23rd ESA Symposium on European Balloon and Rocket Programmes and Related Research

NASA Balloon Highlights 2015-2017

Debora Fairbrother
NASA Balloon Program Office
Suborbital and Special Orbital Projects Directorate
Wallops Flight Facility
June 12, 2017

Presentation Highlights

- *Paper highlights the NASA Balloon Program activities since the last ESA Symposium*
- *Campaign Activities*
  - *Launch Locations*
  - *Science*
  - *Education*
  - *Piggybacks*
- *Technology Efforts*

Goddard Space Flight Center

Mission of the NASA Balloon Program

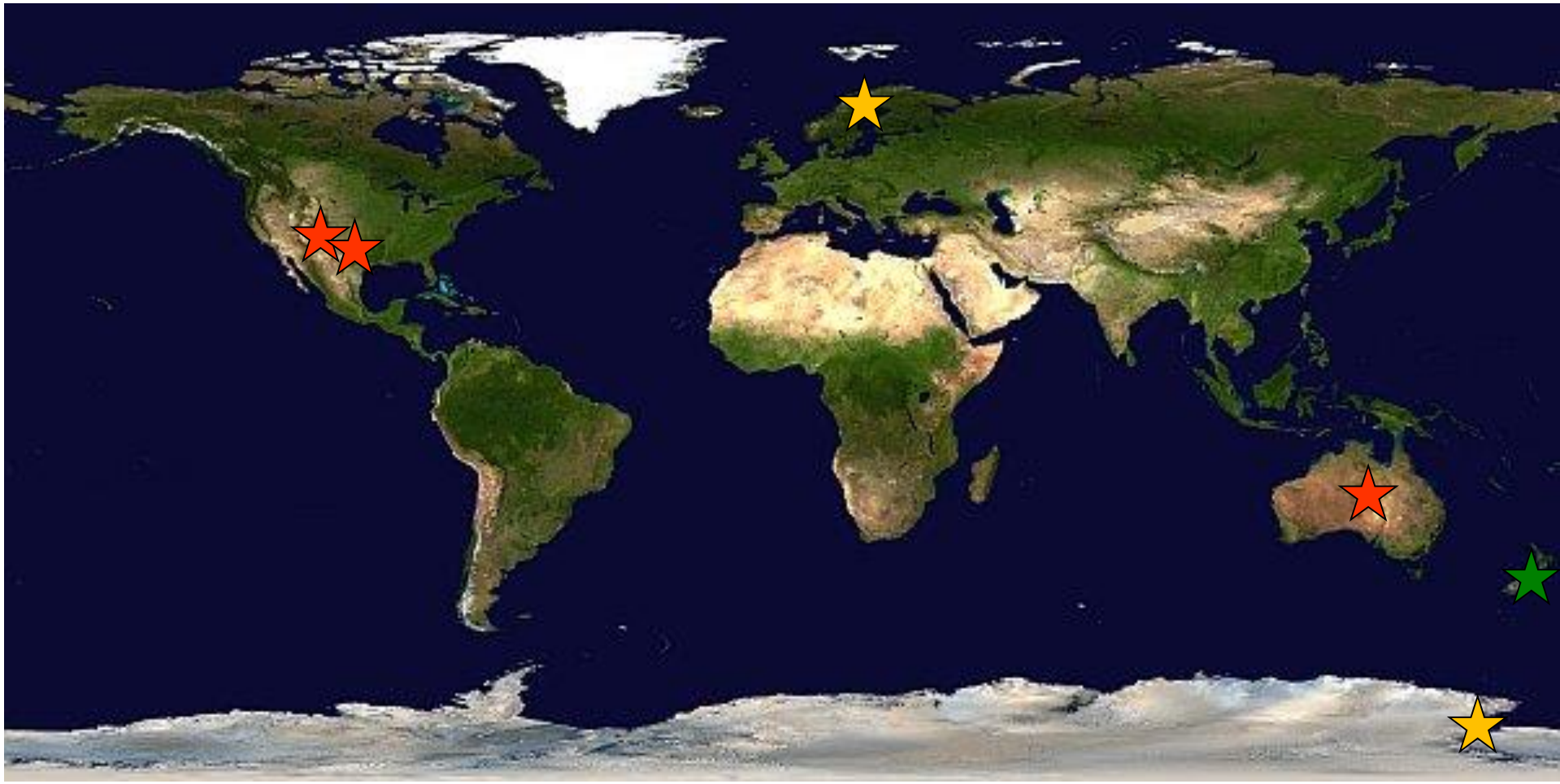
Wallops Flight Facility

- The NASA Balloon Program provides low-cost, quick response, near space access to NASA's science Community for conducting Cutting Edge Science Investigations
- Serve as a technology development platform
- Excellent training for NASA scientists and engineers

