



National Aeronautics and Space Administration

Nuclear Compton Telescope Balloon Launch in Alice Springs, Northern Territory, Australia

High Visibility Type B Mishap

IRIS Case Number S-2010-119-00007

List of Appendices

Volume II of II



Date of Mishap: April 29, 2010

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APPENDIX A: Event & Causal Factor Tree Diagram

Event and Causal Factor Tree

The event and causal factor tree is a graphical representation of only those events and conditions that have occurred and have caused or contributed to the undesired outcome. This is accomplished by the MIB evaluating the evidence and verifying that there are facts to demonstrate that each event or condition on the tree occurred. Events or conditions on the tree that the MIB were unable to find evidence that supported the event occurrence or the condition existed were eliminated from the tree.

APPENDIX B: Fault Tree

FAULT TREE

The NASA Nuclear Compton Telescope (NCT) Balloon Launch Mishap Investigation Board investigated the mishap using a “fault tree,” a common organizational tool in systems engineering. Fault trees are graphical representations of every conceivable sequence of events that could cause a system to fail. The fault tree’s uppermost level illustrates the events that could have directly caused the inadvertent release of the payload from the launch vehicle resulting in the damage to 2 POVs and the near catastrophic events to spectators watching the balloon launch. Subsequent levels comprise all individual elements or factors that could cause the failure described immediately above it. In this way, all potential chains of causation that lead to the mishap can be diagrammed, and the behavior of every subsystem that was not a precipitating cause can be eliminated from consideration.

The fault tree in itself is very large (over 620 elements) and intricate and was not able to be included in this report. The fault tree is stored with the final report in the NSC IRIS data base system under the RCA tool in which the tree was developed.

APPENDIX C: Test & Analysis

C1 – Tests

C2 - Analysis

C1 – Tests

Field Tests 1 and 2 of the Launch Head Truck Plate Restraint Cable Release

Mechanism

With and Without Applied Pear Ring Loads

Summary: On May 13, 2010 from approximately 9 am to 10 am local time, a simple test was performed aimed at discovering the approximate forces required to pull the lanyard cable and retract the restraint cable release pin under a variety of loading conditions. The pear ring hanging from the *release* pin was subjected to a range of loading from zero to 1400 lbs in order to determine the relationship between the release pin shear loading and the load required to pull the release lanyard. The resulting lanyard forces ranged from approximately 50 lbs at zero load to 300 lbs at 1400 lbs load.

Background: Some evidence indicated that there was an attempt to pull the lanyard cable that retracts the release pin during the launch attempt, but the lanyard did not release the pin as expected. The test was designed to determine the approximate lanyard force required to release the pin under several conditions. Since the release pin can be loaded through a ring via the restraint cables, a variety of loads was applied to a flight type ring using suspended loads.

Mechanism description: The release mechanism uses a spring loaded pin through a pillow block to retain a ring connected to the restraint cables. The pin is actuated through a 3/16 inch metal cable attached to the base of the pin and travels through a 90 degree pulley to a fulcrum arm that pivots on the launch head frame. A cable continues back from the outer end of the fulcrum arm through a metal ring back toward the personnel platform on the front of the launch vehicle. The fulcrum measurements of interest are 13.5 inches and 4.5 inches, providing a 3:1 mechanical advantage. The pin is held in the engaged position with a preload spring which reacts against the launch head frame and the base of the pin. The pin is 1 inch in diameter and engages the far pillow block by approximately 3/8 inch. (See Figures C1-1 through C1-3).

The truck plate is retained on the main *launch* pin by two 1/4 inch steel cables that attach to the bottom of the truck plate via eyebolts and swaged cable ends. This cable pair terminates in the direction of the launch vehicle in a pear shaped ring. It is this pear ring that is captured by the engaged restraint pin in the pillow block. (See figure C1-4).

It was noted during pre-test observations that the restraint pin was not well lubricated and felt relatively 'dry' to the touch. This was also true of the pulley used to redirect the cable from the release pin to the fulcrum.

Significance of the test: During the launch process, the launch director is required to release the truck plate from the launch pin via the release lanyard. If the restraint pin is loaded through the pear ring, the lanyard pull force increases with increase pin loading. Forces are created through friction with the pear ring and with the pillow block. The test is intended to determine the relationship of pear ring loading to the required lanyard pulling force.

Test Set Up and Procedure (As Run): The crane and launch head were used in their unchanged flight conditions. The crane boom was positioned in the transportation position (horizontal) rather than in the raised launch condition. This configuration is shown below.



Figure C1-1. Launch Head Mounted to Crane

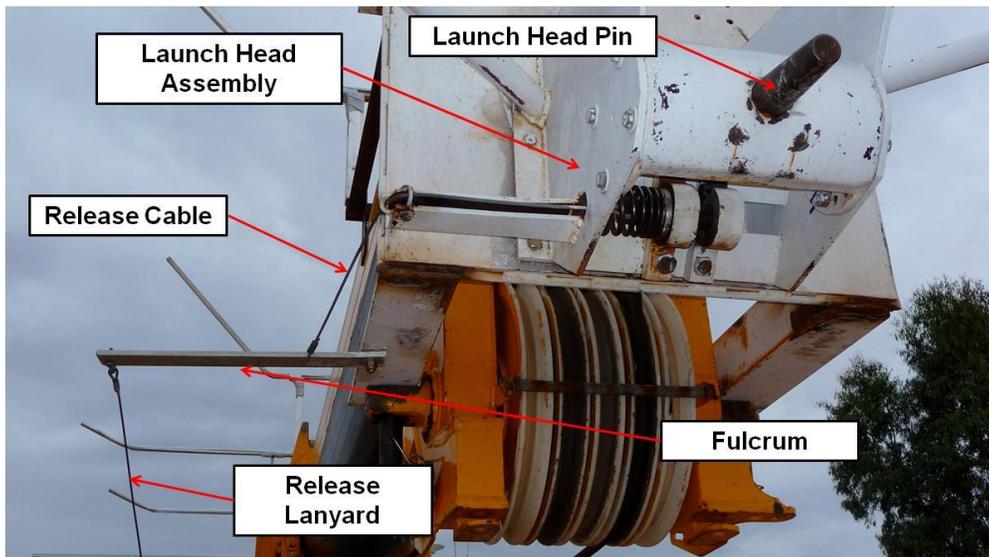


Figure C1-2. Launch Head Mounted to Crane

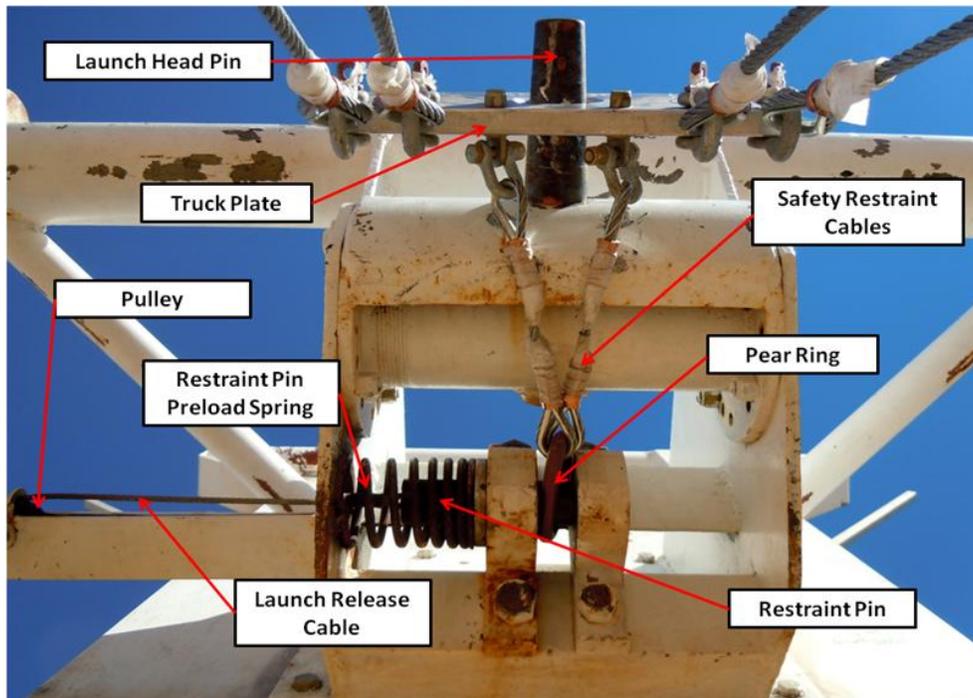


Figure C1-3. Annotated View From Under Launch Head

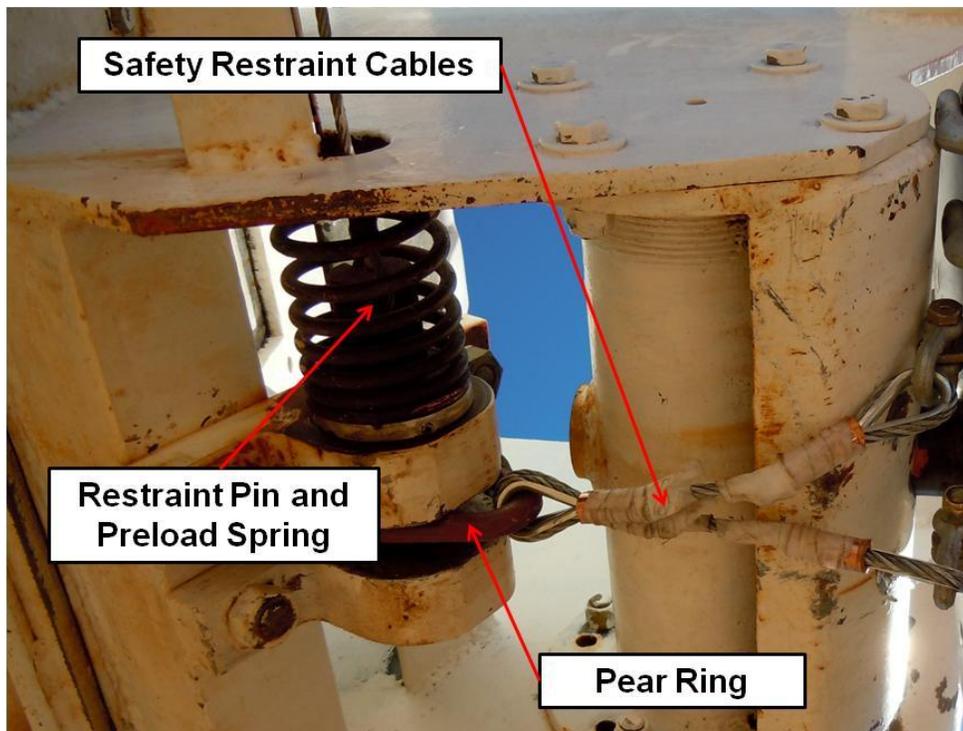


Figure C1-4. Another View of the Launch Head Assembly

A new pear ring with a lift strap was placed in the restraint mechanism over the pin within the pin block in the same way as the pear ring is captured during operations. (See Figures C1-5 and C1-6). Premeasured loads of 300, 600 and 1400 pounds were suspended. The 300 and 600 pound loads were hook and pulley blocks and the 1400 pound load was a concrete block.



Figure C1-5. Test Configuration with Loading Hardware



Figure C1-6. Full Test Configuration with Load

A scale was used to determine the pull force required to retract the pin and release the load from the restraint pin. For loads up to 50 lbs, a digital “fish scale” (Figure C1-7) was selected and for loads in excess of 50 lbs, an in-line digital readout load scale (Figure C1-8) was used.



Figure C1-7. Spring Type Hand Scale



Figure C1-8. Load Cell Type Digital Scale

The 3/16” steel cable lanyard was fed back through the eyebolt (Figure C1-9) that is used to redirect the lanyard down to the flight director who is located in the personnel basket on the front of the crane. The eyebolt with lanyard is shown below.



Figure C1-9. Steel Release Lanyard through Eye on Crane Boom

The lanyard force measurements were taken by applying pulling force by hand and reading real time from the scale display (Figure C1-10). The lanyard pulling force measurements were estimated to be within +/- 10 lbs using this technique. Multiple people were used to apply the force when necessary.



Figure C1-10. Side view of Crain

Test Results:

Table C1-11 below shows the raw results for Field Test 1 & 2. Field Test 1 was conducted to determine the “no load” force required to release just the pear ring. This was repeated several times and the results are shown below.

In Field Test 2 convenient objects were used to increase the shear loading on the restraint pin. As stated above, this test was accomplished in a very short period of time and only one measurement was made for each suspended load. A quick look at the data shows, as expected, the lanyard pull force increased as the suspended load was increased. Figure C1-12 depicts the results graphically.

Suspended Load	Units	Lanyard Force Required	Units	Uncertainty
0 lb		47 lb		+/- 5 lbs
0 lb		54 lb		+/- 5 lbs
0 lb		50 lb		+/- 5 lbs
300 lb		110 lb		+/- 10 lbs
600 lb		200 lb		+/- 10 lbs
1400 lb		290 lb		+/- 10 lbs

Figure C1-11. Results of Field Tests 1 & 2 for Direct Loading of Restraint Pin

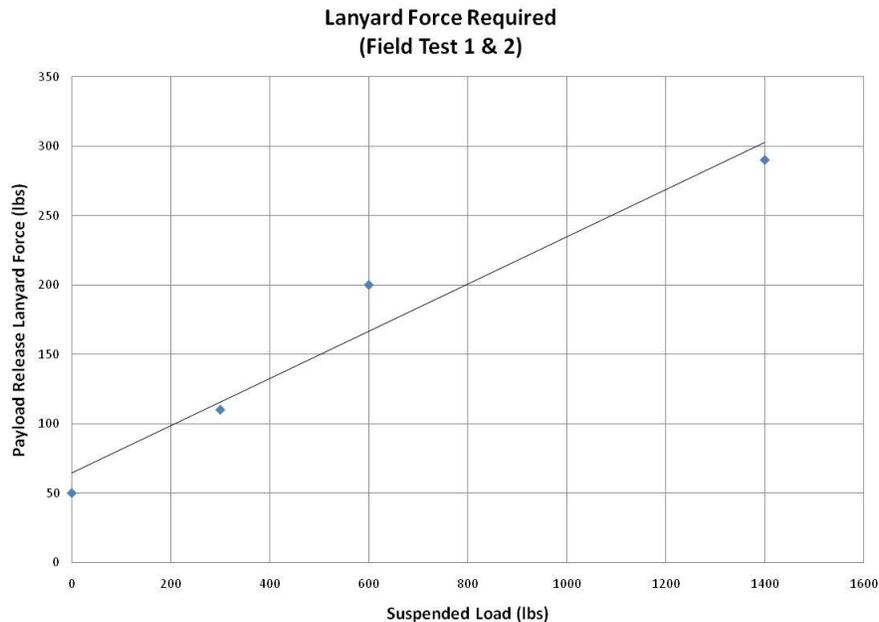


Figure C1-12. Field Tests 1 & 2 Results: Direct Loading of Restraint Pin with Least Squares Best Fit Line

Test Conclusions:

The results of this test were generally as expected, showing an increase of the required lanyard pull force with increasing load on the pear ring. The pull force without any pear ring load is about 50 lbs. While the determination is somewhat subjective, the pull force would become difficult for the average person in the 80 to 125 lb range, which is reached between 200 and 350 pounds of suspended weight.

A simple analysis of the force transfer appears to be consistent with the test results. Figure C1–13 repeats the test data with the addition of predicted lanyard forces assuming that the fulcrum advantage is 3:1 and that the effective coefficient of friction between the pear ring and the restraint pin is 0.60. This coefficient of friction is consistent with kinetic friction between two non-lubricated pieces of steel. In this system there are also some losses in the pulley and at the eyebolt that also is proportional to the total load.

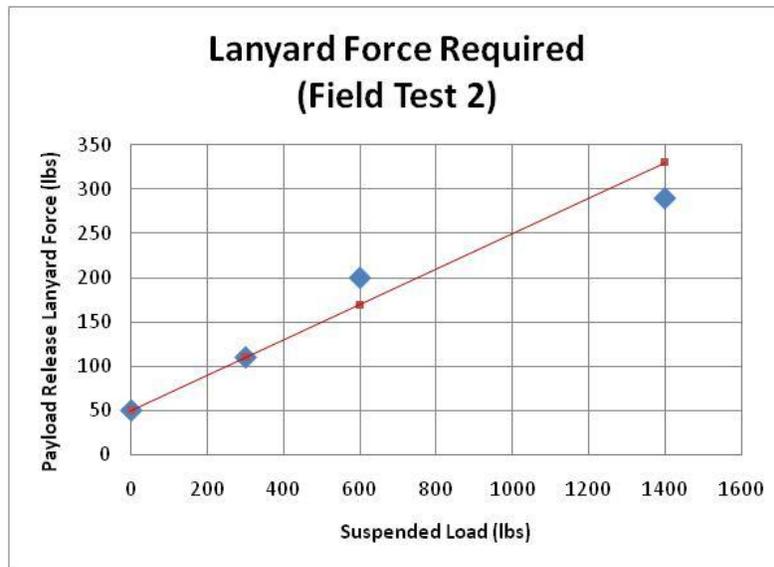


Figure C1–13. Modeled (in red) and Measured (blue diamonds) Lanyard Force vs Pear Ring Load

Field Test of the Launch Head Truck Plate Restraint Cable Release Mechanism with Applied Truck Plate Loads

Summary: On May 14, 2010 from approximately 1 pm to 4 pm local time, a simple test was performed aimed at discovering the approximate forces required to pull the lanyard cable and retract the restraint cable release pin as a result of applied loads to the truck plate. This test differed from the previous day's test in that the loads were applied to the truck plate instead of directly to the pear ring. The purpose of the test was to determine if loads applied to the truck plate through the flight train during launch operations would be translated into loads on the pear ring sufficient to make release difficult for personnel. The truck plate was loaded in several representative ways to simulate potential launch loads. (See Figure C1-14 for the basic setup). The applied loads were limited for two reasons: 1. To keep the crane and fitting loads many multiples below the ratings for safety, 2. To keep the required lanyard loads small enough for two people to be able to actuate the release – this simplified the test setup. The applied loads were approximately 1000 and 2000 lbs and were applied at forward and side angles of approximately 8 degrees and 15 degrees, including combinations of forward and side angles. The resulting lanyard forces ranged from approximately 100 lbs at 1000 lbs with zero forward and side angles to approximately 210 lbs at 2000 lbs with 15 degrees forward angle and zero degrees side angle.

Background: Some evidence indicated that there was an attempt to pull the lanyard cable that retracts the release pin during the launch attempt, but the lanyard did not release the pin as expected. The test was designed to determine the approximate lanyard force required to release the pin under several loading conditions.

Mechanism description: The release mechanism uses a spring loaded *restraint* pin through a pillow block to retain a ring connected to the restraint cables. The pin is actuated through a 3/16 inch metal cable attached the base of the pin and travels through a 90 degree pulley to a fulcrum arm that pivots on the launch head frame. A cable continues back from the outer end of the fulcrum arm through a metal ring back toward the personnel platform on the front of the launch vehicle. The fulcrum measurements of interest are 13.5 inches and 4.5 inches, providing a 3:1 mechanical advantage. The pin is held in the engaged position with a spring which reacts against the launch head frame and the base of the pin. The pin is approximately 1 inch in diameter and engages the far pillow block by approximately 3/8 inch.

The truck plate is retained on the main launch pin by two ¼ inch steel cables that attach to the bottom of the truck plate via eyebolts and swaged cable ends. This cable pair terminates in the direction of the launch vehicle in a pear shaped ring. It is this pear ring that is captured by the engaged restraint pin in the pillow block.

The *launch* pin is tapered and is typically adjusted in the launch head so that when the launch vehicle (crane) boom is raised in to launch position (about 27.5 degrees), the effective angle of the bottom of the pin relative to the horizontal is approximately 16.75 degrees above the horizon.

Please reference the “Field Test of the Launch Head Truck Plate Restraint Cable Release Mechanism with Applied Pear Ring Loads” for additional figures of the mechanism.

Significance of the test: During launch operations, if the net upwards force on the truck plate is applied at an angle forward of normal to the bottom of the launch pin, a component of that force will be carried by the restraint cables and pear ring into the restraint pin. The purpose of the restraint hardware is to prevent the truck plate from coming free from the launch pin before it is desired. A concomitant result is that normal (or shear) loading on the restraint pin is a factor of the various forces on the cable ladder introduced by the buoyant and aerodynamic forces on the balloon and by the gondola. A forward angle (balloon ahead of the launch vehicle) of the flight train loading tends to pull the truck plate away from the launch head and toward the end of the launch pin. (See Figure C1-15)



Figure C1-14. Basic Loading Set-Up for Forward Load Angle

This action extends the restraint cables and loads the restraint pin. Generally, the greater the forward angle, the greater part of the force is reacted at the restraint pin.



Figure C1–15. Position of the Truck Plate and Restraint Cables When Pulled Forward

Note: Cables to Upper Crane for Test are not Shown Here

In addition, a sideward angle has the effect of lifting the nearer (to the direction of the load) corner of the truck plate and twisting the truck plate such that the nearer restraint cable is loaded due to the twisting action of the truck plate. (See Figure C1–16) The safety restrain cable on the low end of the truck plate is unloaded. The test was intended to quickly assess the possible individual and combined effects of these two loading conditions.



Figure C1-16. Truck Plate Twisted by a Manually Applied Force

Test Procedure (As Run):

The crane and launch head were used in their unchanged flight condition. Unlike the first tests, the boom was raised to the launch angle of approximately 27.5 degrees. This boom launch angle was repeatable due to steel chain restraints on the boom that had not been altered from the launch attempt.

A truck plate prepared for the next flight was used in the test. It was installed on the launch head with the restraint cables in normal flight configuration. The four cables that normally would carry the load of the gondola were attached to the top of the truck plate to simulate introducing loads through the flight train. No gondola load was applied.

A second yard crane was rented and used to apply an upward load to the truck plate through a load cell. The load cell had a mechanical dial readout and was rated to 5000 lbs. The yard crane also had a load readout.

For each loading condition, photographs were taken to record the approximate forward and side load angle of the test. The applied load was measured by sight through a pair of binoculars and confirmed with the yard crane operator. It should be noted that due to time constraints, the field tests were limited to a few test combinations and the applied angles were approximated when loading and determined after the tests were complete.

Test Results:

The table below C1-17 shows the raw test results. A quick look at the data shows that the lanyard pull force varies as the forward and side loads change magnitude and direction. Generally, as the forward angle increases and the load increases, the lanyard force increases. Side angle without forward angle also results in increased required lanyard force, but the relationship isn't as strong as for the forward load angle. (See Figures C1-18 through C1-20)

Note that for combined forward and side load test cases L and M, the resulting lanyard force dropped as the side load increased from 12 to 22 degrees with a roughly constant forward angle (18 to 16 degrees). This test was repeated in test N because the result was not necessarily expected.

Lanyard Pull Force vs Truck Plate Load									
Test	Associated Photos	Upward Load	Units	Uncertainty	Forward Load Angle	Sideward Load Angle	Lanyard Force Required	Units	Uncertainty
							Incl ~ 20 lbs Load Cell Weight		
A	100_1902	850	lb	+/- 50 lbs	0	0	88	lb	+/- 10 lbs
B	100_1903	1000	lb	+/- 50 lbs	0	0	75	lb	+/- 10 lbs
C	100_1905	1900	lb	+/- 50 lbs	0	0	110	lb	+/- 10 lbs
D	100_1908	1000	lb	+/- 50 lbs	9.9	0	110	lb	+/- 10 lbs
E	100_1911	1810	lb	+/- 50 lbs	12.6	0	165	lb	+/- 10 lbs
F	100_1913	1000	lb	+/- 50 lbs	23	0	180	lb	+/- 10 lbs
G	100_1916	1950	lb	+/- 50 lbs	17	0	210	lb	+/- 10 lbs
H	100_1919	1000	lb	+/- 50 lbs	0	18.3	90	lb	+/- 10 lbs
I	100_1923	2000	lb	+/- 50 lbs	0	9.25	90	lb	+/- 10 lbs
J	100_1925	1000	lb	+/- 50 lbs	0	17	100	lb	+/- 10 lbs
K	100_1926	2000	lb	+/- 50 lbs	0	15.3	150	lb	+/- 10 lbs
L	100_1927, 1928	1000	lb	+/- 50 lbs	18	12.4	210	lb	+/- 10 lbs
M	100_1929, 1930	1000	lb	+/- 50 lbs	15.75	22	115	lb	+/- 10 lbs
N	100_1931, 1932	1000	lb	+/- 50 lbs	17.5	22.8	115	lb	+/- 10 lbs

Figure C1-17. Field Test 3 Tabulated Measured Data

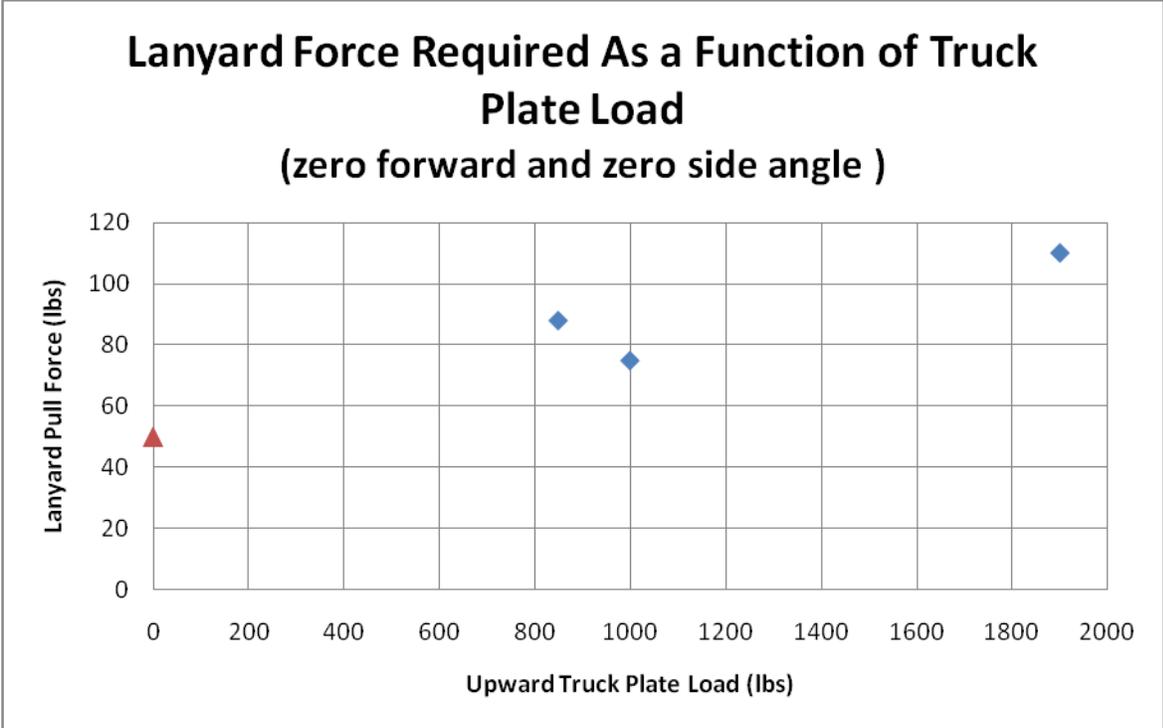


Figure C1-18. Lanyard Force vs Vertical Load (Data at zero load is taken from Test 1)

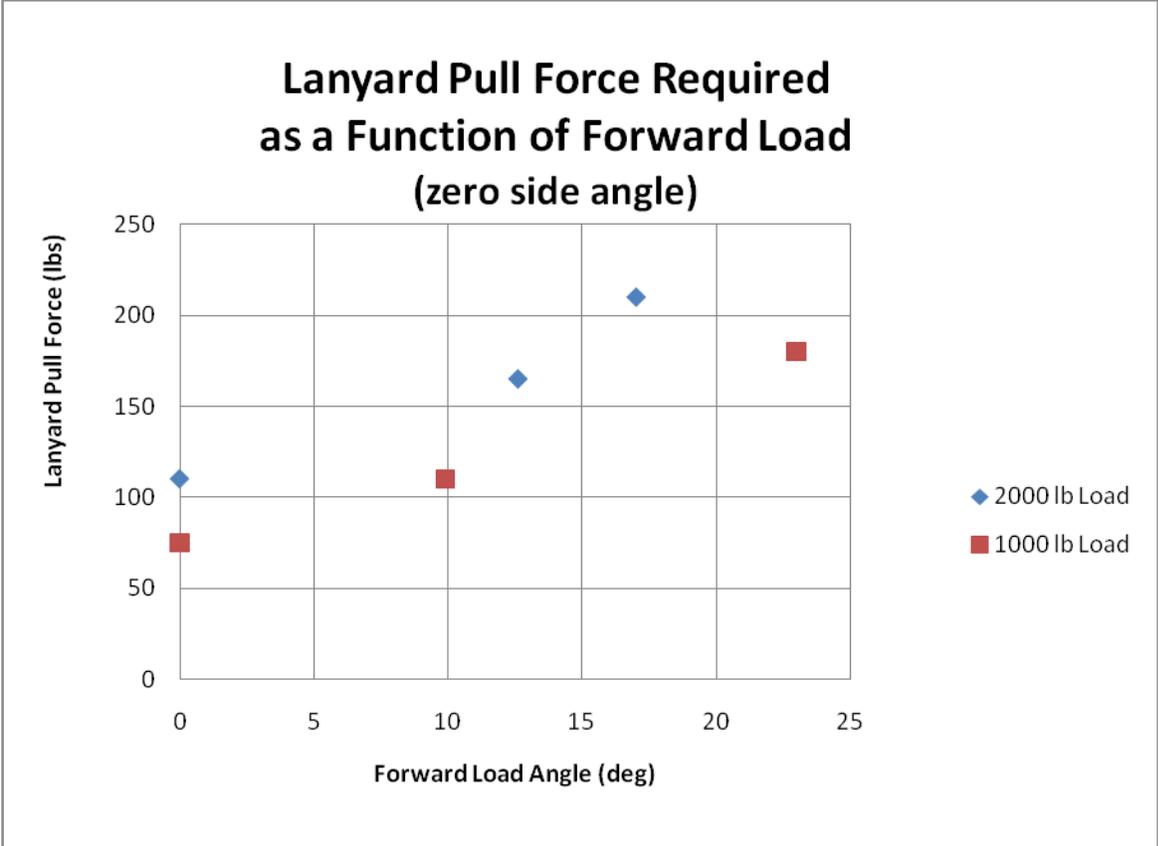


Figure C1-19. Lanyard Force vs Forward Load Angle and Load Magnitude

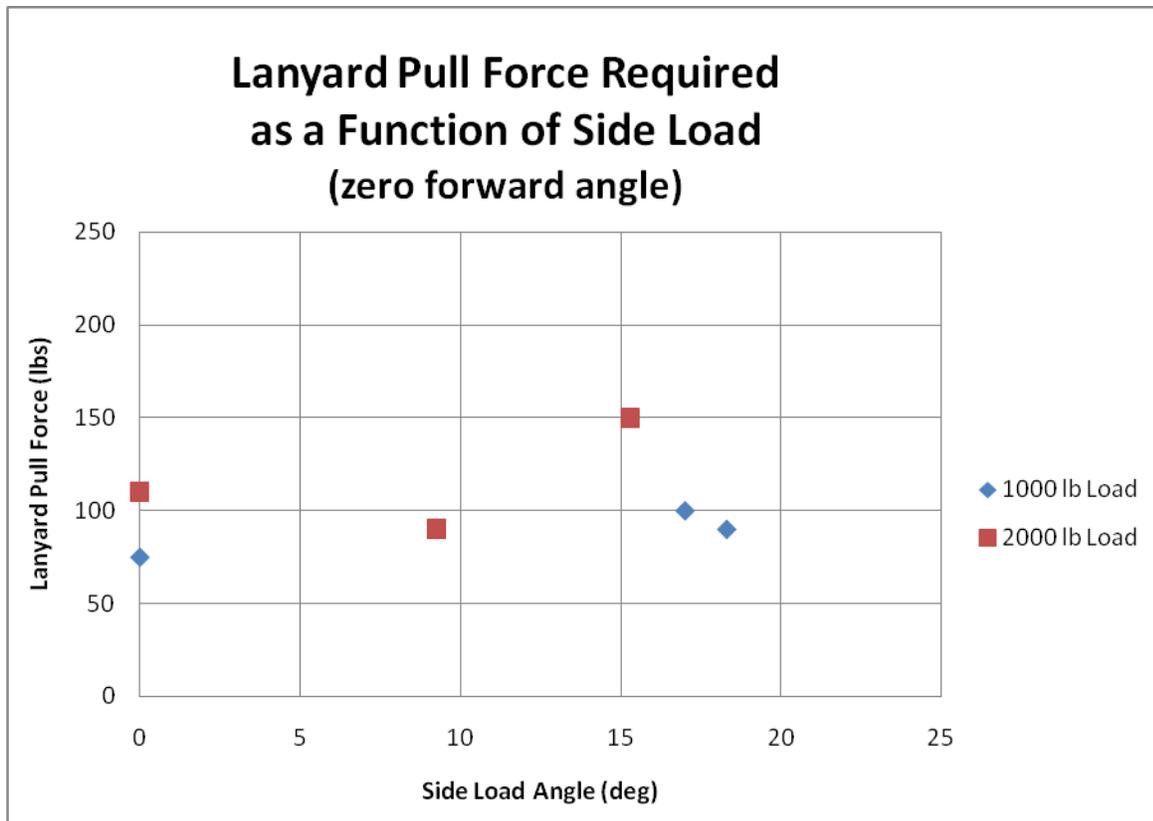


Figure C1-20. Chart 3 Lanyard Force vs Side Load Angle and Load Magnitude

Test Conclusions:

The results of this test were generally as anticipated. Increasing loads increased the lanyard pull force. Increasing forward load angle increased the lanyard pull force. Increasing side angle increased the lanyard force only mildly, except for some combine load conditions where the lanyard force appeared to decrease.

Considering that the designed free lift (net lifting force on the launch pin) is about 985 lbs, the lanyard force required for a balloon directly overhead would seem reasonable at about 80 pounds. However, the tests indicate that with relatively small forward angles of 10 to 15 degrees (balloon ahead of the launch crane), the lanyard force could rise to 125 to 150 pounds. Adding loads created by the wind on the balloon could easily take the lanyard loads to over 200 pounds.

C2 - Analysis

Estimates of Balloon and Flight Train Forces at Several Stages during the Attempted Launch and Abort Process

Summary:

Analysis was conducted to bound the potential forces that were extant in the balloon and flight train elements during the Nuclear Compton Telescope inadvertent payload release. The knowledge of these forces is important for the investigation. Analysis included approximations of the balloon and flight train distributed weights, the drag forces produced by the relative wind on all elements, and the lift forces generated by the buoyant forces on the contained helium. The system of structural elements and forces produces a complex catenary. The geometry is well represented by Figure C2-1 which shows the system near the time of the incident. This catenary system was modeled using two different methods, a multi-element equilibrium steady state shooting method and a dynamic model that solves the accelerations of lumped mass and spring system. The models show considerable forces at the truck plate at the moments of the launch attempt, the holding and backing at the fence, and at the time of the safety restraint cable rupture. The estimated forces and apparent geometries of the application of those forces are consistent with the inability to actuate the lanyard pull successfully during the launch attempts. The estimated forces and apparent geometries of the application of those forces are also consistent with the rupture of the restraint cable assemblies at the time of the unplanned payload release.

There is also evidence that the payload, while supported by the launch vehicle, experienced pendulous motion. This motion also produced forces on the truck plate that were transmitted to the restraint system and may have added to the difficulties with payload release and loads that caused rupture at the time of the inadvertent release. While the horizontal forces on the bottom of the truck plate due to payload pendulous motion can be significant and sufficient to prevent a lanyard pull, it is difficult to confirm that the gondola was swinging in an unfavorable direction at the moment of lanyard pull attempts.



Figure C2-1. Image of the NCT Balloon System at the Airport Fence

Section 1 – Catenary Forces

System Description

Weight Distribution:

The flight train is made up of a number of different sections and the distribution of weight was determined using the mechanical description for the standard 120' chute system and the flight weight breakdown. The weight distribution of the balloon was estimated by proportioning the total weight of the manufactured balloon as a function of the approximate local radius of the design shape. In this case, the fully inflated balloon float shape was approximated as a sphere for the purpose of approximating the weight distribution.

Drag:

The balloon was modeled based on the geometry determined by photographs of the system during the times of interest. In all cases, the collar had already been released. The photographs were analyzed to approximate the projected area of the spherical top, the triangular “sail” section, and the remaining “rope section” (see figure 1). The parachute and risers were modeled as a cylinder and the cable ladder section was modeled as four 3/8 “cables. Coefficients of drag were estimated based on information from Hoerner and others. Drag coefficient estimates for the parachute and the various balloon sections are difficult to estimate because the sections are flexible, the material is very compliant and “flagging” occurs, and the overall boundary changes as a function of the applied force. For this analysis, the upper spherical “cap section” was assigned a Cd of 0.5, the “sail section” 1.5, and the “rope section” a Cd of 1.5. The parachute and risers section was assigned a Cd of 1.5 and the wire rope cables a Cd of 1.5. It would be reasonable to expect these Cd's and the corresponding drag forces to be within 25% to 30% of the actual.

The piball wind data before and after the attempted launch was used to establish a wind velocity for each altitude layer and drag was calculated for each section.

Steady State Equilibrium Analysis:

For the steady state analysis, the catenary system was modeled as a series of rods or chain links, each with external weight, lift and drag forces. The system was arbitrarily divided into 100 elements for analysis. A seed initial angle for the top balloon element is provided and the equilibrium solution is obtained. The initial angle and drag were adjusted until the shape of the modeled catenary matched closely with the photograph (see figure C2-2).

Dynamic Analysis:

For the dynamic analysis, the system was modeled as a lumped mass system connected by springs. The dynamics were integrated from spool release using a Runge Kutta method. As above, the forces were distributed to the representative nodes.

Drag Analysis Results:

The catenary Steady State Equilibrium (Static) analysis for the crane positioned at the Airport fence solution produced a reasonable geometric fit with the photographic evidence as is shown in figure C2-2. The necessary forces at the truck plate to support the system weight and drag through the catenary were calculated to be approximately 9280 lbs. at approximately 38 degrees from horizontal. Matching the observed catenary required a drag adjustment factor of about 0.65 resulting in a total horizontal drag force of about 7300 lbs.

At the fence condition, the results of the independent Dynamic Analysis confirm the estimated horizontal drag force to be about 7200 lbs and the flight train angle with the horizontal at the crane to approximately 38 degrees. The total load at the crane head for this analysis is 9300 lbs.

A simple check can be accomplished by resolving the net vertical force (lift – weight) in the system along the known ladder angle at the crane head. The angle is determined from the photo evidence to be about 38 degrees. Resolving the net 5745 lbs along this angle gives a necessary total reactive force of 9350 lbs.

