

# *Recent Developments from the NASA Balloon Program Office*

***Sarah Roth***

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



## Strategic Objective:

Enable discovery through conduct of frequent scientific balloon flight opportunities for NASA scientific, technology development, and educational investigations.

## Balloons provide low-cost, quick response, near space access for:

- Conducting cutting-edge research.
- Developing technologies to enable future spacecraft science missions.
- Advancing lighter-than-air platform technologies.
- Providing Calibration and Validation of on-orbit instrumentation.
- Enabling Hands-on Training of the next generation of scientists and engineers.

### Annual Program Snapshot

8-12 Launched

3+ campaigns

300+ ugrad/grad students participate

40+ Research Institutions



Super-Pressure Balloon



STO-2



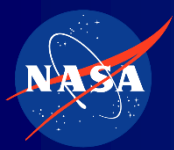
HASP



X-Calibur/WASP



COSI

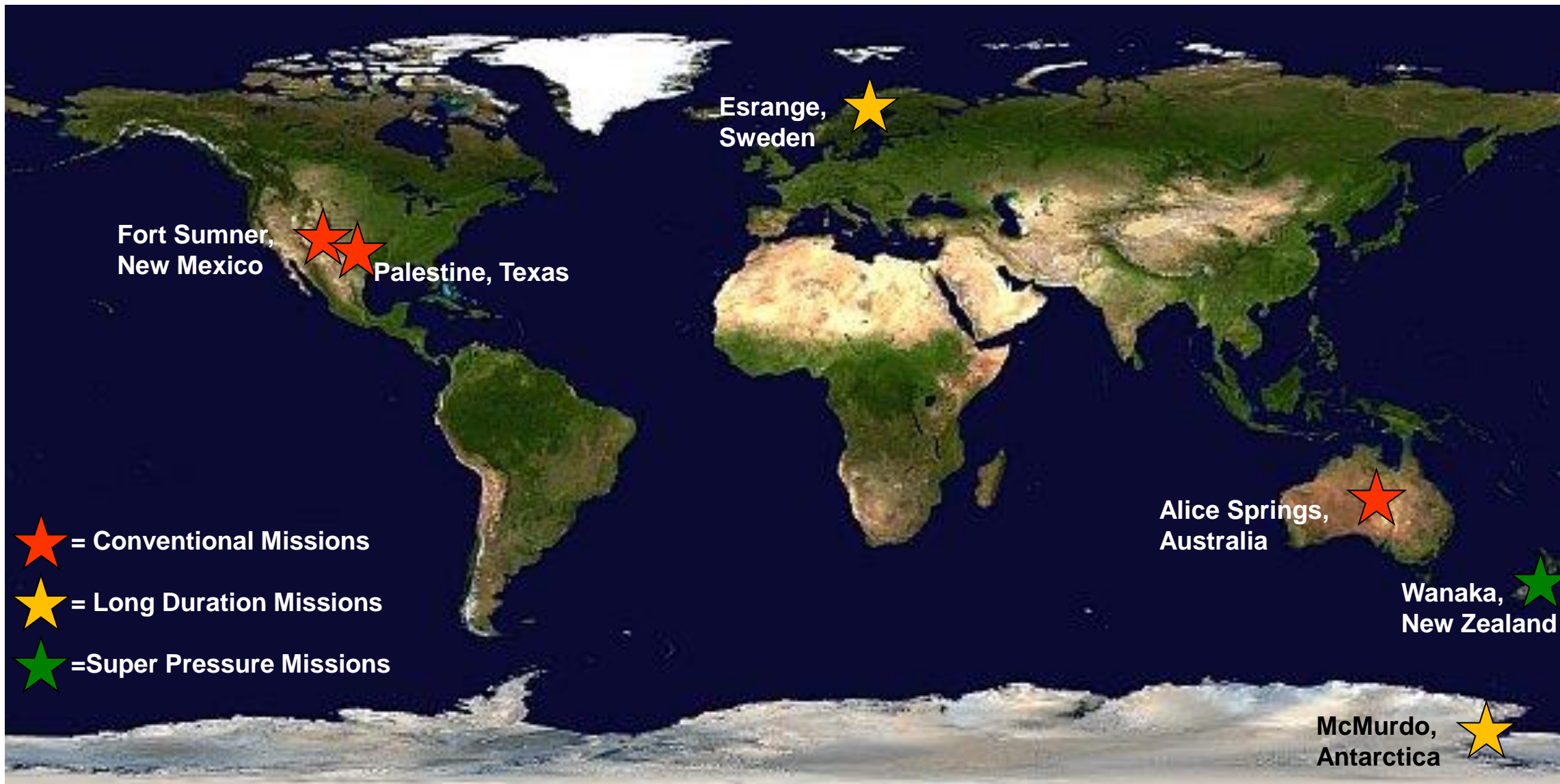


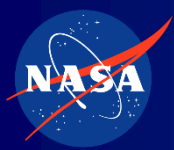
# NASA Launch Locations



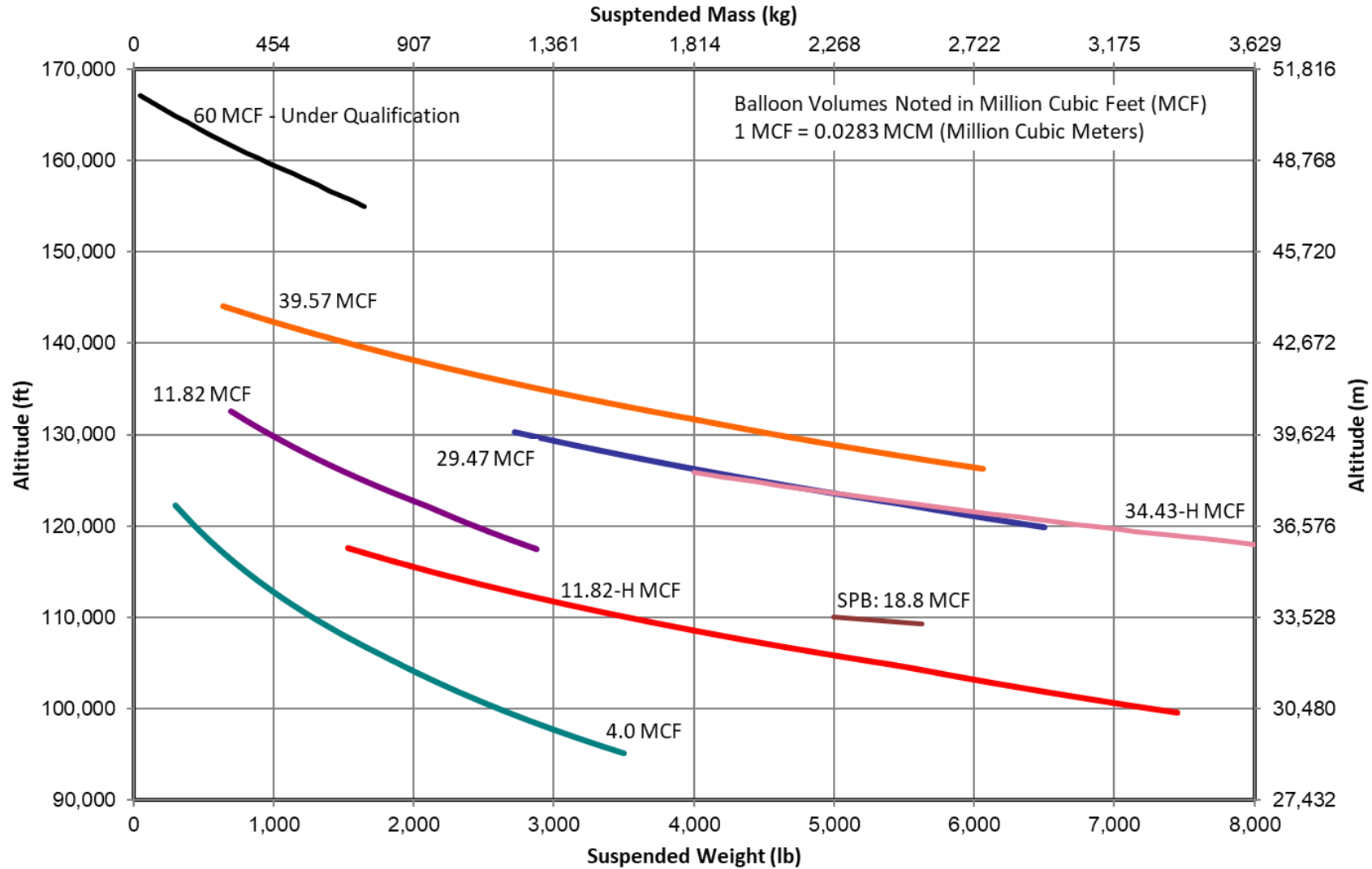
Goddard Space Flight Center

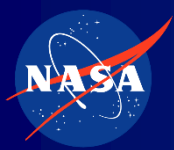
Wallops Flight Facility





# NASA Balloons





# NASA Support Systems



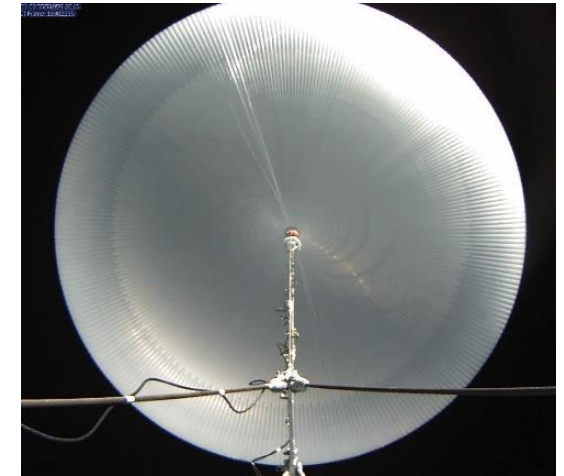
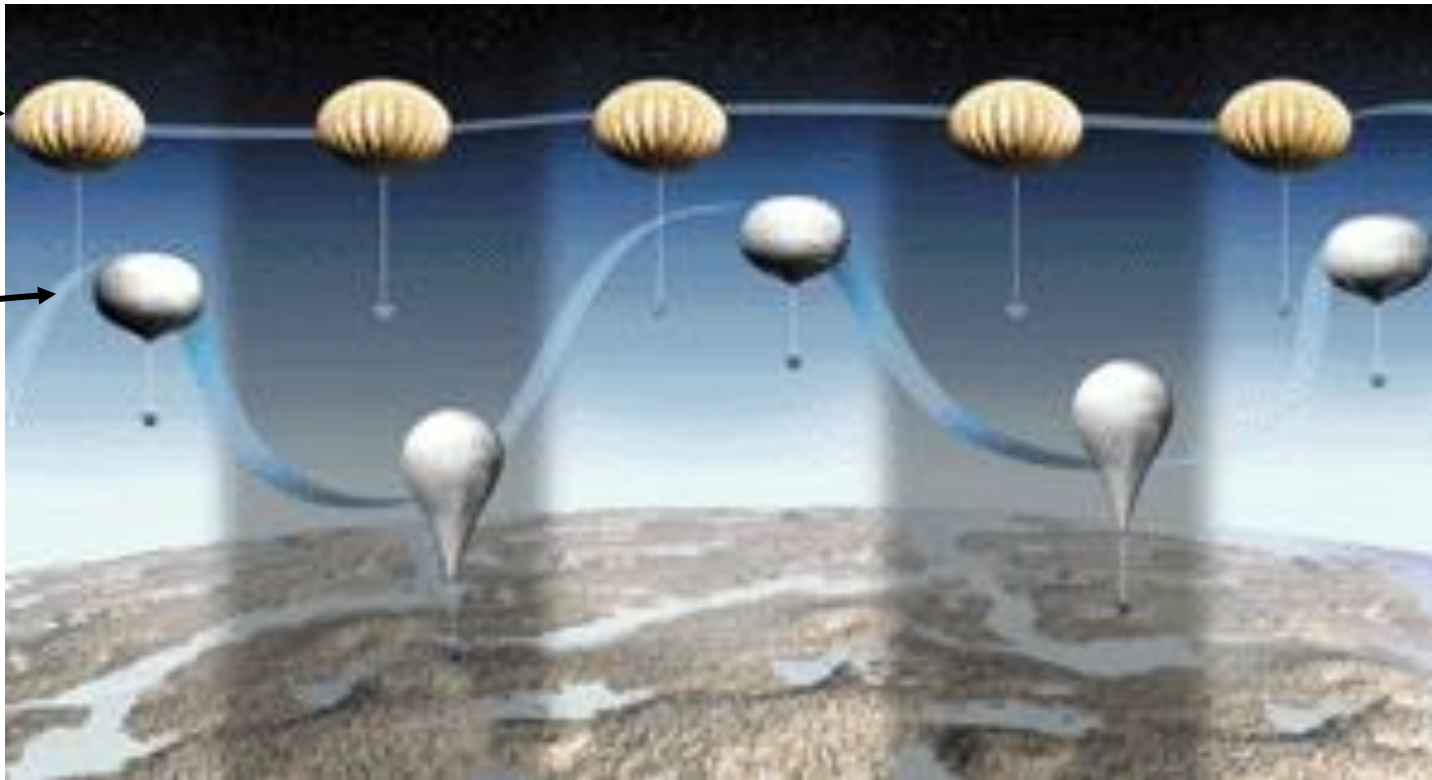
Goddard Space Flight Center

Wallops Flight Facility

Balloon Type	Zero Pressure (ZP) Hand Launch (HL)	ZP	ZP	Super Pressure (SP)
<b>Mission Type</b>	Conventional *LDB and SPB in development	Conventional	Long Duration	Long Duration / Ultra-Long Duration
