“Balloon Program Update”

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Scientific Ballooning in Antarctica

• Since the first successful launch in 1991 by the NASA/NSF Division of Polar Programs partnership, 47 Long-Duration Balloon (LDB) flights have been conducted over Antarctica, an average of ~ 2 balloon flights per year (890 total flight days).

• Since 1991, the historical average LDB flight duration is 19 days.

• Since 2002, 15 flights have requested double orbits
  • Of those, half achieved 30 days or longer duration.

Flight Duration Frequency (Days)

<table>
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<tr>
<th>Flight Duration Frequency (Days)</th>
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<tr>
<td>0-10</td>
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<td>0</td>
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Triple circumpolar LDB flight of
CREAM - 42 days
Dec.-Jan. 2004-05

Triple circumpolar LDB flight of Super
Tiger - 55 days
Dec.-Feb. 2012-13
Recent and Near-Term Antarctic LDB Flights

- FY 2013 Campaign (2012-2013 Season) 96 days.
  - Balloon Large Aperture Sub-millimeter Telescope (BLAST).
  - E and B EXperiment (EBEX).
  - Super-Trans Iron Galactic Element Recorder (Super-TIGER).
  - EBEX and Super-TIGER left on the Ice.


  - Antarctic Impulsive Transient Antenna (ANITA).
  - A Large Angular Scale Millimeter-wave Polarimeter (SPIDER).
  - Compton Spectrometer Imager (COSI) on a Super-Pressure Balloon.

- FY 2016 Upcoming Campaign (2015-2016 Season) has two known candidates at this time:
  - Stratospheric Terahertz Observatory (STO-2).
  - Gamma Ray burst Investigation by Polarimetry and Spectroscopy (GRIPS).
The NASA – NSF Long-Duration Ballooning (LDB) partnership implements the annual LDB campaign.

**NSF provides annual support for:**
- Setup and outfitting of LDB facilities
- LDB Camp Management
- Launch pad maintenance and grooming
- Transportation, logistics, and housing for science teams
- Aircraft operations support and recovery of payloads
- Retrograde shipment

**Infrastructure and Operations augmentations are underway to enable a sustained three-launch capability, including:**
- A third Antarctic Payload Processing Facility is being implemented in 2015 & 2016 to support three large science payloads in a single campaign (start in FY17).
- Dedicated aircraft support for timely recovery of balloon payloads late in the Antarctic season.
**Very Successful NASA/NSF Partnership**

- NASA/NSF partners have focused on expanding the highly successful LDB flight capability in Antarctica.
  - Proven history of scientific discoveries from Antarctica.
  - Many high priority projects require Antarctica flights.
  - Implementing 3 flights every year with increased duration.

- Super-Pressure Balloon (SPB) / Ultra Long Duration Ballooning (ULDB),
  - SPB offers a great increase in capability, e.g., ULDB flights.
  - ULDB flights leaving Antarctica will yield long exposures: 60-100 days should be possible in local summer.
  - SPB opens areas of exploration closed to zero-pressure balloons in non-polar / mid-latitude regions.

- NASA/NSF can leverage ULDB flights leaving Antarctica with recovery in South America, New Zealand, or Australia.

- Flights comparable to Antarctic LDB flights should be possible from Wanaka, NZ in local summer.
FY-15 Campaign of 3 Balloon Flights

- **COSI** (COmpton Spectrometer and Imager) Boggs/UCB gamma-ray telescope on Super Pressure Balloon (SPB).
  - To understand the development of structure and the cycles of matter and energy in the evolving universe.
  - It was planned for an extended flight with potential recovery off the Antarctic continent.

- **ANITA** (ANtarctic Impulsive Transient Antenna) Gorham/UH cosmic neutrino detector.
  - Radio detection of neutrinos with energy above $10^{18}$ eV interacting in Antarctic ice, as well as ultra high-energy cosmic ray showers with similar energies.

- **SPIDER** Jones/Princeton CMB detector to study the genesis of the early Universe.
  - A balloon-borne polarimeter that borrows heavily from combined heritage of the successful BOOMERANG and BICEP experiments.
FY 2015 Antarctic Campaign (40 days)

SPB/C OSI
~2 days

ANITA
22 days, 9 hours, 14 min

SPIDER ~15 days
British Antarctic Survey (BAS) Recovered payload to Argentina.