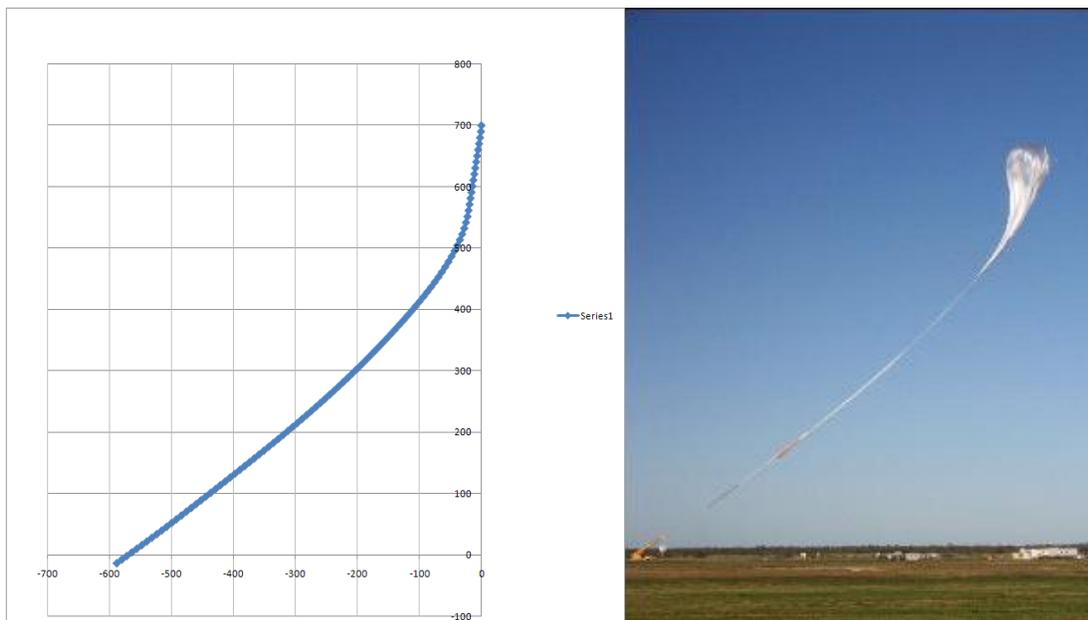


Figure C2-2. Catenary Analysis of the NCT Flight Train

Using the dynamic and static analysis techniques, additional considerations were made for the system at four key events: Attempted Launch, At the Fence, The Backing Maneuver, and The Inadvertent Release. It should be noted that the purpose of the analysis is to determine if the observed events are reasonably explained by estimates of the forces present and the capabilities of the operators and capacities of the hardware.

Some general time-dependent results are presented below in Figures C2-3 through C2-6. The time dependent position of the launch vehicle (crane) was taken from the science payload GPS information made available to the MIB. The GPS data frequency was 1/5 Hz. The time dependent position of the balloon and flight train were determined through the dynamic simulation using the wind data and time-dependent drag coefficient estimates backed out from the static conditions and from video evidence (for instance, for the spool lift-off period). Further video correlation with balloon/crane relative position and flight train shape was accomplished and is presented in Appendix G.



Figure C2-3. Ladder Elevation vs Time Estimate Gs from Dynamic Simulation

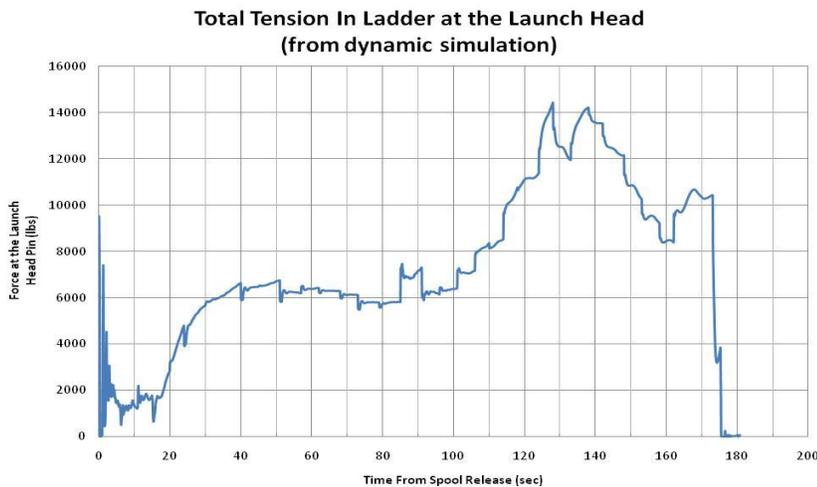


Figure C2-4. Ladder Tension at the Launch Head vs Time Estimates from Dynamic Simulation

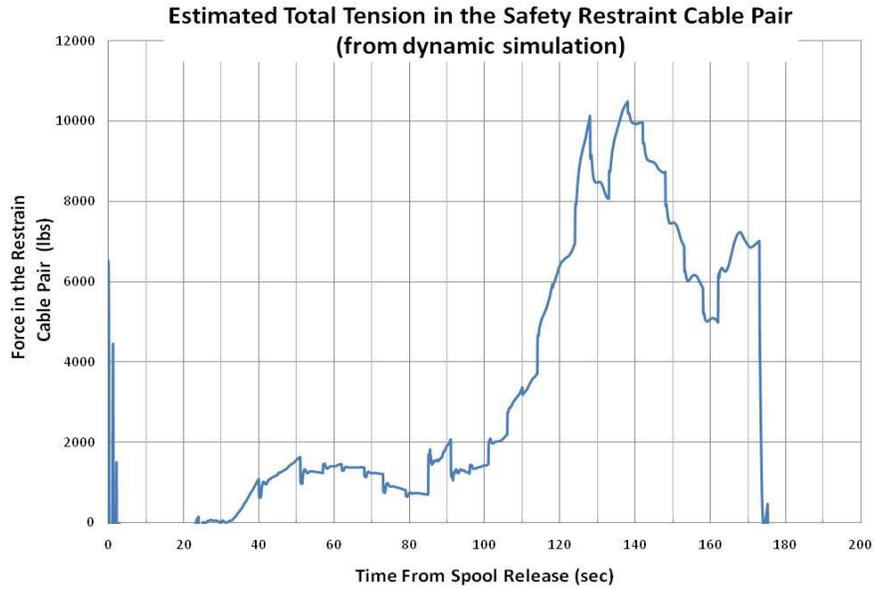


Figure C2-5. Safety Restraint Cable Forces (pair) vs Time Estimates from Dynamic Simulation

Balloon and Launch Vehicle Ground Track
(from dynamic simulation)

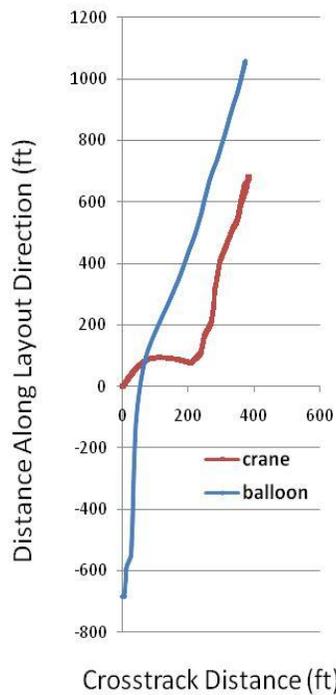


Figure C2-6. Ground Track Estimates vs Time Estimates From Dynamic Simulation

Attempted Launch –

For the launch attempt analysis, the important result is to estimate the pull force required on the release lanyard at the time of the launch attempt. Shear forces are applied to the release pin through the pear ring, the safety restraint cables, the truck plate, the flight train ladder, and eventually the balloon. The lanyard pull force is a function of the shear force on the release pin, therefore a function of the forces generated by the balloon and the relative geometry of the balloon and the launch vehicle.

From photographic evidence, the forward angle at the launch attempt appears to be about 10 to 12 degrees (78 - 80 degrees from horizontal). The effective angle of the launch head pin from the horizontal was a function of the crane boom angle, the launch head pin angle within the launch head assembly and the launch head pin taper. This effective angle is approximately 25 degrees from the horizontal, but is in practice dynamic, changing as the crane moves over the terrain. At this angle, the load in the safety restraint cables after resolving the force along the launch head pin is reduced to about 60% of the load in the flight train. (For reference see Figure C2-7 below) The analysis assumes no appreciable reduction due to friction. This is a reasonable approximation since the truck plate/launch head pin normal forces are relatively small since the truck plate sees the force difference between the payload weight and the upward flight train loads. Preliminary calculations showed force modifications on the safety restraint cables due to friction to be on the order of 200 lbs. The remainder of the ladder force on the truck plate is reacted in the pin in shear and bending. The static catenary analysis shows a total flight train force introduced into the truck plate of about 6000 lbs. The resulting total force in the safety restraint cable pair is then about 1500 lbs after allowing for the offset due to the payload weight (4787 lbs), reacted at the bottom of the truck plate. For comparison, the dynamic analysis shows a total force of about 6900 lbs and a slightly higher force on the restraint cable pair.

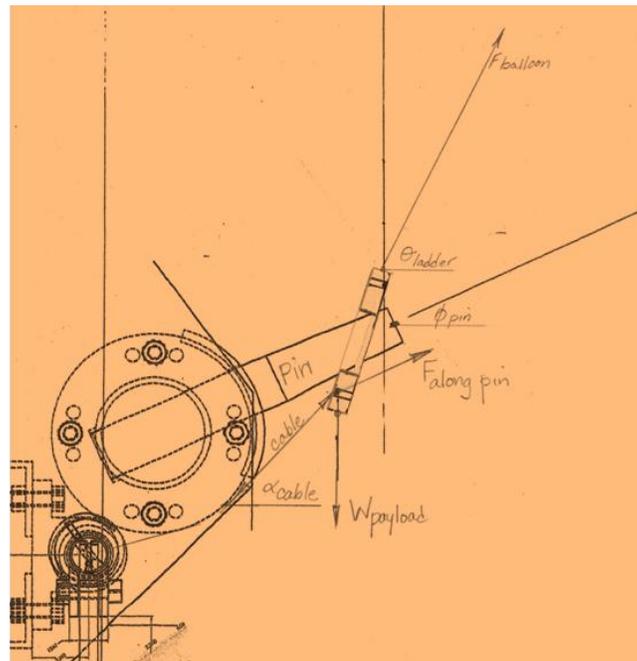


Figure C2-7. Launch Head Pin, Restraint Cable and Truck Plate Sketch

Using the data from Field Test 1 repeated below in Figure C2-8, the resulting lanyard pull force would be predicted to be about 320 lbs (test data only covered up to 1400 lbs applied load). The 300+ pounds of pull force required to release the payload exceeded the maximum reasonable human capability of about 100 lbs. Human factors research (Das and Wang, International Journal of Occupational Safety and Ergonomics, 2004, Vol. 10, No 1, 43-58 and Aghazadeh, Advances in Industrial Ergonomics VI, Taylor and Francis, 2010) suggests that realizable downward pull force for a male in standing position is in the range of 85 to 100 lbs.

Lanyard force models developed from the Field Test results were coupled with the dynamic model to estimate the pull force throughout the launch timeline. These results are presented in Figure C2-9. Note that pull force is predicted to change quite abruptly at about 86 seconds when the launch vehicle slows for the attempt. This is consistent with the inertial and increased drag loading of the balloon system as the launch vehicle slows. The implication is that an attempt just prior to slowing is predicted to take about 200 lbs, where just after it decelerates is increased to over 300 lbs. The dynamic analysis is consistent with the static analysis regarding the lanyard pull force.

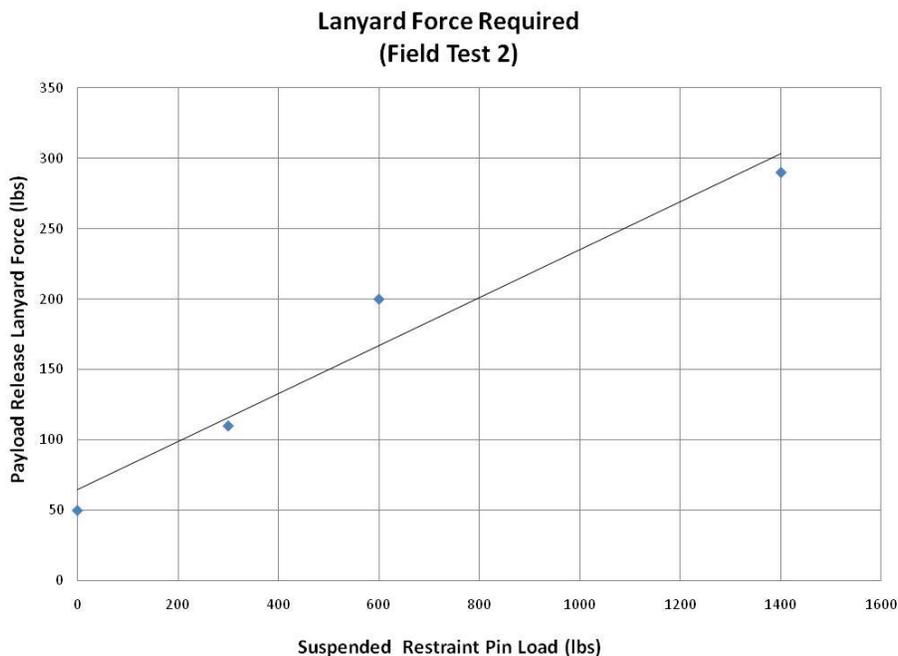


Figure C2-8. Release Lanyard Pull Force vs Pear Ring (equivalent total restraint cable) Loading

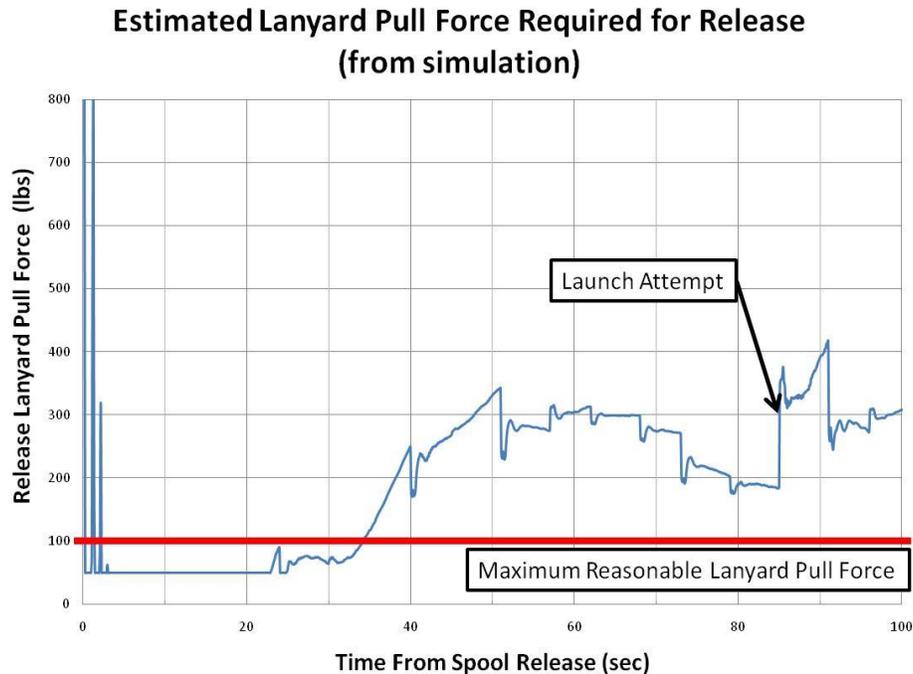


Figure C2-9. Estimated Release lanyard Pull Force vs Time Estimates from Dynamic Simulation

Conclusions:

These results suggest that the lanyard pull force due to the forces resulting from the balloon and flight train catenary was approximately 200 to 350 pounds during the first and second pull launch attempts. The required pull force during the launch attempts was clearly well in excess of typical human capabilities. Further, at no time after the crane was aligned with the wind direction was there a time that the launch attempt could have been completed successfully.

At The Fence –

At the time that the crane stopped at the Airport fence, the flight train was determined to be at 38 degrees from the horizontal at a total force of about 9350 lbs. Resolving these forces along the launch head pin gives a force along the pin direction of about 9200 lbs. This resultant force is then reacted by the payload weight and the tension in the restraint cables. The truck plate is constrained to move along the launch head pin, which also constrains the cables to react the load at an angle not aligned with the launch head pin. The cables with no payload weight would react with 9500 lbs. This restraint cable force is then corrected by the component of payload weight along the restraint cable direction. This correction is approximately 3200 lbs, yielding reactive force in the *cable pair* of about 6300 lbs. This compares to the specified ultimate load of the restraint cables of 7,000 lb *each* CSBF document OM-200-18-D, (“Aircraft Cable Approved Load Rating”).

The 5/16” Crosby chain shackles and the AN46 38” – 24 UNF eyebolts are rated at 9,000 lb ultimate and 7015 lb according to documents OM-200-19-D and an email from CSBF.

Conclusions:

If the total force from the balloon and flight train catenary system estimate is reasonable, it speaks to why the restraint cables did not rupture while the crane was at the fence.

During the Backing Maneuver –

During the backing maneuver, the drag forces were increased by the added relative wind velocity due to the backing speed of the crane. The backing speed of the crane was approximately 4 to 9 feet per second with the winds at about 21 ft/s. This produces a factor of 1.2 to 1.4 relative velocity and a resulting drag component factor of 1.4 to 2.0. The result would be a total force in the ladder between 11,800 and 15,000 lbs, pushing the cable pair loading to between 8,600 and 11,800 lbs. The dynamic simulation results were consistent, showing restraint cable forces peaking just under 10,500 lbs. It should be noted that pendulous motions which were present during the period would add to the maximum forces seen by the restraint cables.

Conclusions:

The estimates of the cable forces during the backing maneuver are consistent with the restraint cables not breaking during this maneuver. However, when used in this manner, the estimated safety factor based on the cable specification was only about 1.3 for this particular situation. The loading due to pendulous motion or wind gusts may have taken the system to a near failure condition.

At Inadvertent Release –

At the time of the unintended release from the launch head pin, the crane was headed generally in an anti-wind direction at several feet per second which would have generated ladder forces greater than 10,000 lbs and less than 12,000 lbs. This results in restraint cable forces (in the pair) of 7,000 to 8,000 lbs. In addition, loads produced by the pendulous motion of the payload would add to these forces to produce the maximum forces at the time. The process of turning the launch vehicle away from the downwind direction also changed the way the loads were introduced into the truck plate. Ground testing after the incident showed that side loads introduced through the flight train caused the truck plate to rotate about the launch head pin. This rotation of the truck plate in turn prevents the load from being carried symmetrically by the restraint cables. (See Figure C2-10)



Figure C2-10. Illustration of Twisted Truck Plate

For extensive rotation which would be produced by the configuration at cable rupture, one cable is essentially relieved of force and the entire load is carried by a single cable. Therefore, there was enough load reacted at the truck plate to rupture the single loaded cable assembly carrying the predominance of the load. The second cable assembly would then be subjected to the total local load and would also rupture. The ultimate ratings of the eyebolt that ruptured (after considering the bending loads produced as it was employed) and the cable that ruptured are both less than the predicted load.

Conclusions:

The estimated forces produced at the time of the inadvertent release are entirely consistent with the rupture of the restraint cables. The cables likely rupture one at a time as the load was carried first by one, then the next cable. (See Figure C2-11 below)

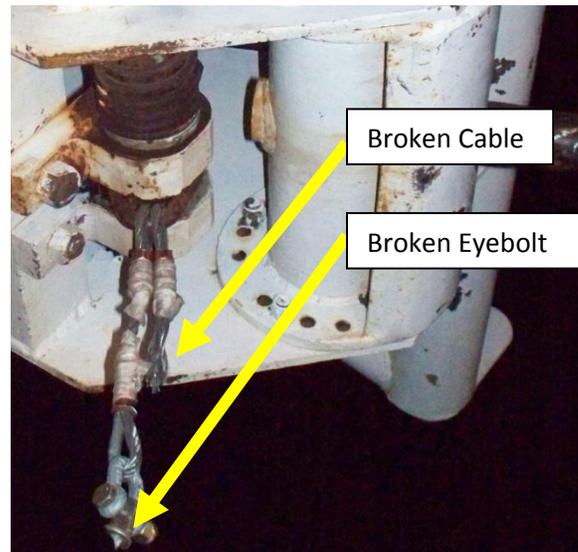


Figure C2-11. Illustration of Broken Cable and Broken Eyebolt

Section 2 - Pendulous Forces

System Description:

The payload is supported as a simple pendulum from the launch head pin. While the flexible cables used in the suspension make it possible to have a “wristing” action under certain circumstances, those effects are neglected here. The suspended weight is 4787 lbs with the center of mass at approximately 15 feet from the suspension point.

Analysis:

The forces of interest in this pendulum system are produced by two accelerations. One is from the acceleration of gravity, producing the weight component, and the produced other from the acceleration due to the circular motion, producing the centrifugal force component. Both the weight and centrifugal force components are maximum at the bottom of the swing, but at that location produce no horizontal (fore and aft) component to be transmitted into the bottom of the truck plate. The horizontal force magnitude varies as a function of maximum displacement angle (imparted energy) and the instantaneous angle of the payload center of mass. For small total displacements, under 10 to 15 degrees, the combined horizontal force is maximum at the maximum angle, is due completely to the horizontal component of the tension due to weight, and is practically linear with angle. For larger total angular displacements, over about 30 degrees, the horizontal force is maximum at intermediate angles due to the contribution from the velocity of the swinging mass. From 10 to 30 degrees total displacement the horizontal forces are nonlinear over the range and are maximum at the maximum angle.

For the launch conditions here, peak angular amplitudes were observed to 20 degrees, which can produce horizontal forces up to 1400 lbs. (See Figure C2-12 below) It is extremely challenging to determine the angular position of the gondola at the times of attempted lanyard pull.

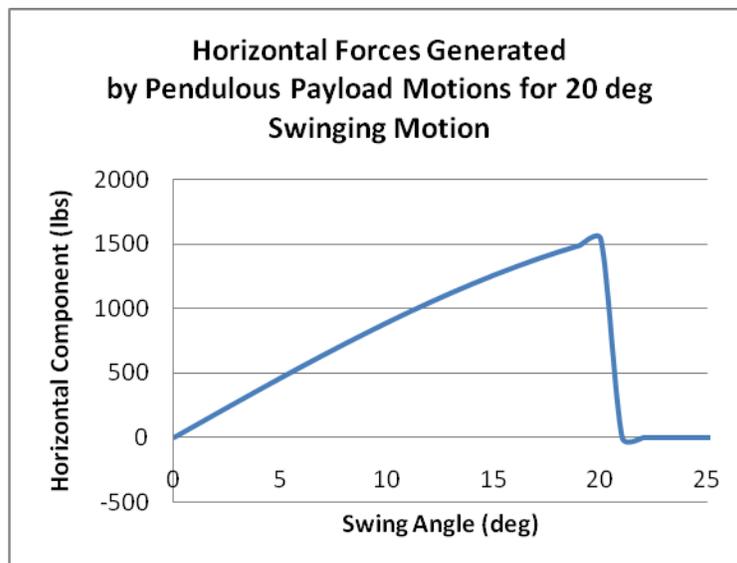


Figure C2-12. Potential Horizontal Forces Produced by Payload Pendulous Motions

Conclusions:

It is sufficient to say that pendulous motions have the potential for generating sufficient forces to prevent the lanyard pull, as well as add to the forces already present in the restraint cables due to the forces in the flight train from the balloon. At the same time, the pendulous forces, when acting in a favorable direction (payload swing toward the crane) have the potential to overcome some of the 1500 lbs of restraint pin loading generated by the balloon and flight train at the time of the launch attempt.

Section 3 - Forces at the Crane Launch Head for a Hypothetical No-Collar Release Condition

A brief analysis was accomplished to determine the likely level of forces at the crane launch head mechanism at the time of inadvertent release for a condition where the reefing collar had not been released prior to release from the launch pin. This question arose out of consideration of the launch process that generally includes instances both where the collar is released prior to the pin release and post pin release.

Analysis Approach:

The drag areas were determined based on photographic evidence of the balloon just prior to the collar release. (See Figure C2-13) In this condition, the drag area is somewhat less than that observed after the collar release. The new drag area was used with the same effective drag coefficient that was shown to cause analysis agreement with both the overall catenary shape and terminal angle at the launch head.

Results:

Application of the same static analytical technique yielded an ultimate force at the launch head of approximately 8000 lbs with the collar compared to 10000 lbs without the collar. The resulting angle with the horizontal is calculated to be closer to 50 degrees with the collar as compared to about 47 degrees without it. Applying an approximate 80% reduction would put the safety restraint cable forces between 5500 and 6500 lbs.



C2-13. Balloon with Collar

Conclusions:

Maintaining the collar until after pin release would have reduced the cable load on the safety restraint cables. The loads are predicted to be reduced to a point where, if one neglects potential pendulous payload dynamics loads or wind gust loads, the restraint cables may not have ruptured at the time. However, consideration of these additional loads creates a situation that may still have led to cable rupture

Section 3 – Predicted Release Lanyard Forces for the Hypothetical Case of no Traction Loss at PET = 62 Seconds

A brief analysis was accomplished to determine the predicted release lanyard pull force required at the time of launch attempt under the hypothetical condition that the launch vehicle (crane) did not lose traction at PET = 62 seconds. The dynamic simulation was used by modifying the launch vehicle (crane) velocity profile to allow a constant acceleration through the period around 62 s. In addition, the vehicle path was modified to better intersect the balloon by steering along the layout azimuth.

Again, it should be noted that the simulation uses PiBal information prior to and after the launch attempt to estimate the wind velocities as a function of altitude and use drag estimates that produced similar catenary shapes during static conditions (e.g., at the fence). The balloon position ground track position is influenced in simulation by both the aerodynamic drag forces and by the forces imparted by the launch vehicle (crane). Therefore, the Balloon Ground tracks are estimates only and do not represent any measured positions.

Results:

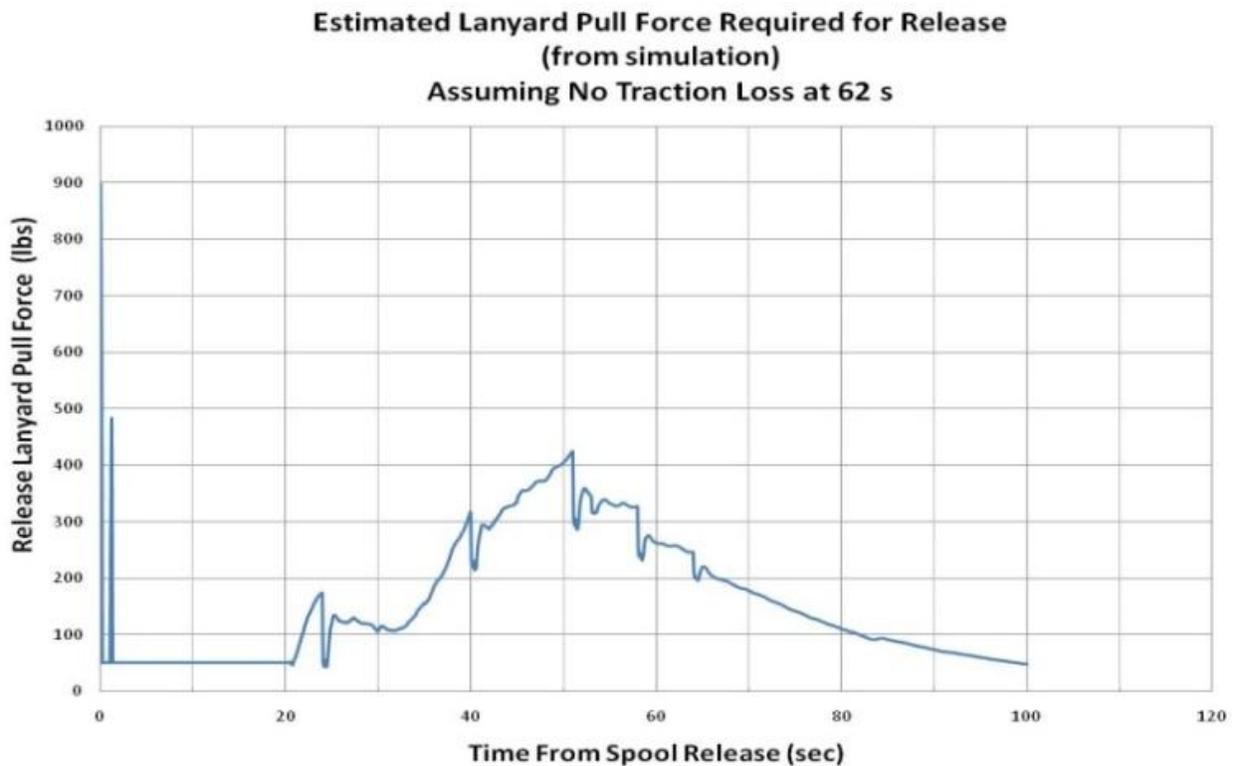


Figure C2-14. Estimated Lanyard Release Force for Hypothetical Case of No Traction Loss and Improved Driving Direction

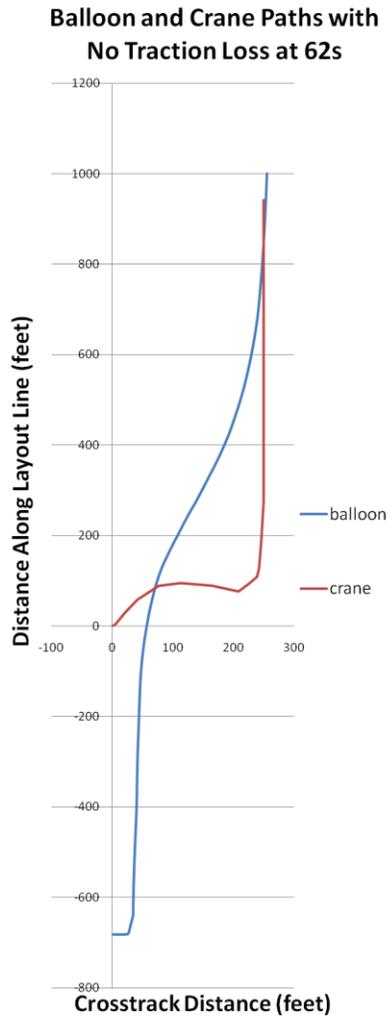


Figure C2-15. Balloon and Crane Ground Tracks for Hypothetical Case of No Traction Loss and Improved Driving Direction

The simulation presented shows that at the time of the actual launch attempts at about 86 seconds, the lanyard pull forces are predicted to be within the range of the operator (less than 100 lbs) if the traction loss had not been a factor and a slightly better driving azimuth had been followed.

Conclusions:

Given slightly different conditions, even with the wide right turn that was executed, it is predicted that the NCT launch was possible with the vehicle and hardware compliment that existed. It should be noted that the launch vehicle would have been out of the Category A Hazard Area.

APPENDIX D: SAFETY ANALYSIS

D1 – Safety Requirements Assessment

D2 – Safety Assessment Results

D3 – Human Error Assessment

D1 – Safety Requirements Assessment

Safety Requirements Assessment

The MIB conducted a Safety Requirements Assessment to determine areas where the applicable safety requirements were either overlooked (constituting non-compliance) or implemented poorly (constituting nonconformance with intent of the requirement). The requirements documentation examined for compliance included, but were not limited to: NASA Policy Directives; NASA Procedural Requirements; NASA Standards; NASA Range Safety Manuals; GSFC/Wallops Procedural Requirements; Suborbital and Special Orbital Project Balloon Procedures and Guidelines; Program Office Procedures and Guidelines; WFF Safety Office Procedures and Guidelines; WFF Safety Office work instructions; and the CSBF Contract documentation.

These requirements were compared with the information gathered through review of GSFC/WFF and CSBF program and activity documentation and records, witness statements, witness interviews, video documentation, and still photography.

The findings of the requirements assessment are provided within this section. Matrices mapping the results of this assessment to the root cause and interim cause findings of this MIB report, along with listings of the referenced safety requirements and excerpts of referenced requirements, are located in Appendix D-2.

D1.1 Protection of the Public

“It is NASA policy to protect the public... from potential harm as a result of NASA activities and operations by factoring safety as an integral feature of programs, projects, technologies, operations, and facilities.” (NPR 8700.1)

The NASA General Safety Program Requirements, NPR 8715.3C, and the NASA Range Safety Program Procedural Requirements, NPR 8715.5, both function to provide requirements for implementation of the policy to protect the public.

These general Agency-level requirements should flow to each program, including the BPO (cite NPR). The implementing document for the BPO is the WFF RSM 2002. The WFF Range Safety Manual, RSM 2002 fails to flow the policy down into WFF Range Ground Safety requirements. Public safety is only addressed in the context of Flight Safety requirements (section 6 of RSM 2002). In addition, the CSBF Ground Safety Plan (OF-610-00-P) does not address the need for public safety in its scope or practice. The CSBF Contract NAS5-03003, Attachment D, Safety and Health Plan policy statement, also does not include safety of the

public. The only reference to “public safety” that can be found in the CSBF contract is if one traces the referenced NASA FAR supplemental (NFS) clause 1852.223-70, Safety and Health to its source.

It is worth noting that neither the CSBF contract NAS5-03003 Statement of Work (SOW) nor the Safety and Health Plan mandate implementation of specific, applicable NASA public safety requirements.

The Balloon Program also failed to implement standard protective controls for personnel that would have also benefited public safety. Hazardous operating procedures were not instituted for launch activities as required by NPR 8715.3; NPR 8715.5; NASA FAR supplemental 1852.223-70; and the Contract NAS5-03003 Health and Safety Plan. WFF Procedures and Guidelines for control of public safety, such as those found in 800-PG-8715.1.1 and 800-PG-8715.0.3, including roadblocks and dedicated viewing areas, were not implemented for the Balloon Program nor were dedicated safety professionals (e.g., RSO, MRSO and OSS) assigned to oversee the launch process as required by NPR 8715.5 and RSM 2002.

D1.2 Protection of Personnel

RSM 2002 Ground Safety, Section 5.1.1, states that “the ground safety goal of GSFC’s WFF is to minimize the risks to personnel and property involved in conducting operations at GSFC’s WFF and to prevent mishaps that would result in embarrassment to NASA or the United States Government.” Section 5.1.2 also requires “that all systems be designed such that it will take a minimum of two independent, unlikely failures occurring in order for personnel to be exposed to a hazard” and that (Section 5.2.4) the CSBF Ground Safety Plan (OF-610-00-P) identify “the potential hazards and describe the system design and methods employed to control the hazards.”

The CSBF Ground Safety Plan (OF-610-00-P) echoes these goals; it too states that CSBF’s ground safety goal is to minimize risks to personnel. However, the Plan does not adequately address the requirements to identify potential hazards, to describe the design of hazardous systems, and to provide methods of hazard control for each identified hazard in order ensure personnel safety.

D1.3 Hazard Analysis

The Balloon Program’s lack of stringent hazard analysis left them vulnerable to non-compliances with Agency and WFF Range Safety Requirements.

NPR 8715.5, Range Safety Program under Range Safety Analysis (Section, 3.2.1), requires that “each range operation shall undergo a range safety analysis to establish any design or operational constraints needed to control risk to persons and property.” (Note: Range Operation is defined as

the flight of a launch vehicle including payload at a range, to or from a range, or to or from launch sites or landing sites.) The BPO and the WFF Safety Office failed to perform or to ensure that adequate analyses were performed for the preflight phase of the balloon launch process. As a result of this omission, the balloon program operated without properly identified hazards and without adequate hazard controls.

The Range Safety Manual (RSM) states that the ground safety plan must also include a description and technical evaluation of the hazardous system's compliance with the design requirements of section 5.1.2, which stipulates "that all systems are designed such that it will take a minimum of two independent, unlikely failures occurring in order for personnel to be exposed to a hazard." Further section 5.3 (Specific Policies and Criteria) provides specific requirements for potentially hazardous systems including safety critical Ground Support Equipment (GSE) (5.3.5.1), electrically operated GSE used on Category A systems (5.3.5.6), ground support pressure systems (5.3.5.12), RF systems (5.3.5.8), and lifting devices and equipment (5.3.5.5).

The CSBF Ground Safety Plan, OF-610-00-P, does not include the required design descriptions and assessments nor does it identify all known hazards and controls associated with the launch pre-inflation, inflation, and launch phases. Examples of hazards not adequately addressed within the current Ground Safety Plan include the following:

1. Structural failure of launch equipment
2. Collision of moving/swinging payload with personnel or property (suspended loads)
3. Collision or tipping of mobile crane with personnel or property
4. Over pressurization or rupture of the balloon inflation system
5. Inadvertent/premature release of the payload
6. Inadvertent/premature ignition of pyrotechnics
7. Inadvertent/premature abort
8. Collision with aborted/released parachute train equipment

There is no evidence to suggest that a comprehensive safety analysis was performed for the balloon program for either the hardware or the operations associated with the launch process. Adequate documentation was not found in the Ground Safety Plan nor any other documentation reviewed. Operational constraints, hardware failure mechanisms, and limits were not identified.

RSM 2002 prescribes the methodology for analysis and control implementation in the Ground Safety Hazard Control (Section 5.2). The RSM requires that the following hazard control methods to be used to "protect personnel and property and minimize risk when conducting potentially hazardous operations":

- A. Identify all known hazards associated with the program
- B. Implement safety design criteria

- C. Minimize exposure of personnel to hazardous systems
- D. Establish safe operating procedures
- E. Plan for contingencies

The typical ground plan will contain a list of all procedures (non-hazardous, hazardous, and safety critical), procedure descriptions, task summary details including hazards and precautions, and list of required PPE, identification of emergency and abort/back-out actions and a list of personnel training, certification and experience requirements for each type of hazardous operation such as ordnance, radiation and crane operations, and description of test performed on hazardous and safety critical systems. In addition a hazard analysis is included for each hazardous system and an Operating and Support Hazard Analysis (O&SHA) is provided for each hazardous operation. The O&SHA worksheets typically provide the following information: general hazard group, specific hazard condition, effect of hazard if not controlled, hazard control hardware, hazard control procedure, hazard control personnel. The plan also provides a mechanism for verifying that all hazard controls are in place prior to the beginning of the launch operation.

Individual hazard reports would have helped to ensure that the hazards, their causes, consequences, and controls were accounted for appropriately through the review and update of the reports prior to each mission.

D1.4 Hazardous Operating Procedures

The CSBF launch operations took place without the benefit of hazardous operating procedures. Lack of written hazardous procedures constitutes non-compliance with both Agency safety requirements and the WFF/CSBF contract.

NPR 8715.3, NASA General Safety Program Requirements, (section 1.4.3.j) states that the Center Director shall “ensure that for hazardous NASA operations, procedures are developed for the following circumstances: 1) to provide an organized and systematic approach to identify and control risks, 2) when equipment operations, planned or unplanned, are hazardous or constitute a potential launch, test, vehicle, or payload processing constraint, or 3) when an operation is detailed or complicated and there is reasonable doubt that it can be performed correctly without written procedures.” NPR 8715.3, section 3.8. Hazardous Operations, also stipulates that Center Directors and project managers “shall ensure that all hazardous operations have a Hazardous Operating Procedure or a Hazardous Operating Permit (HOP), and that all procedures include sufficient detail to identify residual hazards and cautions to NASA personnel.” “The Center SMA Director or designee shall review and approve the HOP.”