<b>Duration</b>	2 hours to 6 hours	2 hours to 3 days	Typical 5-15 days Flight history of 55 days (no diurnal)	100+ Days (full diurnal)
<b>Maximum Science Payload Weight</b>	72 lbs	6000 lbs	6000 lbs	2500 lbs
<b>Total Suspended Weight</b>	130 lbs	1250 lbs to 8000 lbs	1250 lbs to 8000 lbs	5500 lbs
<b>Typical Float Altitude</b>	128kft	90Kft to 160 kft	90 kft to 160kft	110 kft
<b>Support Package</b>	CSBF HL Package Iridium Based LOS/OTH Up to 12 Mbit LOS option	CIP, CSBF HL Package, MiniSIP LOS systems with up to 12 Mbit LOS options	SIP LOS and OTH options Up to 12Mbit LOS option OTH Iridium Short Burst Data OTH TDRS 1Mbit option	SIP LOS and OTH options Up to shared 12Mbit LOS option OTH Iridium Short Burst Data OTH Shared TDRS 1Mbit
<b>Launch Locations</b>	Fort Sumner, NM Palestine, TX McMurdo, Antarctica Esrangle, Sweden Wanaka, New Zealand Alice Springs, Australia Other sites (domestic and international) are possible	Fort Sumner, NM Palestine, TX McMurdo, Antarctica Esrangle, Sweden Wanaka, New Zealand Alice Springs, Australia Other sites (domestic and international) are possible	Fort Sumner, NM Palestine, TX McMurdo, Antarctica Esrangle, Sweden Wanaka, New Zealand Alice Springs, Australia Other sites (domestic and international) are possible	Wanaka, New Zealand McMurdo, Antarctica Alice Springs, Australia *International Overflight Permissions for Northern Hemisphere limit launch sites

## Super Pressure Balloon maintains nearly constant volume – *under development*

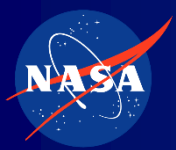
- Allows Ultra Long Duration Balloon (ULDB) Flights
- Provides stable altitude Long Duration Balloon (LDB) flights at mid-latitudes



