2017 Scientific Ballooning Technologies Workshop

NASA Super Pressure Balloon

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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

615N BLAST, +1,429 m -1,910 m
61GNT Super Pressure Balloon, +212 m -182 m
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>
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<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>
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<tr>
<td>18.8 MCF</td>
<td>5,000 Lbs</td>
<td>~110 KFT</td>
<td>631 NT</td>
<td>6.5 hours</td>
<td>Aug 14, 2012</td>
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<tr>
<td></td>
<td>5,000 Lbs</td>
<td></td>
<td>659 NT</td>
<td>43 hours</td>
<td>Dec 28, 2014</td>
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<td></td>
<td>5,000 Lbs</td>
<td></td>
<td>662 NT</td>
<td>32 days</td>
<td>Mar 26, 2015</td>
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<tr>
<td></td>
<td>5,000 Lbs</td>
<td></td>
<td>669 NT</td>
<td>46 days</td>
<td>May 16, 2016</td>
</tr>
<tr>
<td></td>
<td>5,500 Lbs</td>
<td></td>
<td>679 NT</td>
<td>12 days</td>
<td>April 24, 2017</td>
</tr>
<tr>
<td>26 MCF</td>
<td>4,000 Lbs</td>
<td>~117 KFT</td>
<td></td>
<td></td>
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</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
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
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 m³ (~18,793,000 ft³)
Launch Date: May 16, 2016 @ 23:35 Z
Suspended Load: 2,268 kg (5,000 lbs.)
Flight Time – 46 Days, 20 hours, 19 minutes
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.
Super Pressure Flight 669NT - Differential Pressure

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

Differential Pressure (Pa) vs. Date

DPT Average

- Graph showing differential pressure over time with specific dates and pressures.

- Diagram includes a title and legend for clarity.
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
2017 - 18.8 MCF SPB
2017 - 18.8 MCF SPB

Flight: 679NT - Charted Data

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
2017 - 18.8 MCF SPB
- 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