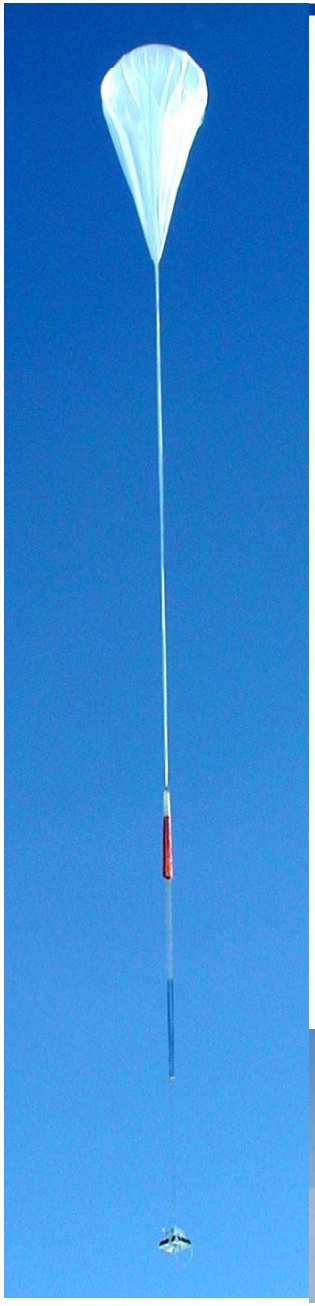

NASA Balloons Return To Flight Update To the Astrophysics Subcommittee Meeting

February 23-24, 2012

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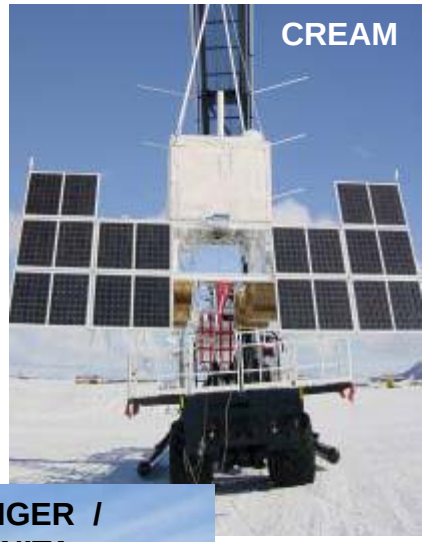
Science Mission Directorate
NASA Headquarters

AGENDA

- Introduction
- Australia Mishap Response
- Corrective Action Plan and Lessons Learned
- Changes to Balloon Operations
  - Actions, Documentation
  - Hazard Areas/ Road Blocks
- Safety Process Toward Launch
- Changes for Balloon Operations
- Operations Assessment after Return To Flight
- Feedback from the Science Community
- Mission Assurance-related Program Changes
- Acknowledgements

Introduction - NASA Balloon Program

- The Balloon Program provides launch and mission services for scientific, technological, and Educational investigations that can be achieved with scientific balloon platforms.
- NASA enacts **Safety** and **Mission Assurance** functions separately for Suborbital (Balloons) missions.
- **Safety** - Implemented to the fullest extent of agency policies. The Balloon program works with WFF Safety Office to identify hazards associated with the payload/mission and institute/verify controls. WFF safety independently assures suborbital compliance with safety requirements.
- **Mission Assurance** - Balloons is defined by acceptable level of Mission Success – Not Safety. The 85% success rate is used to gauge mission success of the carrier and the science payload.



Balloon Mishap Response

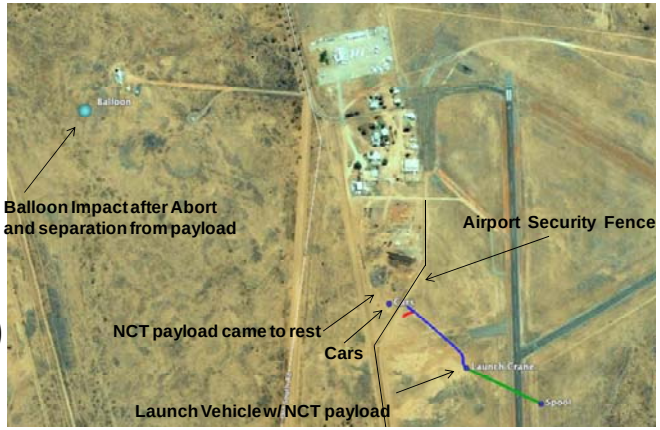
• During the launch attempt of the Nuclear Compton Telescope (NCT) on April 28, 2010, the Balloon Program suffered a high visibility mishap, damaging the NCT payload and posing a grave threat to public safety.

