. A recovery crew is dispatched and guided to the payload, which is then recovered and returned to a designated site for later shipment.

Antarctica Recovery Requirements:

From a science, economical, and environmental standpoint, it is highly desirable to recover 100% of the payload. Recoveries are performed using either a Twin Otter fixed-wing aircraft or helicopter. Twin Otters have rather severe configuration constraints. They are very limited in usable cargo space and load capacity (~2200 lbs.) The helicopters available at McMurdo also have a very limited inside cargo carrying capacity but can sling loads up to 1,800 lbs. Several trips are normally required for a complete recovery using either of the two aircraft above. In designing their systems, science groups should use a modular approach that will allow the payloads to be easily broken down into components that will fit in the Twin Otter or helicopter. Systems must be capable of withstanding extended periods of exposure on the Antarctic surface waiting for a recovery to take place. Sometimes payloads can not be recovered in their entirety during the campaign in which they were launched. In such cases, every possible effort is made to recover mission critical subsystems such as data storage units. However, systems should be designed with the understanding that they might have to remain on the ice until the following year.

Fairbanks and Karlsborg Recovery Requirements:

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 often require helicopter lifts. These payloads are normally recovered shortly following the end of flight.

Flight Environment

The thermal environment is significantly different than the typical spacecraft environment. Balloons are more closely coupled with the atmospheric and ground environment than spacecraft because of the relative velocities to the surface, as well as proximity to surface. As a result, flights in mid-latitude regimes can experience periods of darkness and daylight of up to 12 hours. These extended periods of light and darkness must be accounted for. Antarctic missions are in constant daylight throughout the mission, with an additional high albedo loading coming from the icy surface. The thermal analysis techniques and control methods employed for ballooning are fairly well established and have been proven on many flights. Most of the control methods are passive and do not require thermal blankets or complicated active systems. The required power allocation for thermal control may be higher than for a typical spacecraft.

The following values can be used as general guidelines for the balloon environment, but actual values will need to be determined based upon flight requirements as contained in the LDB Flight Application.

Balloon Vehicle:

- Balloon Ascent Rate: typical 800-1200 fpm
- Balloon Rotation Rates *: typical < 60 deg/min at float; have seen during ascent/descent ~ 180 deg/min (* Information for pointing systems design)

Loads:

- Launch: typical < 1.5 g's
- Ascent: typical < 1.1 g's due to wind shears, ballast drops, etc.
- Terminate: typical < 10 g's
- Impact Velocity: typical < 20 fps

Tropopause:

- Tropics: -90C @ ~ 50-60 k-ft altitude
- Polar: -45C @ ~ 30-35 k-ft altitude
- Mid-latitude: -55C @ ~45-60 k-ft --> -80C in summer (seasonal & latitudinal fluctuations)

Radiation:

- Solar Constant (seasonal):
    - 1312 W/m2 (minimum),
    - 1358 W/m2 (nominal)
    - 1404 W/m2 (maximum)
- Albedo:
    - 0.1 minimum
    - 0.9 maximum polar

Earth Flux:

- 90.7 W/m2 Minimum (cloud top temperatures of 200K)
- 594 W/m2 Maximum (desert @ 320K planet temperature)

Payload/Launch Vehicle Integration

<u>Antarctica:</u>

Because shipment of equipment is due out by mid August, pre-deployment integration at Palestine must be concluded by the end of July each year. Following this integration and compatibility testing, a Mission Readiness Review (MRR) is conducted prior to shipment to assess the readiness of both the experimenter and NASA. It should be understood that all equipment is shipped directly from the NSBF to Port Hueneme, California following pre-deployment integration. No configuration changes to the science experiment or the support systems are allowed following integration without the approval of the Mission Readiness Review technical panel. Shipping of all NSBF equipment in support of each year's campaign is no later than middle of August in order to allow time for equipment to arrive at Port Hueneme, California for ocean shipping to New Zealand and then to McMurdo by air. Although NSBF arranges for shipping from Palestine to Port Hueneme, experimenters are expected to provide proper shipping containers and do their own packing. NSBF ships heavy items such as balloons and helium to McMurdo one-year in advance so special balloon configuration requirements must be identified early in order to allow sufficient time for the balloons to be built and meet shipping schedules.