NASA Launch Locations

Goddard Space Flight Center

Wallops Flight Facility



Goddard Space Flight Center

FY16 Balloon Flight Manifest

Wallops Flight Facility

Principal Investigator (PI) / Institution / Instrument	Discipline	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Fort Sumner, New Mexico	**Fall 15**												
Stilwell / CSBF / Test	Test Flight	♦	**SUCCESS**										
McMurdo, Antarctica	**Winter 15**												
Saint Hilaire / UCB / GRIPS	Heliophysics				♦	**SUCCESS**							
Walker / UA / STO	IR-Submillimeter				**POSTPONED UNTIL FY17**								
Wanaka, New Zealand	**Spring 16**												
Fairbrother / WFF / SPB / Boggs / UCB / COSI	Test Flight								♦	♦	**SUCCESS**		
Palestine, Texas	**Summer 16**												
Jones / Princeton / Super-BIT	UV/Visible									♦	**SUCCESS**		
Esrange, Sweden	**Summer 16**												
Millan / DC / BARREL [8 PI-Hand Launched]	Heliophysics									**SUCCESS**		♦	♦
Fort Sumner, New Mexico	**Fall 16**												
Guzik / LSU / HASP	Student Flight Project									**SUCCESS**			♦
Krawczynski / WUSL / X-Calibur / Stuchlik / WFF / WASP	Gamma Ray/X-Ray										**SUCCESS**		♦
Margitan / JPL / Remote	Upper Atmosphere										**SUCCESS**		♦
Field / CSBF / Test Flight	Test Flight										**SUCCESS**		♦
Reinhart / GSFC / BETTII	IR-Submillimeter							**POSTPONED UNTIL FY17**					
Kogut / GSFC / PIPER	IR-Submillimeter							**POSTPONED UNTIL FY17**					

Goddard Space Flight Center

FY17 Balloon Flight Manifest

Wallops Flight Facility

Principal Investigator (PI) / Institution / Instrument	Discipline	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
McMurdo, Antarctica	**Winter 16**													
Seo / UMD / BACCUS	Cosmic Ray / Particle	←	SUCCESS											
Gorham / UH / ANITA	Cosmic Ray / Particle	←	SUCCESS											
Besson / UK / ANITA HiCAL (HL)	Cosmic Ray / Particle	←	SUCCESS / SUCCESS											
Walker / UA / STO-2	IR-Submillimeter	←	SUCCESS											
Wanaka, New Zealand	**Spring 17**													
Fairbrother / WFF / SPB / Olinto / Chicago / EUSO	Test / Cosmic Ray					←		ANOMALY						
Palestine, Texas	**Summer 17**													
Rinehart / GSFC / BETTII	IR-Submillimeter							◊						
Jones / Princeton / SuperBIT	UV / Visible							◊						
Kogut / GSFC / PIPER	IR-Submillimeter							◊						
Fort Sumner, New Mexico	**Fall 17**													
Moore / WFF / USIP	Student Flight Project									◊				
Toon / JPL / Remote	Upper Atmosphere									◊				
Guzik / LSU / HASP	Student Flight Project										◊			
Kogut / GSFC / PIPER	IR-Submillimeter										◊			
Martin / CalTech / FIREBALL	UV / Visible										◊			
Stuchlik / WFF / WASP	Test Flight										◊			
Fisher / WFF / Big 60	Test Flight										◊			

Goddard Space Flight Center

2015 Fort Sumner – Missions of Opportunity

Wallops Flight Facility

Flight	Org.	PI/Mission	Description
Test Flight #1	MSFC	Christl/ ANS	Advanced Neutron Spectrometer (ANS) will evaluate trigger (identify neutrons, reject gamma rays and charge particles) and measure atmosphere neutron spectrum. ANS planned to fly on both test flights but received all data needed on TF#1 and will not fly on TF#2.
Test Flight #1	GRC	Stevenson/ ANGEL	Autonomously Navigated paragliding Experimental Lander (ANGEL) is designed to demonstrate a controlled descent of a high altitude balloon payload to a predetermined landing zone using an Airborne Systems Microfly guided precision ram-air canopy controlled by an automated guidance unit.
Test Flight #1	U of AZ	Walker/ LBRSP	The Large Balloon Reflector Sensing Package will fly two instrument packages – one on the apex, the other on the gondola – to measure balloon dynamics.
Test Flight #2	KSC/ ARC	Smith/ EMIST	The Exposing Microorganisms in the Stratosphere (EMIST) is a reflight from last year to find out if known-quantities of spore-forming bacteria can survive once reaching Mars.
Test Flight #2	UAH	Adams/ EUSO IR	Extreme Universe Space Observatory (EUSO) IR is the prototype of the IR camera which will be part of the EUSO Mission on the International Space Station. Biological samples will also be flown with EUSO.
Test Flight #2	USIP/ UVa	Goyne/ JSATCRM	The JefferSat Cosmic Ray Mission (JSATCRM) will measure radiation levels at high altitudes in order to validate existing NASA radiation models. It will also test some controls via smartphone.
Test Flight #2	USIP/ UT St	Fullmer/ RLAGS	The Red-Line Air Glow Sensor (RLAGS) will take high temporal resolution measurements of wind speed over a wide range of altitudes to augment high resolution data on wind speeds in the thermosphere and help answer questions about how neutral winds contribute to energy distributions in the upper atmosphere.
Test Flight #2	GSFC IRAD	Esper/ MIRCA	The Micro-Return Capsule (MIRCA) will verify vehicle COTS avionics and UHF communications link in dynamic environment during ascent and at altitude in near-space environment. MIRCA will also test flight software and collect IMU data both on-board and on the ground in preparation for a drop test on a future flight.

