NASA Balloon Program
JHU Small Missions Workshop
JHU, June 10, 2019

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Why Balloon Payloads?

*Balloons* have provided fundamental discoveries of our Earth, the Sun, the solar system, and the universe, and have also played an important role in developing and validating space technologies as well as train future leaders of the field.

About **Half** of the suborbital PI are first-time suborbital PIs.
Balloon Program Overview

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
Balloon Paylods Low-Cost Rapid Access to Space

Balloon payloads are funded through R&A awards (up to 5 years)

PI lead effort,

PI is in full control of the mission from proposal, instrument development, inflight operations, data analysis, to publication.

NASA is in control of the platform and launch operations.

Balloon payloads are Microcosm of large-scale Missions

Students fully engaged in entire mission lifecycle within graduate school tenure

- Define Science Questions
- Science Requirements Flowdown to Technical Requirements
- Design and Fabrication
- Testing, Integration, and Calibration Experiment/Payload
- Staging, Launch, Recovery, Data Analysis and Presentation

Acceptance of Appropriate Risk and Risk Mitigation

Value lies in building the instrument and the carrying out of the mission

- Suborbital program is operated under NPR 7120.8
- New Science is defined. Technology Readiness is raised to Flight Level (TRL-7).
- Failures that are encountered are in low cost environment. Lessons are learned.
- Systems are exercised prior to deployment on more advanced missions
- Proof of Science and Technical Concepts
Balloon Program Office (BPO)

• Astrophysics Division manages the Balloon Program for all of NASA.

• The Balloon Program Office at WFF (Code 820) provides implementation:
  – Day-to-day operation of the Balloon Program.
  – Management/Oversight of the Contractor (NG) operating the Columbia Scientific Balloon Facility (CSBF) in Palestine, TX (Campaign, balloon launch).
  – Safety and Mission Assurance (Range, Overflight, and Termination).
  – Since 2016 the Palestine Base is NASA Property.

• BPO manages balloon technologies/capabilities development
  – New balloons (Super Pressure Balloon, 60 MCF).
  – Wallops Arc Second Pointer (WASP).
  – New Launch Sites (Wanaka, New Zealand).

• BPO provides consulting on balloon launch activities outside of the SMD mission model (within or outside of US Government, reimbursable)
Balloon Platform Overview

Balloons Payloads

- Float altitude 34 km (super pressure) to 39 km (conventional)
- Float time of average 21 days (conventional) and 60-100 days (super pressure)
- Payload Masses up to 1000 kg (super pressure) to 3600 kg (conventional)
- Experimenter provides gondola
- Fine pointing ~1” is available (WASP)
- Science Disciplines: Particle Astrophysics, γ-ray, hard X-ray, 2100 ± 100 Å window far-IR, sub-mm
- Recoverable/re-flyable
BPO Launch Sites

- Kiruna, Swe
- Alice Springs, Aus
- Wanaka, NZ
- McMurdo, Ant
- Ft. Sumner, Nm
- Palestine, Tx
- Established Launch Site
- New Launch Site
Success Completion of the Sweden 2018 Campaign

AESOP Lite - Flight 682N
Launch May 15, 2018
Duration 5 Days 16 Hours

HiWIND - Flight 683N
Launch June 24, 2018
Duration 5 Days 16 Hours

PMC-Turbo - Flight 684N
Launch July 8, 2018
Duration 5 Days 18 Hours
Successful Completion of Palestine 2018 Campaign

SuperBIT Flight # 1599P
Launch June 6, 2018
17.5 Hours at float

ASCOT Flight # 1600P
Launch July 5, 2018
5 Hours at float
LDB Camp near McMurdo Station, Antarctica

NASA Antarctica LDB program is enabled by support from NSF Office for Polar Program, who operate US Antarctica research stations.

STO-2 trajectory of ~22 days, launch 12/8/2016
Since 2006, NASA utilizes two buildings for payload integration:
- Increasing payloads size often requires one payload per building.
- In some cases, two payloads can share an integration building.
- If needed, a third payload could be accommodated in the Weatherport, a temporary structure.
FY17 Launches from Antarctica

BACCUS ~50 nm from McM, ANITA ~170 nm from SP, and STO-2 1000 feet from SP travers.
Antarctica LDB Campaigns FY18–19

FY18:
• One payload deployed.
• No launch from Antarctica, despite 17 launch attempts.
• All launch attempts had to be scrubbed due to poor ground weather.
• SuperTIGER wintered over in Payload Building for FY19.