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

- Used for Conventional Flights and Polar LDB Flights





# FY21 Flight Manifest

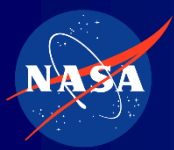


Goddard Space Flight Center

Wallops Flight Facility

Mission	Discipline	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
<b>McMurdo Station, Antarctica</b>	<b>Winter '20</b>	<b>Campaign cancelled by NSF due to COVID-19.</b>											
Roth / BPO / 60 MCF Test Flight	Test Flight			◆ Delayed by NSF due to COVID-19									
Salter / CSBF / TRAVAL-B / Millan / DC / BARREL	Test Flight / BARREL (PB)			◆ Delayed by NSF due to COVID-19									
Jones / PU / SPIDER	UV / Visible			◆ Delayed by NSF due to COVID-19									
Salter / CSBF / TRAVALA	Test Flight			◆ Delayed by NSF due to COVID-19									
<b>Wanaka, New Zealand</b>	<b>Spring '21</b>	<b>Campaign cancelled by BPO due to COVID-19. To be rescheduled for FY22.</b>											
Hall / BPO / SPB Test / Boggs / UCSD / COSI	Test Flight / COSI (PB)							◆ Delayed by BPO due to COVID-19					
<b>Fort Sumner, New Mexico</b>	<b>Spring '21</b>												
Chartier / JHU APL / BBC	Heliophysics (H/L)						Launched ◆						
Kogut / GSFC / BOBCAT-21A/B	IR-Submillimeter						Delayed by PI due to COVID-19 ◆			◆			
Kogut / GSFC / PIPER-21A	IR-Submillimeter						Delayed by PI due to COVID-19 ◆			◆			
Mullenax / CSBF / CSBF Test Flight I/II	Test Flight						Launched; 2 <sup>nd</sup> Flight Cancelled due to Weather ◆◆						
Salter/ CSBF / Test Flight / Jackson / UCSD / ASHI	Test Flight / ASHI (PB)								Launched ◆				
<b>Esrang, Sweden – Alternate to Wanaka</b>	<b>Summer '21</b>	<b>Campaign cancelled by BPO due to COVID-19.</b>											
Hall / BPO / SPB Test SN 07 / Sample / MSU / BOOMS	Test Flight / BOOMS (PB)								◆ Delayed by BPO due to COVID-19				
Roth / BPO / 60 MCF Test	Test Flight								◆ Delayed by BPO due to COVID-19				
<b>Palestine, Texas</b>	<b>Summer '21</b>	<b>Flights moved to spring Ft. Sumner Campaign.</b>											
<b>Fort Sumner, New Mexico</b>	<b>Fall '21</b>												
Salter / CSBF / CSBF Test Flight	Test Flight											Launched ◆	
Mullenax / CSBF / CSBF Test Flight	Test Flight											Launched ◆	
Guzik / LSU / HASP	Education Outreach											Launched ◆	
Stachnik / JPL / JPL-SLS	Upper Atmosphere											Launched ◆	
Kogut / GSFC / BOBCAT-21C/D	IR-Submillimeter									Delayed by PI due to COVID-19 ◆			◆
Martin / CalTech / FIREBall-2	UV / Visible									Delayed by PI due to COVID-19 ◆			
Chakrabarti / UMASS / PICTURE-C	UV/Visible									Cancelled due to weather ◆			
Toon / JPL / JPL-Remote	Upper Atmosphere											Launched ◆	
Nowicki / LANL / LANL OrionEagle	Gamma-Ray (H/L)											Launched ◆	
Kogut / GSFC / PIPER-21B	IR-Submillimeter									Delayed by PI due to COVID-19 ◆			
Boering / UCB / MATTADOR TF	Upper Atmosphere									Delayed by PI due to COVID-19 ◆			
Young / SwRI / THAI-SPICE	UV / Visible									Delayed by PI due to COVID-19 ◆			
Tang / JPL / WHATSUP	Solar System (H/L)											Launched ◆	





# FY22 Flight Manifest - Piggybacks



Goddard Space Flight Center

Wallops Flight Facility

Mission	Discipline	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
<b>Esrange, Sweden</b>													
<b>Summer '22</b>													
Bowman / SNL / Infralite	Infrasound				Unsupportable with loss of HELIX				◇				
Yoder / WFF / DINGO	Tech Demo							Delayed by PI		◇			
<b>Fort Sumner, New Mexico</b>													
<b>Fall '22</b>													
Agee-DeHart / Idoodlelearning.com / CiS	Student Outreach											◇	
Bailey / VT / GLO	Heliophysics									Delayed by PI		◇	
Jackson / UC / ASHI	Heliophysics												◇
John / UA / IRCSP	Upper Atmosphere											◇	
Sewell / NCAR / DIMS	Heliophysics											◇	
Yoder / BPO / SPARROW-III	Tech Demo											◇	
Yoder / BPO / DINGO	Tech Demo											◇	
Barcenas / NPI / EMIDSS-III	Heliophysics											◇	

Primary missions supporting piggybacks during FY22 campaigns:

## Fall Fort Sumner

Salter / CSBF / CSBF Test Flight

- Agee-DeHart/Idoodlelearning.com/CiS
- Bailey / VT / GLO
- Jackson / UC/ ASHI
- John / UA / IRCSP
- Sewell / NCAR / DIMS
- Yoder / BPO / SPARROW-III
- Yoder / BPO / DINGO
- Barcenas / NPI / EMIDSS-III