NPR 8715.5, Range Safety Program (section 1.3.7.c) requires that “for each range operation, the vehicle program manager or NASA designee shall coordinate with the range safety organization

to develop and implement ...procedures” and the NASA FAR supplemental 1852.223-70, Safety and Health (j) as attached to the CSBF contract requires that “before hazardous operations commence, the Contractor shall submit for NASA concurrence (1) Written hazardous operating procedures for all hazardous operations; and/or (2) Qualification standards for personnel involved in hazardous operations.”

The CSBF’s own Health and Safety Plan (section J of the Contract NAS5-03003) states that the “safety of personnel and facilities will be ensured through the use of existing procedures” and that “written procedures for hazardous procedures will be developed and annually reviewed.” The plan also states that “flight line operations procedures are to be maintained by the Operations Manager” and “will be made available to appropriate NASA authorities.”

Despite the agency requirements and the CSBF plan, evidence obtained through witness interviews and document review indicates that the CSBF in fact did not develop or use written hazardous procedures.

Witness interviews uncovered that the contractor launch operators rely solely on checklists, the generic ground safety plan, job knowledge, and experience to execute the complicated and hazardous launch operation steps. Therefore, detailed operating procedures were not used for the Alice Springs NCT launch, nor are they typically used for any launch operations.

The failure of the Balloon Program Office and CSBF to conduct launch operations by the instruction of approved written hazardous operating procedures left the participating crew, personnel, and public vulnerable to increased risks.

D1.5 Ground Safety Plan

The Balloon Program Ground Safety Plan is a generic plan that was produced by the WFF Safety Office in 2004. It is supplemented by experimenter payload data provided in the format of questionnaires prior to each mission, which together with the generic plan, made up a Ground Safety Data Package. Even with the supplements included, the plan failed to contain the necessary information.

The primary deficiencies in the Ground Safety Plan are discussed in D1.3 and D1.4.

Interview evidence indicates that the Balloon Program Office and CSBF contractors believed the Balloon Ground Safety Plan to contain comparable comprehensive information as discussed above for a ‘typical’ ground plan. The Ground Safety Plan was repeatedly referenced in interviews whenever questions relating to system design, operational analysis, keep out zones, hazard controls and hazardous operating procedures were raised. Subsequent review of the generic balloon ground safety plan revealed that the plan failed to provide most of the referenced information.

The Balloon Program Office and the WFF Safety Office failed to sufficiently review the ground safety plan for compliance with the Range Safety requirements and/ or neglected to make the necessary improvements to bring the Balloon Ground Safety Plan into compliance.

D1.6 Safety Oversight

There is evidence of an insufficient safety oversight for the WFF Balloon Program.

NPR 8715.5, Range Safety Program assigns safety oversight requirements to different levels of Agency management, organizations and personnel for the WFF Range Safety and Balloon Programs. There is evidence to suggest that compliance was lacking with regard to oversight responsibilities on all levels.

The NPR 8715.5, Range Safety Program (section 1.3.2) requires that at the Headquarters level, NASA's Range Safety Manager not only evaluates range safety programs but also "ensure consistent implementation of range safety requirements throughout the Agency" Section 1.3.4.2 requires that Center Directors functioning as the authority for fixed or mobile launch sites "establish the processes and associated Center-level requirements needed to ensure the requirements of NPR 8715.5 are met."

Documentation and interview evidence suggest that the Balloon Program was not afforded the same level of safety insight or oversight as other Agency or even WFF Range programs and that range safety requirements were not consistently implemented for the Balloon Program.

NPR 8715.5 (section 1.3.5) gives range safety organization requirements for all range operations that use a Center's range facilities. The requirements state that "the Center range safety organization lead or NASA designee shall: (a) Implement or oversee the implementation of this NPR and associated Center-level processes and requirements including the risk management process of paragraph 3.2.4 of this NPR, (b) identify program data requirements, perform or evaluate and approve required range safety analysis, (c) evaluate and approve all range safety systems, (d) designate a qualified Range Safety Officer (RSO) to support each NASA mission that involves range operations (see paragraph 1.3.8 of this NPR for RSO responsibilities), (e) establish a qualification and training program that satisfies paragraph 3.5 of this NPR for range safety personnel (including RSOs and personnel responsible for range safety systems and range safety analysis) appropriate to the types of vehicles and operations at the range, (f) set operational performance requirements and standards for all range safety systems and (g) ensure the readiness of the range safety systems to support each operation."

The WFF Balloon Program launch activities take place at the contractor CSBF launch facilities or remote locations. However this does not make the BPO exempt from the safety implementation requirements of 1.3.5, based on the intent of NPR 8715.5 Sections 1.3.2 and

1.3.4.2 which are designed to ensure that implementation of safety standards remains consistent for all NASA programs and operations.

The Balloon Program Manager also has a number of required duties designed to provide insight to the balloon launch programs included in NPR 8715.5 (Section 1.3.7, Vehicle Program Manager), the first being to “(a) establish the processes and associated program-level requirements needed to ensure the requirements of this (the Range Safety Program) NPR are satisfied.” Additional oversight requirements include: (c) the coordination of range safety organizations including RSO” to develop and implement operational range safety requirements, plans, procedures, and checklists, including mission rules and flight commit criteria”; “(d) designate a Range Safety Representative for the vehicle program”; “(e) involve range safety personnel and begin the tailoring process by the System Requirements Review (SRR), continuing throughout all pertinent vehicle and payload reviews and during Operations.”; “(f) ensure adequate resources and data are available to support all range safety requirements and activities, including the design, test, and implementation of vehicle range safety systems required to support range safety requirements, the range safety organization/authority supporting the review, and approval process and operational support”; “(g) incorporate the requirements of this document in all launch service provider contracts and flight or other range operation contracts or agreements.”, (j) in coordination with the range safety organization(s), generate a contingency action plan that describes roles and responsibilities in the event of a mishap and provides procedures to secure all data relevant to an investigation.”; “(l) in coordination with any Center that supports the range operation, ensure all employees and visitors are informed of potential hazards associated with a range operation and the actions to take in the event of an emergency.”; “(o) engage the Center range safety organization regarding, and establish a plan for, monitoring of vehicle and range processes during launches, entries, and other range operations and to ensure timely identification and resolution of any violation that might affect launch, entry, or other operational approval. Engage with the NASA Range Safety Manager to perform this function for range operations not supported by a Center range safety organization; and (v) ensure that any vehicle program personnel who perform a range safety function are qualified and trained in accordance with paragraph 3.5 of this NPR.

Evidence suggests the many of these safety responsibilities were not sufficiently performed on the behalf of the Balloon Program leading to inadequate oversight and insight into the Balloon Program launch operations.

The Range Safety Manual also assigned oversight responsibility to the Balloon Program Office. RSM 2002 Section 2.0 requires that “For the Balloon Program, the Chief, Balloon Program office shall ensure that 1) the requirements and the procedure defined in appropriate safety plans and balloon risks analysis are implemented and (2) the operational responsibilities normally assigned to the Mission Range Safety Officer (MRSO), Operations Safety Supervisor (OSS), or Project Manager in this document are implemented for balloon operations” and defines each of these positions.

Evidence suggests that the Balloon Program was noncompliant with these oversight responsibilities. Evidence collected for the Alice Springs NCT launch shows the BPO in fact, did not ensure the implementation of appropriate protection for hazardous launch operations as required nor did they provide the assignment and subsequent performance of the required safety responsibilities of OSS and MRSO.

There is no flow down of direction from the RSM 2002 in the CSBF documentation that requires personnel to assume the safety responsibilities of the MRSO, OSS (and Project Manager). The CSBF Balloon Ground Safety Plan, Chapter 2–Safety Responsibilities, states simply that “the CSBF Operations Department Head (campaign manager at remote sites) is responsible to ensure compliance with the provisions of the BGSP for CSBF operations and for science user operations.” There is no reference to what these “provisions” are and no reference to the duties described in the RSM 2002. (Note: the only other reference to a specific duty is later in the paragraph– “The crew chief is responsible to direct the movement and operation of all heavy equipment used in balloon launch operations in such a way to ensure safety and minimize the number of personnel exposed to hazards associated with this equipment.”) There is no discussion of certification, training, no reference to NASA requirements, and no mention of specific duties as outlined in RSM 2002. (Note the only reference to the RSM 2002 is in Section 1 Scope: “The BGSP is derived from the NASA GSFC/WFF Range Safety Manual, identified as RSM 2002”. The word ‘derived’ is ambiguous. There is no required RSO or OSS or MRSO training provided to the CSBF safety designees.

The lack of a dedicated, trained safety officer engaged in reviewing launch procedures, verifying test results, conducting pre-task briefings, monitoring the hazardous launch operations and making abort decisions left both personnel and the general public vulnerable to potential injury or death. The Campaign Manager and Launch Director were over-burdened with the responsibility of assuming safety monitoring duties in addition to their operational duties; they were also not properly trained to do so.

Insufficient oversight by the WFF Safety Leadership, along with the absence of dedicated safety professionals at the launch site significantly added to the risks of the balloon program launch activities.

D1.7 Closure of Audit Findings and Recommendations

Insufficient management oversight regarding the implementation of the 2002 Balloon Program Independent Safety Assessment (reference QA-D-02-04-001) findings and recommendations allowed required corrective actions to remain incomplete.

NPR 8715.5, Range Safety Program, requires that a NASA Headquarters-level, independent assessment of range programs be conducted periodically. The NPR also states that it is the responsibility of the GSFC Center Director to “support range safety independent assessments and

(to) respond to all findings and recommendations for which the Center is accountable.” The 2002 assessment conducted for the WFF Safety Office (reference QA-D-02-04-001), brought forth twenty-three (23) findings and twenty-five (25) recommendations. Eight years later, many of these findings and recommendations remain inadequately or incompletely addressed. Five such findings have particular relevance to the Alice Springs incident and can be directly linked to either contributing or root causes for the mishap. Discussion of these findings are presented below:

QA-D-02-04-001 Finding 5—*Total Reimbursable Budget Authority (RBA) funding impacts the safety office’s ability to perform its mission. ‘There is no Direct Budget Authority (DBA) funding for the WFF range safety function. Since the WFF is a full cost accounting organization, there is only RBA funding available to the range safety organization. Recommendation: GSFC/WFF management should provide DBA funding based on range safety’s assessment of need. GSFC/WFF range safety organization could also attempt to gain DBA funds through submittal of a request to HQ Code Q POP process.’*

Interview evidence gives indication the WFF Range safety funding is not independent of the vehicle programs and that the funding structure of the WFF/GSFC safety office may still be an issue.

QA-D-02-04-001 Finding 6—*Safety practices not consistent across projects in 810, 820, 830 and 840. ‘WFF team would benefit from consistent and consolidated application of safety practices across the various program offices. Recommendation: WFF management standardize current safety practices in all WFF programs.’*

Evidence suggests however that Range Safety requirements are not equally or consistently applied to the Balloon Program. This is particularly true regarding the safety oversight and insight provided to the WFF Balloon Programs, including CSBF launch campaigns. Interview and document evidence shows that the Balloon program is not managed in the same manner as other Code 800 range programs and that the WFF Safety Organization, Code 803, has very limited interaction with and oversight of the Balloon Program. Interview evidence and document review show that several standard Code 800 and Code 803 range safety requirements and range safety documents (including processes, procedures, guidelines and work instructions) are not applied to the BPO nor have comparable processes and procedures been developed. For example, the Balloon program missions are not assigned RSOs. Also, contractor personnel have not been assigned the duties of MRSO or OSS nor has the required balloon-specific OSS training been provided as required by RSM 2002.

QA-D-02-04-001 Finding 9—*Range safety involvement with Balloon Program inadequate. The balloon programs operated at GSFC/WFF do not have independent range safety oversight or insight. These payloads are potentially hazardous to the public and should be managed consistent with other hazardous, uninhabited programs. Recommendation: GSFC/WFF Management should require range safety involvement in balloon programs. Suggest WFF range*

safety office and balloon program office coordinate a tailored range safety program for balloons.

Documentation and interview evidence suggest that the Balloon Program was not afforded the same level of safety insight or oversight as other Agency or even WFF Range programs and that range safety requirements were not consistently implemented for the Balloon Program.

WFF Range safety provided little or no insight or oversight for the CSBF launches, nor did they assign dedicated range safety personnel in the form of RSO, MRSO or OSS.

The 2002 assessment aptly pointed out the balloon program activity's potential danger to the public and recommended greater Code 803 involvement. Interview and document evidence supports the fact that the Balloon Program still suffers from a lack of oversight. The Safety office to-date does not perform periodic program audits or requirement, document, or analysis reviews, is not present at launch activities and depends on contractor and BPO to impose and maintain safety requirements.

QA-D-02-04-001 Finding 11—WFF pre-mishap planning is inadequate. *Recommendation: WFF should expand and update written pre-mishap plans for operations at WFF. In addition to the initial response actions, plans should also include all mishap hazards, investigation actions and responses in accordance with NPD 8621.1. Failure to adequately pre-plan may place personnel and resources at unnecessary risk and result in loss of investigation critical information.*

The contractor did have a mishap plan, but it was not fully compliant with the requirement of NPR 8621.1. OF-695-21-P, 'Columbia Scientific Balloon Facility Procedures Following Flight Mishap or Incident' requires that after a mishap, hardware not be disturbed prior to inspection by "appropriate personnel" (undefined) and gives the CSBF Operations Department Head or remote Campaign Manager authority to instruct movement or manipulation of hardware. There is no discussion of drug testing in the mishap plan. There is no information regarding potential hazards associated with or the safing of the equipment. The Balloon Program mishap plan does not include IRT information nor adequately address the safing of the mishap area or protection of evidence. The lack of a compliant MPCP left the Balloon Program Office and the CSBF contractors unprepared for the Alice Springs mishap. Evidence shows that post-mishap, the public and personnel were allowed in close proximity to unsafed hazardous systems (including pyrotechnics, and chemical batteries) and that there was significant disturbance of the mishap scene and removal of key evidence.

QA-D-02-04-001 Finding 15—Training documentation lacking. *There is little or no evidence that all training is documented and tracked within the safety office. Recommendation: An ISO process should be established and followed within the safety office (or at the 800 level) to provide requirements for training and to accurately document that training. Expedite the issuance of the ISO ground safety training process.*

There is no evidence of WFF-provided ground safety training for the Balloon Program contractors (CSBF) who were delegated safety responsibility for launch operations (nor of contractors certified based on WFF review of OSS equivalency). Appropriate NASA training was not mandated nor provided to the contractor by WFF Safety or the BPO. The contractor records only indicate on-the-job training records with no attached curriculum. NASA personnel with appropriate range safety training were not assigned as an alternate solution.

QA-D-02-04-001 Finding 21—Operations Safety Supervisor qualifications unclear. *It is not clear how WFF range safety verifies the qualifications of “other personnel” that may be delegated this responsibility. Recommendation: WFF should establish a clear policy for delegation of OSS responsibilities. Consider using EWR 127-1 Para 1.4.3 et al as a guide.*

WFF response to the 2002 audit was that training was being developed to qualify OSS personnel designated by the WFF RSO and that after the summer of 2002; all personnel assigned to OSS duties would be required to have the training. Evidence suggests that this corrective action was never completed. Currently CSBF contractors are not provided OSS training nor are WFF OSS-trained WFF personnel assigned to the balloon launches.

D1.8 Crane Operations

Balloon Program Crane Operations and Hardware was not in compliance with the NASA standards for Lifting Devices and Equipment.

RSM 2002, section 5.3.5.5 requires that “all lifting devices, fixtures, and equipment shall comply with the standards and regulations of NASA-STD-8719.9, Standards for Lifting and Equipment and GPR 8719.1 Certification and Recertification of Lifting Devices and Equipment”. It should be noted that the Balloon Launch Program utilized the crane in an unorthodox manner as a launch vehicle for the payloads. The balloon program’s expanded use of the mobile crane puts even more responsibility on the program to ensure that the intent of the Lifting Devices and Equipment requirements are fulfilled and that the potential hazards associated with each requirement are adequately controlled.

Based on a review of interview, written, photographic and video evidence supported by the GSFC Lifting Device and Equipment Manager (LDEM), the Alice Springs Balloon Launch operation was not in compliance with, nor did it meet the intent of the following NASA-STD-8719.9 requirements.

- Design Section 5.2.4 “Load capability and the desired controlled characteristics with which the crane/derrick handles the load shall be addressed for all designs. Operation requirements shall be considered in the design phase to ensure load and function are adequately defined and crane/derrick design features are incorporated on the delivered units.”

The restraint system yielded under the imposed load and the payload broke free. There is evidence to suggest that the Balloon Program was unaware of the design and operational limitations of the launch system. Analysis was not performed to identify all possible failure modes of the launch hardware.

- Training Section 5.6.2(1)(a) “Classroom training in safety, lifting equipment emergency procedures, general performance standards, requirements, pre-operational and safety related defects, and symptoms (for initial certification and as needed).”

Interview evidence supports the fact that crane operators were not fully knowledgeable regarding the limitations of the system. Crew training did not include emergency or anomaly training, including failed launch attempts. There were also no operating procedures produced or used.

- Operations Section 5.7(i) Cranes/derricks “shall not be side loaded, used to drag loads sideways, or used to pull loads unless specifically designed to do so by the OEM as indicated in the load chart.”

Video and photographic evidence as well as analysis shows that the launch vehicle was indeed at times side loaded and was used both to drag sideways and to pull the balloon induced loads.

- (m) “the operator and ground lead man shall establish appropriate safety zones before initiating operations. Safety zones should have appropriate barriers (rope, cones or other) established prior to lift.”

Video, photographic and interview evidence support that an effective safety zone designed to protect the public was not implemented. The Category A zone was ill-defined, ineffective, and was breached during the launch sequence. There was also no attempt to mark a safety zone appropriately prior to operations with cones, ropes or other barriers. Lack of marking made it inconceivable that the crane operator or other observers would detect when the zone was violated by either the balloon train or the moving crane.

- (t) “during hoisting, care shall be taken that there is not sudden acceleration or decelerations of the moving load and that the load does not contact any obstructions.”

Video and interview evidence support that the launch operation consisted of a number of sudden movements including accelerations and decelerations as well as turns that caused the payload to swing widely. At one point the excessive movement of the payload caused the operator to lose control of the payload tag lines. The rough and unimproved terrain contributed to the movement of the suspended payload. The payload also had potential to contact an obstruction when the launch vehicle was driven to the fence.

- (z) “An operator shall be at the crane /derrick controls at times while a load is suspended” (OSHA requirement). Due to the length of some NASA operations, an operator change may be required while a load is suspended. This shall be accomplished via a procedure designed for the specific crane/derrick and operation, assuring the crane controls are manned at all times.

Video, photographic and interview evidence support that the control cabin was not occupied during the launch attempt. The controls were therefore unmanned while the payload was suspended.

- (ai) “when traveling a mobile crane with a load, a person shall be designated responsible for determining and controlling safety and making decisions as to position of the load, boom location, ground support, travel route and speed of the motion.”

Interview and documented evidence support the fact that there was considerable confusion among both the crew and the Balloon Program regarding specific personnel safety and decision-making responsibilities and authority. It was clear that the launch director was in charge of travel route and speed of the motion; however, the safety control and decision making was not as well defined. There was confusion over who had the abort authority and who was responsible for assuming the role of the Mission Range Safety Officer.

- (ak) “When rotating cranes/derricks, sudden starts and stops shall be avoided. Speed shall be such that the load does not swing out beyond radii at which it can be controlled. A tag line should be used when rotation of load is hazardous”

Video and interview evidence support the fact that the payload swung beyond the radius of control. Excessive swinging of the load caused the technician to lose control of both payload tag lines. He was only able to regain control of one line prior to the unintentional release of the payload.

- Sling Section 10.7(g) “The following materials and techniques shall not be used in slings or rigging hardware to hoist personnel or loads: natural rope, wire rope clips, the fold back metal pressed sleeve or clip technique.”

Photographic evidence shows that the fold back technique was used. The photo also revealed that the cords were improperly taped, making required inspection of the cords impossible.

In addition, video evidence suggested the potential for non-compliance with the Critical and Noncritical Lifting Operations, requirement 1.5.1 that states “Personnel shall not be located under suspended or moving loads unless the operation adheres to the OSHA-Approved NASA Alternate Standard for Suspended Load Operations.”

The movement of the payload was sufficient to cause concern regarding personnel safety. It is suggested that Appendix A of the NASA-STD-8719.9 be examined for possible solutions that may include supporting the payload from underneath, in order to eliminate this potential hazard.

D1.9 Independence of Safety

NPR 8715.5 Chapter 1.3.2 (c) states that the HQ Range Safety Manager will “ensure consistent implementation of range safety requirements throughout the Agency.” Evidence suggests however that Range Safety requirements are not equally or consistently applied to the Balloon

Program. This is particularly true regarding the independence of the safety oversight or insight provided to the WFF Balloon Programs, including launch campaigns. NPR 8715.5 section 1.3.4.3 requires ‘that the Center Director or NASA designee when functioning as the authority for a range shall establish a Center range safety organization (direct or delegated) that is independent of all vehicle programs’.

NPR 8715.3 Section 1.4.3 requires that the Center Director (b) place their safety organization at a level that ensures the safety review function can be conducted independently and (d) “ensure that (1) adequate resources (personnel and budget) are provided to support mishap prevention efforts, (2) resource control is independent from any influence that would affect the independence of the advice, counsel, and services provided and (e) ensure that policies, plans, procedures, and standards that define the characteristics of their safety program are established, documented, maintained, communicated, and implemented.”

Evidence suggests that the independent safety oversight provided to the balloon program was inadequate. The majority of the range safety functions for the Alice Springs NCT launch were carried out by the balloon launch service contractor, CSBF, not an independent source. The WFF Range Safety Office Code 803 had little or no insight or oversight into the technical aspects of the balloon program and provided little in the way of document review, launch site visits, program audits or hazard control verification.

This same lack of independence was observed in the NASA Headquarters’ 2002 WFF Independent Assessment Report from which the following statements are taken: “Unlike other uninhabited flight programs, the policy and practice in effect in the balloon programs operated at GSFC/WFF do not require independent safety oversight or insight.” “With NASA it is common practice to utilize an organization that has no direct stake in the project to establish and implement safety plans, risk analyses and procedures. This independence ensures that the range safety requirements will not be compromised. These payloads are potentially hazardous to the public and should be managed consistent with other hazardous, uninhabited programs.” “Management is accepting an unknown level of risk associated with balloon operations.” The Headquarters assessment team recommended that “GSFC/WFF management should require range safety involvement in the balloon programs. The assessment team suggested that the WFF range safety office and balloon program office coordinate a tailored range safety program for balloons.”

D1.10 Training

The Balloon Program Office and CSBF in lieu of written procedures and explicit hazard controls relied heavily on the on-the-job training provided to the crew.

Interview data determined that despite many hours of on-the job training; crew training did not include specific training for anomalous situations. There was no instruction on specific abort

criteria, response to breach of safety zones or IRT training. Personnel were given limited guidelines regarding hazardous operations and decisions, such as abort criteria. Evidence also indicates uncertainty among both BPO and CSBF personnel regarding who has abort authority, the application of the Category A hazard zone for the launch phase and assigned safety roles and responsibilities.

There is also no evidence of WFF-provided ground safety training for the Balloon Program contractors (CSBF) who were delegated safety responsibility for launch operations (nor of contractors certified based on WFF review of OSS equivalency). The duties of MRSO and OSS were required to be assumed and verified by the BPO in accordance with RSM 2002. However appropriate NASA training was neither mandated nor provided to the contractor by WFF Safety or the BPO. The contractor records only indicate on-the-job training records with no attached curriculum. NASA personnel with appropriate range safety training were not assigned as an alternate solution.

Despite the provision in RSM 2002 (section 2) that the operational responsibilities of the Operational Safety Supervisor (OSS) could be implemented for the balloon program by the contractor; the CSBF personnel were not trained in accordance with the RSM to assume the responsibilities of OSS.

The RSM requires that all personnel designated as OSS are certified by the Safety Office Ground Safety Group (GSG) either by attending a specialized OSS course and successfully completing the testing or by providing satisfactory evidence of the contractor's possession of the required skills and knowledge. The procedure is documented in 800-PG-8715.04A, 'Certification Procedures for Operations Safety Supervisors at WFF'. Balloon-specific (Category II -Balloons) training and certification would have been required for the CSBF crew. Both interview and documentation evidence show that such certification was neither offered by the WFF Safety Office nor otherwise obtained by any of the CSBF crew members.

The Balloon Ground Safety Plan did not provide a full discussion of personnel training and certification requirements for the hazardous operations to be performed. There was no clear system for the verification of the status of operator certification prior to the beginning of the launch operations. Evidence suggests that one of the launch crew member's required crane operator certification was not current.

D1.11 Mishap Response Plan

The CSBF Mishap Plan was not sufficient to meet the requirements of NPR 8621.1 and NPR 8715.5. The plan failed to provide adequate direction to preserve evidence and to keep personnel and public safe in the event of a mishap.

NPR 8715.5, section 1.3.4.2(i) requires that Center Directors functioning as the authority for fixed or mobile launch sites “Develop emergency plans to prevent or mitigate the exposure of the public or employees to any hazard associated with range operation.” NPR 8715.5, section 1.3.7(j) stipulates that the Vehicle Program Manager “In coordination with the range safety organization(s), generate a contingency action plan that describes the roles and responsibilities in the event of a mishap and provides procedures to secure all data relevant to an investigation” and stipulates the use of NPR 8621.1, NASA Procedural Requirements for Mishap Reporting, Investigation and Recordkeeping.

NPR 8621.1, Section 2.2 Program and Project Mishap Preparedness and Contingency Plans, 2.2.1.(a) requires that Program Managers concur with a Program and Project Mishap Preparedness and Contingency Plan (MPCP) that “is a comprehensive plan for all mishaps and close calls that occur offsite, at offsite program/project contractor sites, or in flight.”

The Balloon Program’s contingency plan, ‘Procedures Following Launch/Flight Failures, Mishaps, or Incidents CSBF OF-695-21-P’, did not meet the content requirements of 2.2.1. The following data requirements were not adequately addressed within BPO’s document:

1. Special procedures for emergency response personnel, the IRT, and the incident commander for identifying, safing, and handling hazardous commodities specific to the hardware
2. Training requirements for IRT membership for mishaps and close calls occurring off-site and contractor locations
3. Procedures to impound data, records, equipment, facilities, and property
4. Existing memoranda(s) of agreement with national, state, and local organizations and agencies that may be utilized during a mishap investigation
5. Descriptions of how offsite debris shall be collected, transported, and stored
6. Descriptions of investigation and debris collection process required for any mishap or close call occurring in a foreign country
7. Specification that for NASA-investigated mishaps, NASA personnel shall perform and control the impounding process

The contractor did have a generic mishap plan, but it was not fully compliant with the requirement of NPR 8621.1. OF-695-21-P, ‘Columbia Scientific Balloon Facility Procedures Following Flight Mishap or Incident’ requires that after a mishap hardware not be disturbed prior to inspection by “appropriate personnel” (undefined) and give the CSBF Operations Department Head or remote Campaign Manager authority to instruct movement or manipulation of hardware. There is no discussion of drug testing in the mishap plan. There is no information regarding potential hazards (including radioactive sources) associated with the equipment. The Balloon Program mishap plan neither includes IRT information nor adequately addresses the safing of the mishap area or protection of evidence.

The lack of a compliant MPCP left the Balloon Program Office and the CSBF contractors unprepared for the Alice Springs mishap. Evidence shows that post mishap, the public and personnel were allowed in close proximity to the 'unsafed' hazardous systems (including pyrotechnics, and chemical batteries) and that there was significant disturbance of the mishap scene and removal of key evidence.

D2 – Safety Assessment Results

The safety requirements assessment results are formatted into individual safety topics. Each report references the corresponding Root Cause(s), Intermediate Cause(s), Contributing Factor(s), and/or Observation(s) of this mishap report section 4 (if applicable); followed by a discussion regarding the insufficient application of safety requirements associated with the topic of discussion. The requirements are itemized and then excerpts from the applicable requirements are highlighted for the convenience of the reader.

INADEQUATE PROTECTION OF PUBLIC

Safety Assessment Observation: Public safety is not addressed in the CSBF Ground Safety Plan
Mapping to Report Findings:
<p>R1: WFF safety leadership did not ensure complete flow down of agency requirements to protect the public</p> <p>R2: WFF safety leadership did not provide appropriate oversight to WFF implementation of safety requirements (WFF Safety Office and BPO implementing organizations)</p> <p>R4: GSFC safety leadership did not verify or provide corrective action for flow down of NASA requirements to protect the public</p> <p>I2: A barrier to keep the general public out of all dangerous areas throughout the launch process did not exist</p> <p>I3: No trained individual was in place to ensure public safety</p> <p>I7: Category A hazard area was not well defined</p> <p>I 11: The ground plan did not explicitly address the general public as a target</p> <p>I14: GSFC safety management did not verify or provide corrective action for flow down of NASA requirements to protect the public</p>
Discussion:
<p>“It is NASA policy to protect the public... from potential harm as a result of NASA activities and operations by factoring safety as an integral feature of programs, projects, technologies, operations, and facilities.” - NPR 8700.1</p> <p>The NASA Policy for Safety and Mission Success, NPD 8700.1 establishes public safety as the Agency’s number one policy. [Reference 1] The NASA General Safety Program Requirements, NPR 8715.3C and the NASA Range Safety Program Procedural Requirements NPR 8715.5 both function to provide requirements for implementation of this policy. [Reference 2 & 3] The WFF Range Safety Manual, RSM- 2002, however, fails to flow the policy down into WFF Range Ground Safety requirements. The RSM imposes no requirements for public safety in relation to Ground Safety. [Reference 4] Public safety is only addressed in the context of Flight Safety requirements</p>

(section 6). [Reference 5]

6.1 As a consequence of this omission in the RSM, the CSBF Ground Safety Plan, in parroting the safety goals of the RSM-2002 Ground Safety requirements, does not address the need for public safety in its scope or practice. [Reference 6] The CSBF Contract NAS5-03003, Attachment D, Safety and Health Plan policy statement also does not include safety of the public, only the safety of personnel and equipment are considered. [Reference 7] The only reference to “public safety” that can be found in the CSBF contract is if one traces the referenced NASA FAR supplemental (NFS) clause 1852.223-70, Safety and Health to its source. [Reference 8]

It is worth noting that neither the CSBF contract NAS5-03003 Statement of Work (SOW) nor the Safety and Health Plan mandate implementation of specific, applicable NASA safety requirements, including, but not limited to NPD 1700.1, NPR 8715.3, NPR 8715.5 or RSM-2002 all of which address public safety policy and requirements. [References 9 & 10]

The Balloon Program also failed to implement standard protective controls that would have benefited public safety. Hazardous operating procedures were not instituted for launch activities as required by NPR 8715.3, NPR 8715.5, NASA FAR supplemental 1852.223-70 and the Contract NAS5-03003 Health and Safety Plan [References 11 -14]; WFF Procedures and Guidelines for control of public, such as those found in 800-PG-8715.1.1 and 800-PG-8715.0.3, including roadblocks and dedicated viewing areas, were not implemented for the Balloon Program [Reference 15&16] nor were dedicated safety professionals (e.g., RSO, MRSO and OSS) assigned to oversee the launch process as required by NPR 8715.5 and RSM-2002, and recommended by the HQ independent audit of 2002. [Reference 17-19] If properly implemented one or all might have served to ensure that hazardous operations would not have begun or continued without properly controlling the presence and proximity of bystanders to the hazardous activities.

These requirement omissions were not captured by WFF safety document review or oversight practices. WFF safety leadership therefore did not ensure complete flow down of agency requirements to protect the public nor did GSFC safety leadership verify or provide corrective actions for the flow down of NASA requirements to protect the public.

Applicable Requirements:

NPD 8700.1E, Section 1.0 Policy

NPR 8715.3, NASA General Safety Program Requirements, Section 1.1 Overview, 1.3.1, 3.8.2, 3.8.3

NPR 8715.5, Range Safety Program, P.1 Programs, Section P.1 Purpose, 1.3.7

RSM-2002-Rev B, Range Safety Manual, Section 5.1 Ground Safety, General

RSM-2002-Rev B, Range Safety Manual, Section 6.1.1 Flight Safety, Policies

OF-610-00-P, CSBF Balloon Ground Safety Plan, Section 1.0 Scope NAS5-03003, Contract for the Implementation of the NASA's Balloon Flight Program, Operation and Maintenance of the National Scientific Balloon Facilities (NSBF) in Palestine, Texas and Fort Sumner, New Mexico, and Engineering Support for NASA's Balloon Program.

NASA FAR supplemental 1852.223-70, Safety and Health (a), (g.3)

Detailed Requirements:

[R1]

NPD 8700.1E 1./Policy “It is NASA policy to – a. Protect the public, NASA workforce, high-value equipment and property, and the environment from potential harm as a result of NASA activities and operations by factoring safety as an integral feature of programs, projects, technologies, operations and facilities.” c. “Hold NASA leaders, managers, supervisors, and employees accountable for safety and mission success within their assigned areas of responsibility.”

[R2]

NPR 8715.3/P1.1/Overview of the NASA Safety Program/1.1.2. “As stated in NPD 8700.1, NASA Policy for Safety and Mission Success, the objectives of the NASA Safety Program are to protect the public from harm, ensure the safety of employees, and affect positively the overall success rate of missions and operations through preventing damage to high-value equipment and property.”

NPR 8715.3/1.3 Public Safety/1.3.1 “Center Directors, project managers, supervisors, and NASA employees shall: a. Eliminate risk or the adverse effect of NASA operations on the public, or provide public protection by exclusion or other protective measures where the risk or the adverse effect of NASA operations on the public cannot be eliminated. *Note: The responsibility for public safety includes major events such as air shows, open houses, or other events that may be attended by large crowds.*”

[R3]

NPR 8715.5 / P.1/ Purpose “This NASA Procedural Requirements (NPR) document describes NASA's range safety policy, roles and responsibilities, requirements, and procedures for protecting the safety of the public, the workforce, and property during range operations associated with flight.”

NPR 8715.5 /1.3.4.2 “When functioning as the authority of a range, launch site, (fixed or mobile), or landing site including any airfield used for range operations); or when onsite personnel are affected by range operations, the Center Director or NASA designee shall:...b Ensure all employees and visitors are informed of potential hazards associated with a range operation and the actions to take in the event of an emergency.”

[R4]

RSM-2002 / 5. Ground Safety /5.1 General: “The ground safety goal of the GSFC’s WFF is to minimize risks to personnel and property involved in conducting operations at GSFC’s WFF and to prevent mishaps that might result in embarrassment to NASA and the United States Government.” “It is required that all systems be designed such that it will take a minimum of two independent unlikely failures occurring in order for personnel be exposed to a hazard.”

[R5]

RSM-2002 / 6. Flight Safety /6.1 Policies: “The flight safety goal is to protect the public, range participants, and property from the risk created by conducting potentially hazardous operations at WFF and to prevent mishaps that would result in embarrassment to NASA or the United States Government. Although these risks can never be completely eliminated, the flight should be carefully planned to minimize the risks involved while enhancing the probability for attaining the mission objective.”

[R6]

OF-610-00-P Balloon Ground Safety Plan / 1 Scope: “The ground safety goal of the CSBF is to minimize risks to personnel and property in conducting operations and to prevent mishaps that might result in embarrassment to CSBF, NASA and the United States Government.” “It is the policy of the GSFC/WFF and CSBF that all systems be designed such that a minimum of two independent unlikely failures must occur to expose personnel to a hazard.”

[R7]

CSBF Contract NAS5-03003, Attachment D, Safety and Health Plan 1.1/Policy: “The policy of PSL is to provide a safe and healthful workplace for contract, NASA and user personnel ‘to conserve and protect Government-owned resources,’ and to support the overall NASA safety program. PSL considers the safety of personnel and equipment to be of the utmost importance in all NSBF operations. Every employee knows that safety is a prime consideration for all tasks performed.” (Note: in 1.0, employees include public – there is no such definition for personnel)

[R8]

NASA FAR supplemental 1852.223-70, Safety and Health (a.1): “Safety is the freedom from those conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to or loss of equipment or property, or damage to the environment. NASA’s safety priority is to protect: (1) The public, (2) astronauts and pilots (3) the NASA workforce (including contractor employees working on NASA contracts), and (4) high-value equipment and property.”

NASA FAR supplemental 1852.223-70, Safety and Health (g.3): “The Contractor (or subcontractor or supplier) shall insert the substance of this clause...when the following conditions exist (3) The work, regardless of place and performance, involves hazards that could endanger the public, astronauts and pilots, the NASA workforce (including contractor employees working on NASA contracts), or (4) high-value equipment or property.”

[R9]

CSBF Contract NAS5-03003, Attachment A, Statement of Work 3.0/Summary of Requirements:

To accomplish the objectives of this SOW, the contractor shall: B. Conform with all applicable government and industry standards, procedures and policies. (Note: no specific requirements listed in statement of work.)

[R10]

CSBF Contract NAS5-03003, Attachment D, Safety and Health Plan: (Applicable Requirements) :
No Applicable NASA (or other) Safety requirements listed

[R11]

NPR 8715.3/3.8 Hazardous Operations/3.8.1 -3.8.3

3.8.1 “NASA hazardous operations involve materials or equipment that, if misused or mishandled, have a high potential to result in loss of life, serious injury or illness to personnel, or damage to systems, equipment, or facilities. Adequate preparation and strict adherence to operating procedures can prevent most of these mishaps. ”

3.8.2 “Center Directors and project managers shall: a. Identify, access, analyze, and develop adequate safety controls for all hazardous operations. b. Ensure that all hazardous operations have a Hazardous Operating Procedure or a Hazardous Operating Permit (HOP).”

3.8.3 “Center SMA Directors or their designee shall review and approve HOPs.”

[R12]

NPR 8715.5/1.3 Public Safety/1.3.7 “The Vehicle Program Manager. For each range operation, the vehicle program manager or NASA designee shall: c. Coordinate with the range safety

organization(s), including the RSO or equivalent, to develop and implement operational range safety requirements, plans, procedures, and checklists, including mission rules and flight commit criteria (see paragraph 3.4 of this NPR for operational requirements)

[R13]

NASA FAR supplemental 1852.223-70, Safety and Health (j) “The contractor shall continually update the safety and health plan when necessary. In particular, the Contractor shall furnish a list of all hazardous operations to be performed, and a list of other major or key operations required or planned in the performance of the contract, even though not deemed hazardous by the Contractor. NASA and the Contractor shall jointly decide which operations are to be considered hazardous, with NASA as the final authority. Before hazardous operations commence, the Contractor shall submit for NASA concurrence -

- (1) Written hazardous operating procedures for all hazardous operations; and/or
- (2) Qualification standards for personnel involved in hazardous operations.”

[R14]

CSBF Contract NAS5-03003, Attachment D, Safety and Health Plan/Section 4.0, Hazardous Prevention and Control/4.1.2 Written Procedures: “Written procedures for hazardous operations will be developed. Those procedures currently in use will be reviewed to ensure they address all pertinent safety issues. All procedures will be reviewed to ensure they address all pertinent safety issues. All procedures will be reviewed by the SR&QA manager and the Site Manger and approved by the Program Manger. Copies of all procedures will be reviewed annually or whenever an accident of mishap occurs or when any alteration of the procedure is proposed. Copies of procedures will be maintained by the SR&QA office and in the facility where the procedures occurs. Flight-line operations procedures will be maintained by the Operations Manager. Any information in PSL’s possession regarding hazardous operations will be made available to appropriate NASA authorities.”