• The Balloon Program stood down for 7 months and worked to implement the Mishap Investigation Board's recommendations to protect crew, science and public.

• The Balloon Program returned to flight (December 2010) for the Antarctica Campaign, utilizing the new Safety processes. Balloons conducted Return To Flight Reviews for each campaign location.

• NASA Safety Leadership (OSMA, SMD, GSFC, WFF/SSOPD, Balloon Program Office and WFF Safety) believe the corrective actions undertaken will make the balloon program a safer, more effective program in the future.

• Wallops Safety Leadership is committed to long term implementation of the Corrective Action Plan for all future balloon launch campaigns, and will work with the science community to refine processes to ensure teams can effectively process for launch.



Corrective Action Plan

- The Balloon Program completed the Corrective Action Plan in response to the NCT MIB report to ensure NASA can safely conduct balloon missions. Principle elements of BPO's corrective actions include:

  - The Balloon Program revised ground and flight safety documentation and developed hazard areas to ensure safe execution at launches.

  - Wallops leadership developed new roles at launches, formally defined launch commit, abort & contingency protocols. NASA Range Safety Officer(RSO) participates in launches and serves as the single person (independent of the program) with unquestioned authority to call for a stop during operations.

  - The Balloon Program now completes Interim Response Team (IRT), hazardous systems certifications, and procedural training for each balloon mission. The Balloon Program conducts table top simulations with Safety and the science teams prior to launch.

  - CSBF corrected the design of the launch mechanism, with independent NASA engineering review and successful qualification testing. CSBF completes launch vehicle certification tests prior to each and every campaign.

  - BPO & Safety now co-chair the payload FRR reviews (The PI attends). The WFF Director conducts an Authority to Proceed (ATP) review prior to approving launch operations for the campaign.

Balloon Corrective Actions / Lessons Learned

MIB Finding/ Recommendation	Corrective Action	Lesson Learned
Lack of formal ground and flight safety documentation, and hazard Analyses.	Completed formal hazard analyses, ground and flight Safety Plans with Independent Review prior to FRR. (BPO/CSBF)	Independent review strengthened ground and flight safety processes. New hazardous procedures implemented for payload integration and launch process are independently observed. (BPO/CSBF)
Ground Safety Plan did not cover all relevant hazards	Operations processes modified to incorporate NASA requirements for payload processing. (BPO)	Payload specific hazardous procedures now formally approved by Ground Safety. (PI Input)
Lack of formal procedure exists for the launch process.	Implemented a Launch Procedure for launches. (BPO)	Procedure ensures independent safety oversight of launch. (BPO). Implemented new NASA Roles at launches (OSS, RSO, MM), with launch/abort commit criteria. (NASA Safety)
Lack of training or preparation for anomalous scenarios	Completed Hazard, Safety, and Interim Response Team (IRT) Training. Conducted live Abort. (BPO/CSBF)	Complete NASA training for each campaign. Lifting Certification Training for Science Teams. (PI) Crew exhibit strict adherence to PPE usage. Live Abort test conducted in 2012. IRT Go-kits assembled for each campaign. (BPO/CSBF)
WFF Safety Leadership did not provide appropriate RSO oversight at launch	RSO role/responsibility with Unquestioned Authority was implemented (NASA Safety)	RSO role successfully administered. Ensure independent oversight of launch rules. No impact to Launch Process. (NASA Safety)

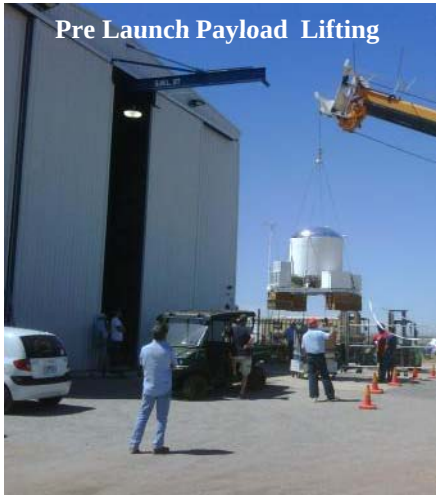
Balloon Corrective Actions / Lessons Learned

