2017 Scientific Ballooning Technologies Workshop

NASA Super Pressure Balloon

Debbie Fairbrother
NASA Balloon Program Office
Suborbital and Special Orbital Projects Directorate
Wallops Flight Facility

May 16, 2017
Two Types of Balloons

Super Pressure Balloon maintains nearly constant volume – under development

- Allows Ultra Long Duration Balloon (ULDB) Flights
- Provides stable altitude Long Duration Balloon (LDB) flights at mid-latitudes

Zero-Pressure (ZP) Balloon changes volume due to radiative input

- Used for Conventional Flights and Polar LDB Flights
Altitude Stability Comparison

Flights from Antarctica

Super Pressure

Zero Pressure

GPS Altitude Variation from Average Float Altitude (m)

Days at Float

-2,000 -1,500 -1,000 -500 0 500 1,000 1,500

-1,429 m -1,910 m
212 m -182 m

615N BLAST
616NT Super Pressure Balloon
Super Pressure Development

• The NASA SPB is being developed to provide a stable platform at constant density altitude for extended duration science investigations at polar and mid-latitudes.

• An incremental approach has been applied to the 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></td>
<td>5,000 Lbs</td>
<td></td>
<td>662 NT 669 NT</td>
<td>43 hours 46 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5,000 Lbs</td>
<td></td>
<td>679 NT</td>
<td>32 days  12 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5,500 Lbs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 MCF</td>
<td>4,000 Lbs</td>
<td>~117 KFT</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Several science groups are requesting a suspended weight of 5,500 pounds on the 18.8 MCF; therefore, some future test flights will have higher suspended weights when appropriate.
Mid-Latitude Location for SPB
Wanaka, New Zealand

- Far Enough North
- Far Enough South
- Airport Location
- Geography
- Low Populations
- Stratospheric Trajectories
- Infrastructure
- Accommodations
Stratospheric Winds
Environmental Considerations

- WFF Completed a Biological Evaluation and Environmental Assessment for SPB (ULDB) Program Southern Hemisphere Flight Operations covering Antarctica and New Zealand-launched SPBs.
- The Program received a Finding Of No Significant Impact and has received approval from NASA and concurrence from NOAA and NSF to proceed with Operations.
- The stratospheric anticyclone over Antarctica provides a stable balloon trajectory, once the anticyclone breaks down trajectories are highly variable.
- Increased operational area (more northern latitudes) for 2017 mission.
- In the event of ocean termination, the entire balloon system will be valve downed to the water surface and submerged.
Safety Considerations

- Trajectory Analysis Pre-Launch
- Airport Closed During Launch Operations
- Roadblocks
- Go-No Go prior to Land Mass
- Go-No Go ~ every 24 hour when over land
Flight Monitoring

• Wanaka team will monitor and support flight from launch pre-ops to end of LOS
• Palestine Operations Control Center will be online at launch and take over after leaving LOS capabilities in Wanaka
• SPB team will monitor the entire flight remotely
• Palestine Operations Control Center will be manned 24 hours from launch until termination
• Science typically monitors from home institution
Launch Site: Wanaka, New Zealand
Volume: ~532,152 m$^3$ (~18,793,000 ft$^3$)
Launch Date: May 16, 2016 @ 23:35 Z
Suspended Load: 2,268 kg (5,000 lbs.)
Flight Time – 46 Days, 20 hours, 19 minutes
Goddard Space Flight Center
Wallops Flight Facility

2016 - 18.8 MCF SPB

669 NT SPB-COSI
Launched: 16 May 2016 / 23:35:00Z
Impact: 2 July 2016 / 19:54:00 Z
Total Flight Time: 46 days, 20 hours, 19 minutes

Lowest Altitude During Flight ~ 22 km Due to Loss of Gas During Flight.
669 NT SPB-COSI
Launched: 16 May 2016 / 23:35:00 Z
Impact: 2 July 2016 / 19:54:00 Z
Total Flight Time: 46 days, 20 hours, 19 minutes
The Balloon Performed as a Hybrid – SPB During Day – ZP at Night Later in the Mission.
• Launch Site: Wanaka, New Zealand
• Volume: ~532,152 m³ (~18,793,000 ft³)
• Launch Date: April 24, 2017 @ 22:50 Z
• Suspended Load: 2,495 kg (5,500 lbs.)
• Flight Time – 12 days, 4 hours, 34 mins
• Flying the Extreme Universe Space Observatory (EUSO) as a Mission of Opportunity
Note: Initially, 1200 pounds of ballast – dropped over 1100 pounds of it in drops on 4/29, 4/30, 5/1, 5/3, and 5/6
SPB Fun Facts

- Inflated volume = 18.8 million cubic feet
- Number of Gores = 280
- Number of Gore Width Measurements = 6,440 (23 per gore)
- Amount of Load Tape Tendon in Balloon = 137,760 feet (26 miles)
- Amount of film visually inspected, re-rolled and dispensed for this balloon > 1.3 million square feet - over 30 acres of film
- Minimum amount of walking just to seal balloon = 55 miles
- Balloon shipping box 16 ft. x 6 ft. x 5.3 ft.
- Gross Weight of Balloon in Box = 8,832 pounds