Mullenax / CSBF / CSBF Test Flight

- Jackson / UC/ ASHI

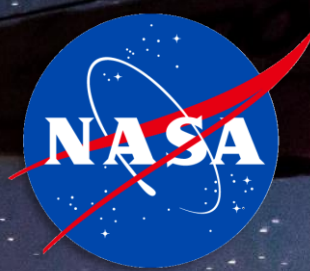
Zhou / UCLA / BALBOA

- Fritts / GATS / PMC-Turbo

Chakrabarti / UMASS / PICTURE-C

- Chakrabarti / UMASS / CoMIC

# *Technology Development*

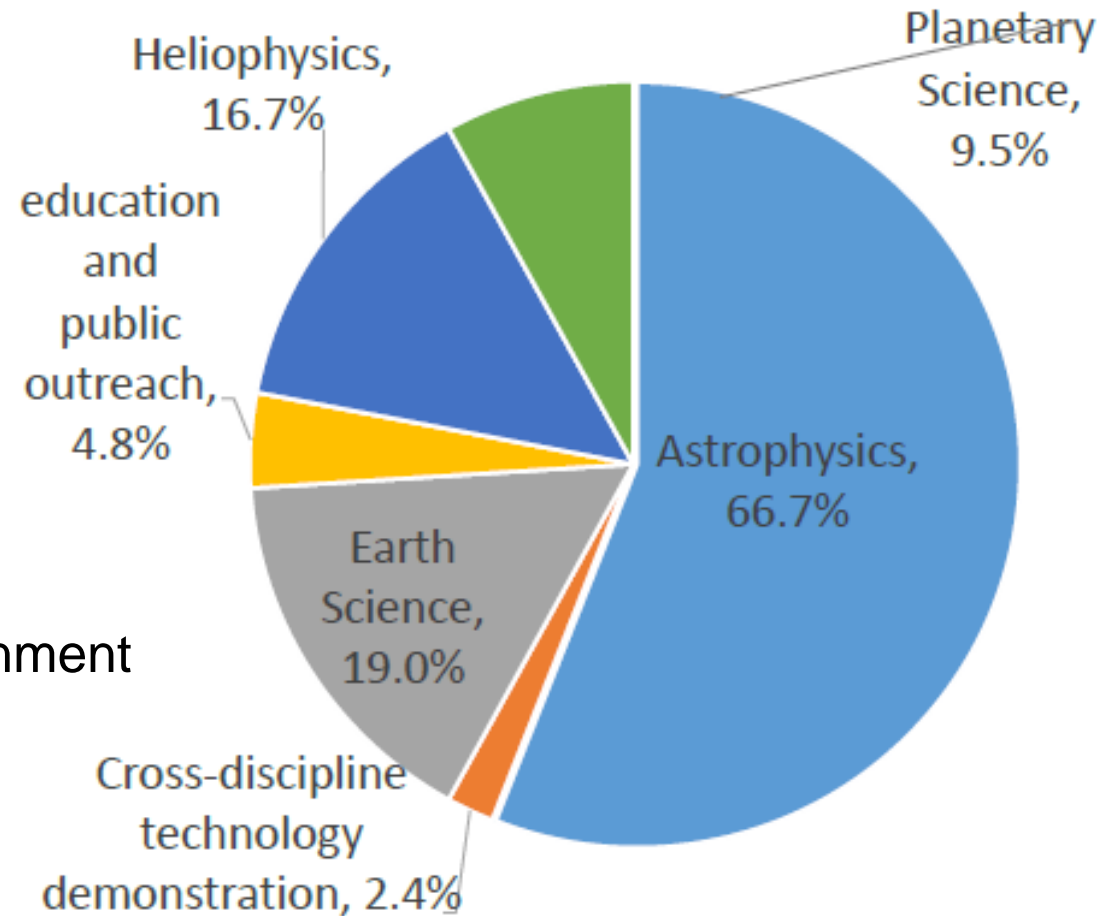




## NASA Scientific Balloon Needs - 2020

Thank you for your participation. The purpose of this survey is to identify our current gaps and to drive the development of new systems. We are looking for feedback on your short term and (10 yr) long term needs.

- 51 responses overall from April 7 to June 30, 2020.
- Responses split between government and non-government
- Prior flight history with NASA Balloon Program:
  - 61% of the respondents have flown previously
  - 39% of respondents have not flown



## Development of a Balloon Roadmap

- Chaired by Dr. Peter Gorham with representatives from the science disciplines and education
- Report outlines:
  - Science Drivers
  - Current Capabilities and Funding Opportunities
  - Workforce Pipeline and Education
  - Findings and Recommendations

---

## A ROADMAP FOR SCIENTIFIC BALLOONING 2020-2030

---



# Goals

Super pressure balloon qualification

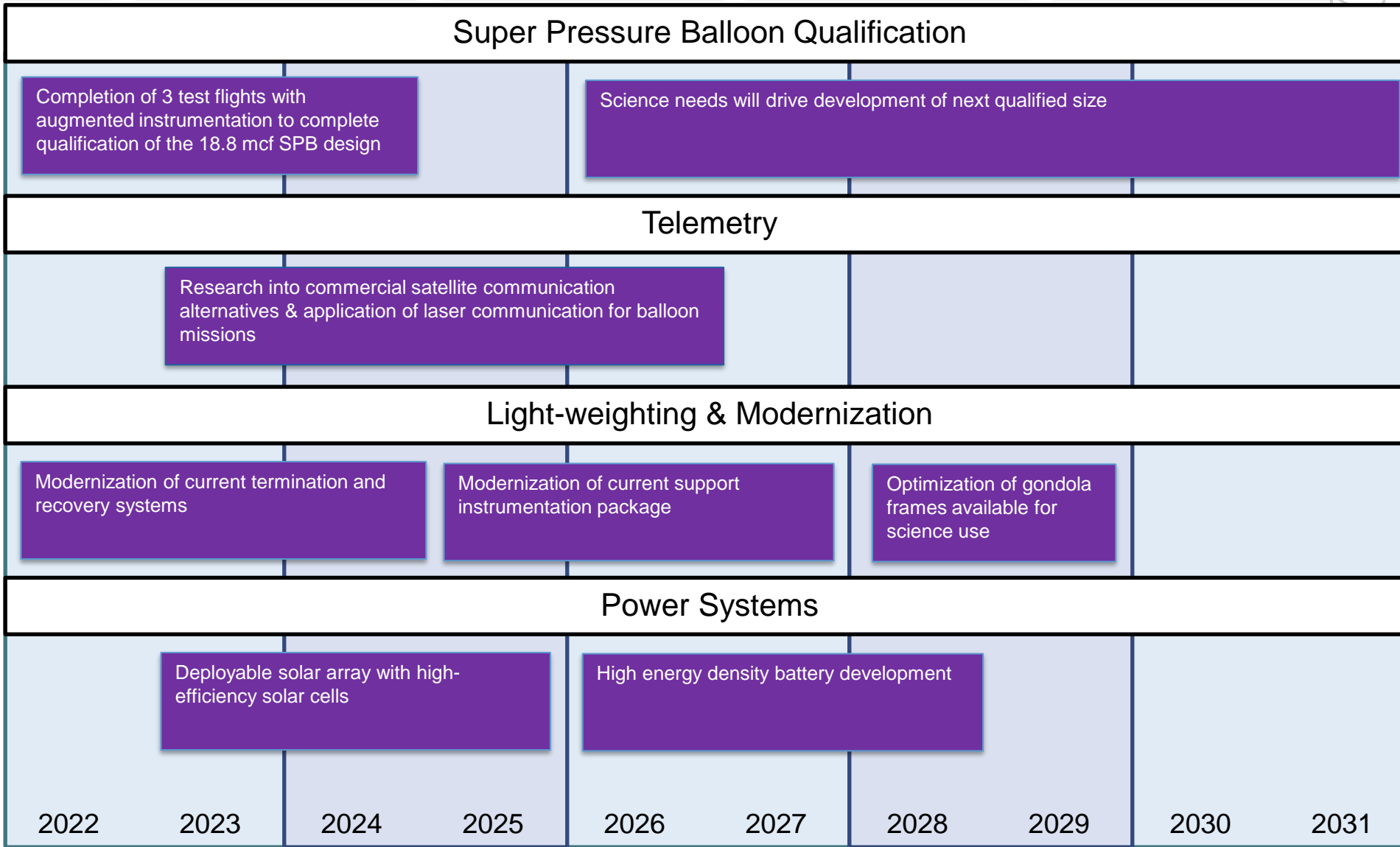
High data rate telemetry

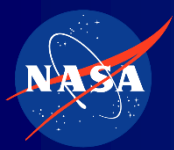
Increase available science mass

Push state-of-the-art for solar panels and battery chemistries

Modernization and standardization of support equipment

## Technology Roadmap





# ULDB Recent Flight History



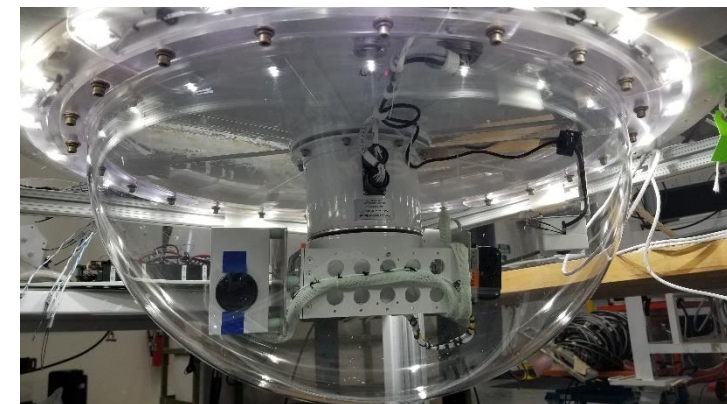
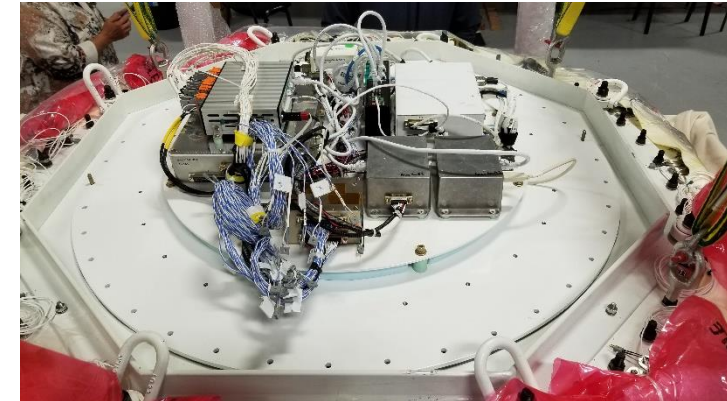
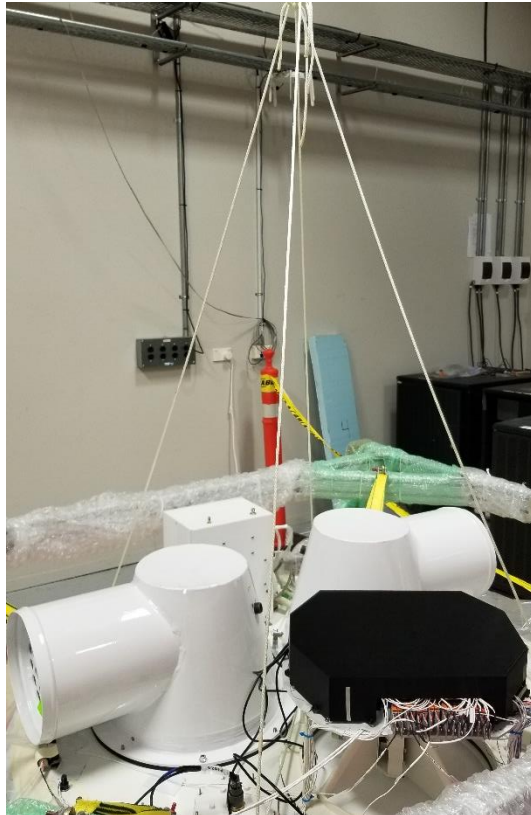
Goddard Space Flight Center