MIB Finding/ Recommendation	Corrective Action	Lesson Learned
Failure to layout and operate within the proper hazard area	Created fixed, clearly defined and marked Launch Hazard Areas (BPO/CSBF)	Hazard Areas worked well. Personnel stations properly implemented. Road blocks are established/coordinated by CSBF. (BPO/CSBF)
Did not properly manage the risk during the launch phase	Implemented improved launch safety process, with Launch Commit Criteria (BPO/CSBF)	Ground and Flight plans with NASA safety have improved launch safety process. Commit Criteria with Go-No Go criteria has worked well. (BPO/CSBF)
Inadequate safety requirements to protect the public. [1]	BPO conducted table top simulations and dress rehearsals with Safety, CSBF, and science teams. (BPO/CSBF)	Dress Rehearsals improved understanding of safety limits and ops planning; Allowed personnel to think through reactions to off nominal cases prior to operations. (BPO/CSBF/PI)
Inadequate safety requirements to protect the public. [2]	BPO/CSBF coordinated with local officials to coordinate road closures (BPO/CSBF)	Provided security for roadblocks and assured 100% compliance with Safety Plans. No intrusions, no problems with launch hazard area. (BPO/CSBF)

Changes to Balloon Operations

Pre-Launch

- Science Teams are required to complete necessary lifting training, now provided/coordinated by CSBF for timing with integration in Texas.
- NASA accepts institutional operations training (e.g., cryo, pressure), but requires hazardous operational procedures and safety supervision.
- Science Teams submit hazardous procedures for review. BPO/CSBF assess hazards and prepare ground and flight safety plans which are approved by NASA Safety. NASA walks through plans with Science teams as part of the table top simulations prior to launch.
- NASA or CSBF Ground Safety support prelaunch I&T and flight line testing/calibration. (e.g., Lifting /Cryogen handling operations)


Pre Launch Payload Lifting

Launch

- Science Teams utilize Personal Protective Equipment and are involved in payload preps/ Go-No-Go decisions until launch.
- Science Teams work with Ground Safety to complete final preps.
- Science Teams have access within Launch Hazard Areas during launch. Payload activities on the flight line during launch operations are controlled and coordinated with science teams.

Payload Pickup, HERO, 4/18/11

Post-Launch

- Science Teams are required to complete payload recovery plans.
- Access to payload after a mishap/anomaly is restricted, until released by NASA Safety.

Safety Process Toward Launch

Mission Element	Status	Description
Lessons Learned from Previous Camp.	Green	Completed
Assess and Flight Anomalies	Green	Assess Fixes/Lessons Learned
Safety Roles/Personnel (OSS,RSO)	Green	Identify before PIC
Safety Documentation	Green	Approval before MRR
Documentation Review by OSMA	Green	To be completed prior to FRR
Safety Training	Green	To be completed prior to FRR
Pre-Mishap Plans & IRT Training	Green	To be completed prior to FRR
Hazard Areas at Launch Site	Green	Defined prior to FRR
Launch Limit Area	Green	Perimeter marked with flags
Roadblocks	Green	Defined prior to FRR
Flight Safety Analysis	Green	To be completed prior to FRR
Launch Equipment	Green	Certification before Operations
Table Top Simulations/Dress Rehearsal	Green	Complete prior to FRR

Hazardous Procedures

Item	Name	Procedure Owner	Status
OF-603-02, Rev. A	Launch Equipment Configuration Certification (LECC)	CSBF	Approved
ES-IOO-20-P, Rev. A	CSBF Ordnance Pre-Flight and Flight Line Checkout	CSBF	Approved
OF-322-15-C, Rev. A	Balloon Inflation (BI) Operations Procedure	CSBF	Approved
OF-434-00-C, Rev. A	Helium Compression Hazardous Procedure	CSBF	Approved
ES-IOO-15-P, Rev. A	SPB Top Hat Package Pre-Flight & Flight line Checkout Hazardous Procedure	CSBF	Approved
820-PROC-2011-04	Payload General Lifting Procedure	Science Team	Approved
820-PROC-2011-05	Payload Gas Filling Procedure	Science Team	Approved
820-PROC-2011-06	AESOP/LEE Instrument Shell Leak Test Procedure	Science Team	Approved
820-PROC-2011-07	Payload Gondola Assembly Lifting Procedures	Science Team	Approved

Launch Vehicle Field Tests Prior to Operations

CSBF completes Launch Vehicle Certification Tests (LECC) at the maximum gross inflation (14,500 lbs) prior to the FRR.