[R15]

800-PG-8715.1.1, Unmanned Roadblocks for Hazardous Operations

P.1 Purpose: “This procedure establishes a process for enforcing road access control for all hazardous operations, especially rocket launch operations on Wallops Island. This directive describes where operational roadblock locations are defined (i.e., in the Ground Safety Plan) how unmanned roadblocks will be enforced, and the possible consequences for violating unmanned roadblocks.”

P.2 Applicability: “Due to the nature of activities pursued by Code 800, guidelines are necessary to ensure personnel safety and to maintain the quality of on-the-job performance. This guideline is applicable to all operations managed by or under the auspices of Code 800 at Wallops Flight Facility (WFF). It is applicable to support contractors and other directorates when their work duties support or are impacted by Code 800 missions.”

P.6 Safety: “Unmanned roadblocks are established at the WFF to prevent personnel from entering a hazardous operations area. Personnel who violate roadblocks may be exposed to great potential danger.”

[R16]

800-PG-8715.0.3, Viewing Location for Personnel Not Essential to Launch Operations

P.1 Purpose: “This procedure establishes a process of safe viewing of launch operations on Wallops Island.”

P.2 Applicability: “Due to the nature of activities pursued by Code 800, guidelines are necessary to ensure personnel safety. This guideline is applicable to all launch related operations managed or under the auspices of Code 800 at WFF. It is applicable to all visitors and facility personnel, including tenants.”

P.6 Safety: “Viewing areas are established to protect personnel not essential to launch operations from the risks associated with launch operations on Wallops Island.”

[R17]

NPR 8715.5 / 1.3.5/ Center Range Safety Organization: “For all range operations that use a Center's range facilities, the Center range safety organization lead or NASA designee shall:... d. Designate a qualified Range Safety Officer (RSO) to support each NASA mission that involves range operations (see paragraph 1.3.8 of this NPR for RSO responsibilities).”

[R18]

RSM-2002/ Section 2.0: “For the Balloon Program, the Chief, Balloon Program Office shall assure that (2) the operational responsibilities normally assigned to the MRSO, OSS, or Project Manager in this document are implemented for balloon operations.”

[R19]

QA-D-02-04-001 / Finding #21: “Operations Safety Supervisor qualifications unclear. It is not clear how WFF range safety verifies the qualifications of “other personnel” that may be delegated this responsibility. Recommendation: WFF should establish a clear policy for delegation of OSS responsibilities. Consider using EWR 127-1 Para 1.4.3 et al as a guide.”

INSUFFICIENT PROTECTION OF PERSONNEL

Safety Assessment Observation: Insufficient protection of personnel from balloon launch hazards
Mapping to Report Findings:
<p>R2: WFF safety leadership did not provide appropriate oversight to WFF implementation of safety requirements (WFF Safety Office and BPO implementing organizations)</p> <p>R3: WFF Safety Office was not sufficiently knowledgeable about the details of the balloon launch process</p> <p>I1: WFF safety office did not perform rigorous hazard analysis</p> <p>I4: The ground safety plan was inadequate to cover all relevant hazards and phases</p> <p>I5: No complete and thorough standard procedure exists at CSBF to cover the launch process</p> <p>I6: Launch crew training did not address failed launch attempts</p> <p>I8: CSBF did not analyze the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt</p> <p>I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch vehicle maneuver</p> <p>I12: The BPO did not have sufficient insight or oversight into the technical aspects of the CSBF's balloon launch process</p> <p>I13: Wind created a challenging environment</p> <p>I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program</p> <p>I15: WFF safety leadership did not thoroughly review balloon safety documentation</p>
Discussion:
CSBF contractor as well as the Balloon Program Office and the WFF Range Safety Office provided insufficient protection to personnel from hazards associated with the balloon launch process.

RSM-2002 Ground Safety, section 5.1.1 states that “the ground safety goal of GSFC’s WFF is to minimize the risks to personnel and property involved in conducting operations at GSFC’s WFF and to prevent mishaps that would result in embarrassment to NASA or the United States Government”. Section 5.1.2 also requires “that all systems be designed such that it will take a minimum of two independent, unlikely failures occurring in order for personnel to be exposed to a hazard” and that (section 5.2.4) the Ground Safety Plan identify “the potential hazards and describe the system design and methods employed to control the hazards”.

The Balloon Ground Safety Plan (OF-610-00-P) echoes these goals; it too states that CSBF’s ground safety goal is to minimize risks to personnel. The Balloon Ground Safety Plan however does not comply with the requirements of the Range Safety Manual. The Balloon Ground Safety Plan does not adequately address the requirements to identify potential hazards, to describe the design of hazardous systems and to provide methods of hazard control for each identified hazard in order ensure personnel safety.

There is also no evidence to support that all hazardous systems were either designed or validated (through test or analysis) to withstand two failures, nor can it be shown that sufficient hazard analysis was performed to identify all hazards for the launch phase (including those caused by mechanical limitations or hardware operational constraints) or that all known controls were effectively implemented.

Examples of inadequate protection of personnel can be described in terms of deficiencies regarding system description, hazard identification and corresponding hazard controls, Personnel Protective Equipment (PPE), hazardous operating procedures, training and safety oversight.

System Description

The Ground Safety Plan is not compliant with the RSM-2002 requirement to describe the hazardous system design. System descriptions of the ground support equipment and flight hardware should include, but not be limited to, such pertinent design data as pressures systems component parameters, pyro specifications and locations, launch vehicle tolerances and inhibit schemes. Lack of proper descriptions left personnel without insight into the design of hazardous systems and the ability to assess their compliance with design requirements. RSM-2002 (section 5.3.3.5) requires “that no personnel shall be allowed with the danger area of a Category A system if the system has been reduced to only one inhibit.” Such an evaluation is impossible without clear description of the systems and their required inhibits.

Identified Hazards and Corresponding Controls

The Balloon Ground Safety Plan does not adequately identify potential hazards or identify specific mitigations for identified hazard cause. The potential “independent, unlikely failures” that drive the systems design in accordance to the requirements of RSM-2002 are not identified. A number of hazards are either not identified or not discussed in any detail. Examples included the hazards associated the balloon inflation pressure system, and the mobile crane launch vehicle and its operation (e.g., potential mechanical failures, operational constraints and hazards associated with the swinging load in close proximity to the crew).

In many cases, personnel training is the only identified control for serious hazards, essentially putting the burden of control solely on the individual skill and memory of the operator. It was noted that for RF hazards, in lieu of documented controls within the Ground Safety Plan, personnel are provided a reference document for more guidance (“more guidance (if required) for RF hazards to personnel may be found in IEEE C95.1-1999, listed in the reference in Section 5.0”). For hazards associated with chemicals, personnel are required to reference posted Material Safety Data Sheets. Neither of these discussions constitutes adequate identification and control of hazards.

Protective Personnel Equipment (PPE)

PPE requirements were not enforced for the Alice Spring launch.

The Balloon Ground Safety Plan requires that hardhats be worn by crew members during launch operations, however photographic evidence shows at least two crew members participated in launch activities without hard hats.

The Balloon Program also failed to carry forward lessons learned from a previous balloon launch close call, reported in the IRIS system in 2000. The formal corrective action included installation of a safety cage over and around the personnel platform and requiring safety hats, glasses and shoes to be worn by all flight line personnel. The Balloon Program did not carry any of these protective measures forward. The Balloon Ground Safety Plan did not require safety glasses or safety shoes, or that a protective structure be provided.

Hazardous Operating Procedures

The CSBF launch operations took place without the benefit of hazardous operating procedures. Evidence obtained through witness interviews and document review indicates that the CSBF did not develop or use written hazardous procedures. Lack of written hazardous procedures constitutes non-compliance with both Agency safety requirements and the WFF/CSBF contract.

Witness interviews uncovered that the contractor launch operators rely solely on checklists, the generic ground safety plan, job knowledge and experience to execute the complicated and hazardous launch operation steps. Procedures were not used for the Alice Springs NCT launch, nor are they typically used. The operators and WFF management furthermore, had little or no knowledge regarding the existence of hazardous operation procedures, or of the requirements for their use.

Training

The Balloon Program Office and CSBF in lieu of written procedures and explicit hazard controls relied heavily the on-the-job training provided to the crew. In fact, for many of the hazards listed in the Balloon Ground Safety Plan (including handling of ionizing radiation, handling and installing pyrotechnics, operating of heavy equipment and other tasks performed within the hazard area) lists prior personnel training was the only hazard control.

Interview data determined that despite many hours of on-the job training; crew training did not include specific training for anomalous situations. There was no instruction on specific abort criteria, response to breach of safety zones or IRT training. Personnel were given limited guidelines regarding hazardous operations and decisions, such as abort criteria or procedures relating to failed launch attempts. Evidence also indicates uncertainty among both BPO and CSBF personnel regarding who has abort authority, the application of the Category A hazard zone for the launch phase and assigned safety roles and responsibilities.

The Balloon Ground Safety Plan also did not provide a full discussion of personnel training and certification requirements for the hazardous operations to be performed. There was no clear system for the verification of the status of operator certification prior to the beginning of the launch operations. Evidence suggests s that one of the launch crew crane operator certification was not current.

Safety Oversight

Range Safety oversight was conspicuously absent and not in compliance with Range and Agency requirements.

The Balloon program and WFF Range Safety did not assign a Mission Range Safety Officer (MRSO) or Operational Safety Manger (OSS) to the Alice Spring NCT launch as required by NPR 8715.5 and RSM-2002. The lack of a dedicated trained safety officer engaged in reviewing launch procedures, verifying test results, conducting pre-task briefings, monitoring the hazardous launch operations and making abort decisions left both personnel and the general public vulnerable to potential injury or death. Contractor personnel were not given the benefit of undergoing simulation scenarios with a RSO in order to gain hands on experience including safety decision-making tools, and processes in conjunction with vehicle systems or mission rules and range safety flight commit criteria.

The Campaign Manager and Launch Director were over-burdened with the responsibility of assuming safety monitoring duties in addition to their operational duties; they were also not properly trained to do so.

Referenced Document:

IRIS Report 2000-231-00012

Applicable Requirements:

NPR 8715.5, Range Safety Program, 1.3.2, 1.3.4.3

RSM-2002, Range Safety Manual, 2.0, 5.0

NASA FAR supplemental 1852.223-70, Safety and Health (j)

CSBF Health and Safety Plan (Section J of the Contract NAS5-03003)

Detailed Requirements:

INSUFFICIENT HAZARD ANALYSIS

Safety Assessment Observation: The hazard analysis for the Pre-flight launch phases of the balloon launch process was insufficient.

Mapping to Report Findings:

R2: WFF safety leadership did not provide appropriate oversight to WFF implementation of safety requirements (WFF Safety Office and BPO implementing organizations)

R3: WFF Safety Office was not sufficiently knowledgeable about the details of the balloon launch process

R6: Reliance on past success has become a substitute for good engineering and safety practices in the balloon program

I1: WFF safety office did not perform rigorous hazard analysis

I4: The ground safety plan was inadequate to cover all relevant hazards and phases

I7: Cat A hazard area during launch phase was not well defined

I8: CSBF did not analyze the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt

I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt

I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch vehicle maneuver

I12: The BPO did not have sufficient insight or oversight into the technical aspects of the CSBF's balloon launch process

I13: Wind created a challenging environment

I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program

I15: WFF safety leadership did not thoroughly review balloon safety documentation

Discussion:

The Balloon Program's lack of stringent hazard analysis left them vulnerable to non-compliances with Agency and WFF Range Safety Requirements.

NPR 8715.5, Range Safety Program under Range Safety Analysis (section, 3.2.1), requires that "each range operation shall undergo a range safety analysis to establish any design or operational constraints needed to control risk to persons and property". [Reference 1] (Note: Range Operation is defined as the flight of a launch vehicle including payload at, to or from a range, launch sites or landing site.) The Balloon Program Office and the WFF Safety Office failed to perform, or to ensure that adequate analyses were performed, for the preflight phase of the balloon launch process. Due to this omission the balloon program operated without properly identified hazards and without adequate hazard controls.

The Range Safety Manual, RSM-2002 Section 5.2.4 stipulates that a Ground Safety Plan shall "identify the potential hazards and describe the system design and methods employed to control the hazards as well as establish controls to protect high value property." The ground plan must also include description and technical evaluation of the hazardous systems' compliance with the design requirements of section 5.1.2 [Reference 2] and section 5.3 (Specific Policies and Criteria) of the Ranges Safety Manual. Section 5.1 stipulates "that all systems are designed such that it will take a minimum of two independent, unlike design requirements for systems including safety critical Ground Support Equipment (GSE) (5.3.5.1), electrically operated GSE used on Category A systems (5.3.5.6), ground support pressure systems (5.3.5.12), RF systems (5.3.5.8), and lifting devices and equipment (5.3.5.5).

The Balloon Ground Safety Plan, OF-610-00-P does not include the required design descriptions and assessments nor does it identify all know hazards and controls associated with the launch pre-inflation, inflation and launch phases. Examples of hazards not adequately addressed within the current Ground Safety Plan include:

- **Structural failure of launch equipment**
- **Collision of moving/swinging payload with personnel or property (suspended loads)**
- **Collision or tipping of mobile crane with personnel or property**
- **Over pressurization or rupture of the balloon inflation system**
- **Inadvertent/premature release of the payload**
- **Inadvertent/premature ignition of pyrotechnics**
- **Inadvertent/premature abort**
- **Collision with aborted/released parachute train equipment**

There is no evidence to suggest that a comprehensive safety analysis was performed for the balloon program for either the hardware or the operations associated with the launch process. Adequate documentation was not found in the Ground Safety Plan nor any other documentation reviewed. Operational constraints, hardware failure mechanisms, and limits were not identified.

RSM-2002, prescribes the methodology for analysis and control implementation in the Ground Safety Hazard Control (Section 5.2). The RSM requires that the following hazard control methods be used to “protect personnel and property and minimize risk when conducting potentially hazardous operations”:

- **Identify all known hazards associated with the program**
- **Implement safety design criteria**
- **Minimize exposure of personnel to hazardous systems**
- **Establish safe operating procedures**
- **Plan for contingencies”**

Proper implementation of this process would have reduced the Balloon Programs risks of mishaps.

A traditional Operating and Support Hazard Analysis (O&SHA) is most often used to identify and evaluate hazards associated with the associated environment, personnel, procedures, and equipment involved throughout the operation (Reference System Safety Society Handbook). A closed-loop process is then employed to identify the hazards in terms of a) hazard description, b) potential consequences, c) cause, and d) established method(s) to control as well as to track and ensure the status of each hazard control prior to the start of the applicable operation.

Individual hazard reports included within the Ground Safety Plan would have helped to ensure that the hazards, their causes, consequences and controls were accounted for appropriately, through the review and update of the reports prior to each mission.

This type of rigor would help the Balloon Program to remain compliant with the RSM requirement to “identify the potential hazards and describe the system design and methods employed to control the hazards”.

Applicable Requirements:

NPR 8715.5, Range Safety Program, 3.2.1,

RSM-2002-Rev B, Range Safety Manual, 5.1.2, 5.2, 5.2.4, 5.3.5

Detailed Requirements:

[Ref 1]

6.2 NPR 8715.5,3.2 / Range Safety Analysis/3.2.1: Each range operation shall undergo a range safety analysis to establish any design or operational constraints needed to control risk to persons and property.

NPR 8715.5,3.2 / Range Safety Analysis/3.2.2: A range safety organization that is independent of the vehicle program shall review and approve the range safety analysis.

RSM-2002-Rev B, Range Safety Manual/5.0 Ground Safety/5.1 General/ 5.1.1: The ground safety goal of GSFC's WFF is to minimize the risks to personnel and property involved in conducting operations at GSFC's WFF and to prevent mishaps that would result in embarrassment to NASA or the United States Government.

[Ref 2]

RSM-2002-Rev B, Range Safety Manual/5.0 Ground Safety/5.1 General/ 5.1.2: It is required that all systems be designed such that it will take a minimum of two independent, unlikely failures occurring in order for personnel to be exposed to a hazard.

INADEQUATE GROUND SAFETY PLAN

Safety Assessment Observation: The CSBF Ground Safety Plan is not adequate. It does not provide a comprehensive hazard analysis of the launch ground operations and their controls.

Mapping to Report Findings:

R2: WFF safety leadership did not provide appropriate oversight to WFF implementation of safety requirements (WFF Safety Office and BPO implementing organizations)

R6: Reliance on past success has become a substitute for good engineering and safety practices in the balloon program

I1: WFF safety office did not perform rigorous hazard analysis

I4: The ground safety plan was inadequate to cover all relevant hazards and phases

I7: Cat A hazard area during launch phase was not well defined

I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt

I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch vehicle maneuver

I12: The BPO did not have sufficient insight or oversight into the technical aspects of the CSBF's balloon launch process

I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program

I15: WFF safety leadership did not thoroughly review balloon safety documentation

Discussion:

RSM-2002 Section 5.2.4 states that a Ground Safety Plan shall "identify the potential hazards and describe the system design and methods employed to control the hazards" as well as "to establish controls to protect high value property." [Reference 1]

The Range Safety Manual (RSM) states that ground safety plan must also include description and technical evaluation of the hazardous systems' compliance with the design requirements of section 5.1.2 [Reference 2] which stipulates "that all systems are designed such that it will take a minimum of two independent, unlikely failures occurring in order for personnel to be exposed to a hazard." and section 5.3 (Specific Policies and Criteria) which provides specific requirements for potentially hazardous systems including safety critical Ground Support Equipment (GSE) (5.3.5.1), electrically operated GSE used on Category A systems (5.3.5.6), ground support pressure systems (5.3.5.12), RF systems (5.3.5.8), and lifting devices and equipment (5.3.5.5).

RSM-2002 section 5.2.4.3 allows that, "where applicable, a general Ground Safety Plan may be prepared for repetitive operations/programs which shall identify safety planning for all potential hazards. This plan may be augmented for mission operations by a mission specific Ground Safety Plan." The Balloon Program chose to exercise this option. The Balloon Program Ground Safety Plan is a generic plan that was produced by the WFF Safety Office in 2004. It is supplemented by experimenter payload data provided in the format of questionnaires prior to each mission, which together with the generic plan, made up a Ground Safety Data Package. Even with the supplements included, the plan failed to contain the necessary information.

The CSBF Balloon Ground Safety Plan, OF-610-00-P, is not adequate and is not in compliance with the requirements of RSM-2002. It does not deliver a comprehensive hazard analysis of the launch ground operations, including constraints, a thorough description of the system design and constraints or fully identify the required hazard controls.

The hazard analysis provided by the Balloon Ground Safety Plan is not fully developed. The precautions and controls that are provided are not tied to specifically identified hazards and hazard causes and corresponding, verifiable controls. Many hazards are not identified at all. Examples of hazards not adequately addressed within the current Ground Safety Plan include:

- Structural failure of launch equipment
- Collision of moving/swinging payload with personnel or property (suspended loads)
- Collision or tipping of mobile crane with personnel or property
- Over pressurization or rupture of the balloon inflation system
- Inadvertent/premature release of the payload
- Inadvertent/premature ignition of pyrotechnics
- Inadvertent/premature abort
- Collision with aborted/released parachute train equipment

Typically, the Ground Operations Plans (GOP) or Ground Safety Plans (GSP) that NASA programs submit for Range Safety approval (e.g., Expendable Launch Vehicle (ELV) and Manned Space missions) provide detailed descriptions of the hazardous and safety critical operations

associated with a flight system and its associated ground support equipment. These GOP contain a description of planned operations including backout steps and the associated hazard analysis of those operations. The typical ground plan will contain a list of all procedures (non- hazardous, hazardous and safety critical), procedure descriptions, task summary details including hazards and precautions, and list of required PPE), identification of emergency and abort/back-out actions and a list of personnel training, certification and experience requirements for each type of hazardous operation such as ordnance, radiation and crane operations, and description of test performed on hazardous and safety critical systems. In addition a hazard analysis is included for each hazardous system and an Operating and Support Hazard Analysis (O&SHA) is provided for each hazardous operation. The O&SHA worksheets typically provide the following information: general hazard group, specific hazard condition, effect of hazard if not controlled, hazard control hardware, hazard control procedure, hazard control personnel. The plan also provides a mechanism for verifying that all hazard controls are in place prior to the beginning of the launch operation.

Interview evidence indicates that the Balloon Program Office and CSFC contractors believed the Balloon Ground Safety Plan to contain comparable comprehensive information as discussed above for a ‘typical’ ground plan. The Ground Safety Plan was repeatedly referenced in interviews whenever questions relating to system design, operational analysis, keep out zones, hazard controls and hazardous operating procedures were raised. Subsequent review of the generic balloon ground safety plan revealed that the plan failed to provide most of the referenced information.

The Balloon Program Office and the WFF Safety Office failed to sufficiently review the ground safety plan for compliance with the Range Safety requirements and/ or neglected to make the necessary improvements to bring the Balloon Ground Safety Plan into compliance.

Applicable Requirements:

RSM-2002-Rev. B, Range Safety Manual, 5.1.2, 5.2, 5.2.4, 5.3.5,

AFSPMAN 91-710 Vol. 6, Attachment, Ground Operations Plan

Detailed Requirements:

[Ref 1]

RSM-2002-Rev B, Range Safety Manual/5.0 Ground Safety/5.2.4/Ground Safety Plan

5.2.4.1 A Ground Safety Plan will be prepared by the Ground Safety Group (GSG) prior to any potentially hazardous operation or launch conducted at or managed by WFF. This plan will identify the potential hazards and describe the system designs and methods employed to control the hazards. This plan shall also establish controls to protect high value property, as required.

5.2.4.2 For launch or other potentially hazardous ground operations conducted at other ranges, this information shall be provided in a Ground Safety Plan or Ground Safety Data Package.

5.2.4.3 Where applicable, a general Ground Safety Plan may be prepared for repetitive operations/ programs which shall identify safety planning for all potential hazards. This plan may be augmented for mission operations by a mission specific Ground Safety Plan.

[Ref 2]

RSM-2002-Rev B, Range Safety Manual/5.0 Ground Safety /5.1 General/ 5.1.2: It is required that all systems be designed such that it will take a minimum of two independent, unlikely failures occurring in order for personnel to be exposed to a hazard.

INSUFFICIENT HAZARDOUS OPERATING PROCEDURES

Safety Assessment Observation: Hazardous operations are conducted without written operating procedures for NASA balloon launch operations. Failure to provide written procedures constitutes non-compliance with NASA requirements NPR 8715.3, NPR 8715.5 and NASA-STD-8719.9, as well as CSBF policy put forth in the CSBF Health and Safety Plan.

Mapping to Report Findings:

R2: WFF safety leadership did not provide appropriate oversight to WFF implementation of safety requirements (WFF Safety Office and BPO implementing organizations)

R6: Reliance on past success has become a substitute for good engineering and safety practices in the balloon program

I5: No complete and thorough standard procedures exist at CSBF to cover the launch process

I14: GSFC safety management did not verify or provide corrective action for flow down of NASA requirements to protect the public

I15: WFF safety leadership did not thoroughly review balloon safety documentation

Discussion:

The CSBF launch operations took place without the benefit of hazardous operating procedures. Lack of written hazardous procedures constitutes non-compliance with both Agency safety requirements and the WFF/CSBF contract.

NPR 8715.3, NASA General Safety Program Requirements, (section 1.4.3.j) states that the Center Director shall “ensure that for hazardous NASA operations, procedures are developed for the following circumstances: 1) to provide an organized and systematic approach to identify and control risks, 2) when equipment operations, planned or unplanned, are hazardous or constitute a potential launch, test, vehicle, or payload processing constraint, or 3) when an operation is detailed or complicated and there is reasonable doubt that it can be performed correctly without written procedures.” NPR 8715.3, section 3.8. Hazardous Operations, also stipulates that Center Directors and project managers “shall ensure that all hazardous operations have a Hazardous Operating Procedure or a Hazardous Operating Permit (HOP), and that all procedures include sufficient detail to identify residual hazards and cautions to NASA personnel.” “The Center SMA Director

or designee shall review and approve the HOP.” [Reference 1]

NPR 8715.5, Range Safety Program (section 1.3.7.c) requires that “for each range operation, the vehicle program manager or NASA designee shall coordinate with the range safety organization to develop and implement procedures.” [Reference 2] and the NASA FAR supplemental 1852.223-70, Safety and Health (j) as attached to the CSBF contract requires that “before hazardous operations commence, the Contractor shall submit for NASA concurrence (1) Written hazardous operating procedures for all hazardous operations; and/or (2) Qualification standards for personnel involved in hazardous operations.” [Reference 3]

The CSBF’s own Health and Safety Plan (section J of the Contract NAS5-03003) states that the “safety of personnel and facilities will be ensured through the use of existing procedures” and that “written procedures for hazardous procedures will be developed and annually reviewed.” The plan also states that “flight line operations procedures are to be maintained by the Operations Manager” and “will be made available to appropriate NASA authorities.”

Despite all of these the agency requirements and the CSBF plan, evidence obtained through witness interviews and document review indicates that the CSBF in fact did not develop or use written hazardous procedures.

Witness interviews uncovered that the contractor launch operators rely solely on checklists, the generic ground safety plan, job knowledge and experience to execute the complicated and hazardous launch operation steps. Procedures were not used for the Alice Springs NCT launch, nor are they typically used. The operators and WFF management furthermore, had little or no knowledge regarding the existence of hazardous operation procedures, or of the requirements for their use.

Section 3.8.1 of NPR 8715.3 reads that “ NASA hazardous operations involve materials or equipment that, if misused or mishandled, have a high potential to result in loss of life, serious injury or illness to personnel, or damage to systems, equipment, or facilities. Adequate preparation and strict adherence to operating procedures can prevent most of these mistakes. By definition, the balloon launch undeniably constitutes a hazardous operation. The failure of the Balloon Program Office and CSBF conduct launch operations by the instruction of approved written hazardous operating procedures left the participating crew, personnel and public vulnerable increased risks of serious mishaps.

Applicable Requirements:

**NPR 8715.3, NASA General Safety Program Requirements, Section 3.8 Hazardous Operations
3.8.1, 3.8.2.b, 3.8.2.g, 3.8.2.h, 3.8.3**

NPR 8715.5, Range Safety Program, 1.3.7.c, 1.3.8.2.b

NASA FAR supplemental 1852.223-70, Safety and Health, (j)

NASA-STD 8719.9, NASA Lifting Standard, 5.7.b

**NAS5-03003, Balloon Program and National Scientific Balloon Facilities Contract, Attachment J,
Health and Safety Plan, RFP NAS5-03003, 1.2, 4.1.1.2**

820-PG-7120.1.4, Management of the Balloon Program's Safety Implementation, 2.0, 3.0

803-PG-8715.1.14D, Safety Review Process, P.1, P.2

Detailed Requirements:

NPR 8715.3, NASA General Safety Program Requirements, Section 3.8 Hazardous Operations:

“3.8.1 NASA hazardous operations involve materials or equipment that, if misused or mishandled, have a high potential to result in loss of life, serious injury or illness to personnel, or damage to systems, equipment, or facilities. Adequate preparation and strict adherence to operating procedures can prevent most of these mistakes. This paragraph applies to operations that occur on a routine or continuous basis.”

3.8.2 Center Directors and project managers shall b) Ensure that all hazardous operations have a Hazardous Operating Procedure or a Hazardous Operating Permit (HOP) (Req 32324)

Note: HOPs consist of a detailed plan listing step-by-step functions or tasks to be performed on a system or equipment to ensure safe and efficient operations. HOPs list special precautions, start and stop time of the operation, and the approving supervisor(s).

g. Ensure that all procedures include sufficient detail to identify residual hazards and

cautions to NASA personnel (req 32505)

h. Ensure that hazardous procedures are marked conspicuously on the title page to alert operators that strict adherence to the procedural steps and safety and health precautions contained therein are followed (req 32325).

3.8.3 Center SMA Directors or their designee shall review and approve HOPs (req)

NPR 8715.5, Range Safety Program/ 1.3.7: Vehicle Program Manager. For each range operation, the vehicle program manager or NASA designee shall:

c. Coordinate with the range safety organization(s), including the RSO or equivalent, to develop and implement operational range safety requirements, plans, procedures, and checklists, including mission rules and flight commit criteria.

NPR 8715.5, Range Safety Program/ 1.3.8.2: For each range operation, the RSO or equivalent shall:

b. Coordinate with the program to develop and implement operational range safety requirements, plans, procedures, and checklists, including mission rules and flight commit criteria.

NASA-STD 8719.9/ 5.7 Operations/ b: General operating procedures describing operation, emergency steps, communication requirements, and special requirements shall be prepared, approved, and followed for each crane/derrick. There must be a formal system for review, approval, and update to maintain valid operating procedures. Emergency procedures shall be developed for contingency actions such as power loss, brake failures, or other emergencies (also see para 1.5.1.c)

NAS5-03003, Balloon Program and National Scientific Balloon Facilities Contract, Attachment J, Health and Safety Plan, RFP NAS5-03003, Section 4.0, Hazardous Prevention and Control / 4.1.2 / Written Procedures :Written procedures for hazardous operations will be developed. Those procedures currently in use will be reviewed to ensure they address all pertinent safety issues. All procedures will be reviewed to ensure they address all pertinent safety issues. All procedures will be reviewed by the SR&QA manager and the Site Manger and approved by the Program Manger. Copies of all procedures will be reviewed annually or whenever an accident of mishap occurs or when any alteration of the procedure is proposed. Copies of procedures will be maintained by the SR&QA office and in the facility where the procedures occur. Flight-line operations procedures

will be maintained by the Operations Manager. Any information in PSL's possession regarding hazardous operations will be made available to appropriate NASA authorities.

NAS5-03003, Balloon Program and National Scientific Balloon Facilities Contract, Attachment J, Health and Safety Plan, RFP NAS5-03003, Section 4.0, Hazardous Prevention and Control 4.1.1.2

Methodology to Identify and Submit Procedures: PSL will utilize our existing and newly formalized policies and procedures for the implementation of hazardous operations procedure in lieu of submitting procedures to NASA for review and approval. See Section 4.1.1.1 for further discussion on the planned implementation description.

820-PG-7120.1.4, Management of the Balloon Program's Safety Implementation/ 2.0 Operational Ground Safety: "For operational ground safety, the safety related references (P4 items d through q) should normally have precedence. The cases not covered by these safety references shall require a specific Ground Safety Plan to be generated by the Contractor [CSBF] and approved by the Chief of Balloon Program Office or designee to ensure safe operating procedures are planned and implemented."

820-PG-7120.1.4, Management of the Balloon Program's Safety Implementation /3.0 Operational Payload Safety

"For operational ground safety, the safety related references (P4 items d through q) should normally have precedence. The cases not covered by these safety references shall require a specific Payload Safety Plan to be generated by the Contractor [CSBF] and approved by the Chief of Balloon Program Office or designee to ensure safe operating procedures are planned and implemented."

803-PG-8715.1.14D, Safety Review Process/ P.1 Purpose: This document establishes the procedures for Safety Review of projects and operations conducted and managed by GSFC/WFF.

803-PG-8715.1.14D, Safety Review Process/ P.2 Applicability: The methods in this procedure are used to review all Safety Analyses, Safety Plans, and Operations Plans generated by the Safety Office. This procedure is also applicable to hazardous procedures conducted in support of flight operations, safety graphic display configurations and wind weighting packages.

NASA FAR supplemental 1852.223-70, Safety and Health/ (j): that is a part of the contract which requires that "The Contractor shall continually update the safety and health plan when necessary". In particular, the Contractor shall furnish a list of all hazardous operations to be performed, and a

list of other major or key operations required or planned in the performance of the contract, even though not deemed hazardous by the Contractor. NASA and the Contractor shall jointly decide which operations are to be considered hazardous, with NASA as the final authority. Before hazardous operations commence, the Contractor shall submit for NASA concurrence -

(1) Written hazardous operating procedures for all hazardous operations; and/or

(2) Qualification standards for personnel involved in hazardous operations.

NPR 8715.5, Range Safety Program/ 1.3.7: Vehicle Program Manager. For each range operation, the vehicle program manager or NASA designee shall:

c. Coordinate with the range safety organization(s), including the RSO or equivalent, to develop and implement operational range safety requirements, plans, procedures, and checklists, including mission rules and flight commit criteria.

NPR 8715.5, Range Safety Program/ 1.3.8.2: For each range operation, the RSO or equivalent shall:

b. Coordinate with the program to develop and implement operational range safety requirements, plans, procedures, and checklists, including mission rules and flight commit criteria.

NPR 8715.3, NASA General Safety Program Requirements, Section 3.8 Hazardous Operations:

“3.8.1 NASA hazardous operations involve materials or equipment that, if misused or mishandled, have a high potential to result in loss of life, serious injury or illness to personnel, or damage to systems, equipment, or facilities. Adequate preparation and strict adherence to operating procedures can prevent most of these mistakes. This paragraph applies to operations that occur on a routine or continuous basis.”

“3.8.2 Center Directors and project managers shall b) Ensure that all hazardous operations have a Hazardous Operating Procedure or a Hazardous Operating Permit (HOP)”

Note: HOPs consist of a detailed plan listing step-by-step functions or tasks to be performed on a system or equipment to ensure safe and efficient operations. HOPs list special precautions, start and stop time of the operation, and the approving supervisor(s).

g. Ensure that all procedures include sufficient detail to identify residual hazards and cautions to NASA personnel

h. Ensure that hazardous procedures are marked conspicuously on the title page.....to alert operators that strict adherence to the procedural steps and safety and health precautions contained therein are followed.

3.8.3 Center SMA Directors or their designee shall review and approve HOPs

INSUFFICIENT SAFETY OVERSIGHT

Safety Assessment Observation: GSFC/WFF leadership provided insufficient safety oversight

Mapping to Report Findings:

R2: WFF safety leadership did not provide appropriate oversight to WFF BPO's implementation of safety requirements (WFF Safety Office and BPO as implementing organizations)

R3: WFF Safety office was not sufficiently knowledgeable about the details of the balloon launch process

R4: GSFC Safety leadership did not verify or provide corrective action for flow down of NASA requirements to protect the public

R5: NASA HQ Range Safety Program Office failed to ensure corrective actions were accomplished from previous agency audits

R6: Reliance on past success has become a substitute for good engineering and safety practices in the balloon program

I1: WFF Safety office did not perform rigorous hazard analysis

I3: No trained individual was in place to ensure public safety

I4: The ground safety plan did not cover all relevant hazards and phases

I5: No complete and thorough procedures exists at CSBF to cover launch process

I7: Cat A hazard area during launch phase was not well defined

I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt

I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch vehicle maneuver

I11: The ground safety plan did not explicitly address the protection of the general public

I12: The BPO did not have sufficient insight or oversight into the technical aspects of the CSBF's balloon launch process

I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program

I15: WFF safety leadership did not thoroughly review balloon safety documentation

Discussion:

There is evidence of an insufficient safety oversight for the WFF Balloon Program.

NPR 8715.5, Range Safety Program assigns safety oversight requirements to different levels of Agency management, organizations and personnel for the WFF Range Safety and Balloon Programs. There is evidence to suggest that compliance was lacking with regard to oversight responsibilities on all levels.

The NPR 8715.5, Range Safety Program (section 1.3.2) requires that at the Headquarter level, NASA Range Safety Manager not only evaluate range safety programs but also "ensure consistent implementation of range safety requirements throughout the Agency" Section 1.3.4.2 requires that Center Directors functioning as the authority for fixed or mobile launch sites "establish the processes and associated Center-level requirements needed to ensure the requirements of NPR 8715.5 are met."

Documentation and interview evidence suggest that the Balloon Program was not afforded the same level of safety insight or oversight as other Agency or even WFF Range programs and that range safety requirements were not consistently implemented for the Balloon Program.

The NPR (section 1.3.5) gives range safety organization requirements for all range operations that use a Center's range facilities. The requirements state that the Center range safety organization lead or NASA designee shall: (a) Implement or oversee the implementation of this NPR and associated Center-level processes and requirements including the risk management process of paragraph 3.2.4 of this NPR (b) identify program data requirements, perform or evaluate and approve required range safety analysis. (c) evaluate and approve all range safety systems, (d) designate a qualified Range Safety Officer (RSO) to support each NASA mission that involves range operations (see paragraph 1.3.8 of this NPR for RSO responsibilities), (e) establish a qualification and training program that satisfies paragraph 3.5 of this NPR for range safety personnel (including RSOs and personnel responsible for range safety systems and range safety analysis) appropriate to the types of vehicles and operations at the range, (f) set operational

performance requirements and standards for all range safety systems and (g) ensure the readiness of the range safety systems to support each operation.

The WFF Balloon Program launch activities take place at the contractor CSBF launch facilities or remote locations. However this does not make the BPO exempt from the safety implementation requirements of 1.3.5, based on the intent of NPR 8715 Sections 1.3.2 and 1.3.4.2 which a designed to ensure implementation of safety standards remain consistent for all NASA programs and operations.

The Balloon Program Manager also has a number of required duties designed to provide insight to the balloon launch programs included in NPR 8715.5 (Section 1.3.7, Vehicle Program Manager), the first being too (a) establish the processes and associated program-level requirements needed to ensure the requirements of this (the Range Safety Program) NPR are satisfied. Additional oversight requirements include: (c) the coordination of range safety organizations including RSO to develop and implement operational range safety requirements, plans, procedures, and checklists, including mission rules and flight commit criteria; (d) designate a Range Safety Representative for the vehicle program; (e) involve range safety personnel and begin the tailoring process by the Systems Requirement Review (SRR), continuing throughout all pertinent vehicle and payload reviews and during Operations.; (f) ensure adequate resources and data are available to support all range safety requirements and activities, including the design, test, and implementation of vehicle range safety systems required to support range safety requirements, the range safety organization/authority supporting the review, and approval process and operational support; (g) incorporate the requirements of this document in all launch service provider contracts and flight or other range operation contracts or agreements, (j) in coordination with the range safety organization(s), generate a contingency action plan that describes roles and responsibilities in the event of a mishap and provides procedures to secure all data relevant to an investigation; (l) in coordination with any Center that supports the range operation, ensure all employees and visitors are informed of potential hazards associated with a range operation and the actions to take in the event of an emergency; (o) engage the Center range safety organization regarding, and establish a plan for, monitoring of vehicle and range processes during launches, entries, and other range operations and to ensure timely identification and resolution of any violation that might affect launch, entry, or other operational approval. Engage with the NASA Range Safety Manager to perform this function for range operations not supported by a Center range safety organization; and (v) ensure that any vehicle program personnel who perform a range safety function are qualified and trained in accordance with paragraph 3.5 of this NPR.

Evidence suggests the many of these safety responsibilities were not sufficiently performed on the behalf of the Balloon Program leading to inadequate oversight and insight into the Balloon Program launch operations.

The Range Safety Manual also assigned oversight responsibility to the Balloon Program Office. RSM-2002 Section 2.0 requires that the Balloon Program, the Chief, Balloon Program office shall ensure that 1) the requirements and the procedure defined in appropriate safety plans and balloon risks analysis are implemented and (2) the operational responsibilities normally assigned to the Mission Range Safety Officer (MRSO), Operations Safety Supervisor (OSS), or Project Manager in this document are implemented for balloon operations and defines each of these positions.

Evidence suggest that the Balloon Program was non compliant with these oversight responsibilities. Evidence collected for the Alice Spring NCT launch shows the BPO in fact, did not ensure the implementation of hazardous launch operations as required and nor the assignment and subsequent performance of the required safety responsibilities of OSS and MRSO.