2016 Fort Sumner – Missions of Opportunity

Payload	PI	Organization
MIRCA	*Jaime Esper*	GSFC
SISE	*Eliot Young*	*Southwest Research Institute*
USIE	*Daniel Bowman*	*University of NC at Chapel Hill*
CIS	*Daniel Bowman*	*University of NC at Chapel Hill*

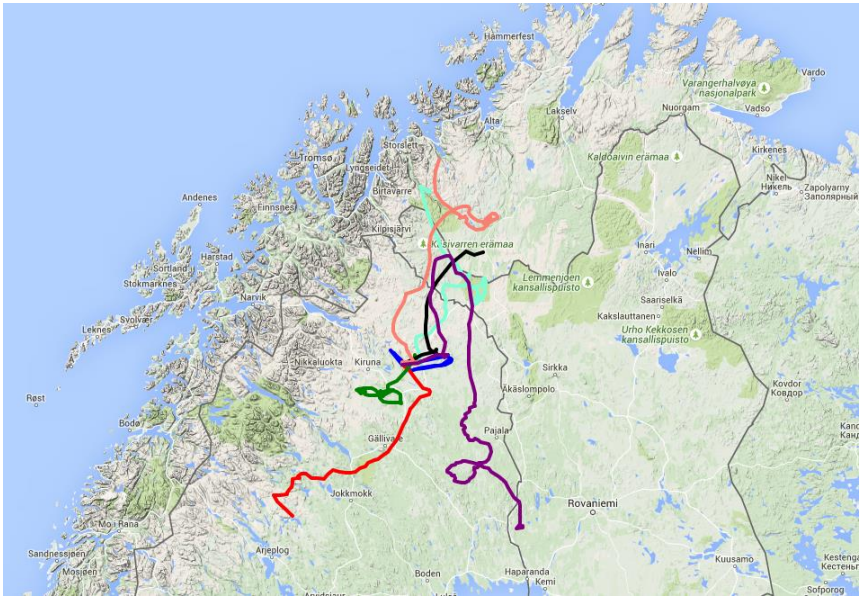
Goddard Space Flight Center

BARREL Sweden Campaign 2015

Wallops Flight Facility

Balloon Array for Radiation-belt Relativistic Electron Losses (BARREL), a Living With a Star (LWS) Mission of Opportunity (MoO), will extend the Antarctic Science campaigns into the northern hemisphere with science launches from Esrange Space Center.

BARREL will quantify and reveal the processes responsible for catastrophic losses of electrons from Earth's outer radiation belt. BARREL is managed out of WFF.