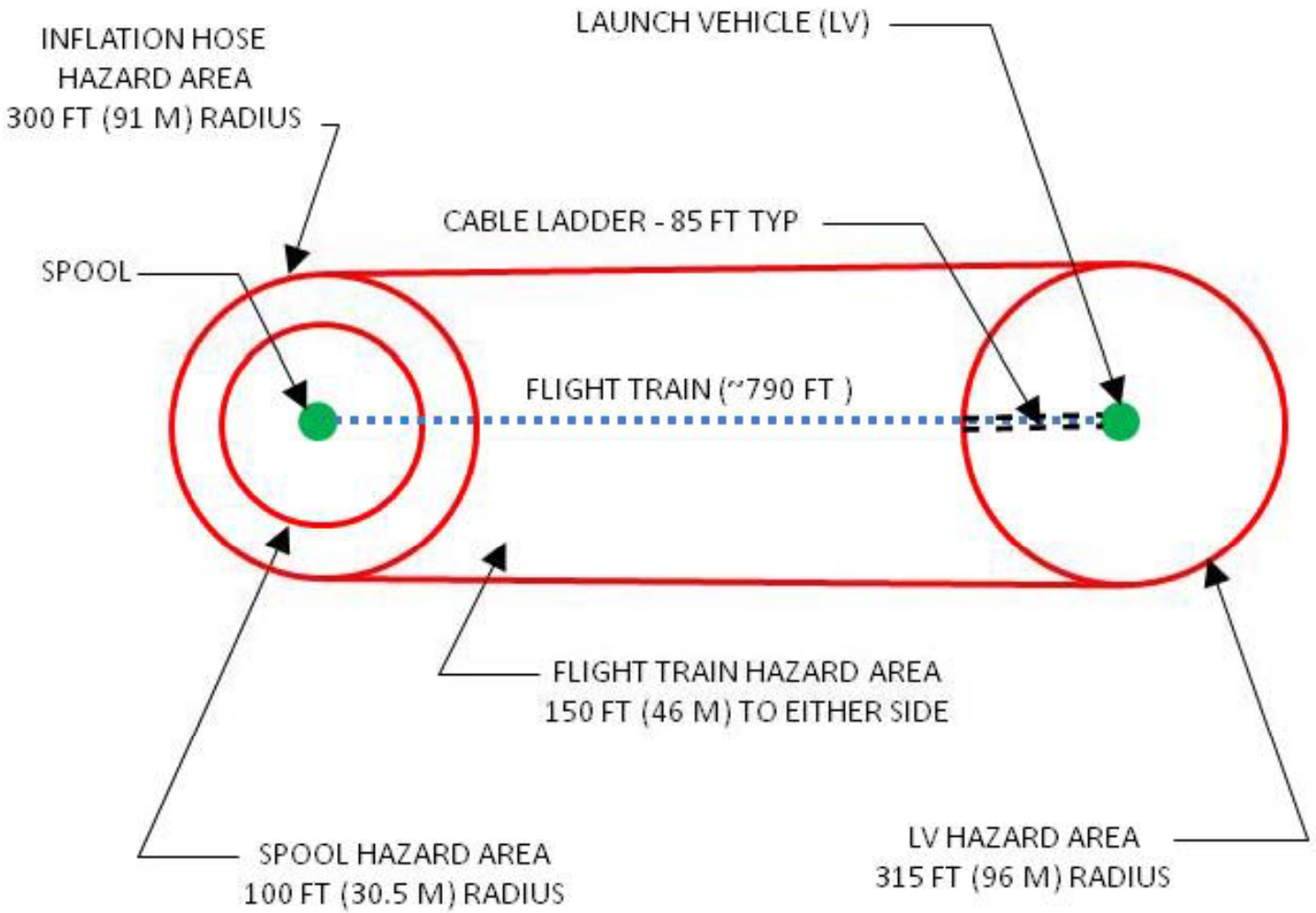
Launch Vehicle Cert Test (LECC)

CSBF completes Launch Head Certification “drop test” at the specified qualification load of 3600lbs prior to the LECC.