Wallops Flight Facility

Year	FLT #	SN #	Size (MCF)	Site	Duration	Summary	Env	Config
2008	591NT	SN01	7	Ant	54 D	Completely successful mission exhibiting no performance issues. Mission terminated due to forecast continental departure. Balloon not recovered.	Polar	Heritage Clamped Design w/ TackyTape
2009	599NT	SN01	14.9	Swe	4.2 H	Holes developed near the base during pressurization with significant gas loss, flight terminated shortly after reaching float. Balloon recovered/inspected.	Polar	
2010	608NT	SN02	14.9	Ant	2.8 H	Balloon catastrophically burst during pressurization event. Balloon recovered/inspected. Peeled seal discovery.	Polar	
2011	616NT	SN03	14.9	Ant	22 D	Completely successful mission exhibiting no performance issues. Mission terminated due to recovery of high value electronics. Balloon not recovered.	Polar	
2012	631NT	SN02	18.8	Swe	6.5 H	Successful mission exhibiting no discernable performance issues. Mission terminated due to turnaround conditions. Balloon recovered/inspected.	Polar	
2014	659NT	SN03	18.8	Ant	43 H	Successful pressurization but significant performance issues exhibited 1.5 days after launch. Mission terminated in recoverable location but balloon not found.	Polar	Heritage Clamped Design w/ TackyTape; Changed to reduced fitting diameter for 2 tendons/pin
2015	662NT	SN04	18.8	NZ	32 D	Successful pressurization and float. Nominal performance through 32 days. Exhibited performance issues over Australian Outback, significant gas loss over last 12 hour period. Anomalous balloon termination but recovered/inspected	Diurnal	
2016	669NT	SN05	18.8	NZ	46 D	Successful pressurization and initial float. Exhibited slowly deteriorating performance over month-long period. Balloon recovered/inspected.	Diurnal	Revised seal and clamping design; utilized white silicone gasket
2017	679NT	SN06	18.8	NZ	12 D	Anomalous launch event (early collar release); data indicated leak from initial float; Zero Pressure behavior after 3 days; Terminated into water; unable to make continent for recovery/inspection of balloon	Diurnal	Additional revision to seal and clamping design; utilized red-orange silicone gasket

NZ 2022 test flight/SN07 will be similar to 679NT/SN06 from 2017 with limited changes:

- Addition of diagnostic SPB instrumentation (SPBi) to characterize balloon performance
- Minor modification to the Load Tape Tendon (LTT) configuration, controlled glue application
- Apex and Base fitting “sealing” enhancements
- Utilizing low temperature black gasket

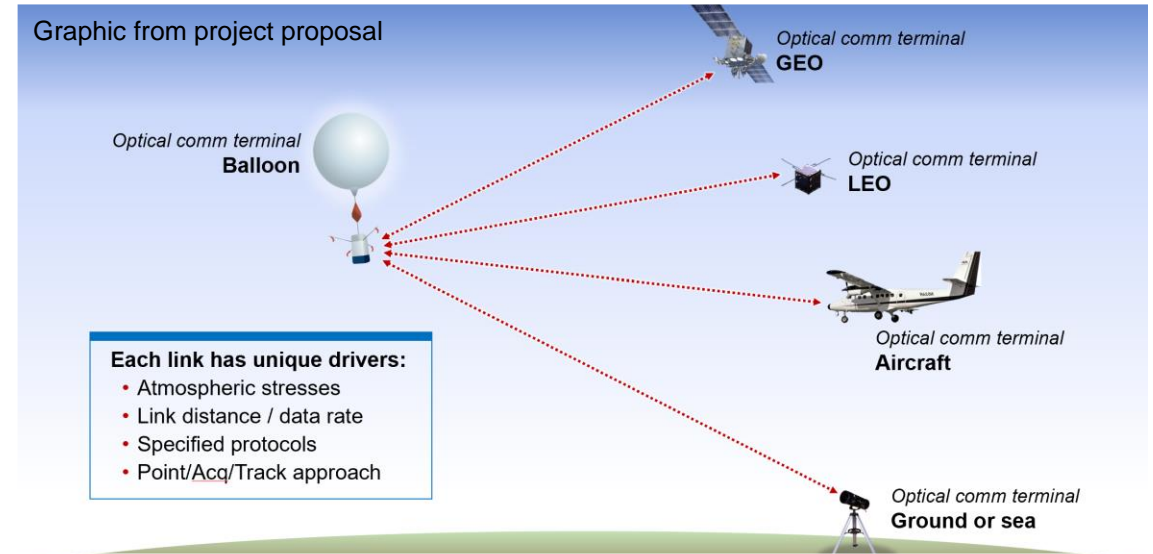


- Ultra Long Duration Balloon (ULDB) Test Flights:
  - 7th & 8th test flight of the 18.8 MCF Super Pressure Balloon
  - 5th & 6th test flight from New Zealand
- Campaign Primary Objective:
  - Demonstrate the 18.8 MCF Super Pressure Balloon system
- Campaign Window:
  - Late March- early June candidate window
  - Specific launch time not required for primary objective
- Payload:
  - Diagnostic Instrumentation
  - Science Mission of Opportunity
- Flight Duration:
  - Overall program seeks to demonstrate up to 100 days of flight
  - Minimum criteria of 5 days
- Recovery:
  - Desire, but not required
  - Realtime decision based on mission performance status & safety