** Super-TIGER was fully recovered after spending two seasons on the ICE!
Super Pressure Balloon (SPB)
“First Totally New Balloon Design in more than 60 Years”

Schematic / Statistics
• Volume = 420,150 m³ (14.837 MCF)
• Diameter = 105.832 m
• Height = 65.946 m
• Number of gores = 230
• Gore length stressed = 139.023 m
• Gore width stressed = 1.471 m
• Film thickness 38 microns (1.5 mil)

Photograph of 7 MCF SPB at float
Altitude: ~33.87 km (~111,100 ft)
• 54-day test flight 12/28/08 – 2/20/09
• 22-day flight of 14.8 MCF with 4000 lb payload during January 2011
Representative Average Float Altitude Variation for ~9 Days for 615N BLAST and 616NT Super Pressure Balloon

615N BLAST, +4,688 ft -6,267 ft
616NT Super Pressure Balloon, +696 ft -597 ft
14.9 MCF Super Pressure Balloon Test Flight

616NT Super Pressure Balloon

Date

Altitude (ft)
Balloon Launch Sites

- McMurdo, Antarctica
- Alice Springs, Australia
- Wanaka, New Zealand
- Kiruna, Sweden
- Lynn Lake, Canada
- Ft. Sumner, New Mexico
- Palestine, Texas

Established Launch Site

New Launch Site

March 17, 2015
Astrophysics Subcommittee
Flight Statistics

Total Flights per Fiscal Year

Government Shutdown Prevented Conduct of Two Additional Flights from FY14 Antarctic Campaign.
LDB / ULDB SPB Mission Profile

- SPB Mid-latitude Mission approval for flight between 29° and 85° S enables 60 - 100 Day LDB / ULDB missions.
- Mission allowed to depart and overfly Countries/Territories in Southern Hemisphere.
  - State Department reviewing Overflight Agreements.
- Alternate termination procedures for Off-Nominal Water Terminations (Valve down).
- Studies indicate good chance for terra firma termination of 60 - 100 day flights:
  - New Zealand: ~75% (South America Termination).
- OTH Command/Control resident to CSBF Operations Control Center for SPB and Mission Operations.
- Mission Operations Center (MOC) established at WFF for BPO / RSO Insight/ Oversight.
  - MOC will duplicate real time flight performance data and flight tracking.
  - MOC Provides Safety Office insight throughout mission.

March 17, 2015
Astrophysics Subcommittee
• Wanaka is a mid-latitude location that meets safety constraints to conduct launch and provide acceptable trajectories with nominal land termination locations in South America.

• Flight Safety will implement an Active Risk Assessment approach utilizing Go/No Go criteria for continental overflights. BPO will utilize established ground and launch safety protocols.

• Prior to continental transit an Operational Go/No Go decision will be based on Risk (combination of Overflight location and Dwell time).

• South America preferred termination location; Approved for other termination locations and Oceanic, if required.
### Super Pressure Balloon Development

<table>
<thead>
<tr>
<th>Volume</th>
<th>Suspended Weight</th>
<th>Altitude</th>
<th>Flight Number</th>
<th>Duration</th>
<th>Launch Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 MCF</td>
<td>1,500 Lbs</td>
<td>~110 KFT</td>
<td>591 NT</td>
<td>54 days</td>
<td>Dec 28, 2008</td>
</tr>
<tr>
<td>14.9 MCF</td>
<td>4,000 Lbs</td>
<td>~110 KFT</td>
<td>616 NT</td>
<td>22 days</td>
<td>Jan 9, 2011</td>
</tr>
<tr>
<td>18.8 MCF</td>
<td>5,000 Lbs</td>
<td>~110 KFT</td>
<td>631 NT, 659 NT</td>
<td>6.5 hours</td>
<td>Aug 14, 2012, Dec 28, 2014</td>
</tr>
<tr>
<td>26 MCF</td>
<td>4,000 Lbs</td>
<td>~117 KFT</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

The 18.8 MCF Super Pressure Balloon is the mid-range for Science!!
### SPB History – Qualification of the 18.8 MCF

<table>
<thead>
<tr>
<th>Flight Center</th>
<th>Launch Window</th>
<th>Flight Type</th>
<th>Assessment of First Flight Items</th>
<th>Deployment</th>
<th>Pressurization</th>
<th>Day/Night Cycling</th>
<th>Flight Duration (constant sunlight)</th>
<th>Day/Night Cycling for Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>August 2012</td>
<td>Turnaround</td>
<td>First 18.8 MCF</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>March 2013</td>
<td></td>
<td>Cancelled To Move Flight to Antarctica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctica</td>
<td>Dec 2013</td>
<td></td>
<td>Cancelled Due to Government Shutdown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ft. Sumner</td>
<td>May 2014</td>
<td></td>
<td>Cancelled Due to Budget Issues-BPO Directed to Fly Antarctica 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctica</td>
<td>Dec 2014</td>
<td>COSI Science (Former NCT)</td>
<td>No Recovery</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>Mid March or later 2015</td>
<td>Circumglobal</td>
<td>Possible if Recovery at end of Mission</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
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<td>New Zealand</td>
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<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
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Some Highlights of the Past Year