Launch Head Cert Drop Test at 3600Lbs

Balloon Launch Pad Operations Perimeter is marked

Pre-Launch Danger Area is Established on Pad



Pad Area/Hazard Areas During Balloon Layout

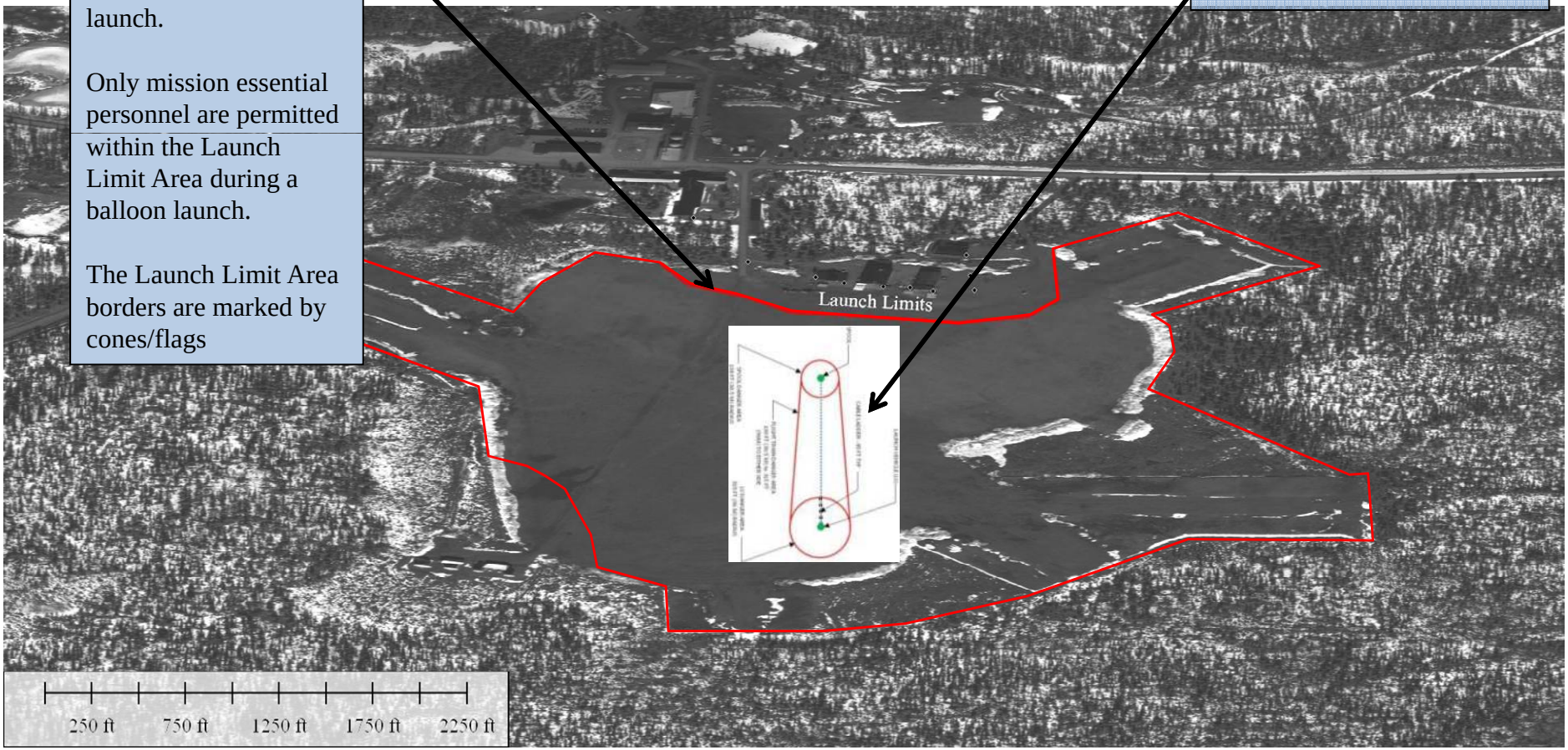
Launch Limit Area:
The **FIXED** Category A launch hazard zone in which the launch vehicle can maneuver to conduct the balloon launch.

Only mission essential personnel are permitted within the Launch Limit Area during a balloon launch.