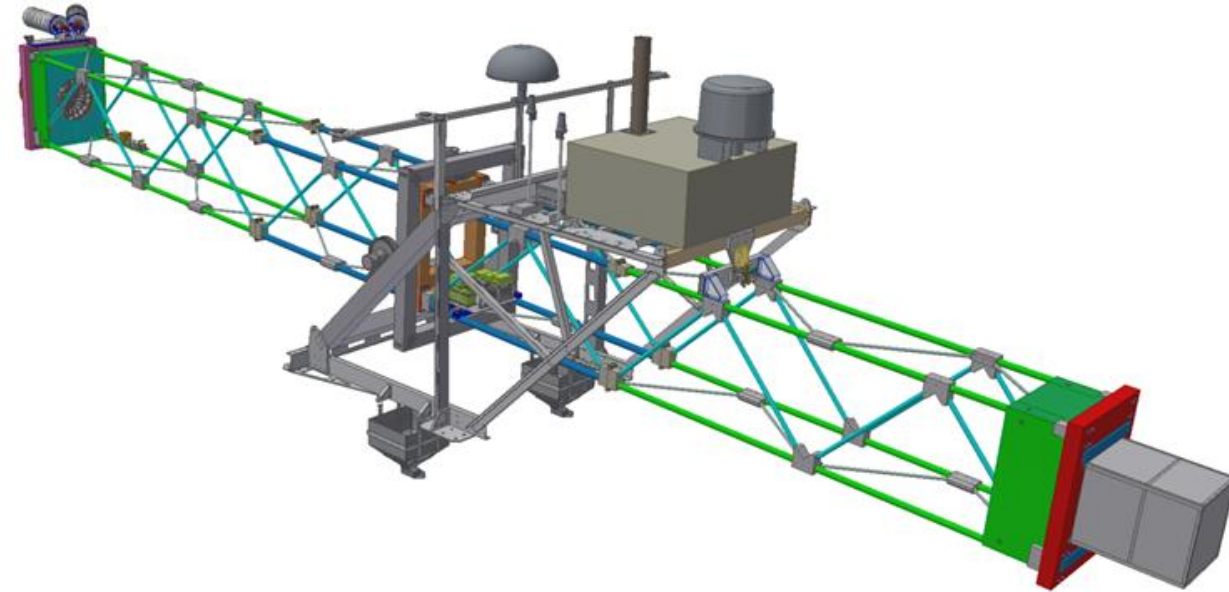
- Research into commercial satellite communication alternatives.
  - Exploring LEO satellite constellations but are constrained to mid-latitude and equatorial regions.
  - Power draw will likely be an issue.
  - TDRSS is end-of-life.

- Application of laser communication for balloon missions will begin with a feasibility study tentatively late 2022 or early 2023.

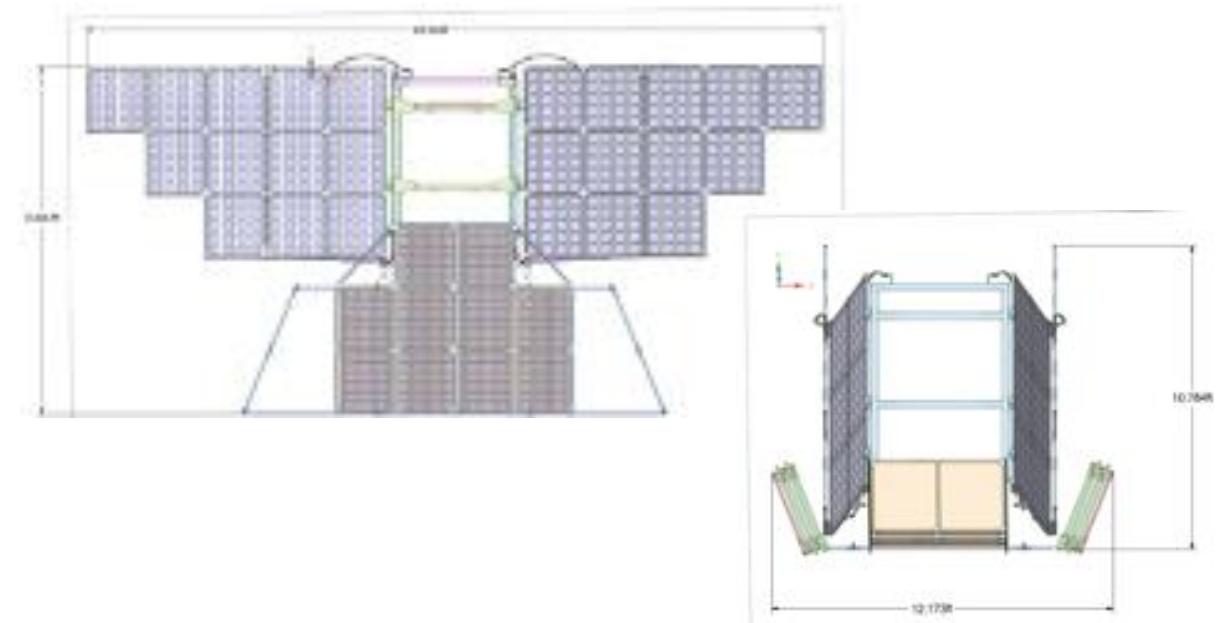


Balloon Type	Zero Pressure (ZP) Hand Launch (HL) - Conventional	ZP - Conventional	ZP – Long Duration	Super Pressure (SP) – Long and Ultra-long duration
Current Telemetry Offerings	Iridium Based LOS/OTH Up to 12 Mbit LOS option	LOS systems with up to 12 Mbit LOS options	LOS and OTH options Up to 12Mbit LOS option OTH Iridium Short Burst Data OTH TDRS 1Mbit option	LOS and OTH options Up to shared 12Mbit LOS option OTH Iridium Short Burst Data OTH Shared TDRS 1Mbit

- Reducing mass of the support equipment and gondola is a high priority to maximize available science mass.
- Modernization of termination and recovery systems.
  - In-depth study of design and materials for the parachute, cables, risers, lines, and crush pads is ongoing.
  - Electronic commanding will be analyzed during the next phase.
  - Planned test flight in fall 2024.
- Modernization and standardization of support instrumentation will involve a complete redesign based on current requirements.
- Optimization of gondola frames will round out the total testing plan and allow for easier plug-and-play architectures for science teams.



Increased requirements for size is a component driving the need for light-weighting  
 - Example above is the XL-CALIBUR payload using the WASP gondola



- Increased launch opportunities can be obtained by reducing the size (footprint) of the suspended body.
- We are assessing the feasibility of utilizing stowed, folding solar array panels which can be deployed later in flight once the balloon is clear of highly populated areas.
- Testing is planned in the fall of 2023.

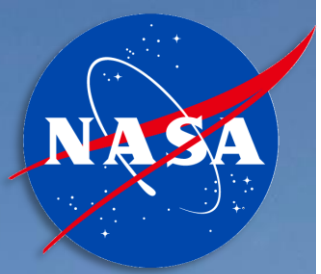
- High-efficiency solar array research is currently in the trade study phase looking at off-the-shelf products.
- Research into high energy density batteries will follow a similar schedule of trade study, lab testing, and test flight.
  - That work is scheduled to begin sometime in 2026.

- **Qualification of the 60 MCF balloon for altitudes above 48 km**
- Flight #1 & #2 – 685NT & 687NT
- Demonstrated successful launch, ascent and float of the 60 MCF vehicle.
  - Total Suspended: 1,650 lbs
  - Float Altitude #1: ~156.2kft
  - Float Altitude #2: ~156.8 kft
  - Total Flight Time #1: 7 hours and 57 minutes
  - Total Flight Time #2: 9 hours and 36 minutes
- Flight #3 planned in Sweden May/June 2022

- **Sensor Package for Attitude, Rotation, and Relative Observable Winds (SPARROW)**
  - To measure the relative winds seen by the gondola during the ascent, float, and descent phases of flight.
  - Identified as a critical milestone for Trajectory Control System (TCS) development.
  - Provide data to verify/validate performance simulations
  - Develop the required software and hardware to support the custom ultrasonic anemometer and other sensors.