There is no flow down of direction from the RSM 2002 in the CSBF documentation that requires personnel to assume the safety responsibilities of the MRSO, OSS (and Project Manager). The CSBF Balloon Ground Safety Plan, Chapter 2 – Safety Responsibilities, states simply that the CSBF Operations Department Head (campaign manager at remote sites) is responsible to ensure compliance with the provisions of the BGSP for CSBF operations and for science user operations. There is no reference to what these “provisions” are and definitely no reference to the duties described in the RSM 2002. (Note: the only other reference to a specific duty is later in the paragraph – “The crew chief is responsible to direct the movement and operation of all heavy equipment used in balloon launch operations in such a way to ensure safety and minimize the number of personnel exposed to hazards associated with this equipment.”) No discussion of certification, training, no reference to NASA requirements, and no mention of specific duties as outlined in RSM-2002. (Note the only reference to the RSM-2002 is in section 1 Scope: “The BGSP is derived from the NASA GSFC/WFF Range Safety Manual, identified as RSM-2002”. The wording ‘derived’ is ambiguous. There is no required RSO or OSS or MRSO training provided to the CSBF safety designees.

The lack of a dedicated trained safety officer engaged in reviewing launch procedures, verifying test results, conducting pre-task briefings, monitoring the hazardous launch operations and making abort decisions left both personnel and the general public vulnerable to potentially injury or death. The Campaign Manager and Launch Director were over-burdened with the responsibility of assuming safety monitoring duties in addition to their operational duties; they were also not properly trained to do so.

Insufficient oversight of the WFF Safety Leadership, along with the absence of dedicated safety professionals at the launch site significantly added to the risks of the balloon program launch activities.

Applicable Requirements:

NPR 8715.5, Range Safety Program, 1.3.2, 1.3.4.3, 1.3.5, 1.3.7

NASA FAR supplemental 1852.223-70, Safety and Health (j)

RSM-2002-Rev. B, Range Safety Manual , 2.0

800-PG-8715.1.13E, Ground Safety Process

803-PG-8715.1.1E, Range Safety Operations Process

803-WI-8715.1.2D, Range Safety Operations Plan

803-WI-8715.1.14D, Safety Review Process

820-PG-7120.1.4.B, Management of the Balloon Program's Safety Implementation

CSBF Health and Safety Plan (Section J of the Contract NAS5-03003)

Detailed Requirements:

NPR 8715.5, Range Safety Program/ 1.3.2/ NASA Range Safety Manager: The NASA Range Safety Manager shall perform the following Headquarters-level functions: b. Serves as the Agency range safety policy including this NPR. c. Lead a team of Range Safety Representatives (see paragraph 1.3.6) to evaluate and resolve range safety program concerns and ensure consistent implementation of range safety requirements throughout the Agency. d. Review Center and program implementation of this NPR and provide findings and recommendations to the responsible Center, program manager, and the Office of Safety and Mission Assurance. e. Conduct independent assessments of applicable NASA Centers, component and range facilities, and programs at least once every 2 years to verify conformance with range safety policies, procedures, and requirements.

- **Insufficient Independence of Range Safety from Balloon Program**

NPR 8715.5, Range Safety Program/ 1.3.4/ Center Directors: The Center Director or NASA designee shall: (a) Ensure the implementation of this NPR for each Center program that involves range operations. (b) Ensure all employees and visitors are informed of potential hazards associated with a range operation and the actions to take in the event of an emergency. (d) Support range safety independent assessments and respond to all findings and recommendations for which the Center is accountable.

1.3.4.3. When functioning as the authority for a range, the Center Director of NASA designee shall establish a Center range safety organization (direct or delegated) that is independent of all vehicle programs and has safety responsibilities for all range operations that use the Center's range facilities (this should include CSBF offsite launches since WFF is the NASA agency procuring their services.)

NPR 8715.5, Range Safety Program/ 1.3.5 / Center Range Safety Organization: For all range operations that use a Center's range facilities, the Center range safety organization lead or NASA Designee shall (c) evaluate and approve all range safety systems. (d) designate a qualified Range Safety Officer (RSO) to support each NAA mission that involves range operations.

NPR 8715.5, Range Safety Program/ 1.3.6 / Range Safety Representative for a Center or a vehicle program shall: 1.3.6.1 Monitor the implementation of this NPR

NPR 8715.5, Range Safety Program/ 1.3.8/ Range Safety Officer (RSO) (or equivalent)/1.3.8.1: The RSO or equivalent for each NASA range operation shall be a qualified NASA or DoD employee or a person operating under an FAA license.

820-PG-7120.1.4, Management of the Balloon Program's Safety Implementation/ 2.0/ Operational Ground Safety: For operational ground safety, the safety related references (P4 items d through q) should normally have precedence. The cases not covered by these safety references shall require a specific Ground Safety Plan to be generated by the Contractor [CSBF] and approved by the Chief of Balloon Program Office or designee to ensure safe operating procedures are planned and implemented.

820-PG-7120.1.4, Management of the Balloon Program's Safety Implementation /3.0 Operational Payload Safety: For operational ground safety, the safety related references (P4 items d through q)

should normally have precedence. The cases not covered by these safety references shall require a specific Payload Safety Plan to be generated by the Contractor [CSBF] and approved by the Chief of Balloon Program Office or designee to ensure safe operating procedures are planned and implemented.

INADEQUATE CLOSURE OF AUDIT FINDINGS AND RECOMMENDATIONS

Safety Assessment Observation: Insufficient management oversight regarding the implementation of the 2002 Balloon Program Independent Safety Assessment findings and recommendations allowed required corrective actions to remain incomplete.

Mapping to Report Findings:

R7: NASA Agency Range Safety Program failed to ensure corrective actions were accomplished from previous agency audits

I12: The BPO did not have sufficient insight or oversight into the technical aspects of the CSBF's balloon launch process

I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program

Discussion:

NPR 8715.5, Range Safety Program, requires that a NASA Headquarters-level, independent assessment of range programs be conducted periodically. [Reference 1] The NPR also states that it is the responsibility of the WFF/GSFC Center Director to “support range safety independent assessments and (to) respond to all findings and recommendations for which the Center is accountable.” [Reference 2] The 2002 assessment conducted for the WFF Safety Office (reference QA-D-02-04-001), brought forth twenty-three (23) findings and twenty-five (25) recommendations. Eight years later, many of these finding and recommendations remain inadequately or incompletely addressed. Five such findings have particular relevance to the Alice Spring incident and can be directly linked to either contributing or root causes for the mishap. Discussion of these finding are presented below:

QA-D-02-04-001 Finding #5 – Total Reimbursable Budget Authority (RBA) funding impacts the safety office's ability to perform its mission. ‘There is no Direct Budget Authority (DBA) funding for the WFF range safety function. Since the WFF is a full cost accounting organization, there is only RBA funding available to the range safety organization. Recommendation: GSFC/WFF management

should provide DBA funding based on range safety's assessment of need. GSFC/WFF range safety organization could also attempt to gain DBA funds through submittal of a request to HQ Code Q POP process.'

NPR 8715.5 section 1.3.4.3 requires 'that the Center Director or NASA designee when functioning as the authority for a range, shall establish a Center range safety organization (direct or delegated) that is independent of all vehicle programs'. NPR 8715.3 Section 1.4.3 requires that the Center Director (b) place their safety organization at a level that ensures the safety review function can be conducted independently and (d) ensure that (d) (1) Adequate resources (personnel and budget) are provided to support mishap prevention efforts (2) resource control is independent from any influence that would affect the independence of the advice, counsel, and services provided and (3) ensure that policies, plans, procedures, and standards that define the characteristics of their safety program are established, documented, maintained, communicated, and implemented.'

Interview evidence gives indication the WFF Range safety funding is not independent of the vehicle programs and that the funding structure of the WFF/GSFC safety office may still be an issue.

QA-D-02-04-001 Finding #6 - Safety practices not consistent across projects in 810, 820, 830 and 840. *'WFF team would benefit from consistent and consolidated application of safety practices across the various program offices. Recommendation: WFF management standardize current safety practices in all WFF programs.'*

NPR 8715.5 Chapter 1.3.2 (c) states that the HQ Range Safety Manager will "ensure consistent implementation of range safety requirements throughout the Agency." Evidence suggests however that Range Safety requirements are not equally or consistently applied to the Balloon Program. This is particularly true regarding the safety oversight and insight provided to the WFF Balloon Programs, including CSBF launch campaigns. Interview and document evidence has repeatedly shown that the Balloon program is not managed in the same manner as other Code 800 range programs and that the WFF Safety Organization, Code 803, has very limited interaction with and oversight of the Balloon Program. Interview evidence and document review show that several standard Code 800 and Code 803 range safety requirements and range safety documents (including processes, procedures, guidelines and work instructions) are not applied to the BPO nor have comparable processes and procedures been developed. The Balloon program missions are not assigned RSO's. Contractor personnel have not been assigned the duties of MRSO or OSS nor has the required balloon-specific OSS training been provided as required by RSM-2002. It is these inconsistencies that led among other things to the absence of a trained safety professional acting to protect the public from harm (through the use of barrier, roadblock and monitoring activities).

QA-D-02-04-001 Finding #9 – Range safety involvement with Balloon Program inadequate. The balloon programs operated at GSFC/WFF do not have independent range safety oversight or insight. These payloads are potentially hazardous to the public and should be managed consistent with other

hazardous, uninhabited programs. Recommendation: GSFC/WFF Management should require range safety involvement in balloon programs. Suggest WFF range safety office and balloon program office coordinate a tailored range safety program for balloons.

Documentation and interview evidence suggest that the Balloon Program was not afforded the same level of safety insight or oversight as other Agency or even WFF Range programs and that range safety requirements were not consistently implemented for the Balloon Program.

NPR 8715.5 (section 1.3.5) stipulates that for *all range operations that use a Center's range facilities*, the Center range safety organization lead or NASA designee shall: (a) Implement or oversee the implementation of this NPR and associated Center-level processes and requirements including the risk management process of paragraph 3.2.4 of this NPR.

(b) Identify program data requirements, perform or evaluate and approve required range safety analysis. (c) Evaluate and approve all range safety systems. (d) Designate a qualified Range Safety Officer (RSO) to support each NASA mission that involves range operations (see paragraph 1.3.8 of this NPR for RSO responsibilities). (e) Establish a qualification and training program that satisfies paragraph 3.5 of this NPR for range safety personnel (including RSOs and personnel responsible for range safety systems and range safety analysis) appropriate to the types of vehicles and operations at the range. (f) Set operational performance requirements and standards for all range safety systems and (g) Ensure the readiness of the range safety systems to support each operation. The BPO launches occur at off-center locations, however Safety Management was required to ensure that comparable Range safety functions be performed to ensure safe operation for all Agency launch operations.

The NPR 8715.5, Range Safety Program (section 1.3.2) requires that at the Headquarter level, NASA Range Safety Manger not only evaluate range safety programs but also “*ensure consistent implementation of range safety requirements throughout the Agency*” Section 1.3.4.2 requires that Center Directors functioning as the authority for fixed or mobile launch sites “*establish the processes and associated Center-level requirements needed to ensure the requirements of NPR 8715.5 are met.*”

Despite these requirements, WFF Range safety provided little or no insight/oversight for the CSBF launches, nor were dedicated range safety personnel in the form of RSO, MRSO or OSS assigned.

The 2002 assessment aptly pointed out the balloon program activity's potential danger to the public and recommended greater Code 803 involvement. Interview and document evidence supports that the Balloon Program still suffers from a lack of oversight. The Safety office to-date does not perform periodic program audits or requirement, document, or analysis reviews, is not present at launch activities and depends on contractor and BPO to impose and maintain safety requirements.

QA-D-02-04-001 Finding #11 – WFF pre-mishap planning is inadequate. Recommendation:

WFF should expand and update written pre-mishap plans for operations at WFF. In addition to the initial response actions, plans should also include all mishap hazards, investigation actions and responses in accordance with NPR 8621.1. Failure to adequately pre-plan may place personnel and resources at unnecessary risk and result in loss of investigation critical information.

The CSBF Mishap Plan was not sufficient to meet the requirements of NPR 8621.1 and NPR 8715.5. The plan failed to provide adequate direction to preserve evidence and to keep personnel and public safe in the event of a mishap.

NPR 8715.5, section 1.3.4.2(i) requires that Center Directors functioning as the authority for fixed or mobile launch sites “Develop emergency plans to prevent or mitigate the exposure of the public or employees to any hazard associated with range operation.” NPR 8715.5, section 1.3.7(j) stipulates that the Vehicle Program Manager “In coordination with the range safety organization(s), generate a contingency action plan that describes the roles and responsibilities in the event of a mishap and provides procedures to secure all data relevant to an investigation” and stipulates the use of NPR 8621.1, NASA Procedural Requirements for Mishap Reporting, Investigation and Recordkeeping.

NPR 8621.1, section 2.2 Program and Project Mishap Preparedness and Contingency Plans, 2.2.1.(a) requires that Program Mangers concur with a Program and Project Mishap Preparedness and Contingency Plan (MPCP) that “is a comprehensive plan for all mishaps and close calls that occur offsite, at offsite program/project contractor sites, or in flight.”

The contractor did have a mishap plan, but it was not fully compliant with the requirement of NPR 8621.1. OF-695-21-P, ‘Columbia Scientific Balloon Facility Procedures Following Flight Mishap or Incident’ requires that after a mishap hardware not be disturbed prior to inspection by “appropriate personnel” (undefined) and give the CSBF Operations Department Head or remote Campaign Manger authority to instruct movement or manipulation hardware. There is no discussion of drug testing even though on contract to do so. CSBF Site Manager coordinates appointment of investigation team. There is no information regarding potential hazards associated with or the safing of the equipment. The Balloon Program mishap plan does not include IRT

information nor adequately address the safing of the mishap area or protection of evidence. The lack of a compliant MPCP left the Balloon Program Office and the CSBF contractors unprepared for the Alice Spring mishap. Evidence shows that post-mishap, the public and personnel were allowed in close proximity to unsafed hazardous systems (including pyrotechnics, and chemical batteries) and that there was significant disturbance of the mishap scene and removal of key evidence.

QA-D-02-04-001 Finding #15 – Training documentation lacking. *There is little or no evidence that all training is documented and tracked within the safety office. Recommendation: An ISO process should be established and followed within the safety (or at the 800 level) to provide requirements for training and accurately document that training. Expedite the issuance of the ISO ground safety training process.*

RSM-2002 requires that the operational responsibilities of the OSS be implemented for the balloon program. The CSBF personnel were however not trained in accordance with the requirements of RSM-2002 to assume the responsibilities OSS.

RSM 2002 states that the Balloon Office “shall ensure that the responsibilities normally assigned to the OSS are implemented for the balloon operations.” [Reference 3]

RSM-2002, Section 2.0 the Operational Safety Supervisor (OSS) requires that all personnel designated as OSS are certified by the Safety Office through attending an OSS course and participating in OSS testing performed by the Ground Safety Group (GSG). The procedure for this process is documented in 800-PG-8715.04A, Certification Procedures for Operations Safety Supervisors at WFF. This PG stipulates that there be balloon-specific (Category II -Balloons) training and certification provided for balloon launch OSS or provide satisfactory evidence of the required skill and knowledge.

There is no evidence of WFF provided ground safety training for the Balloon Program contractors (CSBF) who were delegated safety responsibility for launch operations (nor of contractors certified based on WFF review of OSS equivalency). The duties of MRSO and OSS were required to be assumed and verified by the BPO in accordance with RSM-2002. However appropriate NASA training was not mandated for, nor provided to the contractor by WFF Safety or the BPO. The contractor records only indicate on-the-job training records with no attached curriculum. NASA personnel with appropriate range safety training were not assigned as an alternate solution.

QA-D-02-04-001 Finding #21- Operations Safety Supervisor qualifications unclear. It is not clear how WFF range safety verifies the qualifications of “other personnel” that may be delegated this responsibility. Recommendation: WFF should establish a clear policy for delegation of OSS responsibilities. Consider using EWR 127-1 Para 1.4.3 et al as a guide.

RSM-2002 states that the Balloon Office “shall ensure that the responsibilities normally assigned to the OSS are implemented for the balloon operations.” [Reference 3]

WFF response to the 2002 audit was that training was being developed to qualify OSS personnel designated by the WFF RSO and that after the summer of 2002; all personnel assigned to OSS duties would be required to have the training. Evidence suggests that this corrective action was never completed. Currently CSBF contractors are not provided OSS training nor are WFF OSS-trained WFF personnel assigned to the balloon launches.

Reference Document:

QA-D-02-04-01, WFF Independent Assessment, Final Report WFF Range Safety Office

Applicable Requirements:

NPR 8715.5, Range Safety, 1.3.2.e, 1.3.4.2.d, 1.3.8.2.d

800-PG-8715.04A

803-WI-8072.1.1 (RSM-93), 2.4, 2.6

Detailed Requirements:

[R1]

NPR 8715.5, Range Safety/section 1.3.2: The NASA Range Safety Manger shall perform the following Headquarters-level functions. (e) Conduct independent assessments of applicable NASA Centers, component and range facilities, and programs at least once every 2 years to verify conformance with range safety policies, procedures, and requirements.

[R2]

NPR 8715.5, Range Safety/section 1.3.4.2: The Center Director or NASA designee shall: (c) Support range safety independent assessments and respond to all findings and recommendations

for which the Center is accountable.

[R3]

RSM-2002/ Section 2.0: “For the Balloon Program, the Chief, Balloon Program Office shall assure that (2) the operational responsibilities normally assigned to the MRSO, OSS, or Project Manager in this document are implemented for balloon operations.”

UNSAFE CRANE OPERATIONS

Safety Assessment Observation: Balloon Program Crane Operations and Hardware was not in accordance with the NASA standards for Lifting Devices and Equipment.

Mapping to Report Findings:

R2: WFF safety leadership did not provide appropriate oversight to WFF BPO's implementation of safety requirements (WFF Safety Office and BPO as implementing organizations)

R3: WFF Safety office was not sufficiently knowledgeable about the details of the balloon launch process

R6: Reliance on past success has become a substitute for good engineering and safety practices in the balloon program

I1: WFF Safety office did not perform rigorous hazard analysis

I4: The ground safety plan did not cover all relevant hazards and phases

I5: No complete and thorough procedures exists at CSBF to cover launch process

I6: Launch crew training did not address failed launch attempts

I7: Cat A hazard area during launch phase was not well defined

I8: CSBF did not analyze the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt

I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt

I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch vehicle

I12: The BPO did not have sufficient insight or oversight into the technical aspects of the CSBF's balloon launch process

I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program

I15: WFF safety leadership did not thoroughly review balloon safety documentation

Discussion:

RSM-2002, section 5.3.5.5 requires that “all lifting devices, fixtures, and equipment shall comply with the standards and regulations of NASA-STD-8719.9, Standards for Lifting and Equipment and GPR 8719.1 Certification and Recertification of Lifting Devices and Equipment”. It should be noted that the Balloon Launch Program utilized the crane in an unorthodox manner as a launch vehicle for the payloads. The balloon program’s expanded use of the mobile crane puts even more responsibility on the program to ensure that the intent of the Lifting Devices and Equipment requirements are honored and that the potential hazard associated with each requirement are adequately controlled.

Based on a review of interview, written, photographic and video evidence supported by the GSFC Lifting Device and Equipment Manager (LDEM), there is sufficient indication that the Alice Spring Balloon Launch operation was not in compliance with, nor met the intent of the following NASA-STD-8719.9 requirements.

•Design Section 5.2.4 “Load capability and the desired controlled characteristics with which the crane/derrick handles the load shall be addressed of all designs. Operation requirements shall be considered in the design phase to ensure load and function are adequately defined and crane/derrick design features are incorporated on the delivered units.”

The restraint system yielded under the imposed load and the spacecraft broke free. There is evidence to suggest that the Balloon Program was unaware of the design and operational limitations of the launch vehicle. Analysis was not performed to identify all possible failure modes of the launch hardware.

•Training Section 5.6.2(1)(a) (“Classroom training in safety, lifting equipment emergency procedures, general performance standards, requirements, pre-operational and safety related defects, and symptoms (for initial certification and as needed”).

Interview evidence supports that crane operators were not fully knowledgeable regarding the limitations of the system. Crew training did not include emergency or anomaly training, including failed launch attempts. There were also no operating procedures produced or used.

• Operations Section 5.7(i) Cranes/derricks “shall not be side loaded, used to drag loads sideways, or used to pull loads unless specifically designed to do so the OEM as indicated in the load chart.”

Video and photographic evidence as well as analysis shows that the launch vehicle was indeed at times side loaded and was used both to drag sideways and to pull the balloon induced loads.

o (m) “The operator and ground lead man shall establish appropriate safety zones before initiating operations. Safety zones should have appropriate barriers (rope, cones or other) established prior to lift”.

Video, photographic and interview evidence support that an effective safety zone designed to protect the public was not implemented. The Category A zone was ill-defined and ineffective. There was also no attempt to mark a safety zone appropriately prior to operations with cones, ropes or other barriers. Lack of marking made it inconceivable that the crane operator or other observers would detect when the zone was violated by the either the balloon train or the moving crane.

o (t) “During hoisting, care shall be taken that there is not sudden acceleration or decelerations of the moving load and that the load does not contact any obstructions.”

Video and interview evidence support that the launch operation consisted of a number of sudden movements including accelerations and decelerations as well as turns that caused the payload to swing widely. At one point the excessive movement of the payload caused the operator to lose control of the payload tag lines. The rough and unimproved terrain contributed to the movement of the suspended payload. The payload also had potential to contact an obstruction when the launch vehicle was driven to the fence.

o (z) “An operator shall be at the crane /derrick controls at times while a load is suspended” (OSHA requirement). Due to the length of some NASA operations, an operator change may be required while a load is suspended. This shall be accomplished via a procedure designed for the specific crane/derrick and operation, assuring the crane controls are manned at all times.

Video, photographic and interview evidence support that the control cabin was not occupied during the launch attempt. The controls were therefore unmanned while the payload was suspended.

o (ai) “When traveling a mobile crane with a load, a person shall be designated responsible for determining and controlling safety and making decisions as to position of the load, boom location, ground support, travel route and speed of the motion.”

Interview and documented evidence support that there was considerable confusion among both the crew and the Balloon Program regarding specific personnel safety and decision making responsibilities and authority. It was clear that the launch director was in charge of travel route and speed of the motion; however, the safety control and decision making was not as well defined. Confusion included who had the abort authority and who was responsible for assuming the role of the Mission Range Safety Officer.

o (ak) “When rotating cranes/derricks, sudden starts and stops shall be avoided. Speed shall be

such that the load does not swing out beyond radii at which it can be controlled. A tag line should be used when rotation of load is hazardous”

Video and interview evidence support that the payload swung beyond radii of control. Excessive swinging of the load caused the technician to lose control of both payload tag lines. He was only able to regain control of one prior to the unintentional release of the payload.

•Sling Section 10.7(g) “The following materials and techniques shall not be used in slings or rigging hardware to hoist personnel or loads: natural rope, wire rope clips, the fold back metal pressed sleeve or clip technique”.

Photographic evidence shows that fold back technique was used. The photo also revealed that the cords were improperly taped, making required inspection of the cords impossible.

In addition, video evidence suggested the potential for non-compliance with the Critical and Noncritical Lifting Operations, requirement 1.5.1 that states “Personnel shall not be located under suspended or moving loads unless the operation adheres to the OSHA-Approved NASA Alternate Standard for Suspended Load Operations.”

The movement of the payload was sufficient to cause concern regarding personnel safety. It is suggested Appendix A of the NASA-STD-8719.9, be examined for possible solutions that may include supporting the payload from underneath, in order to eliminate this potential hazard.

Applicable Requirements:

RSM-2002-Rev. B, Range Safety Manual, 5.3.5.5

NASA-STD-8719.9, Standards for Lifting and Equipment, 1.5.1, 5.2.4, 5.6.2, 5.7, 10.7

Detailed Requirements:

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INSUFFICIENT INDEPENDENCE OF SAFETY

Safety Assessment Observation: Insufficient Independence of Range Safety from Balloon Program

Mapping to Report Findings:

R2: WFF safety leadership did not provide appropriate oversight to WFF BPO's implementation of safety requirements (WFF Safety Office and BPO as implementing organizations)

R5: NASA HQ Range Safety Program Office failed to ensure corrective actions were accomplished from previous agency audits

I12: The BPO did not have sufficient insight or oversight into the technical aspects of the CSBF's balloon launch process

I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program

I15: WFF safety leadership did not thoroughly review balloon safety documentation

Discussion:

NPR 8715.5 Chapter 1.3.2 (c) states that the HQ Range Safety Manager will “ensure consistent implementation of range safety requirements throughout the Agency.” Evidence suggests however that Range Safety requirements are not equally or consistently applied to the Balloon Program. This is particularly true regarding the independence of the safety oversight or insight provided to the WFF Balloon Programs, including launch campaigns. NPR 8715.5 section 1.3.4.3 requires ‘that the Center Director or NASA designee when functioning as the authority for a range, shall establish a Center range safety organization (direct or delegated) that is independent of all vehicle programs’.

NPR 8715.3 Section 1.4.3 requires that the Center Director (b) place their safety organization at a level that ensures the safety review function can be conducted independently and (d) “ensure that (d) (1) Adequate resources (personnel and budget) are provided to support mishap prevention efforts, (2) resource control is independent from any influence that would affect the independence of the advice, counsel, and services provided and (e) ensure that policies, plans, procedures, and standards that define the characteristics of their safety program are established, documented,

maintained, communicated, and implemented.

Evidence suggests that the independent safety oversight provided to the balloon program was inadequate. The majority of the range safety functions for the Alice Spring NCT launch were carried out by the balloon launch service contractor, CSBF, not an independent source. The WFF Range Safety Office Code 803 had little or no insight or oversight into the technical aspects of the balloon program and provided little in the way of document review, launch site visits, program audits or hazard control verification.

This same lack of independence was observed in the NASA Headquarters' 2002 WFF Independent Assessment Report from which the following statements are taken: "Unlike other uninhabited flight programs, the policy and practice in effect in the balloon programs operated at GSFC/WFF do not require independent safety oversight or insight. With NASA it is common practice to utilize an organization that has no direct stake in the project to establish and implement safety plans, risk analyses and procedures. This independence ensures that the range safety requirements will not be compromised. These payloads are potentially hazardous to the public and should be managed consistent with other hazardous, uninhabited programs. Management is accepting an unknown level of risk associated with balloon operations. The Headquarters assessment team recommended that GSFC/WFF management should require range safety involvement in the balloon programs. The assessment team suggests the WFF range safety office and balloon programs office coordinate a tailored range safety program for balloons." [Ref 2]

Applicable Requirements:

NPR 8715.3, NASA General Safety Program Requirements, 1.4.3

NPR 8715.5, Range Safety Program , 1.3.2, 1.3.4.3

QA-D-02-04-001 Independent Assessment, Final Report Wallops Flight Facility Range Safety Office

Detailed Requirements:

NPR 8715.5, NASA General Safety Program Requirements / 1.3.2 (c): States that the HQ Range Safety Manager will "ensure consistent implementation of range safety requirements throughout the Agency."

[Ref 1]

NPR 8715.5, NASA General Safety Program Requirements/ 1.3.4 Center Directors / 1.3.4.3: When functioning as the authority for a range, the Center Director of NASA designee shall establish a Center range safety organization (direct or delegated) that is independent of all vehicle programs and has safety responsibilities for all range operations that use the Center's range facilities (this should include CSBF offsite launches since WFF is the NASA agency procuring their services.

[Ref 2]

QA-D-02-04-001, Independent Assessment 2002 / Observation: (ITEM 9): Unlike other uninhabited flight programs, the policy and practice in effect in the balloon programs operated at GSFC/WFF do not require independent safety oversight or insight.

Findings: Within NASA, it is.

Methods of Closure: 803 oversight/insight visit to balloon launch contractor planned annually.

Recommendation: GSFC/WFF management should require range safety involvement in the balloon programs. The assessment team suggests that WFF range safety office and balloon programs office coordinate a tailored range safety program for balloons.

INSUFFICIENT TRAINING

Safety Assessment Observation: Contractor safety training insufficient

Mapping to Report Findings:

- R2: WFF safety leadership did not provide appropriate oversight to WFF BPO's implementation of safety requirements (WFF Safety Office and BPO as implementing organizations)**
- R4: GSFC Safety leadership did not verify or provide corrective action for flow down of NASA requirements to protect the public**
- R5: NASA HQ Range Safety Program Office failed to ensure corrective actions were accomplished from previous agency audits**
- R6: Reliance on past success has become a substitute for good engineering and safety practices in the balloon program**

- I2: A barrier to keep the general public out of dangerous areas throughout the launch process did not exist**
- I3: No trained individual was in place to ensure public safety**
- I4: The ground safety plan did not cover all relevant hazards and phases**
- I5: No complete and thorough procedures exists at CSBF to cover launch process**
- I6: Launch crew training did not address failed launch attempts**
- I7: Cat A hazard area during launch phase was not well defined**
- I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt**
- I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch vehicle maneuver**
- I11: The ground safety plan did not explicitly address the protection of the general public**
- I12: The BPO did not have sufficient insight or oversight into the technical aspects of the CSBF's balloon launch process**

I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program

Discussion:

Insufficient oversight by WFF Safety Leadership and the Balloon Program of the balloon program resulted in insufficient contractor training.

Operations Training

The Balloon Program Office and CSBF in lieu of written procedures and explicit hazard controls relied heavily the on-the-job training provided to the crew. In fact, for many of the hazards listed in the Balloon Ground Safety Plan (including handling of ionizing radiation, handling and installing pyrotechnics, operating of heavy equipment and other tasks performed within the hazard area) lists 'prior personnel training' as the only hazard control.

Interview data determined that despite many hours of on-the job training; crew training did not include specific training for anomalous situations. There was no instruction on specific abort criteria, response to breach of safety zones or IRT training. Personnel were given limited guidelines regarding hazardous operations and decisions, such as abort criteria. Evidence also indicates uncertainty among both BPO and CSBF personnel regarding who has abort authority, the application of the Category A hazard zone for the launch phase and assigned safety roles and responsibilities.

MRSO and OSS Training

There is also no evidence of WFF provided ground safety training for the Balloon Program contractors (CSBF) who were delegated safety responsibility for launch operations (nor of contractors certified based on WFF review of OSS equivalency). The duties of MRSO and OSS were required to be assumed and verified by the BPO in accordance with RSM-2002. However appropriate NASA training was not mandated for, nor provided to the contractor by WFF Safety or the BPO. The contractor records only indicate on-the-job training records with no attached curriculum. NASA personnel with appropriate range safety training were not assigned as an alternate solution.

Despite the provision in RSM-2002 (section 2) that the operational responsibilities of the Operational Safety Supervisor (OSS) could be implemented for the balloon program by the contractor; the CSBF personnel were not trained in accordance with the RSM to assume the

responsibilities OSS.

The RSM requires that all personnel designated as OSS are certified by the Safety Office Ground Safety Group (GSG) either by attending OSS an specialized course and successfully completing the testing or by provide satisfactory evidence of the contractor's possession of the required skills and knowledge. The procedure is documented in 800-PG-8715.04A, 'Certification Procedures for Operations Safety Supervisors at WFF'. Balloon-specific (Category II -Balloons) training and certification would have been required for the CSBF crew. Both interview and documentation evidence show that such certification was neither offered by the WFF Safety Office nor otherwise obtained by any of the CSBF crew members.

Certification Requirements and Verifications

The Balloon Ground Safety Plan did not provide a full discussion of personnel training and certification requirements for the hazardous operations to be performed. There was no clear system for the verification of the status of operator certification prior to the beginning of the launch operations. Evidence suggests that one of the launch crew required crane operator certification was not current.

Applicable Requirements:

RSM-2002-Rev. B, Range Safety Manual, 2.0

800-PG-8715.04A, Certification Procedures for Operations Safety Supervisors at WFF

Detailed Requirements:

INSUFFICIENT MISHAP RESPONSE PLAN

Safety Assessment Observation: Balloon Program Pre-Mishap Preparedness and Contingency Plan was not compliant with NPR 8621.1

Mapping to Report Findings:

- R2: WFF safety leadership did not provide appropriate oversight to WFF BPO's implementation of safety requirements (WFF Safety Office and BPO as implementing organizations)**
- R5: NASA HQ Range Safety Program Office failed to ensure corrective actions were accomplished from previous agency audits**

- I3: No trained individual was in place to ensure public safety**
- I5: No complete and thorough procedures exists at CSBF to cover launch process**
- I14: WFF safety leadership did not provide appropriate oversight to WFF safety office's responsibilities with regard to the balloon program**
- I15: WFF safety leadership did not thoroughly review balloon safety documentation**

Discussion:

The CSBF Mishap Plan was not sufficient to meet the requirements of NPR 8621.1 and NPR 8715.5. The plan failed to provide adequate direction to preserve evidence and to keep personnel and public safe in the event of a mishap.

NPR 8715.5, section 1.3.4.2(i) requires that Center Directors functioning as the authority for fixed or mobile launch sites "Develop emergency plans to prevent or mitigate the exposure of the public or employees to any hazard associated with range operation." NPR 8715.5, section 1.3.7(j) stipulates that the Vehicle Program Manager in coordination with the range safety organization(s), generate a contingency action plan that describes the roles and responsibilities in the event of a mishap and provides procedures to secure all data relevant to an investigation and stipulates the use of NPR 8621.1, NASA Procedural Requirements for Mishap Reporting, Investigation and Recordkeeping.

NPR 8621.1, section 2.2 Program and Project Mishap Preparedness and Contingency Plans, 2.2.1.(a) requires that Program Mangers concur with a Program and Project Mishap Preparedness and Contingency Plan (MPCP) that “is a comprehensive plan for all mishaps and close calls that occur offsite, at offsite program/project contractor sites, or in flight.”

The Balloon Programs contingency plan, ‘Procedures Following Launch/Flight Failures, Mishaps, or Incidents CSBF OF-695-21-P’, did not meet the content requirements of 2.2.1. The following data requirements were not adequately addressed within their document:

- **Special procedures for emergency response personnel, the IRT, and the incident commander for identifying, safing and handling hazardous commodities specific to the hardware;**
- **training requirements for IRT membership for mishaps and close calls occurring off-site and contractor locations;**
- **procedures to impound data, records, equipment, facilities, and property;**
- **existing memorandas of agreement with national, state, and local organizations and agencies that may be utilized during a mishap investigation;**
- **descriptions of how offsite debris shall be collected, transported, and stored;**
- **descriptions of investigation and debris collection process required for any mishap or close call occurring in a foreign country;**
- **specification, that for NASA-investigated mishaps, NASA personnel shall perform and control the impounding process.**

The contractor did have a generic mishap plan, but it was not fully compliant with the requirement of NPR 8621.1. OF-695-21-P, ‘Columbia Scientific Balloon Facility Procedures Following Flight Mishap or Incident’ requires that after a mishap hardware not be disturbed prior to inspection by “appropriate personnel” (undefined) and give the CSBF Operations Department Head or remote Campaign Manger authority to instruct movement or manipulation of hardware. There is no discussion of drug testing even though it is in the contract to do so. CSBF Site Manager coordinates appointment of investigation team. There is no information regarding potential hazards (including radioactive sources) associated with or the safing of the equipment. The Balloon Program mishap plan does not include IRT information nor adequately address the safing of the mishap area or protection of evidence.

The lack of a compliant MPCP left the Balloon Program Office and the CSBF contractors unprepared for the Alice Spring mishap. Evidence shows that post mishap, the public and personnel were allowed in close proximity to the ‘unsafed’ hazardous systems (including pyrotechnics, and chemical batteries) and that there was significant disturbance of the mishap scene and removal of key evidence.