The Launch Limit Area borders are marked by cones/flags

Pre-launch Danger Area

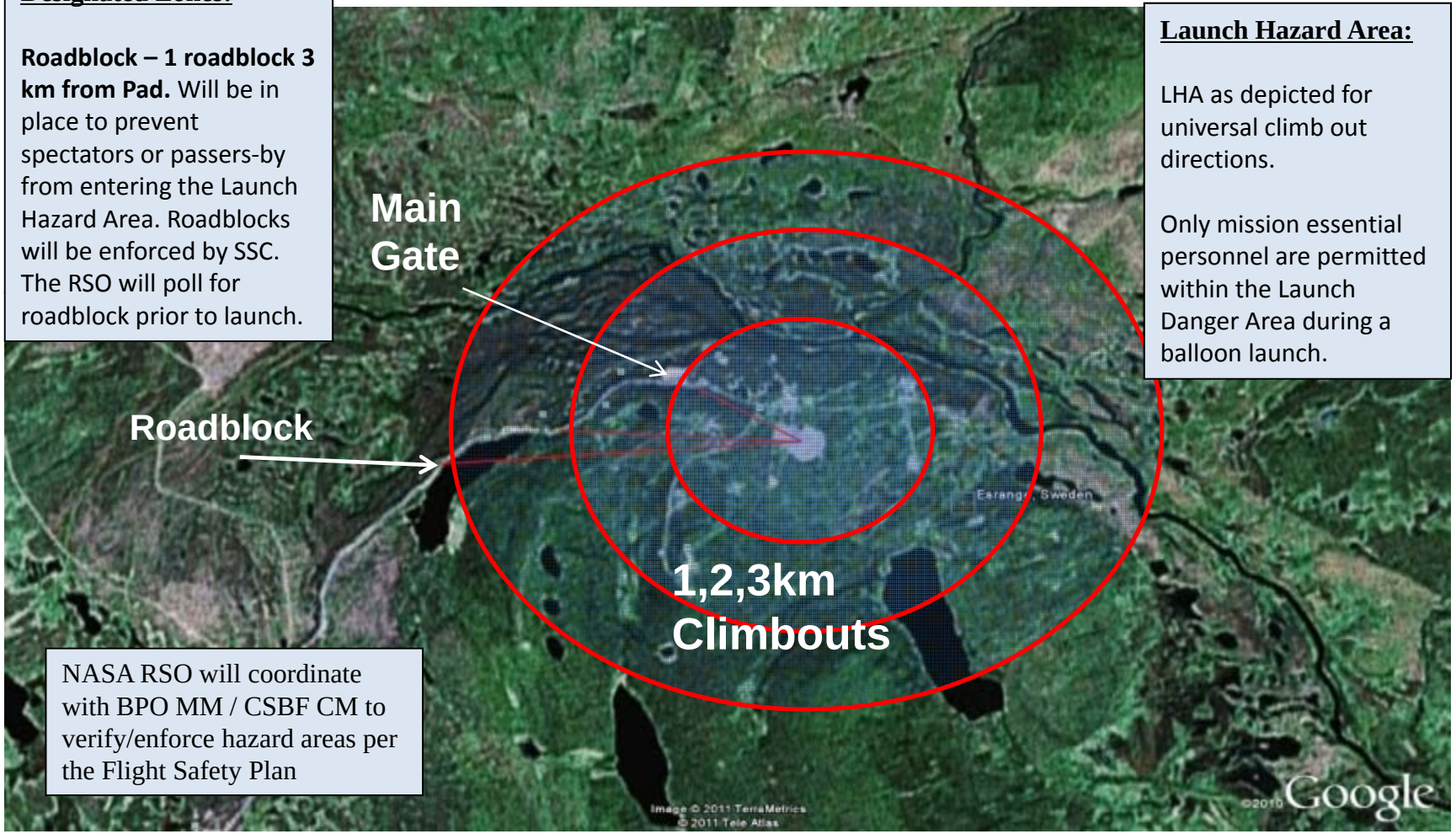
PLDA = 315 ft about payload launch vehicle



Down Range Launch Hazard Areas

Designated Zones:

Roadblock – 1 roadblock 3 km from Pad. Will be in place to prevent spectators or passers-by from entering the Launch Hazard Area. Roadblocks will be enforced by SSC. The RSO will poll for roadblock prior to launch.



Launch Hazard Area:

LHA as depicted for universal climb out directions.

Only mission essential personnel are permitted within the Launch Danger Area during a balloon launch.

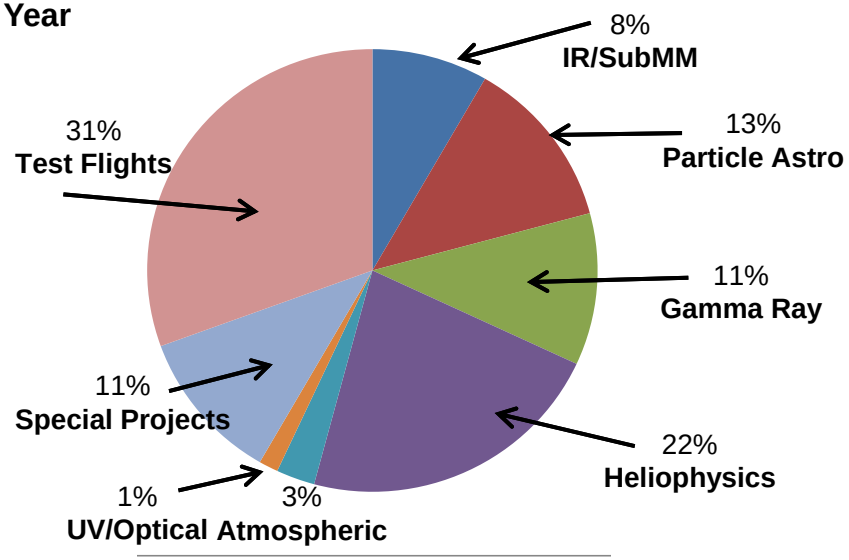
NASA RSO will coordinate with BPO MM / CSBF CM to verify/enforce hazard areas per the Flight Safety Plan