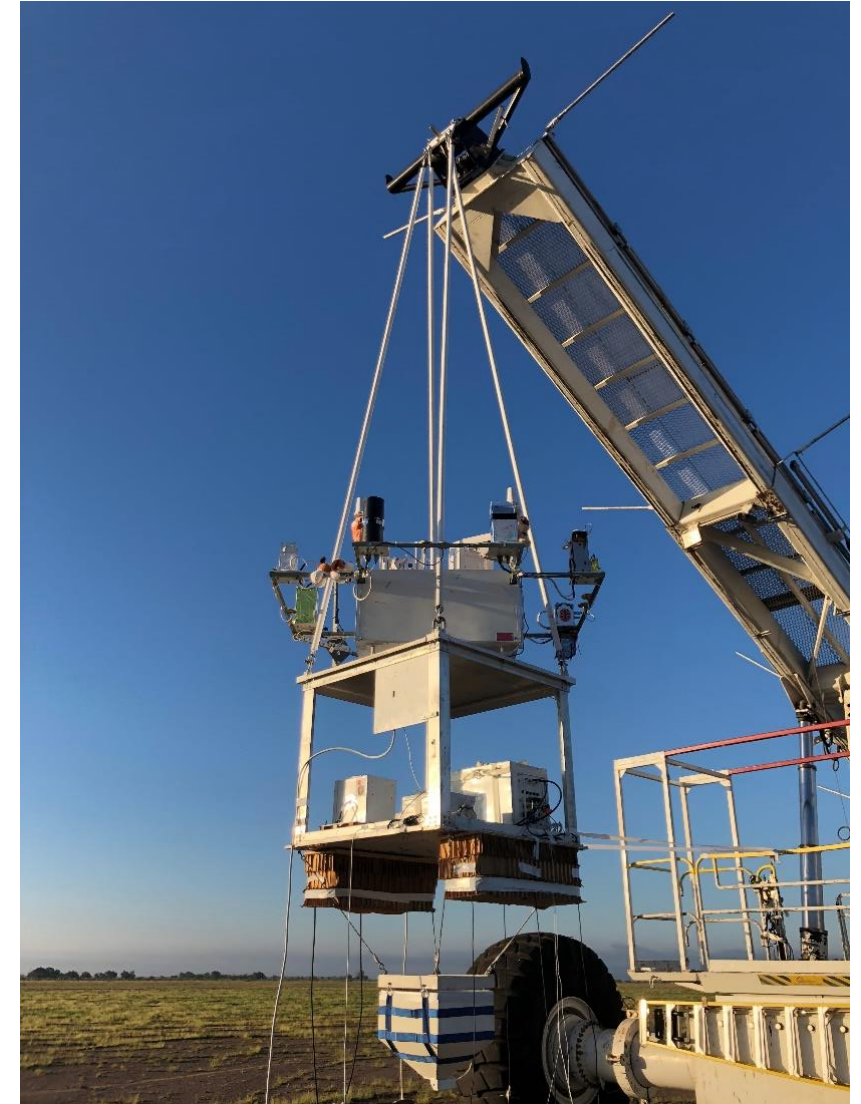
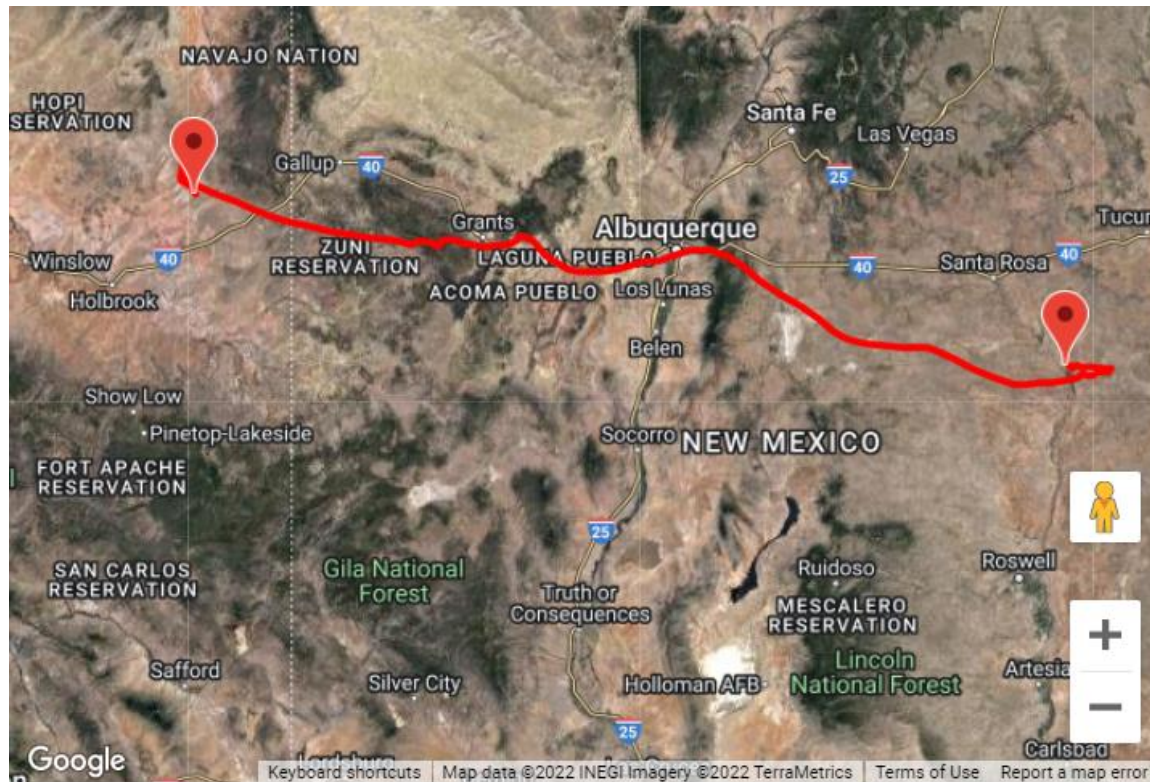


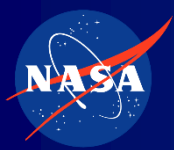
# *Student Opportunities*



## HASP – Flight 716N – *Dr. Gregory Guzik, Louisiana Space Consortium*

- ❖ High Altitude Student Platform (HASP) provides launch opportunity for experiments designed and built by students at universities worldwide.
- ❖ Fifteenth launch since inception of project.
- ❖ Launched: 14 September 2021 / 14:02:08 Z
- ❖ Terminated: 15 September 2021 / 06:03:34 Z
- ❖ Total Flight Time: 16 hours and 46 minutes





# FY21 Fort Sumner – HASP Student Payloads



Goddard Space Flight Center

Wallops Flight Facility

Payload Number	Name	Institution
1	Stratospheric Measurements of Charged and Neutral Radiation	McMaster University
2	OreSat1B - Environmental Testing of OreSat Subsystems	Westview High School & Portland State University
3	Calculating Orientation and Measuring Pointing Angle for Scientific Systems (COMPASS)	Louisiana State University
4	RAT (Radiation vs Altitude and Time)	Fort Lewis College
5	WANKA – A Mission to Measure Stratospheric Aerosols Parameters Using Low - Cost Commercial Sensors	Universidad Nacional de Ingeniería (PERU)
6	Measuring the Speed of Sound inside simulated Asteroid Regolith in the HASP environment. “MESSAR-1”	Inter-American University of Puerto Rico
7	Measurements of Bad Ozone in Troposphere and Good Ozone in Stratosphere Using Improved Sensors	University of North Florida and University of North Dakota
8	Antimatter Particle Scintillator	College of The Canyons
9	Gannon University Cosmic-Ray Calorimeter 3.0 (GU-CRC3)	Gannon University
10	Project WWASP’s (sub-millimeter Water Wave SPectrometer)	Arizona State University
11	Montana Space Grant Consortium Eclipse Payload Testing	Montana State University