Fairbanks:

Pre-deployment integration at Palestine will be normally concluded by the middle of April. A MRR will be conducted following integration and compatibility testing to assess readiness prior to shipping of equipment to Fairbanks. It should be understood that all equipment is shipped directly from the NSBF to Fairbanks following pre-deployment integration. No configuration changes to the science experiment or the support systems are allowed following integration without the approval of the Mission Readiness Review technical panel.

Karlsborg:

Pre-deployment integration at Palestine will normally be concluded by the middle of February. A MRR will be conducted following integration and compatibility testing to assess readiness prior to shipping of equipment to Sweden. It should be understood that all equipment is shipped directly from the NSBF to Sweden following pre-deployment integration. No configuration changes to the science experiment or the support systems are allowed following integration without the approval of the Mission Readiness Review technical panel.

Planning, Budgeting, and Other Miscellaneous Information

For planning and budget purposes, the following costs for Balloon Program standard services on long duration balloon missions may be used. The numbers are in FY03 dollars and inflation rates as outlined in Appendix B should be applied to obtain costs for the year flight support is required. Costs are predicated on the continuing level of infrastructure in the Balloon Program.

LDB Campaign Costs - FY03 Dollars

McMurdo, Antarctica	Fairbanks, Alaska	Karlsborg, Sweden
$1100K	$1650K	$1950K

The costs presented were developed to cover nominal services required to conduct one LDB science mission with a SMEX payload at the indicated locations. It should be noted that flights in Antarctica require considerable support from the National Science Foundation (NSF). The NSF has to approve each specific science mission and they also levy certain requirements on all groups supported by them. Detailed information concerning NSF requirements may be obtained upon request. The costs above include the following:

- Integration and functional ground testing at Palestine, TX.
- Shipping of user and National Scientific Balloon Facility equipment from Palestine, TX, to the launch site.
- Travel, per diem, and overtime costs for NSBF operations personnel.
- Balloon and helium sufficient to perform one flight operation.
- All equipment rental required by NSBF operations personnel at the launch site.
- The provision and operation of standard LDB ground control, tracking and data acquisition systems at the launch site and Palestine, TX, when required.
- Communications costs, both for voice and satellite data uplink and downlink.
- Nominal recovery as described within the preceding section entitled "Launch Sites, Flight Windows and Trajectories."
- Normal on-board mechanical support hardware utilized by NSBF operations personnel to conduct launch, flight, and recovery operations.
- All other miscellaneous hardware required by the NSBF operations personnel.
- Prorated facilities infrastructure support costs.

The costs presented do not include the following:

- Any test flights. A test flight is not required for Explorer Class LDB missions. Explorer Class instruments must demonstrate verification of systems qualification for the mission environment.

- Any unique flight or ground support systems. Standard LDB missions require use of a SIP. A small inventory of standard SIP's and sun pointing rotators exist which were created to support traditional LDB users in the Balloon Program. The SIP is designed to meet NASA requirements for balloon control and to offer the SMEX user telemetry and command support. However the SMEX user would have to compete for its use along with the other LDB candidates. Furthermore, any damage or loss of the borrowed SIP or rotator would have to be covered by the SMEX user. It is highly recommended that the SMEX user plan to fund the construction of a new SIP and rotator which would be dedicated to his or her mission support.
- Any other special requirements or out-of-pocket costs not specifically addressed here.

For the purpose of estimating other options, the following additional cost information is provided for a SIP deemed acceptable for Explorer missions, as provided by the NASA Balloon Program (FY03 Dollars.) Also included is costing information for a Mini-SIP (which is used for LDB ground testing purposes in lieu of a more expensive full up SIP, that emulates all the science interface functions of the full SIP), A LDB Sun Pointing Rotator, and test flights at Palestine, TX and Ft. Sumner, NM.