FY19:
• LDB camp opening was delayed by ~3 weeks, due to bad weather around McMurdo.
• Three science payloads deployed plus a trajectory pathfinder for GUSTO.
• First two launches (SuperTIGER and X-Calibur) had anomalies due to Balloon leaks.
• BLAST wintering over for FY20, Polar Vortex was starting to break down and minimum flight requirements for science could not be met.
Antarctic LDB flight Durations

Flight Duration for Antarctic LDB Payloads

Average Flight Duration is 20 days.
Super Pressure Balloon and Southern Hemisphere mid-latitude ULDB Flights

Super-Pressure: Ultra Long Duration Balloon (ULDB) "Pumpkin"

Inflated volume ~ 18.8 MCF
1 ton of science to 110,000 feet
Super pressure maintains balloon volume even with diurnal changes

Wanaka, NZ, is the newest mid-latitude location that meets safety constraints for launch with acceptable trajectories offering land termination locations in South America.
Compton Spectrometer and Imager (COSI) was launched on May 16, 2016 and stayed at float for 46 days observing the gamma-ray emission from our Milky Way galaxy.

On May 30 COSI detected a gamma-ray burst.

published first results
https://arxiv.org/abs/1701.05558
Launches from Wanaka, NZ

- COSI launch was conducted on the runway. Due to frequent launch attempts, airport operation was adversely impacted.
- New launch pad has been constructed away from the runway, so flight operations has to only be halted during inflation and launch not for rollout and layout.
- Presently, the Hanger used for integration limits supportable payload size.
- In out years, NASA is planning to construct a payload assembly building.
## Number of Flights by Discipline

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GUSTO the Explorer Suborbital Mission

GUSTO, led by PI Chris Walker from the University of Arizona, is an Astrophysics Explorer (MO) balloon mission and is an advanced version of STO-2.

GUSTO uses large scale surveys & spectral diagnostics of the ISM to answer key questions about the Life Cycle of the ISM and massive star formation.

Explorer are operation under a more stringent Project Management (NPR 7120.5) than the Balloon Program. The PI and the Explorer Program Office have tailored the Program Management for GUSTO to maintain the lower cost benefits of the balloon program while meeting the mission assurance and success requirements for an Explorer Mission.
GUSTO Mission Summary

GUSTO surveys will provide Milky Way and LMC templates from which star formation can be understood throughout cosmic time. ~300 dedicated SOFIA flights are required for GUSTO survey.

SPB trajectory pathfinder for GUSTO: FY19, >70 days.

Flight Strategy: Launch on SPB from McM and allow payload to leave continent. Instrument recovery preferred, but optional. Baseline mission requires ~75 days, acceptable threshold mission requires 20 days, cryogen life time for >100 days.
STO-2 [CII] On-the-Fly Map of Carina Nebula
Accomplishments and Future GUSTO Milestones

March 12, 2019  GUSTO was confirmed by HQ to proceed into Phase C Peer-Review of Subsystems.

Late July 2019  Critical Design Review (TBC).

Mid Dec 2021  Target Launch Date from LDB in Antarctica.
### Acronyms

<table>
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<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tr>
<td>APD</td>
<td>Astrophysics Division in the Science Mission Directorate at NASA HQ</td>
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<td>ACER</td>
<td>Advanced Collar Electronics</td>
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<td>BPO</td>
<td>Balloon Program Office at Wallops Flight Facility</td>
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<td>CSBF</td>
<td>Columbia Scientific Balloon Facility</td>
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<td>EC</td>
<td>Executive Council</td>
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<td>EUSO</td>
<td>Extreme Universe Space Observatory</td>
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<td>LDB</td>
<td>Long Duration Ballooning</td>
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<td>Million Cubic Feet</td>
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<td>SPB</td>
<td>Super-Pressure Balloon</td>
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<tr>
<td>WFF</td>
<td>Wallops Flight Facility</td>
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</table>
SuperTIGER Balloon Leak Summary

SuperTIGER PI is Brian Rauch from Washington U, St Louis.

Super Trans Iron Galactic Element Recorder is Particle Astrophysics payload measuring abundance of ultra-heavy element in the cosmic-radiation.

Launched from Antarctica on 2018-12-19.

Balloon failed to reach design float altitude.

Science minimum was not achieved.

Full payload recovery and post-recovery instrument verification.

Ascent rate initially nominal up to ~22.3 km, then simulation is best match with 0.041 m² hole opened 2.7 hours after launch at inflation tube.
X-Calibur Balloon Leak Summary

X-Calibur PI Hernic Krawczynski from Washington U, St Louis.
X-Calibur is a pointing X-ray (20-60 keV) polarimeter with an 8 m truss.
Launched from Antarctica on 2019-12-29, 74 hours float time.
Science minimum was not achieved, however, team was able to observe two source (GX 301-2, Vela X-1) for ~ 1.5 days.
High-priority science items have been recovered.
Balloon reached design float altitude and began slow decent late on day 2.

Best match is small hole expanding at 43 hours after launch.