- The 18.8 MCF Super Pressure Balloon (SPB) was originally integrated for flight in the Spring Fort Sumner campaign.
  - Flight was cancelled, and the SPB was shipped to Antarctica for the FY15 campaign with the first piggyback science instrument.
  - This SPB developed a leak during the second day!
- Successful test flight of the Low Density Supersonic Decelerator (LDSD) from Hawaii in FY14.
- Two successful Wallops Arc Second Pointer (WASP) test flights during 2014 Fall Fort Sumner campaign.
  - Piggyback science instruments: HySICS and OPIS.
- 9th High Altitude Student Platform (HASP) mission also flown during that Fall Fort Sumner campaign.
  - 3 Undergraduate Student Investigator Program (USIP) payloads also flown during Fall Fort Sumner campaign.
  - 4th USIP instrument will fly during Fall 2015 Fort Sumner.
- The CSBF Support Contract awarded to Orbital Sciences Corporation, effective February 1, 2015.
  - Base plus option periods total 5 years.
JPL Low Density Supersonic Decelerator test for landing larger/heavier payloads on Mars.

Inflatable SIAD and largest supersonic parachute ever built.

First balloon launch of a rocket since small scale rockets launched in the 1950’s.

Specialized launch tower (static launch) and new flight electronics developed by PSL/CSBF.

Highly sophisticated meteorological support for ascent time/trajectories required by PMRF/WFF Safety.

7,861 lb Suspended.

34 MCF Heavy Balloon.

Flight time 3 hours, 35 minutes

Operations and Test Success.
• NSF has exceded their CSBF land and NSF buildings.
  ✓ NASA has filed paperwork to accept that property at no cost.
  ✓ GSA will request OMB approval for no-cost transfer.

• Complications prevented moving out on the third Antarctic Payload building in 2014.
  ✓ Discussions with NSF and ASC are planned in early April 2015.
  ✓ Current target is to put a prefab building on a resupply ship in late 2016.
  ✓ Assemble it in Antarctica for first use during FY18 Campaign (Dec 2017 – Jan 2018).

• The Biological Evaluation and Environmental Assessment for ULDB Program Southern Hemisphere Flight Operations was:
  ✓ Completed for SPBs launched in Antarctica and New Zealand

• All high priority items were recovered for the Super-Tiger, ANITA II, SPIDER and COSI Antarctic LDB flights.
CSBF Operations Contract Has Changed!

- CSBF is a **Government Owned Contractor Operated** (GOCO) Facility.
- Request for Proposals (RFP) was Released January 8, 2014.
- Initial proposals were due March 10, 2014.
- Two proposals were received:
  - Orbital Science Corporation (Orbital).
  - New Mexico State University (NMSU)/Physical Science Laboratory (PSL).
- Both offerors were notified on July 30, 2014 that they were in the competitive range and that NASA would go into discussions.
- Final proposals were due September 10, 2014.
- Selection was announced November 13, 2014.
- Phase-In process started December 1, 2014.
- Orbital Contract started February 1, 2015.
- The Contract with NMSU/PSL (NAS5-03003) was extended beyond March 2013 with a 15 month extension and 7 one-month options.
  - End of options was January 31, 2015.
Incumbent Capture

• The Orbital Team has hired 69 of the former 75 NMSU/PSL employees.
  - 64 are now Orbital Employees.
  - 5 are now Hawk Employees.

• 6 Employees Did Not Transition.
  - 1 Retired.
  - 4 Remained with PSL.

• Orbital has subcontracted with PSL for their support.
  - 1 pursued new opportunity with PSL.
    - He may be involved in select activities.
NASA SMD manages the **Suborbital Research Program**, which provides

- Cutting edge Earth and Space science,
- Developing space technologies to enable new missions, and
- Promoting STEM and inspiring students through hands-on student training missions.

This **Program is characterized by** frequent flight opportunities utilizing:

- Aircraft,
- Balloons,
- Sounding Rockets,
- Cube Sats,
- Commercial Reusable Vehicles, and
- Small ISS payloads.
Need for a Suborbital Strategic Plan

Since FY 2011, SMD has:

• Launched **114 Sounding Rocket and Balloon missions**;

• Flown over **14,100 airborne science hours** in support of science and technology investigations;

• While providing **3,900 undergraduate and graduate students** the opportunity to participate in scientific research!

Suborbital Strategic Plan.

• The **Senior Program Executive for Suborbital Programs**, and

• **Senior Scientist for Suborbital Research**, have suggested this need, and it was recently

• **Suggested independently** by the Balloon Working Group (BWG).
Thank You!