• Polar SIP (With HF-ARGOS/TDRSS)	$1000K
• Non-Polar SIP (With TDRSS/INMARSAT)	$1000K
• LDB Sun Pointing Rotator	$ 210K
• CONUS Test Flight (Palestine)	$ 150K
(Ft. Sumner)	$ 175K
• LDB Mini-SIP (Used on Test Flights to emulate the SIP)	$ 150K

Proposers Requesting the New Extreme Altitude 59.84MCF Balloon

Proposers wishing to take advantage of the higher altitude capability that this balloon has to offer, must contact the NASA Balloon Program Office for assistance with formulation of specific missions, schedules, and budgets.

Other Budget Considerations

Multiple flights may be proposed under this Announcement of Opportunity. The current LDB mission model consists of two two-flight campaigns each year; one in the Northern Hemisphere in the late June - early August time frame and one in the Southern Hemisphere (Antarctica), in the December-January time frame. There are no known technical restraints associated with multiple flights proposed within this model. However all flights, regardless of number, require the approval of NASA headquarters.

The NASA Balloon Program levies no requirements on users for special facilities, equipment, or services, i.e. clean room assembly areas, etc. Any non-standard services for mission-unique requirements identified by the user should be included in preparation of the cost proposal. Any reasonable request for use of existing permanent facilities within the NASA Balloon Program at Palestine, TX or Ft. Sumner, NM will be provided at no cost to the user. Mission-unique requirements for specialized equipment, support services or facilities that are not currently provided by the Balloon Program within its normal infra-structure must be identified and accounted for separately in the cost proposal. An example of a mission-unique requirement would be a clean room for payload preparation at a launch site such as Antarctica where such facilities do not exist; or special handling equipment for the Ballooncraft.

Points of Contact

Technical questions concerning the NASA Balloon Program opportunity should be directed to Mr. David Gregory (phone: 757-824-2367, e-mail: David.D.Gregory@nasa.gov. Questions of a programmatic nature should be directed to the Explorer Program Scientist as specified in the SMEX AO.

ACRONYM LIST

ACU	Attitude Control Unit
ADU	Attitude Determination Unit (GPS)
ARO	After Receipt of Order (contract issuance, funds transfer, etc.)
CONUS	Continental United States
DGPS	Differential GPS (ADU is more accurate terminology)
fpm	Feet Per Minute
fps	Feet Per Second
GPS	Global Positioning System
GSE	Ground Station Equipment
HF	High Frequency
HGA	High Gain Antenna
kbps	Kilo Bits Per Second
k-ft	Kilo Feet
LDB	Long Duration Balloon
LDPE	Linear Density Polyethylene
LEO	Low Earth Orbiting
MA	Multiple Access (TDRSS mode)
Mb	Millibar (pressure)
MCF	Million Cubic Feet
MRR	Mission Readiness Review
NASA	National Aeronautics and Space Administration
NSBF	National Scientific Balloon Facility
NSF	National Science Foundation
OCC	Operation Control Center
OTH	Over-the-Horizon
PV	Photovoltaic
ULDB	Ultra Long Duration Balloon
ROCC	Remote Operation Control Center
SIP	Support Instrument Package
SMEX	Small Explorer
T&E	Test and Evaluation
TDRSS	Tracking Data Relay Satellite System
TM	Telemetry
TURFTS	TDRSS User RF Test Set
UHF	Ultra High Frequency

Appendix

LONG DURATION BALLOON OPTIONS FOR INCORPORATION OF NASA TDRSS HIGH GAIN ANTENNA (HGA) AND SUPPORT SUBSYSTEMS

27 January 2003

This document supercedes any previous Explorer Library documents concerning the use of the Balloon TDRSS High Gain antenna.

Summary

The NASA Balloon TDRSS High Gain Antenna (HGA) subsystem may be offered to Explorer Class science users as one of the following options:

Option #1: Science users may procure the HGA system to incorporate into their own telemetry systems that they provide.

Option #2: Science users may utilize the HGA as part of the LDB SIP to achieve higher "return" telemetry rates.

With Option #1, the science user assumes a greater level of systems engineering and systems support responsibility. With Option #2, the NASA Balloon Program Office will offer all the systems engineering and operational support required for the HGA.