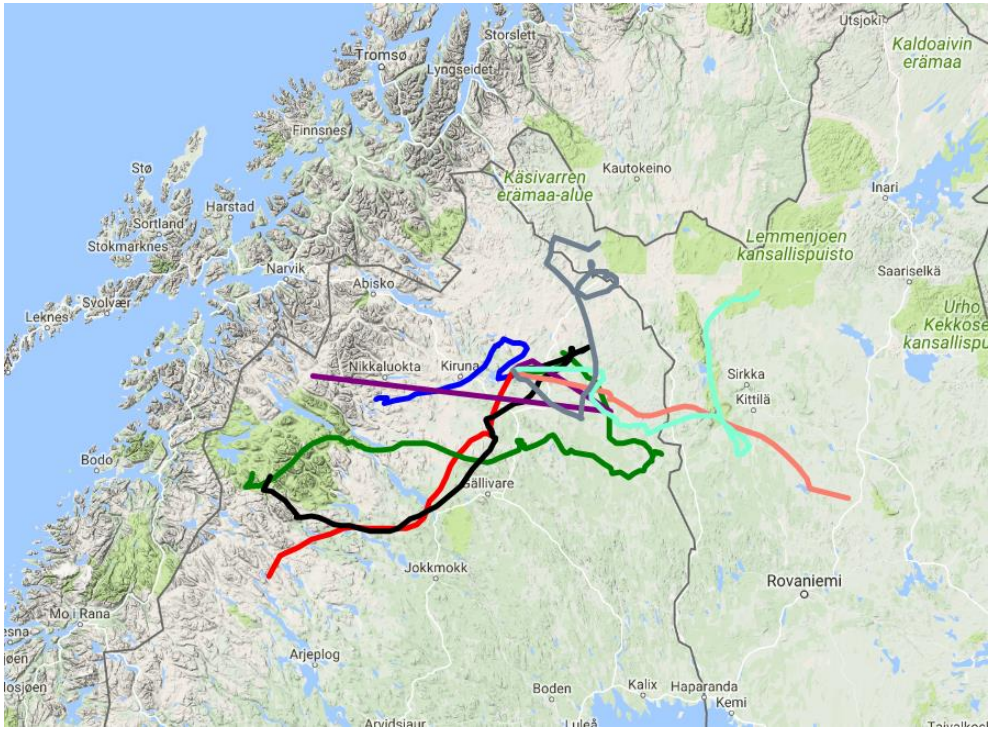
BARREL Sweden Campaign Achievements and Highlights*:*

- Seven successful flights with durations ranging from roughly 7-36 hours.
- 92.8 hours of observations above our science altitude of 27 km.
- 10 very close conjunctions between a balloon and a Van Allen Probes satellite. Additional conjunctions with the FIREBIRD and AC-6 cubesats, and nearby passes of Cluster, THEMIS, and MMS.

BARREL Sweden Campaign 2016

Balloon Array for Radiation-belt Relativistic Electron Losses (BARREL)

- Launched: 8 Flights flown between August 13 and 31 from Esrange in Sweden
- Terminated: In Sweden and Finland
- Over 116 hours of flight
- Multiple conjunctions with both the Van Allen Probes and the MMS spacecraft



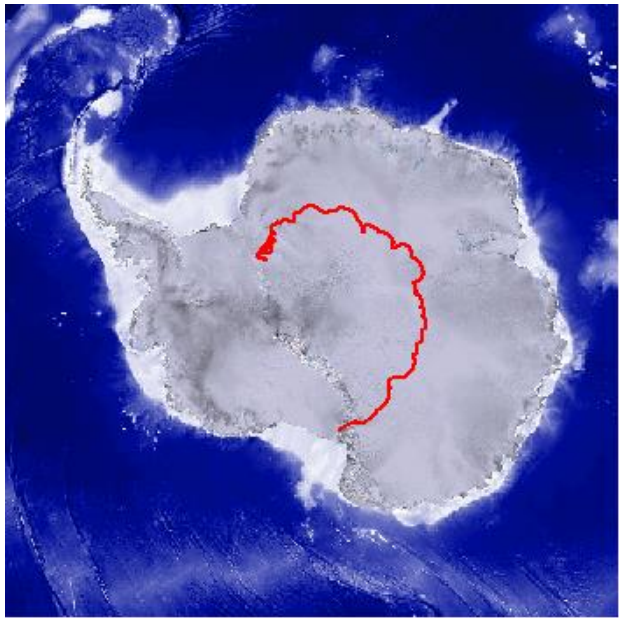
Goddard Space Flight Center

FY16 Antarctica Campaign – Flight 668N

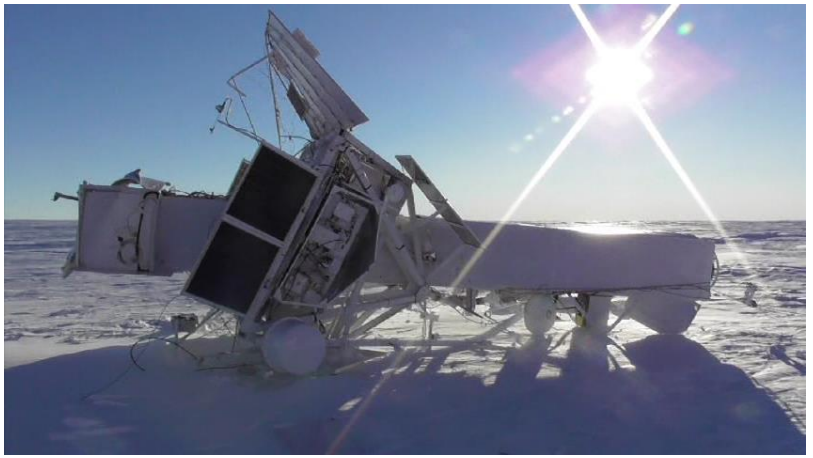
Wallops Flight Facility

Gamma-Ray Imager/Polarimeter for Solar flares (GRIPS) -
Dr. Pascal Saint-Hilaire, UC Berkeley

- Flight Ready: December 25, 1st Antarctica Flight
- Balloon: 39.57MCF
- Launch Date: January 19
- Total Flight Time: 11 days, 19 hours, 50 minutes
- Operations and Science Success



Latest LDB Launch in History!