Applicable Requirement:

NPR 8715.5, Range Safety Program, 1.3.4.2.i and 1.3.7 (j)

NPR 8621.1, NASA Procedural Requirements for Mishap Reporting, Investigation and Recordkeeping, 2.2

Detailed Requirements:

NPR 8621.1, NASA Procedural Requirements for Mishap Reporting, Investigation and Recordkeeping / 2.2 / Program and Project Mishap Preparedness and Contingency Plans:

2.2.1 The program/project manager shall concur in a Program/Project Mishap Preparedness and Contingency Plan that:

- a. Is a comprehensive plan for all mishaps and close calls that occur offsite, at offsite program/project (as defined by NPR 7120.5) contractor sites, or in flight.**
- b. Is consistent with the Centers' Mishap Preparedness and Contingency Plans, for all Centers in which the program operates.**
- c. Covers any information and procedures required specifically by the program that are not covered in the Centers' Mishap Preparedness and Contingency Plans (i.e., special procedures for safing, handling, or containing hazardous chemicals present in the program's/project's hardware).**
- d. Describes the procedures to comply with NPR 8621.1 notification, reporting, investigating, and recording requirements for all program/project activities not located at a Center or managed by a Center (e.g., program/project activities managed by Headquarters and located at a University, contractor site, or other off-Center location).**
- e. Describes the training requirements and the IRT's membership for mishaps and close calls that occur offsite, at offsite program/project (as defined by NPR 7120.5) contractor sites, or in flight.**
- f. Describes any special procedures for the emergency response personnel, the IRT, and the incident commander that are not covered in the Center Mishap Preparedness and Contingency Plan or the emergency response plan (e.g., identification and handling of hazardous commodities specific to the program) .**
- g. Describes the procedures to impound data, records, equipment, facilities, and property not located at a NASA facility.**
- h. Identifies existing memoranda of agreement with national, state, and local organizations and agencies that may be utilized during a mishap investigation.**
- i. Describes how offsite debris shall be collected, transported, and stored.**

- j. Describes the investigation and debris collection process required for any mishap or close call occurring in a foreign country.**
- k. Requires that, for NASA-investigated mishaps, NASA personnel shall perform and control the impounding process.**
- l. Lists the personnel who will assist in performing the procedures to impound data, records, equipment, facilities, and other property.**
- m. Identifies the national, state, and local (and, where applicable, international) organizations and agencies which are most likely to take part in debris collection; identifies the roles and responsibilities of each organization; and identifies a point of contact.**
- n. Addresses the responsibilities and procedures for mishap investigation in the bilateral or multilateral agreements when the program involves international partners, program managers, and project managers.**
- o. Describes the resources that may be needed from other government agencies (e.g., Federal Emergency Management Agency, NTSB, DoD, Department of Justice) during a Type A mishap or Type B mishap investigation; identifies the point of contact and contact information for each of these Agencies; describes the procedures to acquire their assistance; and identifies the potential roles and responsibilities of each Agency.**
- p. Includes a list of information such as databases, Web sites, documentation (including hardware history), drawings, basic system operation, and procedures that may be scrutinized in a Type A mishap involving loss of a vehicle and/or major facility damage and frequently updates this information so that it is easily deliverable to a mishap investigation board, and includes points of contact for the information.**
- q. Describes the information technology plan to provide computer data retrieval and data archive support to the investigating authority.**
- r. Describes the requisite security clearances, if any, for investigating authority members, chair, and ex officio participating in program/project investigations.**
- s. Describes the "chain of custody process" that will be used to secure and safeguard personal effects and sensitive information related to injured or deceased individuals.**
- t. Names of key personnel from the Agency Public Affairs Office and Office of External Relations (OER) that should be notified for all Type A and Type B mishaps.**
- u. States the expiration date.**
- v. Describes appropriate steps to be taken in advance to ensure that assigned IRT and potential MIB members have authority and resources (including, but not limited to, travel, contractual authority, and salaries) to expeditiously deploy to the mishap scene, effectively preserve mishap evidence, interview witnesses and conduct an orderly investigation without administrative delay.**

D3 – Human Error Assessment

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
1	CSBF crew allowed general public to gather in the projected flight path	Error of Omission: Public not prevented from entering unsafe area.	Interpretation Error – failure to recognize data as hazardous: CSBF crew did not initially recognize the public gathering outside of fence to watch the launch as a hazardous situation and took no action to restrict access or to move the people.	Barriers to keep general public out of all dangerous areas thorough launch process did not exist. No trained individual was independently in place to ensure range safety. There were no written procedures on how or where to control crowds nor was there any information in the Ground Safety Data Package. The only safety zone designated (the Cat A. zone) did not work as a mechanism to keep spectators situated. The public was rarely, if ever in a downwind location during launch operations therefore CSBF may not have recognized the hazard associated with the collecting crowd outside of the fence.	<p>Recommend training the crew in hazard identification, using analysis to determine safe viewing areas, using procedures for spectator controls, setting up barriers and providing an independent, trained safety officer on-sight during launch operations.</p> <p>Analysis</p> <ul style="list-style-type: none"> • Recommendation I1-1: WFF safety office should perform a complete hazard analysis, considering all phases of the balloon launch process. This hazard analysis should be validated by independent review. <p>Barriers</p> <ul style="list-style-type: none"> • Recommendation I2-1: In each launch location, the BPO should ensure that dedicated safety personnel thoroughly examine(s) the potential for spectators or passer-by entering hazardous areas and implement barriers or controls to prevent entry during the launch process. <p><i>(12:A barrier to keep the general public out of all dangerous areas throughout the launch process did not exist)</i></p> <p>Safety Personnel</p> <ul style="list-style-type: none"> • Recommendation I3-1: WFF Safety Office should assign a range safety officer who is properly trained in range safety and who does not have a role in ensuring mission success. <p><i>(13: No trained individual was in place to ensure public safety)</i></p>

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
					<p>Launch Procedures</p> <ul style="list-style-type: none"> •Recommendation I5-1: BPO should develop a hazardous operating procedures to cover the launch process in accordance with NPR 8715.3. <p>Recommendation I5-2 BPO should establish Launch Commit Criteria and flight rules.</p> <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Ground Safety Plan Protection of Public</p> <ul style="list-style-type: none"> •Recommendation I11-1: WFF safety office should specifically address how to deal with the general public in the ground safety plan. <p><i>(I11: The ground safety plan did not explicitly address the protection of the general public)</i></p> <p>Hazard Awareness Training</p> <ul style="list-style-type: none"> •Recommendation O10-1: WFF safety office should ensure CSBF personnel has appropriate hazard awareness training for all hazards associated with each launch. <p><i>(O-10 – CSBF personnel seemed unaware of a number of potential operational hazards and constraints)</i></p>

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
2 [Timeline Event 16]	Launch personnel does fails to move public to safe location.	Error of Commission: In appropriate movement/placement of spectators	Decision Making Failure – failure to select correct/ appropriate action: Personnel failed to effectively move general public to a safe area.	<p>Launch director notices spectators in the downwind flight path and request their relocation.</p> <p>Launch Director recognized hazard associated with public in the intended launch path and asked that they be moved. South Wales University personnel, CSBF crew and volunteers when alerted attempted to move the spectators out of the way; however did so without the benefit of a procedure, explicit directions or an understanding of which locations were hazardous and which were safe. The move(s) were not effective and ultimately people were moved more into harm's way. There was no independent, trained safety officer in place to ensure public was protected or to stop operations until safe to continue.</p>	<p>Recommend using safety analysis to determine safe areas for launch viewing, putting procedures in place for erecting barriers and restricting public access, and providing an independent, trained safety officer on-sight during launch operations.</p> <p>Analysis</p> <ul style="list-style-type: none"> •Recommendation I1-1: WFF safety office should perform a complete hazard analysis, considering all phases of the balloon launch process. This hazard analysis should be validated by independent review. <i>(I1: WFF did not perform rigorous hazard analysis)</i> <p>Barriers</p> <ul style="list-style-type: none"> •Recommendation I2-1: In each launch location, the BPO should ensure that dedicated safety personnel thoroughly examine(s) the potential for spectators or passer-by entering hazardous areas and implement barriers or controls to prevent entry during the launch process. <i>(I2:A barrier to keep the general public out of all dangerous areas throughout the launch process did not exist)</i> <p>Safety Personnel</p> <ul style="list-style-type: none"> •Recommendation I3-1: WFF Safety Office should assign a range safety officer who is properly trained in range safety and who does not have a role in ensuring mission success. <i>(I3: No trained individual was in place to ensure public safety)</i>

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
					<p>Launch Procedures</p> <ul style="list-style-type: none"> •Recommendation I5-1: BPO should develop a hazardous operating procedures to cover the launch process in accordance with NPR 8715.3. •Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules. <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Ground Safety Plan Protection of Public</p> <ul style="list-style-type: none"> •Recommendation I11-1: WFF safety office should specifically address how to deal with the general public in the ground safety plan. <p><i>(I11: The ground safety plan did not explicitly address the protection of the general public)</i></p> <p>Hazard Awareness Training</p> <ul style="list-style-type: none"> •Recommendation O10-1: WFF safety office should ensure CSBF personnel has appropriate hazard awareness training for all hazards associated with each launch. <p><i>(O-10 – CSBF personnel seemed unaware of a number of potential operational hazards and constraints)</i></p>
3	Launch Director and Campaign Manager failed to get	Error of Omission: Failed to obtain positive feedback on request to	Decision Making Error/Perception Error: Attention	Both the Launch Director and the Campaign Manager have been tasked to be the pseudo safety officers for	Recommend providing an independent, trained safety officer on-sight during launch

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
	confirmation that people were relocated to a safe location.	move spectators	Overload	<p>the launch operations. The additional safety oversight responsibility was 1) in conflict with their primary goal to complete the launch and 2) incompatible with their primary responsibilities to pay attention to the balloon overhead and to concentrate on the relative positioning of the launch vehicle and balloon for a successful collar release/launch. In addition, neither had had the required safety training.</p> <p>A dedicated, independent, and properly trained safety officer should have been assigned to the launch – whose sole responsibility was to ensure the safety of the operations without additional distractions or conflicting interests.</p>	<p>operations.</p> <p>Safety Personnel</p> <p>•Recommendation I3-1: WFF Safety Office should assign a range safety officer who is properly trained in range safety and who does not have a role in ensuring mission success.</p> <p><i>(I3: No trained individual was in place to ensure public safety)</i></p>
4 [Timeline Event 16]	CSBF continued launch operations without verification of corrected positioning of public	Error of Commission: Continued hazardous operations without moving public to safe location.	<p>Interpretation Error – failure to understand severity of the hazard:</p> <p>CSBF Crew continued the launch operations with general public still in launch path.</p>	<p>After direction to move people was given, there was no verification on the part of the CSBF crew (including Campaign Manager and Launch Director) that spectators were out of the flight path. Although the hazard of the public in the launch path was initially acknowledged, the severity of it was not. Therefore, not recognizing the severity of the hazard, the operation was continued.</p> <p>There was no safety professional in place to ensure public was no longer in a hazardous area nor to stop operations until safe to continue. No analysis to determine safe area. There were no procedures in place for public safety and</p>	<p>Recommend training the crew in hazard identification, putting procedures and defining go-no go criteria in writing, and providing an independent, trained safety officer on-sight during launch operations.</p> <p>Analysis</p> <p>•Recommendation I1-1: WFF safety office should perform a complete hazard analysis, considering all phases of the balloon launch process. This hazard analysis should be validated by independent review.</p> <p><i>(I1: WFF did not perform rigorous hazard analysis)</i></p> <p>Barriers</p> <p>•Recommendation I2-1: In each launch location, the BPO should ensure that dedicated safety</p>

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
				spectator control.	<p>personnel thoroughly examine(s) the potential for spectators or passer-by entering hazardous areas and implement barriers or controls to prevent entry during the launch process.</p> <p><i>(12:A barrier to keep the general public out of all dangerous areas throughout the launch process did not exist)</i></p> <p>Safety Personnel</p> <ul style="list-style-type: none"> • <u>Recommendation I3-1</u>: WFF Safety Office should assign a range safety officer who is properly trained in range safety and who does not have a role in ensuring mission success. <p><i>(I3: No trained individual was in place to ensure public safety)</i></p> <p>Launch Procedures</p> <ul style="list-style-type: none"> • <u>Recommendation I5-1</u>: BPO should develop a hazardous operating procedures to cover the launch process in accordance with NPR 8715.3. <p>Recommendation I5-2 BPO should establish Launch Commit Criteria and flight rules.</p> <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>• Ground Safety Plan Protection of Public</p> <p><u>Recommendation I11-1</u>: WFF safety office should specifically address how to deal with the general public in the ground safety plan.</p> <p><i>(I11: The ground safety plan did</i></p>

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
					<p><i>not explicitly address the protection of the general public)</i></p> <p>Hazard Awareness Training</p> <ul style="list-style-type: none"> •Recommendation O10-1: WFF safety office should ensure CSBF personnel has appropriate hazard awareness training for all hazards associated with each launch. <p><i>(O-10 – CSBF personnel seemed unaware of a number of potential operational hazards and constraints)</i></p>
<p>5 [Timeline Events 24, 29, 30]</p>	<p>Launch vehicle did not follow a suitable path to enable a successful launch</p>	<p>Error of Commission: Irregular launch vehicle path.</p>	<p>Perception Error- failure to perceive or detect: Launch driver’s perception of the anticipated balloon direction and speed may have been inaccurate and negatively influenced the path chosen to align with it.</p>	<p>The Launch Director is responsible for guiding the launch vehicle into an acceptable orientation for launch. This involves anticipating the movement of the balloon and giving the driver directions designed to position the vehicle under the balloon in a timely manner.</p> <p>The launch director relies on his/her perception of wind direction, balloon movements, launch vehicle speed and relative position, and depends on perceived knowledge of the crane’s maneuverability.</p> <p>The Launch Director ordered driver to drive forward, making a sweeping right 90 degree turn, and later to turn left to align with balloon’s flight path. The vehicle slows down due to loss of traction and then speeds up to catch the balloon.</p>	<p>Recommend that the Balloon Program taking initiative to characterize and expand launch opportunities, defining launch operation criteria (including launch conditions and acceptable maneuvers), and writing and using launch procedures.</p> <p>Launch Procedures</p> <ul style="list-style-type: none"> •Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3. •Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules. <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>System Analysis for Payload Release</p> <ul style="list-style-type: none"> •Recommendation I9-1: BPO should require in the contract that CSBF perform a thorough analysis

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
				<p>The very fragile nature of the balloon launch process leaves little margin for error. Evidence from analysis shows that the window for opportunity is exceedingly small.</p> <p>Evidence shows that some of the turns taken by the launch vehicle caused the vehicle to lose ground on catching the balloon; wind, rough terrain and limited launch area contributed as well.</p>	<p>of the payload restraint and release system to establish an acceptable angular range of balloon relative to crane for launch attempt.</p> <p><i>(I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt)</i></p> <p>Wind criteria</p> <ul style="list-style-type: none"> • Recommendation I13-1: The BPO should establish firm, written criteria for wind limits and factor these into all go/no-go and abort criteria and any specific restrictions on a particular launch. <p><i>(I-13 Wind created a challenging)</i></p> <p>Improved Launch Conditions</p> <ul style="list-style-type: none"> • Recommendation I8-1: BPO should perform a cost, utility and feasibility assessment for improving the terrain at Alice Springs, Airport. <p><i>(I8: Terrain was rough and unimproved.)</i></p>
6 [Timeline Event 31]	Launch Vehicle Breaches Category A Hazard Zone	Error of Commission: Breach of hazard zone.	Perception Error – Failure to perceive or detect: CSBF crew failed to detect breach of Category A hazard zone.	There were no markings or barriers to indicate the designated safety zone, nor to indicate when the zone was breached. Whether static or moving – at some point the Category A hazard zone (the hazardous area surrounding the launch vehicle) was breached either by the vehicle leaving the fixed hazardous area or by the vehicle moving within a prohibited proximity to personnel and	<p>Recommend clearly defining and marking Category A zone and providing an independent, trained safety officer on-sight during launch operations.</p> <p>Safety Personnel</p> <ul style="list-style-type: none"> • Recommendation I3-1: WFF Safety Office should assign a range safety officer who is properly trained in range safety and who does not have a role in ensuring

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				<p>public not authorized within the zone. This breach was not noticed because the zone was not visibly marked. Interview evidence revealed that the launch crew only visually identified of the boundaries of the zone by landmarks in the terrain and relied solely on memory to identify the area during operations. There was no safety officer assigned to ensure the zone was properly maintained.</p>	<p>mission success.</p> <p><i>(13: No trained individual was in place to ensure public safety)</i></p> <p>Launch Procedures</p> <ul style="list-style-type: none"> •Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3. •Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules. <p><i>(15: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Category A Hazard Area</p> <ul style="list-style-type: none"> •Recommendation I7-1: WFF safety office should clearly and unambiguously define the Category A hazard zone and should require that it be implementable in practice with visible markings. <p><i>(17: Cat A hazard area during launch phase was not well-defined)</i></p> <p>Ground Safety Plan</p> <ul style="list-style-type: none"> •Recommendation I4-1: The WFF Safety Office should revise the balloon ground safety plan to cover all phases, from inflation through recovery, identify all hazards from the Hazard Analysis, and resulting restrictions and implementation of operational requirements. <p><i>(14: The ground safety plan did not cover all relevant hazards and phases)</i></p>

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
					<p>Ground Safety Plan Protection of Public</p> <p>•Recommendation I11-1: WFF safety office should specifically address how to deal with the general public in the ground safety plan.</p> <p><i>(I11: The ground safety plan did not explicitly address the protection of the general public)</i></p> <p>Hazard Awareness Training</p> <p>•Recommendation O10-1: WFF safety office should ensure CSBF personnel has appropriate hazard awareness training for all hazards associated with each launch.</p> <p><i>(O-10 – CSBF personnel seemed unaware of a number of potential operational hazards and constraints)</i></p>
7 [Timeline Event 32]	Launch director was not in suitable position to begin launch attempt	Error of Commission: Launch director began launch attempt when balloon was not suitably overhead	Error of Perception- failure to perceive or detect: appropriate position of balloon	<p>Launch director did not attempt pin release under the right conditions</p> <p>Launch director thought that the balloon was suitably (sufficiently) overhead to attempt a launch</p> <p>The balloon was not within acceptable range of the launch vehicle during the attempt.</p> <p>No definition of acceptable angular range of balloon relative to launch vehicle</p>	<p>Recommend analysis of launch parameters, launch procedures, clearly defined launch constraints and possible improvements of surface conditions.</p> <p>Launch Procedures</p> <p>•Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3.</p> <p>•Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules.</p> <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance</i></p>

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				<p>exists.</p> <p>CSBF has not analyzed system to establish acceptable ranges.</p> <p>There are no written launch procedures.</p> <p>There are no definitive mechanical indications of correct balloon/launch vehicle positions. Visual cues are the only determination. Operators rely on On-the-job training in place of explicit rules and procedures.</p> <p>The launch process is fragile; based on dependency of visual assessments and good judgment. The launch process is highly sensitive to errors in judgment, perception and visualization.</p>	<p>with NPR 8715.5).</p> <p>System Analysis for Payload Release</p> <p>•Recommendation I9-1: BPO should require in the contract that CSBF perform a thorough analysis of the payload restraint and release system to establish an acceptable angular range of balloon relative to crane for launch attempt.</p> <p><i>(I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt)</i></p> <p>Improved Launch Conditions</p> <p>•Recommendation I8-1: BPO should perform a cost, utility and feasibility assessment for improving the terrain at Alice Springs, Airport.</p> <p><i>(I8: Terrain was rough and unimproved.)</i></p> <p>Wind criteria</p> <p>•Recommendation I13-1: The BPO should establish firm, written criteria for wind limits and factor these into all go/no-go and abort criteria and any specific restrictions on a particular launch.</p> <p><i>(I-13 Wind created a challenging)</i></p>
8 [Timeline	Payload controller lost hold of the payload taglines (Team member	Change in State: The tag lines are pulled from hands of operator when the payload jerks in response to sharp	Action Execution Error – Physical inability to make response: Controller loses grip	The path of the vehicle along with the wind creating a challenging environment and rough and unimproved terrain and the	Recommend analysis of launch parameters, launch procedures, clearly defined launch constraints and possible improvements of

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
Event 33]	controlling the taglines to the payload loses hold of the payload restraint straps and the payload starts swinging wildly)	deceleration.	on tag lines.	<p>launch vehicle could not catch the balloon within the confines of the fenced area.</p> <p>No standard procedures exist at CSBF to cover the launch process; training did not provide sufficient guidance to deal with all credible situations during launch (insufficient guidance to deal with anomalous or contingency situations).</p>	<p>surface conditions.</p> <p>Launch Procedures</p> <ul style="list-style-type: none"> •<u>Recommendation I5-1</u>: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3. •<u>Recommendation I5-2</u>: BPO should establish Launch Commit Criteria and flight rules. <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>System Analysis for Payload Release</p> <ul style="list-style-type: none"> •<u>Recommendation I9-1</u>: BPO should require in the contract that CSBF perform a thorough analysis of the payload restraint and release system to establish an acceptable angular range of balloon relative to crane for launch attempt. <p><i>(I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt)</i></p> <p>Improved Launch Conditions</p> <ul style="list-style-type: none"> •<u>Recommendation I8-1</u>: BPO should perform a cost, utility and feasibility assessment for improving the terrain at Alice Springs, Airport. <p><i>(I8: Terrain was rough and unimproved.)</i></p>

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					<p>Wind criteria</p> <p>•Recommendation I13-1: The BPO should establish firm, written criteria for wind limits and factor these into all go/no-go and abort criteria and any specific restrictions on a particular launch.</p> <p><i>(I-13 Wind created a challenging environment)</i></p>
<p>9 [Timeline Events 34/35]</p>	<p>Failed Launch attempt(s)</p>	<p>Correct Action: The Launch Director correctly pulled on the launch release cable</p>	<p>Action Execution Error – Physical inability to make response: Launch Director lacked physical strength to pull the launch release cable to open restraint pin</p>	<p>The payload did not release when launch cable pulled.</p> <p>The release mechanisms experienced loads requiring superhuman forces to enable release.</p> <p>The restraint pin would not come free when pulled.</p> <p>A secondary release mechanism did not exist.</p>	<p>Recommend performing analysis of launch parameters, clearly defining launch constraints and abort criteria and writing launch procedures, conducting anomaly training including failed launch attempts and possibly adding a secondary release mechanism.</p> <p>Launch Procedures</p> <p>•Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3.</p> <p>•Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules.</p> <p>•Recommendation I5-3: BPO should establish and document firm and unambiguous criteria for aborts during the launch phase.</p> <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Failed launch attempts</p> <p>•Recommendation I6-1: BPO should ensure that training for the launch crew covers the widest possible set of anomalous</p>

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					<p>occurrences in the launch process including, but not limited to, failed launch attempts, breaches and near-breaches of the Hazard Zone, loss of payload control straps, loss of communication, and scenarios that would lead to an abort.</p> <p><i>(16: Launch crew training did not address failed launch attempts)</i></p> <p>System Analysis for payload release</p> <p>•Recommendation I9-1: BPO should require in the contract that CSBF perform a thorough analysis of the payload restraint and release system to establish an acceptable angular range of balloon relative to crane for launch attempt.</p> <p><i>(19: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt.)</i></p> <p>Wind criteria</p> <p>•Recommendation I13-1: The BPO should establish firm, written criteria for wind limits and factor these into all go/no-go and abort criteria and any specific restrictions on a particular launch.</p> <p><i>(I-13 Wind created a challenging)</i></p> <p>Restraint pin lubrication</p> <p>•Recommendation CF1-1: BPO should perform analysis and/or test to determine the relationship between pin lubrication and lanyard pull force to establish lubrication guidelines for proper operation.</p> <p><i>(CF1: Restraint pin was not</i></p>

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					<p>sufficiently lubricated.)</p> <p>No secondary release mechanism</p> <p>•Recommendation CF2-1: BPO should analyze, evaluate, and test the hardware to understand its capabilities and operating range, as well as to determine failures and associated sensitivities. Based on the results of this analysis and a mapping against detailed understanding of the launch process, BPO should determine whether a hardware re-design is in order and take appropriate steps.</p> <p><i>(CF2: Secondary release mechanism did not exist.)</i></p>

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
10 [Timeline Event 37]	Continuation of launch attempt	Error of Commission: Continued to chase balloon in the direction of public spectators	Decision-Making Error - failure to consider alternate behaviors, failure to select correct or appropriate action: Possible missed opportunity for abort	<p>Launch director felt there was a chance he could still chase the balloon and launch successfully. (Launch driver orders launch vehicle driver to go forward to catch the balloon.)</p> <p>In the past CSBF has launched successfully after failed attempt. Launch operator was most likely applying his training – without taking into account dissimilar situations and surroundings.</p> <p>Documentation does not specify abort criteria, training does not address attempt failed launches or abort criteria, CSBF has previously launched successfully after a failed attempt.</p>	<p>Recommend performing analysis of launch parameters, clearly defining launch constraints and abort criteria and writing launch procedures, conducting anomaly training including failed launch attempts and abort scenarios and providing an independent, trained safety officer on-sight during launch operations.</p> <p>Launch Procedures</p> <ul style="list-style-type: none"> • Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3. • Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules. • Recommendation I5-3: BPO should establish and document firm and unambiguous criteria for aborts during the launch phase. <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Failed launch attempts</p> <ul style="list-style-type: none"> • Recommendation I6-1: BPO should ensure that training for the launch crew covers the widest possible set of anomalous occurrences in the launch process including, but not limited to, failed launch attempts, breaches and near-breaches of the Hazard Zone, loss of payload control straps, loss of communication, and scenarios that would lead to an abort. <p><i>(I6: Launch crew training did not address failed launch attempts)</i></p>

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					<p>System Analysis for payload release</p> <p>•Recommendation I9-1: BPO should require in the contract that CSBF perform a thorough analysis of the payload restraint and release system to establish an acceptable angular range of balloon relative to crane for launch attempt.</p> <p><i>(I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt.)</i></p> <p>Wind criteria</p> <p>•Recommendation I13-1: The BPO should establish firm, written criteria for wind limits and factor these into all go/no-go and abort criteria and any specific restrictions on a particular launch.</p> <p><i>(I-13 Wind created a challenging)</i></p> <p>Improved Launch Conditions</p> <p>•Recommendation I8-1: BPO should perform a cost, utility and feasibility assessment for improving the terrain at Alice Springs, Airport.</p> <p><i>(I8: Terrain was rough and unimproved.)</i></p>
11 [Timeline Event 39]	Launch vehicle stops at airport perimeter fence.	Error of Commission: Driving launch vehicle to proximity of public spectators.	Interpretation Error- Failure to recognize data as hazard/ severity of hazards: Crew did not recognize the potential for unintentional release of payload due to	Launch Director and the launch crew only recognized the danger to the public as 1) collision with the launch vehicle and 2) aborting over people.	Recommend performing analysis of launch parameters and mechanisms, clearly defining launch constraints and abort criteria and writing launch procedures, conducting anomaly training including failed launch attempts and abort scenarios and providing an independent, trained

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			mechanical failure.	<p>Launch Director made attempt to avoid both of these hazards. Additional hazards and their associated severity were not considered. CSBF crew did not consider breach of safety zone as a serious hazard nor did they recognize the hazard of unintentional release of the payload due to structural failure. This hazard had not been properly analyzed and communicated to the crew. There was no hazard awareness, procedures or training. There was no independent safety officer overseeing the launch.</p>	<p>safety officer on-sight during launch operations and crew hazard awareness training.</p> <p>Launch Procedures</p> <ul style="list-style-type: none"> •Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3. •Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules. •Recommendation I5-3: BPO should establish and document firm and unambiguous criteria for aborts during the launch phase. <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Failed launch attempts</p> <ul style="list-style-type: none"> •Recommendation I6-1: BPO should ensure that training for the launch crew covers the widest possible set of anomalous occurrences in the launch process including, but not limited to, failed launch attempts, breaches and near-breaches of the Hazard Zone, loss of payload control straps, loss of communication, and scenarios that would lead to an abort. <p><i>(I6: Launch crew training did not address failed launch attempts)</i></p> <p>System Analysis for payload release</p> <ul style="list-style-type: none"> •Recommendation I9-1: BPO should require in the contract that CSBF perform a thorough analysis of the payload restraint and release system to establish an

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					<p>acceptable angular range of balloon relative to crane for launch attempt.</p> <p><i>(I9: CSBF has not analyzed the payload release system to establish acceptable angular range of balloon relative to launch vehicle for launch attempt.)</i></p> <p>Mechanism Evaluation</p> <p>•Recommendation I10-1: BPO should evaluate balloon launch hardware mechanisms through testing and review of documentation and specifications to determine proper operating conditions and ranges. The results of this evaluation should then be used to define operating limits of launch hardware and specify abort criteria.</p> <p><i>(I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch attempt)</i></p> <p>Wind criteria</p> <p>•Recommendation I13-1: The BPO should establish firm, written criteria for wind limits and factor these into all go/no-go and abort criteria and any specific restrictions on a particular launch.</p> <p><i>(I-13 Wind created a challenging)</i></p>
12 [Timeline Event 40]	Decision on Safe Method for abort. (Due to spectators being in the downwind path and close proximity launch	Error of Omission: Launch crew failed to consider alternate solutions for abort.	Decision-Making Error: Failed to consider moving spectators prior to any abort attempt.	Launch Director was correct in recognizing that an abort over the people would be dangerous. There was a missed opportunity to hold the	Recommend performing analysis of launch parameters and mechanisms, clearly defining launch constraints and abort criteria and writing launch procedures, conducting anomaly training including failed launch attempts and abort scenarios and providing an independent, trained

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	director cannot order flight termination.)			<p>launch vehicle position and clear the area of people.</p> <p>Crew was not aware of potential for structural failure. Did not consider this hazard.</p> <p>There were no written procedures or abort criteria. System analysis had not been sufficiently performed to characterize the launch system and launch constraints. Crew training did not include anomaly and contingency training including failed launch attempt and abort scenarios.</p> <p>No safety officer was overseeing the launch operation.</p>	<p>safety officer on-sight during launch operations and crew hazard awareness training.</p> <p>Safety Personnel</p> <ul style="list-style-type: none"> •Recommendation I3-1: WFF Safety Office should assign a range safety officer who is properly trained in range safety and who does not have a role in ensuring mission success. <p><i>(I3: No trained individual was in place to ensure public safety)</i></p> <p>Launch Procedures</p> <ul style="list-style-type: none"> •Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3. •Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules. •Recommendation I5-3: BPO should establish and document firm and unambiguous criteria for aborts during the launch phase. <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Failed launch attempts</p> <ul style="list-style-type: none"> •Recommendation I6-1: BPO should ensure that training for the launch crew covers the widest possible set of anomalous occurrences in the launch process including, but not limited to, failed launch attempts, breaches and near-breaches of the Hazard Zone, loss of payload control straps, loss of communication, and scenarios

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					<p>that would lead to an abort.</p> <p><i>(I6: Launch crew training did not address failed launch attempts)</i></p> <p>Mechanism Evaluation</p> <p>•Recommendation I10-1: BPO should evaluate balloon launch hardware mechanisms through testing and review of documentation and specifications to determine proper operating conditions and ranges. The results of this evaluation should then be used to define operating limits of launch hardware and specify abort criteria.</p> <p><i>(I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch attempt)</i></p> <p>Hazard Awareness Training</p> <p>•Recommendation O10-1: WFF safety office should ensure CSBF personnel has appropriate hazard awareness training for all hazards associated with each launch.</p> <p><i>(O-10 – CSBF personnel seemed unaware of a number of potential operational hazards and constraints)</i></p>
13 [Timeline Event 41]	Launch vehicle starts moving in reverse	Error of Commission-Backing up of the launch vehicle induced excessive load on system.	Interpretation Error – Failure to recognize data as hazard: CSBF failed to recognize the potential for structural failure due to loads excerpted induced by the backing operation.	Lack of procedures, anomaly and contingency training, lack of analysis all contributed to the crew not recognizing the hazards associated with backing the launch vehicle and pulling the balloon.	Recommend performing analysis of launch parameters and mechanisms, clearly defining launch constraints and abort criteria and writing launch procedures, conducting anomaly training including failed launch attempts and abort scenarios and providing an independent, trained safety officer on-sight during launch operations and crew hazard awareness training.

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					<p>Launch Procedures</p> <ul style="list-style-type: none"> •Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3. •Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules. •Recommendation I5-3: BPO should establish and document firm and unambiguous criteria for aborts during the launch phase. <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Failed launch attempts</p> <ul style="list-style-type: none"> •Recommendation I6-1: BPO should ensure that training for the launch crew covers the widest possible set of anomalous occurrences in the launch process including, but not limited to, failed launch attempts, breaches and near-breaches of the Hazard Zone, loss of payload control straps, loss of communication, and scenarios that would lead to an abort. <p><i>(I6: Launch crew training did not address failed launch attempts)</i></p> <p>Mechanism Evaluation</p> <ul style="list-style-type: none"> •Recommendation I10-1: BPO should evaluate balloon launch hardware mechanisms through testing and review of documentation and specifications to determine proper operating conditions and ranges. The results of this evaluation should then be used to define operating limits of

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
					<p>launch hardware and specify abort criteria.</p> <p><i>(I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch attempt)</i></p> <p>Hazard Awareness Training</p> <p>•Recommendation O10-1: WFF safety office should ensure CSBF personnel has appropriate hazard awareness training for all hazards associated with each launch.</p> <p><i>(O-10 – CSBF personnel seemed unaware of a number of potential operational hazards and constraints)</i></p>
14 [Timeline Event 43]	Launch vehicle turns 90 degrees – attempting to turn around.	Error of Commission: Turning of the launch vehicle induced excessive load on system.	Interpretation Error – Failure to recognize data as hazard. CSBF failed to recognize the potential for structural failure due to loads induced by the turning of the launch vehicle.	Lack of procedures, anomaly and contingency training, lack of analysis all contributed to the crew not recognizing the hazards associated with turning the launch vehicle while pulling the balloon.	<p>Recommend performing analysis of launch parameters and mechanisms, clearly defining launch constraints and abort criteria and writing launch procedures, conducting anomaly training including failed launch attempts and abort scenarios and providing an independent, trained safety officer on-sight during launch operations and crew hazard awareness training.</p> <p>Launch Procedures</p> <p>•Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3.</p> <p>•Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules.</p> <p>•Recommendation I5-3: BPO should establish and document firm and unambiguous criteria for aborts during the launch phase.</p>

#	Human Event	Action Type	Error Type	Discussion of Failed Barriers	Recommendations and Finding Mapping
					<p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Mechanism Evaluation</p> <p>•Recommendation I10-1: BPO should evaluate balloon launch hardware mechanisms through testing and review of documentation and specifications to determine proper operating conditions and ranges. The results of this evaluation should then be used to define operating limits of launch hardware and specify abort criteria.</p> <p><i>(I10: CSBF was not aware of hardware limitations that might give rise to a failure during a launch attempt)</i></p> <p>Hazard Awareness Training</p> <p>•Recommendation O10-1: WFF safety office should ensure CSBF personnel has appropriate hazard awareness training for all hazards associated with each launch.</p> <p><i>(O-10 – CSBF personnel seemed unaware of a number of potential operational hazards and constraints)</i></p>
15	Failure to Safe and Secure Mishap Site	Error of Omission: CSBF failed to secure the mishap scene.	Interpretation Error – Failure to recognize data as hazard: Crew did not recognize the hazards of the payload nor the danger of letting personnel and public in close proximity to unsafe hazardous systems after launch abort.	Lack of procedures, anomaly and contingency training, lack of analysis all contributed to the crew not recognizing the hazards associated with backing the launch vehicle and pulling the balloon.	Recommend writing launch procedures, Mishap and Contingency Plan in accordance with requirements, IRT training, conducting anomaly training including failed launch attempts and abort scenarios and providing an independent, trained safety officer on-sight during launch operations and crew hazard awareness training

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					<p>Safety Personnel</p> <ul style="list-style-type: none"> • Recommendation I3-1: WFF Safety Office should assign a range safety officer who is properly trained in range safety and who does not have a role in ensuring mission success. <p><i>(I3: No trained individual was in place to ensure public safety)</i></p> <p>Launch Procedures</p> <ul style="list-style-type: none"> • Recommendation I5-1: BPO should develop a hazardous operating procedure to cover the launch process in accordance with NPR 8715.3. • Recommendation I5-2: BPO should establish Launch Commit Criteria and flight rules. • Recommendation I5-3: BPO should establish and document firm and unambiguous criteria for aborts during the launch phase. <p><i>(I5: Intermediate Cause: No complete and thorough standard procedure exists at CSBF to cover the launch process in accordance with NPR 8715.5).</i></p> <p>Hazard Awareness Training</p> <ul style="list-style-type: none"> • Recommendation O10-1: WFF safety office should ensure CSBF personnel has appropriate hazard awareness training for all hazards associated with each launch. <p><i>(O-10 – CSBF personnel seemed unaware of a number of potential operational hazards and constraints)</i></p>

APPENDIX E: Definitions

Amelioration	Mitigation. The actions that are taken after a target has been affected (from a problem or accident) to reduce the damage that may occur to the target. Amelioration reduces the severity of the undesired outcome by limiting the effects of the hazard. Amelioration includes a detection and correction component; however, these components of amelioration detect and correct the undesired outcome after some form of a negative effect has occurred. Also called Mitigation.
Appointing Official	The official authorized to appoint the investigating authority for a mishap or close call, to accept the investigation of another authority, to receive endorsements and comments from endorsing officials, and to approve the mishap report.
Barrier	A passive physical device or an administrative intervention that is used to prevent or reduce the likelihood that the undesired outcome will occur. Barriers provide physical intervention (e.g., a guardrail) between hazards and the target or provide procedural separation in time and space (e.g., lock-out/tag-out procedure).
Barrier Analysis	A systematic process used to identify physical and administrative barriers and/or controls that should have prevented the occurrence of an undesired outcome.
Cause	An event or condition that results in an effect. Anything that shapes or influences the outcome.
Close Call	An event in which there is no injury or only minor injury requiring first aid and/or no equipment/property damage or minor equipment/property damage (less than \$1000), but which possesses a potential to cause a mishap.
Condition	Any as-found state, whether or not resulting from an event, that facilitates the occurrence of an event and may have safety, health, quality, security, operational, or environmental implications. Conditions exist and are inactive elements in a causal chain.
Contributing Factor	An event or condition that may have contributed to the occurrence of an undesired outcome but, if eliminated or modified, would not by itself have prevented the occurrence. Contributing factors increase the probability that an event or condition will occur.
Corrective Actions	Changes to design processes, work instructions, workmanship practices, training, inspections, tests, procedures, specifications, drawings, tools, equipment, facilities, resources, or material that result in preventing, minimizing, or limiting the potential for recurrence of a mishap.
Control	An active mechanism that is used to detect the initiating event and/or the hazard and enable an active device (hardware, software, or human) to prevent or reduce the potential (likelihood) that the hazard will affect the target (produce an undesired outcome). Controls minimize the effects of the initiating event by detecting and correcting them before they transition to a negative effect.
Descriptor	A phrase that provides detail about the actor, what an actor did, or what object the actor acted on.
Direct Cost of Damage	(For the purpose of mishap and close call classification) The sum of the costs (the greater value of actual or fair market value) of damaged property, destroyed property, or mission failure, actual cost of repair or replacement, labor (actual value of replacement or repair hours for internal and external/contracted labor), cost of the lost commodity (e.g., the cost of the fluid that was lost from a ruptured pressure vessel), as well as resultant costs such as environmental decontamination, property cleanup, and restoration, or the estimate of these costs.
Effect	A change or changed state that occurs as a direct result of an action by somebody or something else. An effect is an outcome.
Engineered Barriers	Hardware and software features that make it less likely that a user will carry out an

	undesirable action.
Event	A real-time occurrence describing one discrete action, typically an error, failure, or malfunction. Examples: pipe broke, power lost, lightning struck, and person opened valve.
Event and Causal Factor Analysis	Event and Causal Factor Analysis identifies the time sequence of a series of tasks and/or actions and the surrounding conditions leading to the occurrence of an undesired outcome. The results are displayed in a graphic that provides an illustration of the relationships between the events, conditions, and undesired outcome.
Event and Causal Factor Tree	A graphical representation of a mishap or close call that shows the undesired outcome (problem or accident) at the top of the tree, depicts the logical sequence of events, illustrates all causal factor(s) (including condition[s] and events) necessary and sufficient for the undesired outcome (mishap or close call) to occur, and depicts the root cause(s) at the bottom of the tree.
Facilities Maintenance	The recurring day-to-day work required to preserve facilities (buildings, structures, grounds, utility systems, and collateral equipment) in such a condition that they may be used for their designated purpose over an intended service life. Maintenance minimizes or corrects wear and tear and thereby forestalls major repairs. Facilities maintenance includes Preventative Maintenance, Predicative Testing & Inspection, Grounds Care, Programmed Maintenance, repair, Trouble Calls, Replacement of Obsolete Items, and Service Request (Not a maintenance item but work performed by maintenance organizations). Facilities Maintenance includes the cost of labor, materials, and parts but does not include new work.
Failure	The inability of a system, component, process, or crew to perform its required functions within specified performance requirements. For humans, this includes Unsafe Acts (violations). A violation is not an error: it is intentional and deliberate on the part of the actor.
Fault	Any change in a state of an item that is considered anomalous and may warrant some type of corrective action.
Fault Tree	An analytical technique, whereby an undesired system state is specified and the system is analyzed in the context of its environment and operation to find all credible ways in which the undesired event can occur. This can be performed by way of a symbolic or graphical logic diagram showing the cause-effect relationship between an undesired top event or failure and one or more contributing causes.
Fault Tree Analysis	An analysis that begins with the definition or identification of an undesired event (failure). The fault tree is a symbolic logic diagram showing the cause-effect relationship between a top undesired event (failure) and one or more contributing causes. It is a type of logic tree that is developed by deductive logic from a top undesired event to all sub-events that must occur to cause it.
Finding	A conclusion, positive or negative, based on facts established during the investigation by the investigating authority (i.e., cause, contributing factor, and observation).
First Aid	Refer to the Occupational Safety and Health Administration definition in 29 CFR 1904.7, General Recording Criteria.
High Visibility Mishap	Those particular mishaps or close calls, regardless of the amount of property damage or personnel injury, that the Administrator, Chief/OSMA, CD, ED/OHO, or the Center SMA director judges to possess a high degree of programmatic impact or public, media, or political interest including, but not limited to, mishaps and close calls that impact flight hardware, flight software, or completion of critical mission milestones.
Incident	An occurrence of a mishap or close call.
Initiating Event	An active event that results in the release of the hazard, energy (kinetic, potential,

	electromagnetic, thermal, steam, or other types of energy) that has the potential to affect the target and lead to an undesired outcome or end state.
Interim Response Team (IRT)	A team that arrives at the mishap scene immediately after an incident; secures the scene; documents the scene using photography, video, sketches, and debris mapping; identifies witnesses; collects written witness statements and contact information; preserves evidence; impounds evidence (at the scene and other NASA locations as needed); collects debris; implements the chain-of-custody process for the personal effects of the injured and deceased; notifies the NASA Public Affairs Officer about casualties, damages, and any potential hazards to the public and NASA personnel; advises the supervisor if drug testing should be initiated; and provides all information and evidence to the investigating authority. The team is considered "interim" because it operates as a short-term response team and concludes its mishap-response activities when the official NASA-appointed investigating authority arrives to the scene and takes control.
Intermediate Cause	An event or condition that created the proximate cause that, if eliminated or modified, would have prevented the proximate cause from occurring. There may be one too many intermediate causes for a single proximate cause. The intermediate cause is between the proximate cause and the root cause in the causal chain.
Investigating Authority	The individual mishap investigator, mishap investigation team, or mishap investigation board authorized to conduct an investigation for NASA. This includes the mishap investigation board chairperson, voting members, and ex officio but does not include the advisors and consultants.
Lessons Learned	The written description of knowledge or understanding that is gained by experience, whether positive (such as a successful test or mission), or negative (such as a mishap or failure).
Lost Time Injury/Illness	A nonfatal traumatic injury that causes any loss of time from work beyond the day or shift it occurred; or a nonfatal no traumatic illness/disease that causes disability at any time.
Maintenance	The recurring day-to-day, periodic, scheduled or unscheduled work required to preserve or restore a piece of equipment, a system, or utility to such a condition that it can be effectively utilized for its intended purpose, output, redundancy, and availability. The term includes work undertaken to prevent damage to a facility that otherwise would be more costly to restore.
Mishap	An unplanned event that results in at least one of the following: a. Injury to non-NASA personnel, caused by NASA operations. b. Damage to public or private property (including foreign property), caused by NASA operations or NASA-funded development or research projects. c. Occupational injury or occupational illness to NASA personnel. d. Mission failure before the scheduled completion of the planned primary mission. e. Destruction of, or damage to, NASA property except for a malfunction or failure of component parts that are normally subject to fair wear and tear and have a fixed useful life that is less than the fixed useful life of the complete system or unit of equipment, provided that the following are true: 1) there was adequate preventative maintenance; and 2) the malfunction or failure was the only damage and the sole action is to replace or repair that component.
Mishap Investigation Board (MIB)	A sponsored board that: a. Is appointed for a Type A mishap, Type B mishap, high-visibility mishap, or high-visibility close call. Requires concurrence from the Chief, Safety and Mission Assurance, Office of Safety and Mission Assurance (Chief/OSMA), and the Chief Engineer on membership. c. Consists of an odd number of Federal employees (including the chairperson) where the majority of the members are independent from the operation or activity in which the mishap occurred. d. Has a minimum of five voting members for Type A mishaps and three voting members for Type B mishaps. e. Includes a safety officer and a human factors mishap investigator.