Flight Rates During Return To Flight (FY11)

Discipline	FY 08	FY 09	FY 10	FY 11	FY 12
IR/Sub-mm Astrophysics	0	1	1	2	2
Particle Astrophysics	3	3	1	1	1
Gamma Ray/X-Ray Astrophysics	0	1	3	3	1
Heliophysics, Geospace	1	3	4	5	3
Upper Atmos. Research	0	0	0	1	1
UV Optical	0	1	0	0	0
Special Projects	1	1	0	3	3
Test Flight	9	3	2	2	4
Year Total	14	13	11	17	15

DECADAL AVERAGE: 15 Flights per Year

- **During FY11, the Balloon Program completed 17 launches (2 above the decadal average)**
- **Of note, CSBF launched 2 balloons in same day.**



Campaign Activity During Return to Flight (FY11)

• **During FY11, the Balloon Program conducted 3 foreign campaigns (Antarctica, Australia, and Sweden), which is 1 foreign campaign above the decadal average.**

	FY 09	FY 10	FY 11	FY12
Antarctica	3	6	4	2
Ft. Sumner, Spring	4	0	0	0
Alice Springs, Australia	0	2	1	0
Esrange, Sweden	4	0	3	1
Palestine	0	0	3	1
Ft. Sumner, Fall	2	3	6	11
TOTAL	**13**	**11**	**17**	**15**

Feedback from the Science Community

General Comments (7 PIs were selected from the FY11 launches)

1. **Was the ground safety process prior to shipping to the field an impact for your team ?**
   - "The safety training prior to the campaign took us away from our work, was very useful (a pretty good thing), but only allowed us to become "apprentices", with the need to be monitored all the time by both CSBF and Safety, which created schedule problems over weekends; lifts were more time consuming."
   - "The paper work was not onerous, but required rework of procedures. This required additional effort by the science team to address both training and writing procedures. Having each group write its own procedures is pretty inefficient. Suggest Wallops develop a standard procedure (e.g., cryogen) and groups document deviations."

2. **Was the ground safety implementation in the field an impact toward getting flight ready?**
   - "No, this was fine. The safety team was responsive and supportive. Teams often work evenings preparing for launch, and safety oversight caused teams to adjust schedules. For campaigns with multiple users, ongoing safety support for off-hour I&T, given work hour rules is a concern. Implementation in the field was far less of an impact; however lifting/cryo procedures were cumbersome."

3. **Was the pre-launch simulations and safety discussions for launch day useful?**
   - "The safety discussions were very useful and well conducted. The meetings were informative and confirmed understanding of safety restrictions during the launch."

4. **Was the ground process an impact during the launch process?**
   - "No. The process during layout and prior to launch was efficient." "Yes - we were restricted in where we could be on the flight line, access to the payload, and where to be to see the launch."

5. **Did you lose a launch opportunities because of the safety process?**
   - No one suggested they lost a launch opportunity. " CSBF got 2 launches off in the same day – haven't seen that since the 90's, so it can't be that bad"

6. **Overall assessment of the changes (beneficial, neutral, or detrimental) to your launch?**
   - They understand the rationale and are supportive "We all want a safe environment." The community wants to work with the Program and CSBF to refine the process. The Program has implemented CSBF OSS for FY12 and beyond.

Mission Assurance-related Program Changes

- Safety - As part of Return to Flight, Balloons will meet the requirements for safe operations:
  - Ground and Flight Safety
  - Lifting, Hardware Certification, Gondola design
  - Sense is improvements have been beneficial
- Balloons will hold the line on Mission Assurance.
  - Baseline Program: Acceptable risk (85% success) for payload or carrier success
  - Maintain the success of the Balloon Program and not increase the (document/review) burden on science teams.
  - No better motivation toward success than the science/operations teams doing the work.
- Balloons will look for ways to provide value-added support to the Science Teams where it makes sense:
  - Thermal Modeling of payloads
  - TVAC for select LDB payloads

- Decadal "Polar" LDB Flight History (Antarctica & Sweden)
  - Over last decade (2002-2011)

Vehicle Success Rate: $\frac{\text{Total Flights} - \text{Vehicle Failures}}{\text{Total Flights}} = \frac{29 - 1}{29} = 96.5\,\%$

Instrument Success Rate: $\frac{\text{Total Flights} - \text{Instrument Failures}}{\text{Total Flights}} = \frac{29 - 1}{29} = 96.5\,\%$