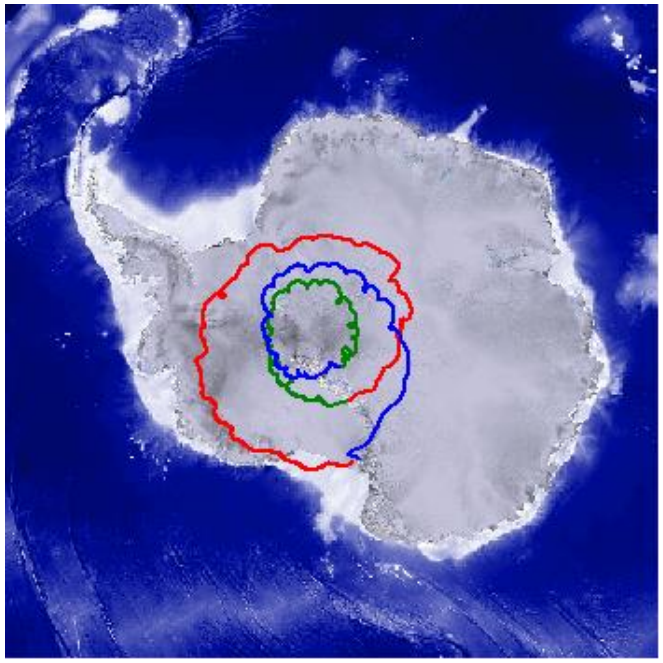
Goddard Space Flight Center

FY17 Antarctica Campaign – Flight 674N

Wallops Flight Facility

Boron and Carbon Cosmic rays in the Upper Stratosphere (BACCUS) – Dr. Seo, University of Maryland

- Launch Date: 28 November 2016 19:00 Z
- Balloon: 39.57 MCF
- Flight Duration: 29 days, 21 hrs, 11 min
- *Operational and Science Success!!!*