	For all Type A mishaps involving injury, illness, or fatality, also includes an occupational health physician (or flight surgeon for aircraft-related mishaps) as a member. f. Is tasked to investigate the mishap or close call and generate the mishap report per the requirements specified in this NPR. A sponsored board that: a. Is appointed for a Type A mishap, Type B mishap, high-visibility mishap, or high-visibility close call. b. Requires concurrence from the Chief, Safety and Mission Assurance, Office of Safety and Mission Assurance (Chief/OSMA), and the Chief Engineer on membership. c. Consists of an odd number of Federal employees (including the chairperson) where the majority of the members are independent from the operation or activity in which the mishap occurred. d. Has a minimum of five voting members for Type A mishaps and three voting members for Type B mishaps. e. Includes a safety officer and a human factors mishap investigator. For all Type A mishaps involving injury, illness, or fatality, also includes an occupational health physician (or flight surgeon for aircraft-related mishaps) as a member. f. Is tasked to investigate the mishap or close call and generate the mishap report per the requirements specified in this NPR.
Mishap Response Contingency Action Plan (MRCAP)	Pre-approved documents outlining timely organizational activities and responsibilities that must be accomplished in response to emergency, catastrophic, or potential (but not likely) events encompassing injuries, loss of life, property damage, or mission failure.
Mission Failure	A mishap of whatever intrinsic severity that prevents the achievement of the mission's minimum success criteria or minimum mission objectives as described in the mission operations report or equivalent document.
Operation	Any activity or process that is under NASA direct control or includes major NASA involvement.
Observation	A factor, event, or circumstance identified during the investigation that did not contribute to the mishap or close call, but, if left uncorrected, has the potential to cause a mishap or increase the severity of a mishap; or a factor, event, or circumstance that is positive and should be noted.
Organizational Factor	Any operational or management structural entity that exerts control over the system at any stage in its life cycle, including, but not limited to, the system's concept development, design, fabrication, test, maintenance, operation, and disposal. Examples: resource management (budget, staff, training); policy (content, implementation, verification); and management decisions.
Pilot Balloon (PiBal)	A meteorological balloon used to observe air currents.
Pivotal Event (or Condition)	An event that is a success or a failure of a barrier or control's response, (or a condition that has occurred or has failed to occur after the initiating event); that can prevent, mitigate, or aggravate the response of the target (change the severity of the consequences).
Preventive Maintenance	Also called time-based maintenance or interval-based maintenance. PM is the planned, scheduled periodic inspection (including safety), adjustment, cleaning, lubrication, parts replacement, and minor (no larger than Trouble Call scope) repair of equipment and systems for which a specific operator is not assigned. PM consists of many check point activities on items that, if disabled would interfere with an essential operation, endanger life or property, or involve high cost or long lead time for replacement. In a shift away from reactive maintenance, PM schedules periodic inspection and maintenance at predefined time or usage intervals in an attempt to reduce equipment failures.
Property Damage	Damage to any type of government or civilian property, including, but not limited to, flight hardware, flight software, facilities, ground support equipment, and test equipment.

Proximate Cause	The event(s) that occurred, including any condition(s) that existed immediately before the undesired outcome, directly resulted in the occurrence of the undesired outcome and, if eliminated or modified, would have prevented the undesired outcome. Also known as the direct cause(s).
Recommendation	An action developed by the investigating authority to correct the cause or a deficiency identified during the investigation.
Responsible Organization	The organization responsible for the activity, people, or operation/program where a mishap occurs or the lowest level of organization where corrective action shall be implemented.
Root Cause	One of multiple factors (events, conditions, that are organizational factors) that contributed to or created the proximate cause and subsequent undesired outcome and, if eliminated or modified, would have prevented the undesired outcome. Typically, multiple root causes contribute to an undesired outcome.
Root Cause Analysis	A structured evaluation method that identifies the root causes for an undesired outcome and the actions adequate to prevent recurrence. RCA should continue until organizational factors have been identified or until data are exhausted.
Serious Workplace Hazard	A condition, practice, method, operation, or process that has a substantial probability that death or serious physical harm could result and the employer did not know of its existence or did not exercise reasonable diligence to control the presence of the hazard.
Situational Awareness	Perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.
Type A Mishap	A mishap resulting in one or more of the following: (1) an occupational injury or illness resulting in a fatality, a permanent total disability, or the hospitalization for inpatient care of 3 or more people within 30 workdays of the mishap; (2) a total direct cost of mission failure and property damage of \$1 million or more; (3) a crewed aircraft hull loss; (4) an occurrence of an unexpected aircraft departure from controlled flight (except high performance jet/test aircraft such as F-15, F-16, F/A-18, T-38, OV-10, and T-34, when engaged in flight test activities).
Undesired Outcome	An undesired outcome in this context refers to any event or result that is unwanted and is different than the desired and expected outcome. This can be loss of productivity, poor quality, production of scrap, increased risk, increased cost, delay in schedule, damage to property, harm to the environment, or harm to personnel. Undesired outcomes may also include intangible costs such as loss of public confidence or a decline in motivation. (When describing an undesired outcome for a mishap or close call investigation, the description should focus on the reason it was classified as a mishap or close call; e.g., property damage, mission failure, fatality, permanent disability, lost-time case, first aid case, etc.)
Witness	A person who has information, evidence, or proof about a mishap and provides his/her knowledge of the facts to the investigating authority.
Witness Statement	A verbal or written statement from a witness that describes his/her account including a description of the sequence of events, facts, conditions, and/or causes of the mishap.

APPENDIX F: Abbreviations and Acronyms

ACT	Australian Central Time
ATC	Air Traffic Control
BGSP	Balloon Ground Safety Plan
BPO	Balloon Program Office
CAP	Corrective Action Plan
CASA	Civil Aviation Safety Authority
CCM	CSBF Crew Member
CD	Center Director
CHMO	Chief Health and Medical Officer
CM	Campaign Manager
CSBF	Columbia Scientific Balloon Facility
CSIRO	Commonwealth Scientific and Research Organization
E&CFT	Event and Causal Factor Tree
FT	Fault Tree
FTA	Fault Tree Analysis
GHB	Goddard Handbook
GMT	Greenwich Mean Time
GPD	Goddard Policy Directive
GPR	Goddard Procedures Requirements
GSFC	Goddard Space Flight Center
HQ	NASA Headquarters
IRIS	Incident Reporting Information System
IRT	Interim Response Team

LD	Launch Director
LDEM	Lifting Device and Equipment Manager
LVD	Launch Vehicle Driver
MI	Mishap Investigator
MIB	Mishap Investigation Board
MISO	Mishap Investigation Support Office
MIT	Mishap Investigation Team
MRCAP	Mishap Response Contingency Action Plan
MRSO	Mission Range Safety Officer
NASA	National Aeronautics and Space Administration
NCT	Nuclear Compton Telescope
NOTAM	Notice to Airmen
NPR	NASA Procedural Requirement
NSC	NASA Safety Center
NT	Northern Territory
OCE	Office of Chief Engineer
ODIN	Outsourcing Desktop Initiative for NASA
OJT	On-the-Job Training
Ops	Operations
OSMA	Office of Safety and Mission Assurance
OSS	Operational Safety Supervisor
PET	Phased Elapsed Time
PI	Principal Investigator
PiBals	Pilot Balloons
PPE	Personal Protective Equipment

PPRS	Payload Parachute Recovery System
RCA	Root Cause Analysis
RCAT	Root Cause Analysis Tool
RFQ	Request for Quotation
RSM	Range Safety Manual
RSO	Range Safety Officer or Office
RSQA	Reliability, Safety, and Quality Assurance
SD	Site Director
SMD	Science Mission Directorate
SMA	Safety and Mission Assurance
TIGRE	Tracking and Imaging Gamma Ray Experiment
WFF	Wallops Flight Facility

APPENDIX G: Photo Evidence

Balloon Inflation



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Balloon Inflation



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Balloon Inflation



Long Range Picture.BOM Station.jpg



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Balloon Post Abort



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Crane Launch



Launch Crane.JPG



Balloon Launch Crane Head 1.JPG



Balloon Launch Crane Head 2.JPG



Balloon Launch Crane Head 3.JPG



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Crane Launch



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Launch Area



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Launch Area



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Launch Area



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NCT Recovery



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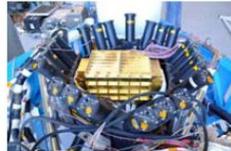
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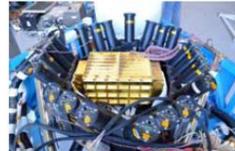
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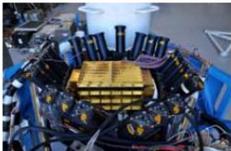
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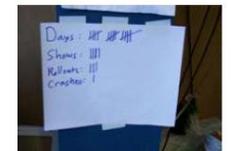
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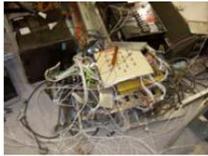
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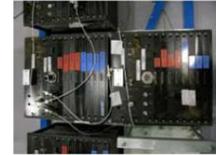
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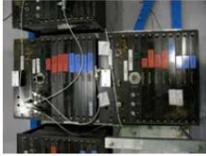
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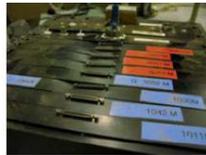
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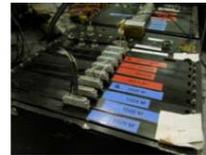
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IMG_7341.JPG



IMG_7342.JPG

NCT Recovery



IMG_7389.JPG



IMG_7390.JPG



IMG_7391.JPG



IMG_7393.JPG



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IMG_7399.JPG



IMG_7400.JPG



IMG_7401.JPG



IMG_7402.JPG



IMG_7403.JPG



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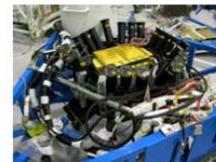
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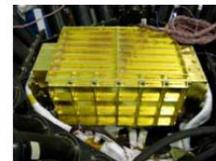
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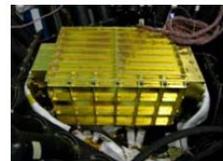
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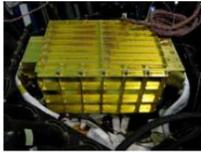


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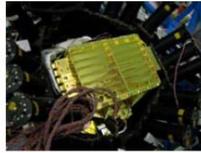


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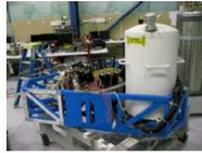
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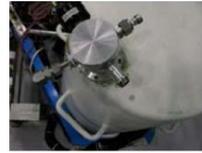
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IMG_7443.JPG



IMG_7444.JPG



IMG_7445.JPG



IMG_7446.JPG



IMG_7447.JPG



IMG_7449.JPG

Payload Drag on Chute



IMG_4844.JPG



IMG_4840.JPG

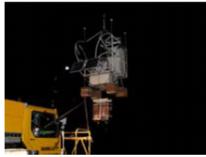


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IMG_4843.JPG

Payload Pickup



IMG_4808.JPG



DSC_0057.JPG



DSC_0058.JPG



DSC_0059.JPG



DSC_0060.JPG



DSC_0061.JPG



DSC_0062.JPG



DSC_0063.JPG



DSC_0064.JPG



DSC_0065.JPG



DSC_0066.JPG



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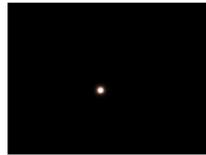
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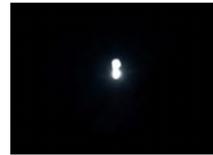
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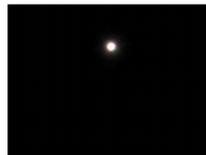
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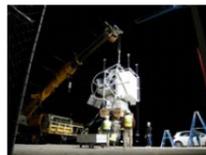
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IMG_2399.JPG



IMG_2400.JPG



IMG_2401.JPG



IMG_2402.JPG



IMG_2403.JPG



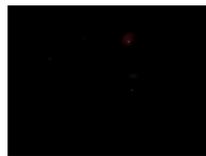
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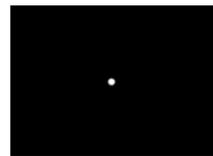
IMG_2405.JPG



IMG_2406.JPG



IMG_2407.JPG



IMG_2408.JPG

Payload Pickup



IMG_2409.JPG



IMG_2410.JPG



IMG_2411.JPG



IMG_2412.JPG



IMG_2413.JPG



IMG_2414.JPG



IMG_4581.JPG



IMG_4582.JPG



IMG_4807.JPG

Post Spool Release



snapshot2.PNG



DSC_0207.JPG



DSC_0212.JPG



DSC_0213.JPG



DSC_5399.JPG



DSC_5400.JPG



DSC_5401.JPG



DSC_5402.JPG



DSC_5403.JPG



DSC_5405.JPG



IMG_2456.JPG



IMG_2457.JPG



IMG_2458.JPG



IMG_2459.JPG



IMG_2460.JPG



IMG_2461.JPG



IMG_2462.JPG



IMG_2463.JPG



IMG_2464.JPG



IMG_2465.JPG



IMG_2466.JPG



IMG_2467.JPG



IMG_2468.JPG



IMG_2469.JPG



IMG_2470.JPG



IMG_2471.JPG



IMG_2472.JPG



IMG_2473.JPG



IMG_2474.JPG



IMG_2475.JPG



IMG_2476.JPG



IMG_2477.JPG



IMG_2478.JPG



IMG_2479.JPG



IMG_2480.JPG

Post Spool Release



IMG_2481.JPG



IMG_2482.JPG



IMG_2483.JPG



IMG_2484.JPG



IMG_2485.JPG



IMG_2486.JPG



IMG_2487.JPG



IMG_2488.JPG



IMG_2489.JPG



IMG_2490.JPG



IMG_2491.JPG



IMG_2492.JPG



IMG_2493.JPG



IMG_2494.JPG



IMG_2495.JPG



IMG_2496.JPG



IMG_2497.JPG



IMG_2498.JPG



IMG_2499.JPG



IMG_2500.JPG



IMG_2501.JPG



IMG_2502.JPG



IMG_2503.JPG



IMG_2504.JPG



IMG_2505.JPG



IMG_2506.JPG



IMG_2507.JPG



IMG_2508.JPG



IMG_2509.JPG



IMG_2510.JPG



IMG_2511.JPG



IMG_2512.JPG



IMG_2513.JPG



IMG_2514.JPG



IMG_2515.JPG

Post Spool Release



IMG_2516.JPG



IMG_2517.JPG



IMG_2518.JPG



IMG_2519.JPG



IMG_2520.JPG



IMG_2521.JPG



IMG_2522.JPG



IMG_2523.JPG



IMG_2524.JPG



IMG_2525.JPG



IMG_2526.JPG



IMG_2527.JPG



IMG_2528.JPG



IMG_2529.JPG



IMG_2530.JPG



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IMG_2532.JPG



IMG_2533.JPG



IMG_2534.JPG



IMG_2535.JPG



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IMG_2538.JPG



IMG_2539.JPG



IMG_2540.JPG



IMG_2541.JPG



IMG_2542.JPG



IMG_2543.JPG



IMG_2544.JPG



IMG_2545.JPG



IMG_2546.JPG



IMG_2547.JPG



IMG_2548.JPG



IMG_2549.JPG



IMG_2550.JPG

Post Spool Release



IMG_2551.JPG



IMG_2552.JPG



IMG_2553.JPG



IMG_2554.JPG



IMG_2555.JPG



IMG_2556.JPG



IMG_2557.JPG



IMG_2558.JPG



IMG_2559.JPG



IMG_2560.JPG



IMG_2561.JPG



IMG_2562.JPG



IMG_2563.JPG



IMG_2564.JPG



IMG_2565.JPG



IMG_2567.JPG



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IMG_2569.JPG



IMG_2570.JPG



IMG_2571.JPG



IMG_2572.JPG



IMG_2573.JPG



IMG_2574.JPG



IMG_2575.JPG



IMG_4823.JPG



IMG_4825.JPG



IMG_4826.JPG



IMG_4827.JPG



IMG_4828.JPG



IMG_4829.JPG



IMG_4830.JPG



IMG_4831.JPG



IMG_4832.JPG



IMG_4833.JPG



IMG_4834.JPG

Post Spool Release



IMG_4835.JPG



IMG_4836.JPG



IMG_4839.JPG



Launch Position.JPG



Long Range Picgture.BOM Station.jpg



P1030958.JPG



P1030959.JPG



P1030960.JPG



P1030961.JPG



P1030962.JPG



P1030963.JPG



P1030964.JPG



P1030965.JPG



snapshot1.PNG

Pre-Launch Layout



NCT Boggs Abort 010.JPG



DSC_0091.JPG



DSC_0092.JPG



DSC_0093.JPG



DSC_0094.JPG



IMG_2415.JPG



IMG_2416.JPG



IMG_2417.JPG



IMG_2418.JPG



IMG_2419.JPG



IMG_2420.JPG



IMG_2421.JPG



IMG_2422.JPG



IMG_2423.JPG



IMG_2424.JPG



IMG_2428.JPG



IMG_2429.JPG



IMG_2430.JPG



IMG_2431.JPG



IMG_2432.JPG



IMG_2433.JPG



IMG_2434.JPG



IMG_4810.JPG



NCT Boggs Abort 003.JPG



NCT Boggs Abort 004.JPG



NCT Boggs Abort 005.JPG



NCT Boggs Abort 006.JPG



NCT Boggs Abort 007.JPG



NCT Boggs Abort 008.JPG



NCT Boggs Abort 009.JPG

Rigging Hardware



Truck Plate.JPG



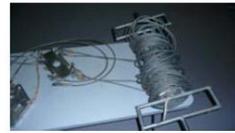
10K Scale.JPG



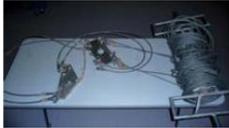
10Scale & Heisse Guages.JPG



15' Cable Ladder Extension.JPG



65' Cable Ladder_Truck Plate.JPG



65' Cable Ladder_Truck Plate_Tri Plate.JPG



120' Chute & Top_Bottom Rings.JPG



Ballast Valves & Rigging Harness.JPG



Balloon Soft Collar.JPG



Balloon Top Plate Bottom Side.JPG



Balloon Top Plate_He Valves.2.JPG



Balloon Top Plate_Helium Valves.1.JPG



Chute Bottom Ring & UTP Basket.JPG



Chute Bottom Ring(L) & Top Ring(R).JPG



Chute Top Ring.JPG



DSCN0137.JPG



DSCN0138.JPG



DSCN0155.JPG



DSCN0156.JPG



Ground Cloths & Pads.JPG



Heisse Scale SN0084.JPG



IMG_2330.JPG



IMG_2331.JPG



IMG_2332.JPG



IMG_2333.JPG



IMG_2334.JPG



IMG_2335.JPG



NCT Payload Scrap Metal.JPG



Release Cable Remnant.JPG



Soft Collar Protective Foam Sleeve.JPG



Tri Plate.JPG

Spool Helium Trailers



Inflation Spool.JPG



Helium Trailer 2.JPG



Helium Trailer.JPG



IMG_2354.JPG



IMG_2355.JPG



IMG_2356.JPG



IMG_2357.JPG



IMG_2358.JPG



IMG_2359.JPG



IMG_2360.JPG



IMG_2361.JPG

Telemetry Electronics



Various_Antennas DwnRad
Xmit Camera ScrapMetal...



Accelerometer_Payload.JPG



Balloon Collar Elect Pkg &
Cutters.JPG



Chute Separate(R)_GAPR
(L).JPG



CIP(R)_CIPBOX(M)_ATC
Xpond(L).JPG



External Electronic
Cabling.JPG



IMG_2336.JPG



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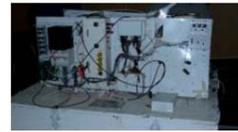
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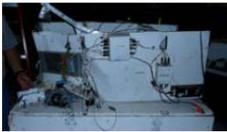
Li Batteries.JPG



M SIP Batt Box.JPG



Mini SIP 1.JPG



Mini SIP 2.JPG



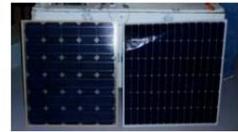
Mini SIP End 1.JPG



Mini SIP End 2.JPG



Mini-SIP GSE.JPG



PV Piggyback Test
Panels.JPG



TM GSE Config NCT.JPG



TM GSE Congig NCT 2.JPG



Universal Terminate
Package.JPG



UTP(R)_UTP BattBox(M)
_StrobeLight(L).JPG

Vehicle Payload Damage



Vehicle damage.JPG



Chute location.JPG



Connectors.JPG



Damage Site 2.JPG



Damage Site 3.JPG



Damage Site 4.JPG



Damage Site.JPG



DSC_0214.JPG



DSC_0215.JPG



DSC_0216.JPG



DSC_0217.JPG



DSC_0218.JPG



DSC_0219.JPG



DSC_0220.JPG



DSC_0221.JPG



DSC_0222.JPG



DSC_0223.JPG



DSC_0224.JPG



DSC_0225.JPG



DSC_0226.JPG



DSC_0227.JPG



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DSC_0229.JPG



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DSC_0231.JPG



DSC_0232.JPG



DSC_0233.JPG



DSC_0234.JPG



DSC_0235.JPG



DSC_0236.JPG



DSC_0237.JPG



DSC_0238.JPG



DSC_0239.JPG



DSC_0240.JPG



DSC_0241.JPG

Vehicle Payload Damage



DSC_5417.JPG



DSC_5420.JPG



DSC_5421.JPG



DSC_5423.JPG



DSC_5426.JPG



DSC_5430.JPG



DSC_5431.JPG



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DSC_5491.JPG



DSC_5492.JPG



DSC_5493.JPG



DSC_5494.JPG



DSC_5496.JPG

Vehicle Payload Damage



DSC_5497.JPG



DSC_5500.JPG



DSC_5502.JPG



DSC_5503.JPG



DSC_5504.JPG



DSC_5508.JPG



DSC_5510.JPG



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DSC_5568.JPG



DSC_5571.JPG



DSC_5572.JPG



DSC_5574.JPG



DSC_5576.JPG



DSC_5581.JPG

Vehicle Payload Damage



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DSC_5587.JPG



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DSC_5597.JPG



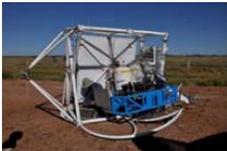
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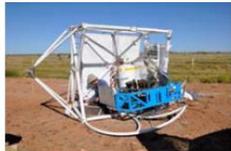
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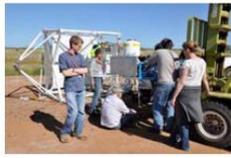


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Vehicle Payload Damage



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DSC_5677.JPG



DSC_5678.JPG



DSC_5680.JPG



DSC_5681.JPG



DSC_5682.JPG



DSC_5683.JPG



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DSC_5766.JPG



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DSC_5772.JPG



DSC_5773.JPG



DSC_5777.JPG

Vehicle Payload Damage



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DSC_5784.JPG



DSC_5787.JPG



DSC_5791.JPG



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DSC_5811.JPG



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IMG_2578.JPG



IMG_2579.JPG



IMG_2580.JPG



IMG_2581.JPG



IMG_2582.JPG



IMG_2584.JPG



IMG_2585.JPG



IMG_2586.JPG



IMG_2587.JPG

Vehicle Payload Damage



IMG_2588.JPG



IMG_2589.JPG



IMG_2590.JPG



IMG_2591.JPG



IMG_2592.JPG



IMG_2593.JPG



IMG_2594.JPG



IMG_2595.JPG



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IMG_2597.JPG



IMG_2598.JPG



IMG_2599.JPG



IMG_2600.JPG



IMG_2601.JPG



IMG_2602.JPG



IMG_2603.JPG



IMG_2604.JPG



IMG_2605.JPG



IMG_2606.JPG



IMG_2607.JPG



IMG_2608.JPG



IMG_2609.JPG



IMG_2610.JPG



IMG_2611.JPG



IMG_2612.JPG



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IMG_2617.JPG



IMG_2618.JPG



IMG_2619.JPG



IMG_2620.JPG



IMG_2621.JPG



IMG_2622.JPG

Vehicle Payload Damage



IMG_2623.JPG



IMG_2624.JPG



IMG_2625.JPG



IMG_2626.JPG



IMG_2627.JPG



IMG_4846.JPG



IRT Ops.JPG



IRT.JPG



NCT Boggs Abort 022.JPG



NCT Boggs Abort 023.JPG



NCT Boggs Abort 024.JPG



NCT Boggs Abort 025.JPG



NCT Boggs Abort 026.JPG



NCT Boggs Abort 027.JPG



NCT Boggs Abort 028.JPG



Payload 2.JPG



Payload damage.JPG



sd_lv fence16.jpg

TIGRE



2010_0416hiball00 pan
1.JPG



2010_0416hiball0001.JPG



2010_0416hiball0002.JPG



2010_0416hiball0003.JPG



2010_0416hiball0004.JPG



2010_0416hiball0005.JPG



2010_0416hiball0006.JPG



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2010_0416hiball0009.JPG



2010_0416hiball0010.JPG



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2010_0416hiball0017.JPG



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2010_0416hiball0019.JPG



2010_0416hiball0020.JPG



2010_0416hiball0021-
50.JPG



2010_0416hiball0021.JPG



2010_0416hiball0026.JPG

Spectators Photos



sd_prespool4.jpg



sd_balloon1.jpg



sd_balloon2.jpg



sd_balloon3.jpg



sd_balloon4.jpg



sd_balloon5.jpg



sd_balloon6.jpg



sd_balloon7.jpg



sd_balloonlv1.jpg



sd_balloonlv2.jpg



sd_balloonlv3.jpg



sd_balloonlv4.jpg



sd_balloonlv5.jpg



sd_balloonlv6.jpg



sd_lvfence1.jpg



sd_lvfence2.jpg



sd_lvfence3.jpg



sd_lvfence4.jpg



sd_lvfence6.jpg



sd_lvfence7.jpg



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sd_lvfence13.jpg



sd_lvfence14.jpg



sd_lvfence15.jpg



sd_lvfence16.jpg



sd_lvfenceswing5.jpg



sd_prespool1.jpg



sd_prespool2.jpg



sd_prespool3.jpg

APPENDIX H: Incident Reporting Information System – IRIS Report

Ex3® EHS Data Management System - NASA Base

Page 1 of 3

Safety Incident Detail Report

As of : 08/19/2010 06:59:45

Incident Number : S-2010-119-00007

Incident Status : Open

ARs Open : 0 Of 0

General			
Region	: Global Region	Country	: United States of America
Campus	: WFF-Wallops - Offsite	General Location	: Offsite
Contract	: NAS5-03003	Mission Directorate	: All
Project	: All	Record Type	: Contractor
Incident Classification	: Type C	Location	: Alice Springs, Australia
Incident Type	: Aircraft-Ground	Incident Sub Type	: Ground Handling
Date Reported	: 04/29/2010	Originator	: Smith, Florence
Incident Stage	: Open Pending Investigation	Report Source	: Normal
Privacy	: No	Site Type	: Offsite
Last Updated On	: 08/14/2010 06:58:29	Specific Location	: Alice Springs, Australia

Brief Description : Balloon launch failure of Nuclear Compton Telescope

Detail Description : The NCT payload balloon mission launch took place on 4/28/10. Launch and balloon inflation was nominal. Civilians who were located outside the airport security fence on the public road were instructed to move to another location prior to launch. Launch was nominal, winds (11-13kts) do not at this time appear to have been an issue. Balloon release from the spool was nominal. In the process of releasing the payload from the launch vehicle, the crew chief was unable to release the payload due to friction between the pin and truck plate pressing up against the safety cables. The Crew Chief attempted to catch up with the balloon to relieve the friction, but the launch vehicle became stuck in the dirt. When free, the launch vehicle was unable to catch the balloon for proper release. In an attempt to abort launch, the crew chief noticed personnel outside the fence, and for safety reasons, decided the safest way to abort was by pulling the balloon down to the ground. During this attempt to abort, the safety cables failed and the NCT payload self released, and then was dragged across the airfield and through the safety fence, impacting a SUV. The payload was substantially damaged.

Associations

Module	Number	Date
Type	Status	

Notes

Investigation Notes : 8/14/10 Extension letter drafted.

Details

RAC/Code	Potential Severity	Probability
----------	--------------------	-------------

Indicators

https://nasa.ex3host.com/iris/reports/html_asp_excel_report.asp?report_name=EX3_SAFE... 8/19/2010

Indicators		Indicator Status	
Vehicle			
Class :	Owner :	Aircraft Type/Model :	
N-Number/Serial Number :	Description :	Affected System (Top 1) :	
Estimated Cost :	Actual Cost :	Equipment Damage Details :	
Remarks :			

Transition					
Tab	Field	Old Value	Transition Date	New Value	Reason For Change

Lesson Learned	
Lesson Learned : Date	Lesson Learned : Text

Action Request		
AR Number :	AR Status :	AR Assigned To :
AR Assigned By :	Parent Case # :	AR Type :
AR Action Type :	Record Type :	Region :
Country :	Site :	Contractor :
Contract :	Directorate :	Organization :
Mission Directorate :	Program :	Project :
Sch. Comp. Date :	Actual Completion Date :	Secure? :
Does this AR contain Private Medical Information? :	AR Title :	Action To Take :
Action Taken :	Created on :	Last Updated on :

Attachments				
Type	Document Description	Privacy Act	Last Updated	Document Tag
pdf	Balloon MIB Appt Letter.pdf	No	05/14/2010	
PDF	MIB Appoint Ltr.PDF	No	05/24/2010	
pdf	Balloon Mishap 60 day status.pdf	No	08/14/2010	

Investigations	
Investigation Code	Investigation Title

Property						
Class	Description	ID Number	Estimate Cost	Damage Cost	Details	Remarks

https://nasa.ex3host.com/iris/reports/html_asp_excel_report.asp?report_name=EX3_SAFE... 8/19/2010

Safety Incident I/I

Employee :	Case :	Injury/Illness :
Name	No.	
Injury/Illness :	Case :	Employee :
Type	Type	Statement

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Legal Stuff

https://nasa.ex3host.com/iris/reports/html_asp_excel_report.asp?report_name=EX3_SAFE... 8/19/2010

APPENDIX I: Mishap’s Direct Cost Breakdown Estimates

Program’s estimated cost of the NCT Mishap

Mission Expendables (Balloon, Helium, Batteries) *	\$ 336,978
Pro-Rata Campaign Cost (Travel, Per Diem, OT, etc) – divided by 3 Payloads *	\$ 659,321
Damage to NCT payload	\$500,000 - \$2,000,000
Damage to CSBF hardware	\$ 20,000
Marching army cost for HERO team	\$ 385,000
Privately Owned Vehicle Damage	\$ 13,500
Airport Property Damage	\$ 10,000
Total	\$928,500 - \$2,428,500

*- Baseline Mission Model sunk cost per 7120.8 Project Plan, under definition of accepted risk. Acceptable risks have been defined in section 3.3.4 to include: In accordance with baseline programmatic implementation and in agreement with the undersigned stakeholders, accepted risks that may result in mission failure shall include, but are not limited to: failure of the balloon during the launch, ascent, or float phases; failure of support equipment or instrumentation; failure of science equipment or instrumentation; and personal property damage or loss.

Payload estimate as of mid August: ~\$1.050k, which includes replacement of the gondola and refurbishment of the instrument. This does not include any student/scientist support, just engineering & materials.

NOTE:

At the time of the Balloon mishap on April 29, 2010, the costs associated with damaged hardware were under assessment by the Balloon Program Office (BPO). The mishap was originally classified as a High Visibility, Close Call mishap. Recently, the BPO provided the MIB with an updated mishap cost estimate. While the BPO does not consider the cost of consumables in their calculations, the NPR clearly requires that the “cost of the lost commodity” be included. After accounting for the cost of the consumables, the current mishap cost estimate is \$1,815,478.00. This falls into the range of a Type B mishap. The Board will note for the record that this mishap is classified as High Visibility Type B mishap. This classification will be noted in the Board’s report.

APPENDIX J: CASA Permits



Australian Government
Civil Aviation Safety Authority

File Ref: EF09/24054

INSTRUMENT NUMBER: WOA 7058

I, Donald Andrew Campbell, Team Leader Flying Operations, Western Region – Adelaide, a delegate of CASA, make this instrument under subregulation 101.030(1) and 101.030(6) of the *Civil Aviation Safety Regulations 1998*.

A handwritten signature in black ink, appearing to read 'D A Campbell'.

D A Campbell
Team Leader - Flying Operations
CASA Operations
Western Region – Adelaide

8 February 2010

Approval – area for the operation of a heavy balloon

1. Application

This instrument applies to the approval of an area for the operation of a heavy balloon, School of Physics, University of New South Wales (Australian Defence Force Academy) (*the operator*).

2. Approval

I approve the area of Alice Springs Airport S23° 48.4; E133° 54.1 as an approved area for the operation of a heavy balloon (*the approved area*).

3. Conditions

The approval is subject to the conditions mentioned in Schedule 1.

4. Validity

This instrument ceases to have effect at the earlier of:

- (a) the letter of agreement between the operator and Airservices Australia ceasing to have an effect; or
- (b) the end of 30 May 2010.

Schedule 1 Conditions

1. The operator must ensure that all operations of the heavy balloon in the approved area are under the control or supervision of Associate Professor Ravi Sood (*the co-ordinator*).

2. The co-ordinator must ensure that he and all operational staff under his control comply with Letter of Agreement Number 3146, Version 1, effective 15 February 2010 to 30 May 2010, between Airservices Australia and School of PEMS, University of NSW.
3. The co-ordinator must ensure the landing area is at least 20 kilometres away from a populous area, as defined in the Civil Aviation Safety Regulations 1998 101.025.

APPENDIX K: NCT Flight Folder Documents

K-1 Flight Plan

K-2 Balloon Flight Requirements

K-3 Operations Pre-Flight Readiness Review

K-4 Pre-Flight Minimum Success Criteria

K-5 Launch Equipment Certification

K-6 Payload & Gondola Certification

K-7 Balloon “AS BUILT” Specifications

K-8 Balloon Load Altitude Curve

K-9 Flight Data Summary

K-10 Inflation Computation

K-11 Launch Director’s Checklist

K-12 Balloon Condition at Launch

K-13 Recovery Information

K-14 Quality Control Information

K-15 Collar Flight Record

K-16 Flight Operations – Rigging Job Assignments

K-17 Rigging Weight Sheet

K-1 Flight Plan

Flight Folder

National Scientific Balloon Facility	Flight Plan
OF-310-00-P Rev-B	Date: 4 October 2005
	Page 1 of 2

Approved by: *Bill Stepp* Date: 4 October 2005

NOTICE: This Flight Plan data is only valid for a launch within 72 hours of the Approved date and time or Renewed date and time. DOCUMENT FOLLOWS.

FLIGHT PLAN

PRINCIPAL INVESTIGATOR / ORGANIZATION Steven Boggs / SSL-UC Berkeley (NCT)

1 SCIENTIFIC REQUIREMENTS

LAUNCH WINDOW April - May 2010 **DESIRED LAUNCH TIME** Morning
DESIRED FLOAT DURATION (HR) 4 days **ALTITUDE (KFT)** 130
FLIGHT PROFILE High as possible as long as possible. Evaluate multiple day durations in real time.

MINIMUM FLOAT DURATION (HR) 24 **ALTITUDE (KFT)** See below
FLIGHT PROFILE (IF DIFFERENT FROM ABOVE) Altitudes: 120 Kft during first day / 110 Kft overnight first night / 100 Kft subsequent nights

DOWN-RANGE SUPPORT AND/OR SPECIAL REPORTING Downrange TM support at Longreach. Need 110 vac for two computer stations. Power and access to the GINCHes

2 REQUIREMENTS FOR ALTITUDE AND TIME CONTROL

BALLOON (1066) W39.57-2-76
PAYLOAD WEIGHT With Ballast (lb) 5489 Without Ballast (lb) 4289
BALLAST 1200 (lb) of Sand with Flow Rate of 169 (lb/min)
ALTITUDE With Ballast (Kft) 128 Without Ballast (Kft) 130.5
Ballast for Sunset (1st) 685 lb (2nd) _____ lb Ballast for Drive-up 370 lb
Ballasting Instructions Conserve ballast on ascent and first sunset, as necessary to meet minimum altitude requirements
VALVE(S) 2 Type EV13 Valving Instructions _____
ANEROID(S) Set Altitude to Arm/Fire N/A / _____ / _____

K-2 Balloon Flight Requirements

Flight Folder

Columbia Scientific Balloon Facility OF-300-00-D	Balloon Pre-Flight Requirements Data Sheet Rev - B	Date- 05-24-06	page 1 of 3
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Approved by Mark Cobble date 5/24/2006

NOTICE: This Checklist is used to review the data received from the customer during a Flight Review checkout: **DOCUMENT FOLLOWS:**

Balloon Flight Requirements Date 15 / March 2010

Organization: SSL - University of California - Berkeley
Project Scientist Steven Boggs (NCT)

Balloon Assignment:

- (1) Model (i.e., W29.47-2-01) W39.57-2-76 CSBF # 1066
 Recommended Payload: Max 6000 lbs. Min 100 lbs.
- (2) Model (i.e., W29.47-2-01) W39.57-2-75 CSBF # 970
 Recommended Payload: Max 6000 lbs. Min 100 lbs.