Acknowledgements

- Executive oversight of the NASA Balloon Program is provided by the Astrophysics Division, Science Mission Directorate, NASA Headquarters
  - Dr. W. Vernon Jones, Senior Scientist for Suborbital Research
  - Mr. Mark Sistilli, Program Executive
- Implementation of the Balloon Program is delegated to the Goddard Space Flight Center Wallops Flight Facility (WFF) at Wallops Island, Virginia http://www.wff.nasa.gov/balloons
- Balloon flights are conducted by the Columbia Scientific Balloon Facility (CSBF) in Palestine, Texas http://www.csbf.nasa.gov/
- The CSBF is managed by the Physical Science Laboratory, New Mexico State University, under contract with WFF
- The balloons are manufactured by Raven Industries, Aerostar Division in Sulfur Springs, Texas

FY11 Manifest

100% Operations and Missions Success

Principal Investigator (PI) / Institution / Instrument	Discipline	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Antarctica	**Winter 10**												
Seo / UMD / CREAM	Particle Astrophysics			♦	SUCCESS								
Pierce / GSFC / SPB (CO)	Super Pressure Test Flight				♦	SUCCESS							
Devlin / Upenn / BLAST	IR Submillimeter			♦	SUCCESS								
Millan / Dartmouth / BARREL (CO, HL)	Heliophysics			♦♦	SUCCESS								
Australia	**Spring 11**												
Ramsey / MSFC / HERO (CO)	Gamma Ray/X-Ray							♦	SUCCESS				
Sweden	**Spring 11**												
Clem / Udelaware / LEE	Solar and Heliospheric Physics								♦	SUCCESS			
Clem / Udelaware / AESOP	Solar and Heliospheric Physics									♦	SUCCESS		
Wu / NCAR / HIWIND	Geospace Sciences									♦	SUCCESS		
Palestine, Texas	**Summer 11**												
Roberts / ULL / Cajun Probe (CO, HL)	Student Flight Project							♦	SUCCESS				
Fort Sumner, New Mexico	**Fall 11**												
Lubin / UCSB / COFE	IR-Submillimeter									SUCCESS			♦
Guzik / LSU / HASP (CO)	Student Flight Project									SUCCESS		♦	
Guzik / LSU / HASP	Student Flight Project									SUCCESS		♦	
McConnell / UNH / GRAPE / Ryan / FACTEL	Gamma Ray/X-Ray									SUCCESS			♦
Margitan / JPL / REMOTE (CO)	Upper Atmosphere									SUCCESS			♦
Fairbrother / GSFC	Test Flight									SUCCESS			♦
Carryover (CO)													
Hand Lanch (HL)													

FY12 Manifest

Principal Investigator (PI) / Institution / Instrument	Discipline	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Fort Sumner, New Mexico	**Fall 11**													
Stuchlik / GSFC / WASP (CO)	Test Flight	◆	**SUCCESS**											
Sofia / Yale / SDS (CO)	Solar and Heliospheric Physics	◆	**SUCCESS**											
Antarctica	**Winter 11**													
Musser / IU / CREST	Particle Astrophysics			◆	**SUCCESS**									
Walker / UA / STO	IR-Submillimeter				◆	**SUCCESS**								
Sweden	**Summer 12**													
Fairbrother / GSFC / 18 MCF Super Pressure (Note 1)	Test Flight									◇				
Pearce / Sweden KTH / Pogo-Lite / (Reimbursable, Note 2)	Special Projects/Reimbursable									◇				
Palestine, Texas	**Summer 12**													
Guzik / LSU / LEGO (HL)	Special Projects										◇			
Fort Sumner, New Mexico	**Fall 12**													
Fairbrother / GSFC / SF-490	Test Flight											◇		
Kobie / JPL / ASTRA / (Reimbursable)	Geospace Sciences/Reimbursable											◇		
Piszscor / GRC / NSCAP / (Reimbursable)	Special Projects/Reimbursable											◇		
Guzik / LSU / HASP	Student Flight Project												◇	
Grindlay / Harvard / PROTOEXIST	Gamma Ray/X-Ray												◇	
Lin / UCB / GRIPS	Solar and Heliospheric Physics												◇	
Stuchlik / GSFC / Wallops Arc Second Pointer	Test Technology Demo												◇	
Kogut / GSFC / BOBCAT (formerly CULTT)	IR-Submillimeter												◇	
Margitan / JPL / REMOTE	Upper Atmosphere													◇

Notes:
1 – Super Pressure Test in accordance with corrective action from fall 2011 seal integrity study.
2 – Swedish mission supported by some NASA flight hardware elements. Contingent upon agreements and readiness of instruments
CO – Carry Over from FY11 Fall Fort Sumner Campaign.
HL – Hand Launch mission.