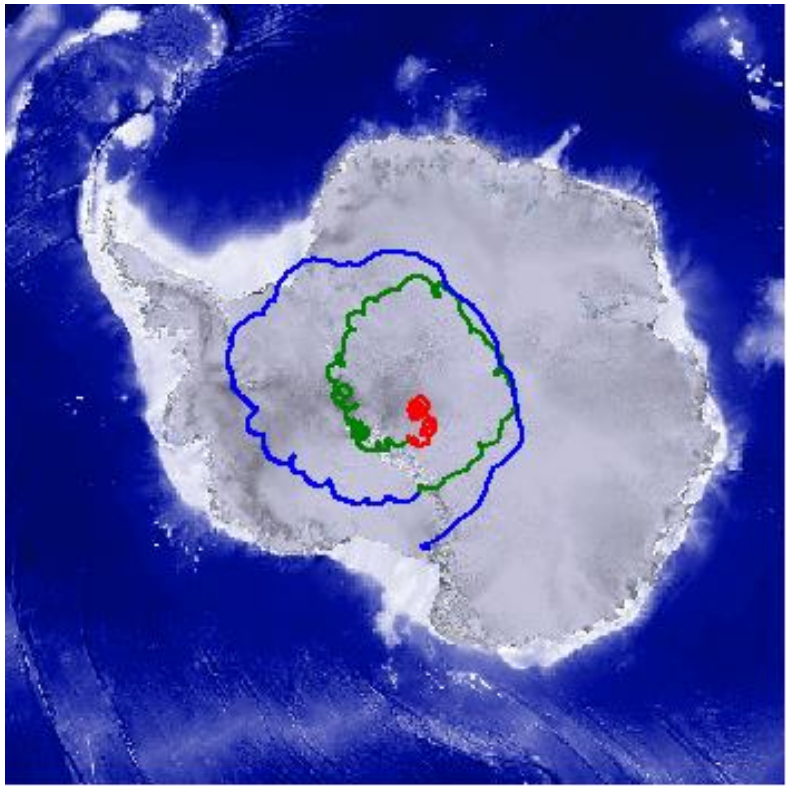
Goddard Space Flight Center

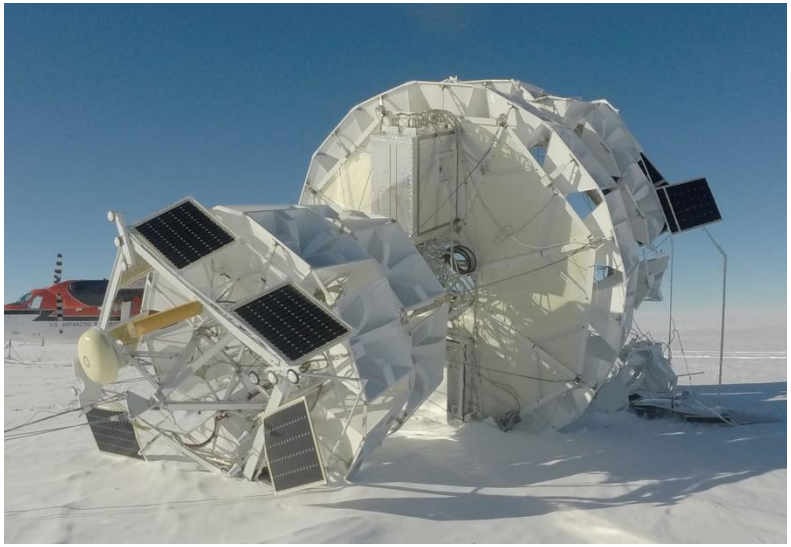
FY17 Antarctica Campaign – Flight 675N

Wallops Flight Facility

Antarctic Impulsive Transient Antenna (ANITA) – Dr. Gorham, University of Hawaii

- Launch Date: 2 December 2016 13:11 Z
- Balloon: 39.57 MCF
- Flight Duration: 27 days, 11 hrs, 15 min
- *Operational and Science Success!!!*





Goddard Space Flight Center

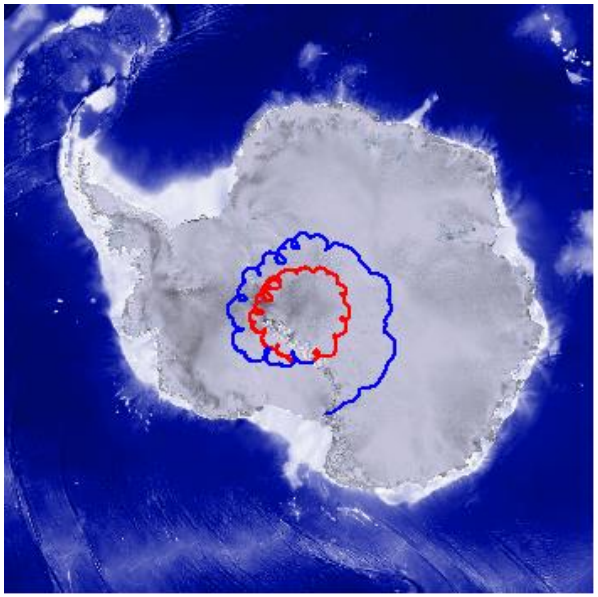
FY17 Antarctica Campaign – Flight 676N

Wallops Flight Facility

Stratospheric Terahertz Observatory (STO-2)

Dr. Walker, University of Arizona

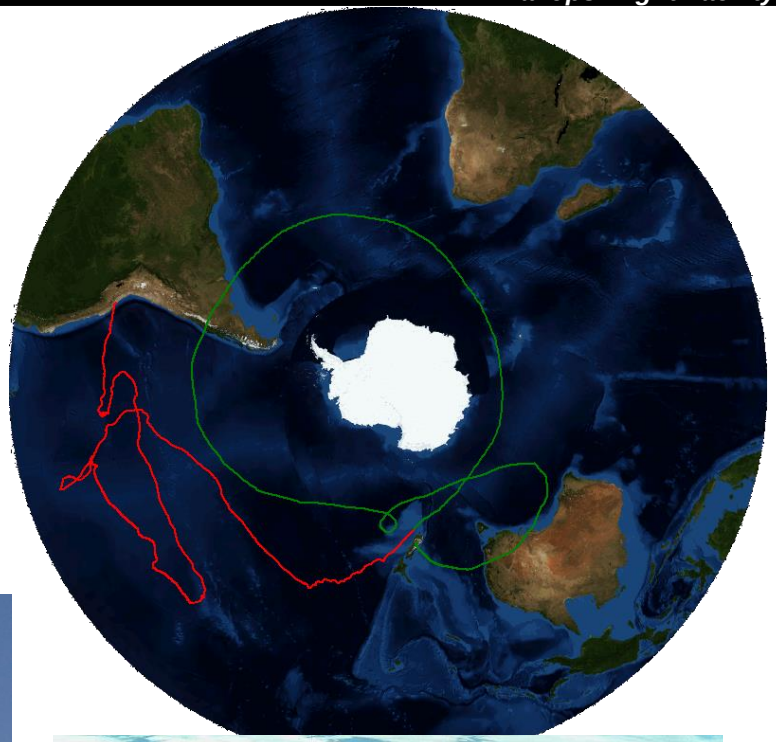
- Launch Date: 8 December 2016 20:53 Z
- Balloon: 39.57 MCF
- Flight Duration: 21 days, 19 hrs, 17 min
- *Operational and Science Success!!!*



FY16 New Zealand Campaign - Flight 669NT

Super Pressure Balloon(SPB)/ Compton Spectrometer and Imager (COSI) – WFF/UC Berkeley

- Launched (Finally!): 16 May at 23:35Z
- Terminated: 2 July at 19:14Z near Camana, Peru
- Over 46 days!!!
- The balloon encountered performance issues during the latter part of the mission due to suspected loss of gas in the system.