2018-09-05 00:24:14

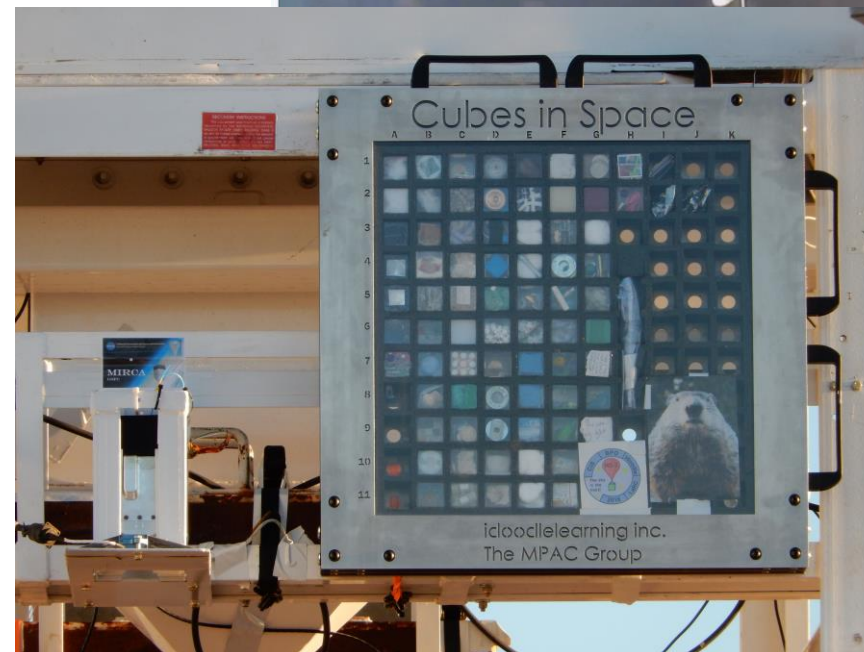


For more information visit: <https://laspaces.lsu.edu/hasp/>

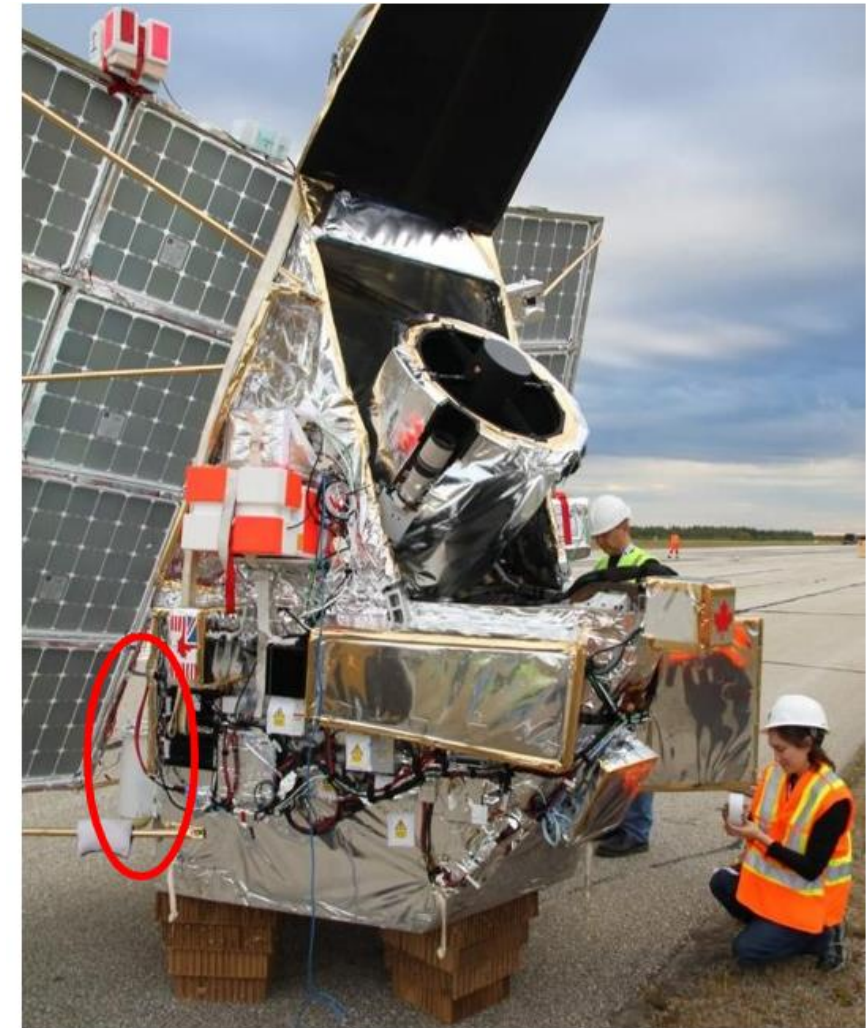
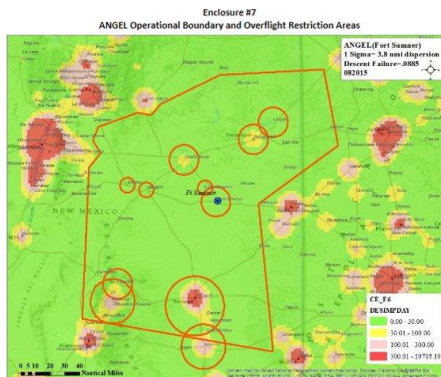
- *Free program begins each fall*
- *Ages 11-18*
- *Provides a curriculum*
- *Opportunity to fly on Sounding Rocket or Scientific Balloon*
- *For more information contact:*  
[info@cubesinspace.com](mailto:info@cubesinspace.com)
- *And visit:*  
<http://www.cubesinspace.com/>

NASA CSBF Operations

973,267 TOTAL VIEWS • 1,372 FOLLOWERS • FOLLOWING



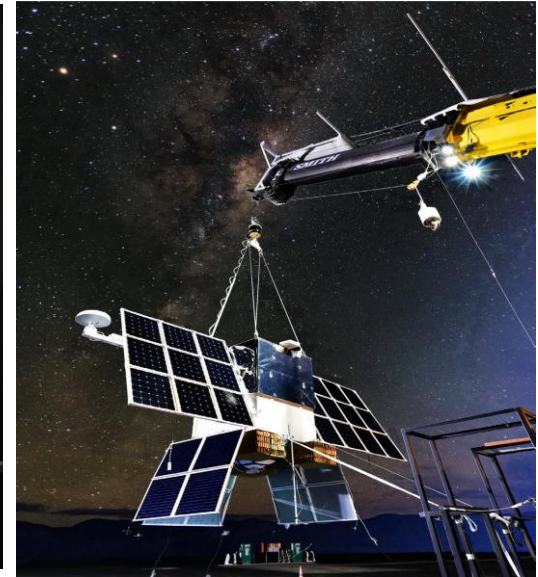
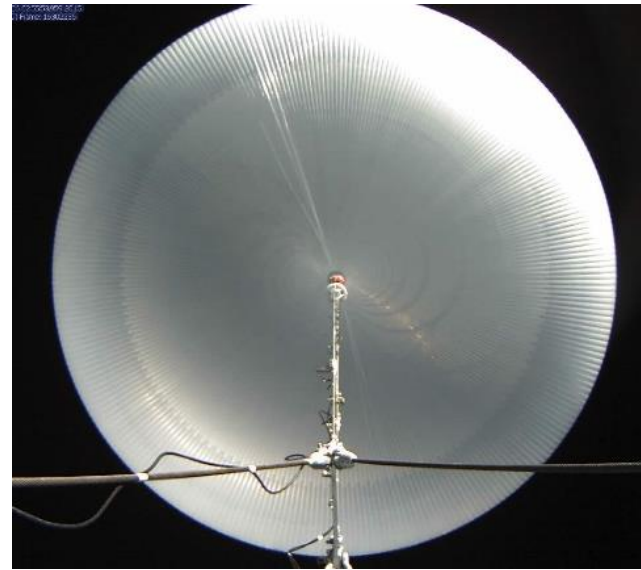
- Formulate, Lift, Observe And Testing the FLOAT student design challenge series. DRAGON edition: Data Recovery And Guided On-board Node
- Teams of students and their faculty advisors will design and prototype ideas for a guided data vault recovery system consisting of: 1) a deployer that can be mounted to a HASP-type balloon/gondola; and 2) a node that can be dropped and fall gracefully to a pre-determined, safe waypoint for recovery.
- Notice of Intent due September 15, 2022
- Finalists selected January 30, 2023
- Integration and flight beginning August 15, 2023



SuperBIT payload in 2019 ahead of a flight from Timmins, Canada, next to an engineer for scale. Note the data vault deployer (in red). Taken from: <https://www.space.com/balloon-space-telescope-design-superbit>

For more information visit: <https://FLOATingDRAGON.nianet.org>

- The NASA Balloon Program has continued to provide stable platforms for science.
- The NASA Balloon Program encourages feedback from the science community on future needs.
- 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 CSBF, Raven Aerostar, the science community, and our support contractors!*