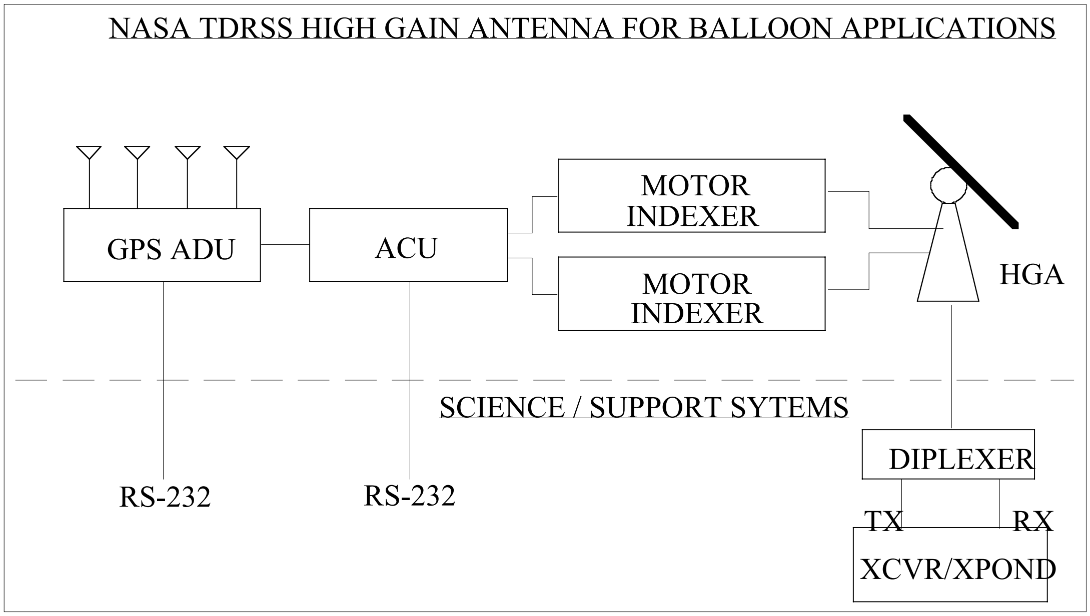
HGA Configuration (Option #1)

The following drawing shows the configuration of subsystems provided under Option #1 as shown for those items above the dashed line. The HGA has demonstrated, in flight, the capability of supporting up to 100 kbps return telemetry at less than 10^{-6} bit error rates for MA combined mode (same data over both I&Q channels). Costs for Option #1 are as follows per current FY'03 pricing (add appropriate inflation increases concurrent with anticipated year of purchase):

Parts and Labor: $150K

The above cost does not include any spares, warranties, or support after delivery. It only includes the subsystems illustrated above the dashed line in the following configuration drawing. Documentation is also included.

As an option, additional support may be arranged for users requesting training, integration and test support, or field support at a cost of $4K/week exclusive of travel and per diem costs. Add travel and per diem costs for two people, as appropriate for your particular requirements, when electing this option.



With the above configuration, the HGA will auto point to the appropriate TDRSS satellite. Additional control flexibility and in-flight configuration changes can be exercised by interfacing the GPS ADU and ACU to the science computer. Details of these controls would be described in the HGA User's Manual, which is not available for release at this time. Plan one year for delivery ARO. Obligation of funds would be required prior to beginning fabrication.

HGA Configuration (Option #2)

Users may elect to utilize the TDRSS HGA on the LDB SIP. At this time, integration and qualification with the LDB SIP has not been completed as the HGA was developed under the NASA ULDB development project. The current schedule is to complete LDB SIP / TDRSS HGA qualification and to build an inventory of units for support of LDB missions in FY04 and FY05. With Option #2, the NASA Balloon Program will take care of all HGA integration and support issues. Science users will realize the same data rate capabilities, as under Option #1, but the science interface will be through the SIP "science data and command interface." The SIP would include the TDRSS Transponder (or Transceiver), diplexer, control of the GPS ADU and ACU. Integration and testing of the HGA on the science gondola will be supported by the NSBF with Option #2.

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