FY17 New Zealand Campaign – Flight 679NT

Super Pressure Balloon/ Extreme Universe Space Observatory (SPB/EUSO) - D. Fairbrother - WFF

- Volume: ~532,152 m^3 (~18,793,000 ft^3)
- Launch Date: April 24, 2017 @ 22:50 Z
- Suspended Load: 2,495 kg (5,500 lbs.)
- Flight Time – 12 days, 4 hours, 34 mins
- EUSO flown as a Mission of Opportunity

Goddard Space Flight Center

New Zealand Launch Pad – Phase I

Wallops Flight Facility

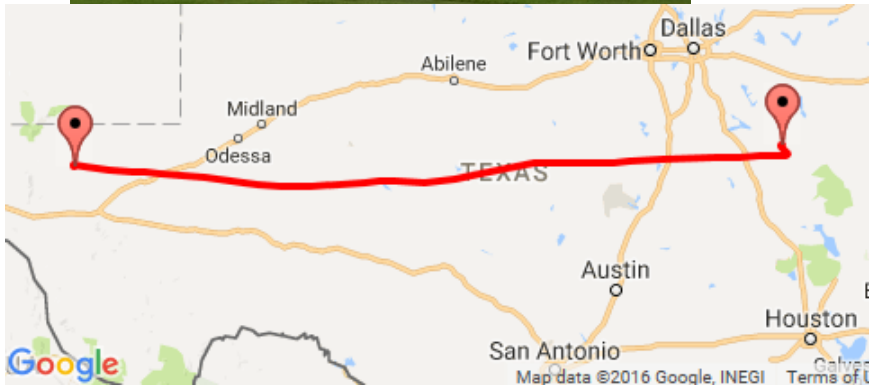
FY16 Palestine Campaign – Flight 1597P

Balloon-Borne Imaging Telescope for Super Pressure Balloon (Super-BIT) - Dr William Jones, Princeton

- Balloon: 11.82 MCF
- Launch Date: 1 July 2016 at 00:13 Z
- Total Flight Time: 10 hours, 36 min
- Operations and Science Success

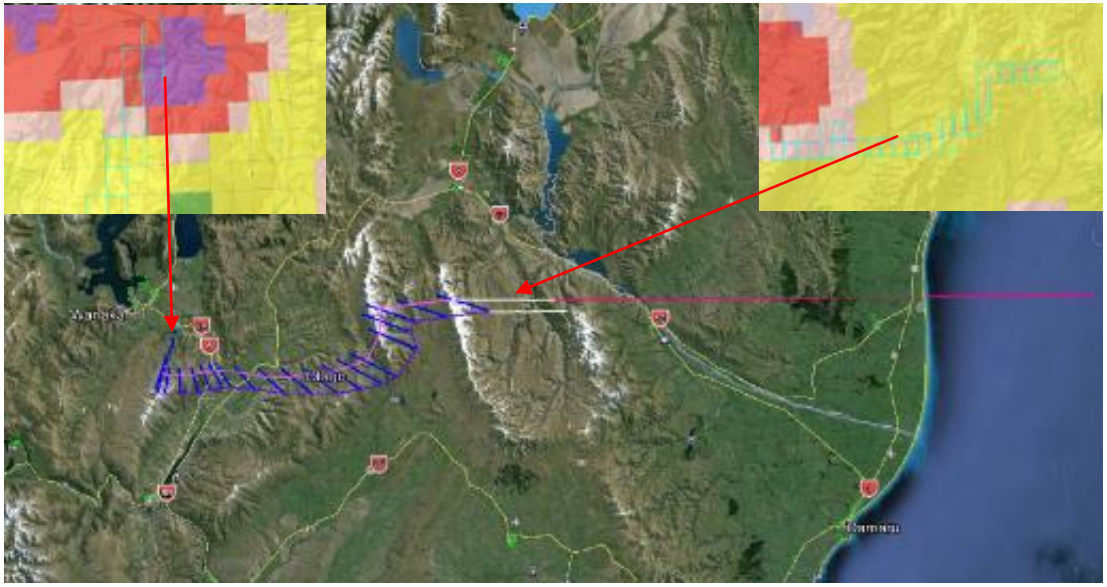
First heavy lift launch from Palestine since 2007

3 Flights manifested to launch from Palestine in 2017



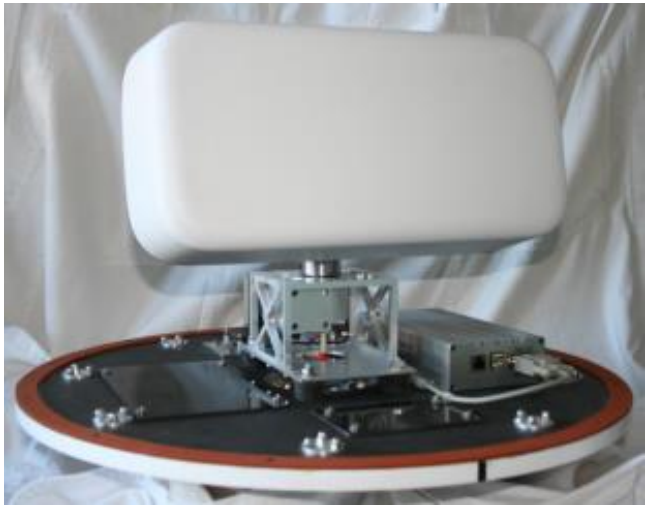
Active Risk Assessment

- *Cumulative risk criteria calculated for Ascent, Float, Descent*
  - *Collective Casualty Expectation (CE) < 100x10-6*
  - *Individual Probability of Casualty (Pc) < 1x10-6 (for Ascent <16K ft.)*
- *L-1 and Show, CSBF delivers climbout trajectories, with descent vectors for both Payload and Balloon*
  - *MRSO evaluates trajectory. Provides results at the L-1 weather briefing. Process repeated at Show to validate risk and incorporate trajectory change.*
  - *MRSO Provides GO/NO GO to CM prior to Gondola pickup.*



Technology Developments

- Improved Rotator
- TDRSS High Gain Antenna
- WFF TDRSS Low-Cost Transceiver (LCT2)
- Charge Controllers
- Valence Lithium Iron Phosphate Batteries
- Indoor Iridium Repeaters
- 60 MCF Balloon (1,400 pounds to 157 kft)



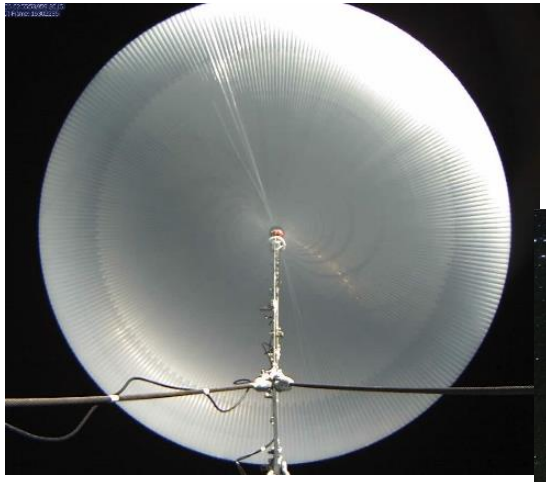
JPL Low Density Supersonic Decelerator (LDSD)

- *Successful 2nd LDSD Balloon Test Flight In 2015*
- *CSBF developed remote operated, heavy lift balloon launch tower system to accommodate payloads incorporating potentially hazardous components in order to insure safe distance for launch personnel*
  - *Launch control executed 152m away from launch tower holding the LDSD Test Vehicle (balloon payload)*
- *JPL LDSD Test Vehicle released from balloon at 36.6 km altitude*
- *After release from balloon, LDSD Test Vehicle spin motors and rocket ignites, accelerating Test Vehicle to ~ Mach 4 and 49 km altitude parabolic trajectory*
- *Test Vehicle deploys recovery systems to test in comparable atmosphere density as anticipated for Mars*

Engaging the Public

Summary

- The NASA Balloon Program has continued to provide stable platforms for science.
- The WASP and SPB developments have continued to advance.
- Balloons provide an excellent training ground for scientists and engineers



Acknowledgements

The activities reported today would not have been possible without the dedication and support from NASA, NSF, the Balloon Program Office, the Columbia Scientific Balloon Facility (CSBF), Raven Aerostar, the science community, and our support contractors.

A special note of appreciation & thanks to Mr. Bryan Stilwell of the Columbia Scientific Balloon Facility / Orbital ATK of Palestine, Texas for his representing the NASA Balloon Program Office when we couldn't be there.

Our sincerest best wishes to our ESA friends and colleagues for a successful & rewarding 23rd Symposium.

Questions?

Contact:

Debora Fairbrother
Chief, NASA Balloon Program Office

Debora.A.Fairbrother@nasa.gov