Flight Requirements:

Number of Flights: 2 Readiness Date: 1 April
 Launch Time (Hr): 07:00 Launch Time (Date): 8 April
 Desired Altitude (K Ft): 120 Minimum Altitude (K Ft): 100
 Desired Float (Hrs): 4 Day Minimum Float (Hrs): 24
 Flight Profile: *(If other than as high as possible for as long as possible)*
1d

(Issue Pre-Flight Minimum Success Criteria Form to P.I.)

Flight Operations Briefing:

Estimated Weight (lbs) of Scientific Payload	<u>3100</u>
Estimated Weight (lbs) of NSBF Equipment	<u>1081</u>
Ballast (lbs): Steel <input type="checkbox"/> Sand <input checked="" type="checkbox"/> Other <input type="checkbox"/>	<u>1200</u>

TOTAL ESTIMATED PAYLOAD WEIGHT (LBS) 5381

Estimated Float Altitude: w/Ballast 128 (Kft); w/o Ballast 130.5 (Kft)
 Chute Diameter: 130 (Ft.); Release: YES; Suspension Ladder (Ft) 75'
 Special flight train length, components, etc... GAPR/SAPR
 Launch Vehicle: Tiny Tim KATO MLV
 BOSS HERCULES Recovery Truck LIEBHERR CRANE XX
 Flight Line Checkout (Hrs/Mins) 10 min Estimated Show Time 1BD
20 min before move to lift crane

Recovery Requirements:

Special recovery requirements/equipment: Remove harddrives/batteries before loading -

(Issue recovery form to Principal Investigator)

Hazardous Materials and Conditions: (check appropriately)

Radioactive Sources	Ground Support	<input checked="" type="checkbox"/> Flight	Recovery
Laser Hazards	Ground Support	Flight	Recovery
Chemical/Cryo/Gas	Ground Support	Flight	Recovery
Pressure Vessel	Ground Support	Flight	Recovery
High Voltage	Ground Support	Flight	Recovery
Pyrotechnics	Ground Support	Flight	Recovery
Magnets	Ground Support	Flight	Recovery

(If required, Issue Ground Safety Plan and Pressure Vessel Certification)

Science Emergency Information - Contact Name @ Location @ Phone #

(1) Eric Bellm @ 0416-860-236 @ Anstodd #216
 (2) Steve McBride @ 0415-934366 @ Anstodd #102

Aviation Support Briefing:

Passengers: Downrange Station 1 Recovery 1 (if downrange)
 (C90 Tail # 240RE (6S) 441 Tail # N6860C (7S))
 CIP Check - Date 10 April Time TBD

SAR Considerations and Limitations:

Restrictions: Standard NASA restrictions and 20 nm from cities for CARA requirements
 (Palestine - minimum impact 150, 250, 350 miles west, footprint dependent)
 (Ft. Sumner - impact < 550 miles west; < 450 miles east & outside corridor.
 Corridor East of Ft. Sumner - 069 deg to 112 deg and 265-450 miles.)

Meteorological Briefing:

Average Float Wind: -7 S.W. 14 Sunrise 0645 Sunset 1927
 Post Flight Met Date (Y/N) _____
 Supplemental WX Data/Support: PO-115

Non-Standard Elect/Mech. Configuration/Squib Applications:

NSBF: SAPR/GAPR - CSBF test solar panel - Video test unit
 Science: Test solar panel

Helium Valves: None _____ One _____ Two EV-13 Three _____

Data Rates:

Rate: 784 kb Code: R10
 Rate: _____ Code: _____
 Rate: _____ Code: _____
 Rate: _____ Code: _____

VCO Requirements:

VCO Channels(s) 1 CMD. Verify, 3 MKS, 5 _____, 7 _____
 8 _____, 9 _____ 10 Mini Encoder, 11 GPS # 1, 12 GPS # 2,
 B _____, E _____ HH _____,

Power Requirements:

CIP: 9.90 Science Transmitters: _____ Other: _____

Special Electronics Considerations:

video unit + camera

<u>Ground Station Requirements:</u>	<u>Launch Site</u>	<u>Down Range</u>
Bit Syncs	_____	_____
Decom's	<u>X</u>	<u>X</u>

Project Scientist: Eric C. Bellm

NSBF Representation: Ball Stop

K-3 Operations Pre-Flight Readiness Review

Flight Folder

National Scientific Balloon Facility	Operations Preflight Readiness Review Checklist	
OF-312-00-C Rev-B	Date: 4 October 2005	Page 1 of 1

Approved by: *Bill Stepp* Date: 4 October 2005

NOTICE: DOCUMENT FOLLOWS.

OPERATIONS PREFLIGHT READINESS REVIEW CHECKLIST

Principal Investigator / Organization: *Dr. S. Boggs/UC-Berkeley*
 Proposed Flight Date / Campaign: *April-May 2010 / Australia*

- A. SCIENTIFIC REQUIREMENTS**
 - Down Range Support / Special Recording ✓
 - Minimum Success Criteria ✓
 - Recovery Instructions ✓
 - Science Command Sheet ✓
 - Ground Safety Plan ✓

- B. FLIGHT OPERATIONS**
 - SAR / Risk Analysis Review ✓
 - Launch Equipment Configuration and Certification (LECC) ✓
 - Pressure Vessel Certification *N/A*
 - Gondola Mechanical Certification ✓
 - Vehicle Pin and Chute Weight *within limits*
 - Max/Min Weight on Balloon *within limits*

- C. FLIGHT ELECTRONICS**
 - Command Sheets ✓
 - Science Off Command(s) ✓
 - Electronic Certification *LDB*

- D. MISCELLANEOUS**
 - Video Personnel ✓
 - Down Range Crew ✓
 - Aircraft Crew ✓
 - Recovery Crew ✓
 - Flight Line Crew ✓
 - Tower Crew ✓
 - Paperwork Distribution *TBD*

NSBF REPRESENTATIVE *Bill Stepp* DATE *7/14/10*

Approved by: Bill Stepp Date: 4 October 2005

NOTICE: DOCUMENT FOLLOWS.

**OPERATIONS PREFLIGHT
READINESS REVIEW CHECKLIST**

Principal Investigator / Organization: Dr. Steve Boggs/UC - Berkeley
 Proposed Flight Date / Campaign: April - May 2010/Australia

- A. SCIENTIFIC REQUIREMENTS**
- Down Range Support / Special Recording no changes
 - Minimum Success Criteria ✓
 - Recovery Instructions ✓
 - Science Command Sheet ✓
 - Ground Safety Plan ✓

- B. FLIGHT OPERATIONS**
- SAR / Risk Analysis Review ✓
 - Launch Equipment Configuration and Certification (LECC) ✓
 - Pressure Vessel Certification ✓
 - Gondola Mechanical Certification ✓
 - Vehicle Pin and Chute Weight ✓
 - Max/Min Weight on Balloon ✓

- C. FLIGHT ELECTRONICS**
- Command Sheets ✓
 - Science Off Command(s) ✓
 - Electronic Certification ✓

- D. MISCELLANEOUS**
- Video Personnel ✓
 - Down Range Crew ✓
 - Aircraft Crew ✓
 - Recovery Crew ✓
 - Flight Line Crew ✓
 - Tower Crew ✓
 - Paperwork Distribution ✓

NSBF REPRESENTATIVE Bill Stepp DATE 28 April 2010

K-4 Pre-Flight Minimum Success Criteria

Flight Folder

National Scientific Balloon Facility OF-314-00-F	Rev-A	Pre-Flight Minimum Success Criteria Date: 10-20-2004	Page 1 of 1
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Approved by _____ William Stepp _____ Date 10/20/04 _____

NOTICE: DOCUMENT FOLLOWS

**PRE-FLIGHT
MINIMUM SUCCESS CRITERIA**

Organization Berkeley/NCT Principal Investigator Steven Boggs

1.) Give a brief statement of minimum scientific objectives which must be met to achieve a mission success (scientific windows, flight profile, valving requirements, etc.)

Observe at least one transit of the Galactic Center at an altitude of 110,000 ft or higher with LOS telemetry.

2.) Balloon / Flight Performance Requirements:

Altitude - Desired 130,000 ft Minimum Acceptable 120,000 ft - day
110,000 ft - first night
100,000 ft - subsequent nights
Duration - Desired 4 days Minimum Acceptable 24 hours
Altitude Stability n/a - see minimums

3.) Required Experiment Performance - Detectors, Pointing Systems, etc . . .

pointing: maintain source in instrument field of view
detectors: 6 detectors x 24 hours or better.

4.) Telemetry Requirements:

LOS telemetry + commanding.

Principal Investigator *Steven G. Boggs* Date 4/14/10
NSBF Ops. Manager *Bill Stepp* Date 4/14/10

K-5 Launch Equipment Certification

March 20, 2010

To: Operations Department

From: Engineering Department, Erich Klein

Subject: *Launch Equipment Configuration Certification (LECC) for 2010 Australia Balloon Campaign*

The following launch equipment has been certified for the 2010 Australia Balloon Campaign.

- **LTM 1100/2 Liebherr Crane (100 metric ton capacity):** Pull tested to a minimum load of 17,000 lbs. (18,000 lb. peak load) using three 65 ft. cable ladders connected end to end. Concrete blocks weighing 4400 lbs. were suspended from the vehicle to simulate an actual payload. The pull test was maintained for more than 5 minutes with no observed deficiencies with the equipment. See attached e-mails dated March 16 and 19 from Mark Cobble addressed to the Engineering Department for specific details.

Reason for pull test: 1 year standard certification.

- **Launch Spool Trailer (NASA # 2126):** Pull tested to a minimum load of 16,000 lbs. (17,400 lb. peak load) for 6 minutes using the LTM 1100/2 Liebherr launch crane. Total weight of the spool was 20,500 lbs. including a fixed steel ingot and 3-2000 lb. drums of steel ballast secured to the trailer. No deficiencies were observed with the equipment. See above referenced emails from Mark Cobble for specific details.

Reason for pull test: 1 year standard certification.

All readings made with a NASA 30k dynamometer. Digital pictures are available as well as support documentation filed with this memo. The launch equipment will remain certified through the **2010 Australia Balloon Campaign.**

EOM

Approved by Erich Klein date 7/15/04

NOTICE: Checklist for LECC information. **DOCUMENT FOLLOWS:**

LAUNCH EQUIPMENT CONFIGURATION CHECKLIST (LECC)

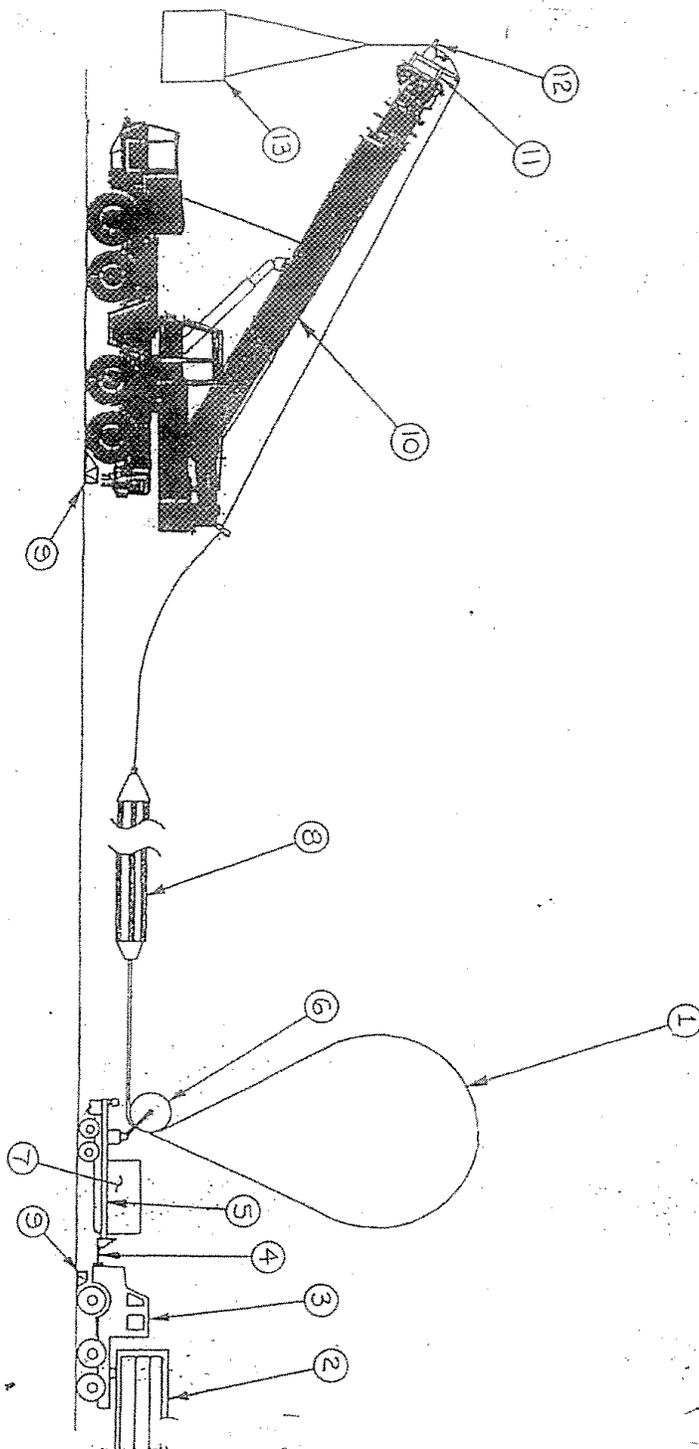
Date March 20, 2010 Location: Palestine Ft. Sumner McMurdo Station Lynn Lake Other Australia

ITEM NO	EQUIPMENT DESCRIPTION	MAXIMUM STRENGTH (LBS)	MAXIMUM WEIGHT (in LBS) ALLOWED BELOW BALLOON	NOTES (see below *)
1	Balloon, R 39.57-2	6060 lbs	6060 lbs	
2	Flat bed trailer with 8 tube helium rack	N/A	8000 lbs	1
3	Kenworth tractor leased from Rentco of Darwin, N.T., Australia	N/A	8000 lbs	1
4	Front bumper/chassis hitch for Australian road trains	N/A	8000 lbs	1
5	Australian spool trailer	N/A	8000 lbs	1 & 2
6	Standard short arm spool assembly	28,800 lbs	8000 lbs	1 & 2
7	Three drums of steel ballast, 2000 lbs. each	N/A	N/A	2
8	Flight train - see mechanical certifications for details	N/A	N/A	4
9	Wheel Chocks	N/A	N/A	
10	LTM 1100/2 Liebherr crane, 100 metric ton capacity	N/A	8000 lbs	1 & 3
11	Crane head adapter for item no. 10	N/A	8000 lbs	1
12	Standard crane head	N/A	8000 lbs	1
13	Science gondola - see mechanical certification for details	N/A	N/A	

- Notes:
1. Maximum allowed weight is based on maximum payload weight limit of a 34.43-3H balloon
 2. Total Spool Weight 20,500 lbs

3. Maximum launch pin height: 39 ft.
4. NO parachute was used for the LECC pull test (as shown in the illustration).

Australian LECC Pictorial, 2010



Erich Klein

From: Mark Cobble [mark.cobble@csbf.nasa.gov]
Tuesday, March 16, 2010 7:53 PM
Erich Klein
Cc: Frank Candelaria
Subject: Spool Pull Test for Australia Campaign LECC

NASA EQUIPMENT PULL TEST

The existing launch spool trailer (NASA #2126) in Alice Springs was refurbished during the latter weeks of February 2010. Those refurbishments included removal and replacement of all springs, 8 tires and wheels, 2 axles, and 2 outer hangers. The tandem axle system was upgraded to a 12 ton capacity (6 ton per axle). The tire/wheel combinations are Firestone Transforce HT LT235/85R16. The spool padding boot was installed afterwards, and was air sprayed with 4 coats of a Mosite 3 part mixture (clear, slippery coating) on 3-17-10. The old spool weights were removed from the deck and the spool weight was observed at 14,500 lbs. Three each 2000 lb barrels of ballast were prepared (6000 lbs total) and secured to the top deck of the spool with three heavy duty ratchet straps. This combined total of trailer, spool and weights equals 20,500 lbs.

On March 16, 2010, a successful pull test of the Launch Spool Trailer (NASA # 2126) was conducted at the Balloon Launching Station in Alice Springs, Australia. The process consisted of a Rental Tractor connected to a rental trailer loaded with an 8 tube Supagas Helium Reservoir and connected to the hitch of the Launch Spool Trailer. The Liebherr (Type LTM 1100/2) 100 metric ton rental crane was backed into the front of the spool trailer/tractor/trailer combo and the crane boom was rotated 180 degrees over the center of the spool. The spool tester unit was attached to the crane hoist and to a pin located at the rear frame of the crane to simulate the force of the balloon angle during inflation. Ethafoam was placed between the spool pull test harness and the spool padding boot. Tension was applied by raising the crane hoist. Incremental observations were made up to a peak load of 17,400 lbs. The test was held in position for 6 minutes as the system tension decreased to 16,000 lbs. The spool was observed by Cobble, Candelaria, Masters, Roberts, and McCabe. This test was absent of any incidence.

Erich Klein

From: Mark Cobble [mark.cobble@csbf.nasa.gov]
To: Erich Klein
Cc:
Subject: Crane Pull Test for Australian Campaign LECC
Attachments:

Sent: Fri 3/19/2010 5:27 PM

NASA EQUIPMENT PULL TEST

The crane to support the 2010 Australia Campaign was leased from "Wanna Lift" of Alice Springs. During the early weeks of March 2010 this crane was modified into a balloon launch vehicle. This modifications consisted of a launch director platform, 2 outriggers with 4 tire/wheel combo, crane head adapter and release, bullhorns, sheaves, turnbuckles, wire rope, chains, clevis, ratchet binders and slings.

The pull test was conducted by CSBF personnel on March 18, 2010. These personnel include Cobble, Candelaria, Roberts, Masters, Chambers, and McCabe. To simulate gondola weight, a pair of concrete blocks totalling 4400 lbs (3000 lbs and 1400 lb) were bound together and attached to the crane head suspension. The crane boom was raised 39 feet in height, with the pin approximately 10' from the front edge of the launch director platform. The hoist cable was routed through a sheave and connected to a chain that was secured to the front frame of the crane. A soft sling was doubled and wrapped around the connection area of the boom housing and main hydraulic piston. Chains and clevises were routed from the soft sling to a tab welded on the front end of the outriggers and tightened with ratchet binders. The crane rotation pin was locked into place and a turnbuckle/double wire rope was used from the rotating body of the crane to a tab welded on the rear of the outriggers. All of these attachments are designed to supplement boom strength (whether upward and/or sideways) during the launch process.

After configuration of the Liebherr LTM 1100/2 (100 metric ton) crane, three 65' ladders were joined in length and extended from the crane head to the 30K dynamometer (NASA # 4172). The dynamometer was connected to the rear of the rental truck (Kenworth tractor). The Kenworth tractor driver was instructed to drive forward and apply tension to the 195' ladder system. The first pull test was performed with the crane axles in the "suspended" mode. During the maximum tension, the rear end of the crane lowered significantly and the rear axle pressure increased. This test proved that "suspended" mode was not recommended for our launch operation. The second pull test was performed with the axles in the "blocked" mode. This test proved to be successful in all regards, including a more even load distribution upon the five axles.

The max load applied was 18,000 lbs. The tension during the test was held in excess of 17,000 lbs for more than 5 minutes. This test was performed twice, once by tensioning with the Kenworth tractor and the other test by tensioning with the Launch Crane. No chocks were used under the wheels for each respective pull test. This pull test was also documented with digital photos. No incidence was observed.

<https://mork.nsbf.nasa.gov/exchange/eklein/Inbox/Crane%20Pull%20Test%20for%20Aust...> 3/19/2010

K-6 Payload & Gondola Certification

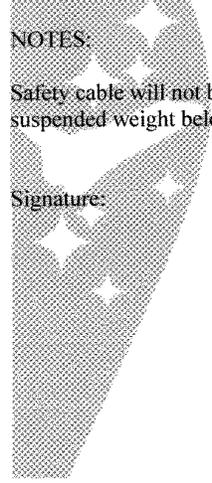
DATE: April 14, 2010
MEMO TO: Operations Department
FROM: Engineering Department
SUBJECT: Gondola Certification
ORGANIZATION: UC Berkeley
SCIENTIST: Dr. Steven Boggs
PROJECT NAME: NCT

The re-certification documents for this payload and rotator have been reviewed and found to be in compliance with CSBF structural requirements. This payload/rotator has now been certified for 5000lbs below the gondola suspension point including 1200 lbs of ballast.

NOTES:

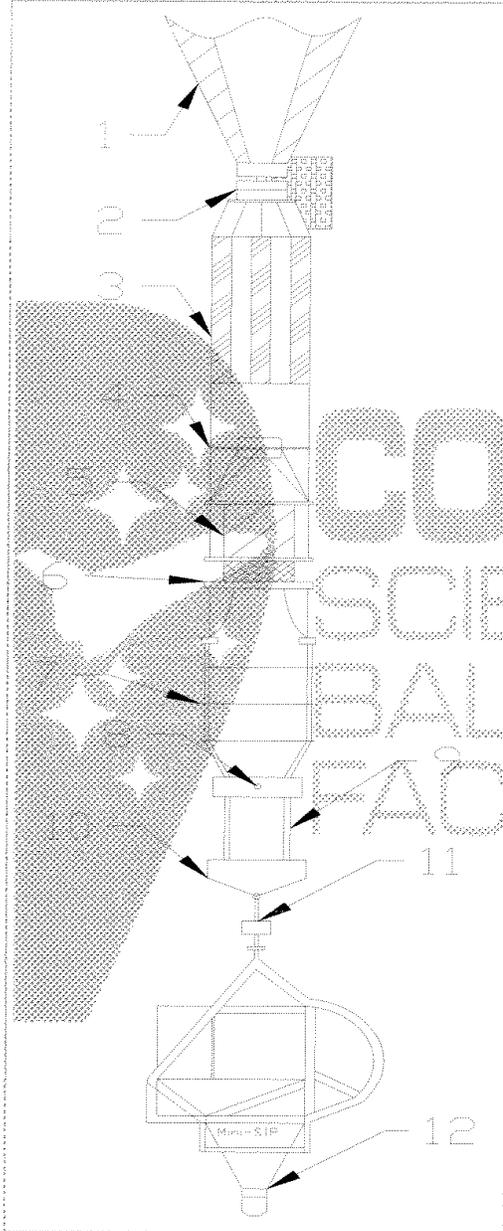
Safety cable will not be required for this flight and any future flights provided the suspended weight below the rotator does not exceed 5,000 lbs.

Signature:



COLUMBIA
SCIENTIFIC
BALLOON
FACILITY





ITEM NO.	DESCRIPTION	MAXIMUM ALLOWED (LBS)
1	W39.57-2-76, #1066	6060
2	Cable Loop Terminate W/Rip Stitch	8000
3	130 ft. Diameter Parachute	6000
4	Parachute Ring W/UTP	5760
5	External Battery Box	5760
6	GAPR Cutaway System with 4 Strand Cutaway and four 1/2" All Thread Rods	5760
7	4 Strand 3/8" Cable Ladder (75 ft. long)	5760
8	Standard Truck Plate with four 7/16" Farmers Shackles on top	5760
9	Four 3/8" dia. X 77" Steel Cables with 7/16" four Farmer Shackles on top and bottom (8)	5760
10	Tri-Plate with four 7/16" Farmer Shackles. (Tri-plate provided by science)	5300
11	Science Rotator	5000
12	Double Ballast Hopper	1200

Notes: Ballast hopper suspension: 4 x 1/4" x 56" Cables

Scientist	NCT-Boggs	
Organization	SSL, Univ. Cal-Berkeley	
Operations File No.	C1000-09	
Approximate Weights (Lbs)	Science Wgt.	3141
	NSBF Above Pin	702
	NSBF Below Pin	451
	Ballast	1200
	Total	5494
Certified By		Date
Rigged as Certified By	<i>[Signature]</i>	Date 19 APR 10
Flight No.	AF307 23	Date 29 APR 10

K-7 Balloon "AS BUILT" Specifications



Sulphur Springs, Texas
 Balloon Specifications for
 (1066) W39.57-2-76

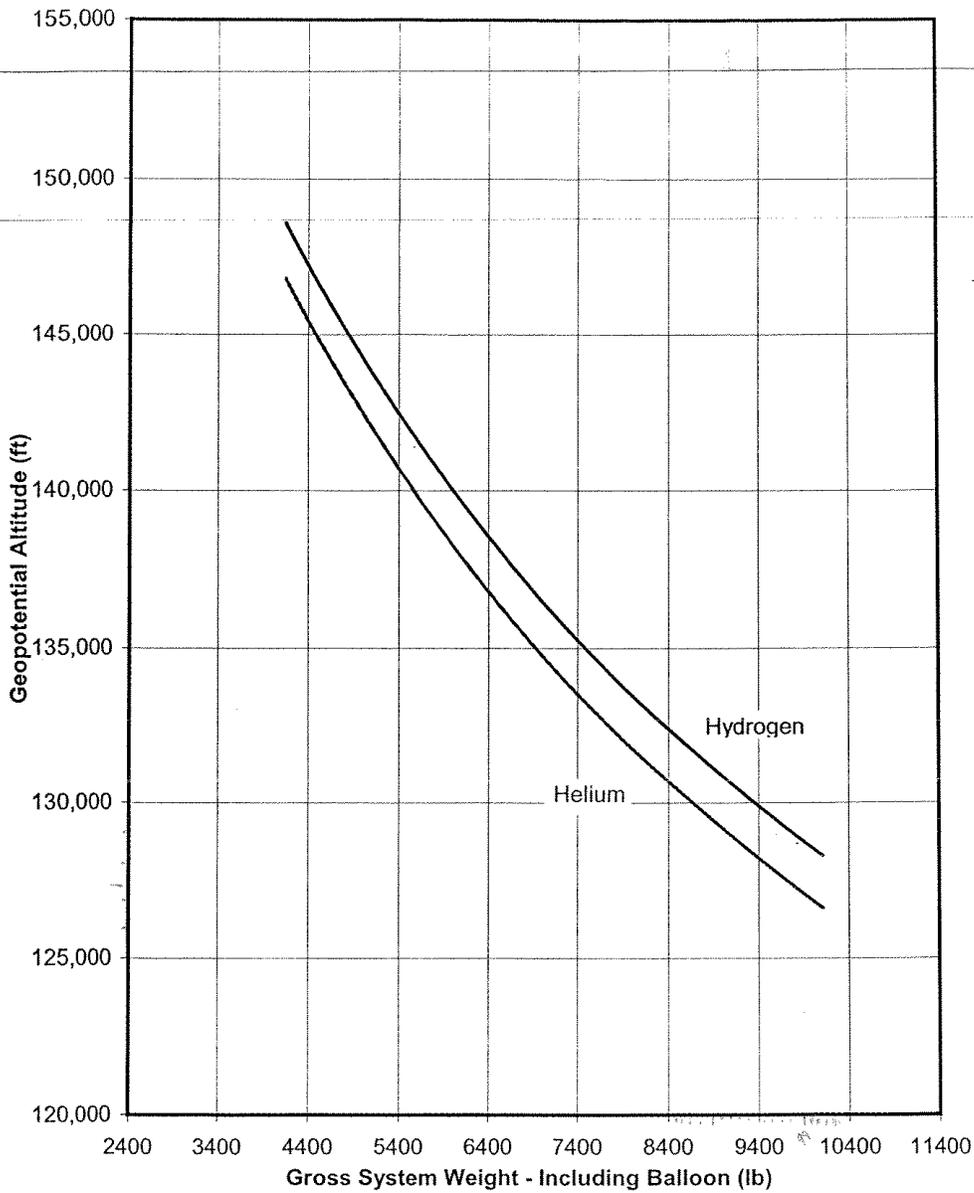
Contract Information	A) RFQ No.: R091809		B) Proposal Number: 16150		C) Specification Date: 10/30/08	
	D) Purchase Order No. P0079802		E) Customer Project No.:		F) Work Order No. 37711	G) Sequence 1 of 1
2) Balloon Information	A) Manufacturer: Aerostar International		B) Model No.: SF4-39.57-.8/.8/8-NA		C) S/N: 76	D) Incl. Dates of Mfr: 10/14/09 - 11/20/09
3) Film Information	A) Manufacturer: Raven		B) Name: SF-450		C) Film Series: 277	
4) Balloon Design:	A) Type: Natural shape, taped, capped			B) Volume: 39.57 mcf	C) No. Gores: 172	D) Theta: 57.6°
	E) Gore Widths: Max.: 100.69 in.		Top: 0.77 in. Base: 2.00 in.		F) Inflated Dimensions: Height: 396.00 ft. Diameter 459.37 ft.	
	G) Nominal Load: 4,000 lbs.		H) Nominal Altitude: 131,700 ft.		I) Recommended Payload Weights: Min: 100 lbs. Max: 6,060 lbs.	
	J) Film Gauge:		Shell: 0.80 mils	Cap 1: 0.80 mils	Cap 2: 0.80 mils	Cap 3: N/A
	K) Surface Area:		574,134 ft²	96,199 ft²	112,800 ft²	
	L) Length: 662.63 ft.		176 ft.		191 ft.	
	M) Cap Location: External	N) Balloon Wt. 4,124 lbs. FC	O) Bubble Marks Every Ten Feet: Min.: 120 ft. Max.: 150 ft.		P) Nominal Launch Mark: 132 ft.	
	5) Load Tapes:	A) Type: Laminated Polyester Fibers		B) Load Rating: 400 lbs	C) Radar Yarn: None	
Reeving Sleeve:		A) Film Gauge: Tear Panel: 0.70 mils Sleeve: 3.0 mils	B) Gore Seam No.: 172	C) Distance from Apex: 160 ft.		
7) Inflation Tubes:	A) Qty: 2	B) Distance From Apex: 48 ft.	C) Gores Locations: 2 and 88	D) Length: 200 ft.	E) Gauge: 3.0 mils	F) Diam.: 9.55 in.
8) Venting Ducts:	A) Qty: 6	B) Distance From Base: 165 ft.	C) Type: Attached	D) Length: 165 ft.		
	E) Gauge: 0.80 mils	F) Area Each: 125 ft²	G) Total Area: 750 ft²	H) Located on Seams 10, 39, 67, 96, 125, and 153		
9) Destruct Device:	A) Rip Line Rating: 1,000 lbs		B) Break line rating: 25 lbs.	C) Dist. from Apex: 10 ft.	D) Gore No. 169	
	Type:	Braided Nylon				
10) Valve Cable:	A) Wires Qty.: 4		B) Sheath Gauge: 1.5 mils	C) Located on Seam No.: 172		
	Gauge:	AWG #16				
11) Top Fitting:	A) Type: Plate, hoop and segmented clamp ring		B) No. of Ports: 1-33" or 2-13"	C) Diameter: 42 in.	D) Weight: 35.4 lbs	
12) Bottom Fitting:	A) Type: Banded Collar and Wedges		B) Load Attachment: 1"-8 UNC Eyunut	C) Diameter: 6.10 in.	D) Weight: 10.1 lbs	
13) Shipping Information:	A) Gross Weight: 5,846 lbs.	B) Box Dimensions: 144 in. long x 72 in. wide x 58 in. high			C) Box Volume: 348 ft³	
14) Notes:	A) Raven Industries, Inc. Stable Table: U.S. Patent No. 4,877,205					
	B) Longest cap is the outermost layer of the balloon wall.					
	C) All exposed surfaces (inside & out) of apex and base fittings painted with Sherwin-Williams White 1400522.					
	D) Collar marks on reeving sleeve at 48.8, 51.8, and 54.9 meters (160, 170, and 180 ft.)					
	E) Use vapor barrier					
	F) Reinforced lower 1 ft of external box between cleats					
	G)					
	H)					

As Built
 H70P 11-20-2009

20-Nov-09

K-8 Balloon Load Altitude Curve

Aerostar International Balloon Performance		
LIFT GAS: HELIUM OR HYDROGEN	ATMOSPHERE: 1962 U.S. STANDARD	
Balloon Design Volume	Balloon Model Number	
39.572 mcf	SF4-39.57-.8/.8/.8-NA	
Nominal Balloon Weight	Max Rec. Payload	Min Rec. Payload
4052 lbs	6060 lbs	100 lbs



Graph No. 102968

May 3, 2006

K-9 Flight Data Summary

National Scientific Balloon Facility	Flight Data Summary Memo
OF-332-00-M Rev - A	Date- 10-27-03 page 1 of 1
Approved by Mark Cobble	date 10-27-03

MEMO TO: NSBF Operations Department Head

FROM: Flight Operations Supervisor, Mechanical

SUBJECT: Flight Data Summary

DATE: 29 APR 2010

Flight Number: ABORT 23 P PT N NT

Organization/Experimenter: UNIV. CALIFORNIA-BERKELEY - STEVEN BOGGS (NCT)

Date/Time Launched (Zulu): 22:38:28Z

Balloon (i.e. Winzen 29.47-3-005): W39.57-2-76

NSBF Balloon Number: 1066 Mil Thickness:(SHELL/CAPS) 0.8 / 0.8

Balloon Weight (lbs): 4124 Experiment Weight (lbs): 3481

Suspended Weight (lbs): 5489 Gross Inflation (lbs): 10574

Free Lift (%): 10

Float Altitude (kft): —

Terminate Date/Time: 28 April 2010 / 22:38:28Z

Impact Date/Time: 23.798S / 133.803E / within boundary of Alice Springs Airport

Location of Impact: Same time as termination - abort

Total Flight Time (hrs, min): N/A

Condition of Payload: _____ Good _____ Fair _____ Poor

Remarks: Aborted launch. Payload sustained significant major damage.

K-10 Inflation Computation

National Scientific Balloon Facility OF-324-00-D Rev-C		Inflation Computation WorkSheet (ref Conversion Factor) Date 09-12-05 Page 1 of 1	
Approved by Mark Cobble		Date 9/12/2005	
INFLATION COMPUTATION - Conversion Factor			
FLIGHT # <u>ABORT 23</u>			
LAUNCH DATE <u>4/29/10</u> L TIME: <u>08:08</u> L		COMPUTED BY: <u>FC</u>	CHECKED BY: <u>MDC</u>
BLN. MFG. & VOL: W39 57-2	SN: 76	NSBF: 1066	4124 LAUNCH SITE: Alice Springs, Aus.
PARACHUTE SIZE: 130' S/N: 0718	LADDER SIZE: 4 x 3/8"	LENGTH: 65'	473 LAUNCH TIME <u>22/38/28Z</u>
STROBE (4) VALVE(S) (14) RFU (6) UTP (38) BATT. BOX w/cutaway/GAPR (97)			159 LAUNCH DRVR <u>D. Roberts</u>
MISC ABOVE PIN: Ripstitch (27) 10 ft. Ladder extension (13) Suspension (26) PVC (4)			70 GND REC.
SCIENTIFIC EXPERIMENT w/MiniSip, Solar Shields, CSBF camera, cryogens, CSBF PV's			3481 A/C CREW: Aussies, Embry
BALLAST TYPE: <u>SAND</u> FLOW RATE 1 @ 87, 1 @ 82 = 169 PPM			1200 LAUNCH CREW: FC, MDC, RH
HOPPER(S) (30) DBL FRAME (23) w/ 1/4" x 56" CABLES			53 DR. RM , RW, LF
CRUSH PAD (52) 2 bottles Deuterium depleted water (1)			53
GONDOLA WEIGHT COMPUTATIONS		GROSS LOAD	9613 SAO: N/A WX: Mullerax
SCIENCE GROUP: U. Cal Berkeley Steven Boggs (NCT)	FREE LIFT <u>10</u> %	961	TERMINATE #BT-20A
	GROSS INFLATION	10574	EXPLOSIVE BOLT # N/A
DATE/TIME OF WEIGH OFF: 12 Apr 10 1730L	LIFT/TUBE HANDBOOK	91.7	91.0 91.0
SCALE/MFG./TYPE: Challenger 2	MULT. BY CONV. FACTOR	8.28	8.47 8.55
	LIFT/TUBE (JBK/OTHER)	759.2	770.17 778.05
DATE OF CALIBRATION: 4/7/2009	MULT. BY NUM TUBES OPEN	8	8 8
WEIGHT VERIFIED BY: (2 OR MORE) FC / J. Jones	TOTAL LIFT AVAILABLE	6074	6166 6224
	SUBTRACT GROSS INFLATION	3524	3525 3525
GONDOLA WT. 3481 SCI. 3132	TOTAL LIFT RMG IN TRAILER	2550	2641 2699
1. WEIGHT INCLUDE BALLAST? NO	DIVIDE BY CONVERSION FACTOR	8.28	8.47 8.55
2. WEIGHT INCLUDE ELECT? Yes, MiniSip	LIFT/TUBE RMG (JBK/OTHER)	307.97	311.8 315.6
3. WEIGHT INCLUDE CRUSH PAD? NO	DIVIDE BY NUMBER TUBES OPEN	8	8 8
4. CRUSHPAD INSTALLED BY? CSBF	P.S.I. EQUIV. (FM HANDBOOK)	38.49	38.97 39.45
	VALVING FROM P.S.I.	2500	2480 2480
5. WEIGHT INCLUDE CRYOGENS ETC? _____ yes, 95 lbs.	TO P.S.I.	995	1005 1025
	SUBTRACT FOR COOLING	-80	-70 -80
6. GONDOLA FLOWN BEFORE? Yes	FINAL CUTOFF PRESSURE P.S.I.	915	935 945
	HELIUM TRAILER #	ISO-3	ISO-1 ISO-2
7. IF (6) ABOVE IS YES, IS THERE A DIFFERENCE IN WEIGHT? Yes, minus science PV	CONVERSION FACTOR	8.28	8.47 8.55
	NUMBER OF TUBES OPEN	8	8 8
8. HAVE ALL WEIGHTS BEEN INCLUDED ON INFLATION COMPUTATION SHEET? Yes	STARTING PRESSURE	2500	2480 2480
	TEMPERATURE FRONT	8	8 8
COLLAR ID <u>21</u>	TEMPERATURE REAR	8	8 8
CUT-A-WAY #26	TEMPERATURE USED	8	8 8
BURST DETECTOR #1007 (Round)	COMMENTS: Minisip (266) SIP solar shields (40)		
BALLAST MOTOR # #570 = 87ppm; #550 = 82ppm	CSBF Test camera w/accessories (35)		
CREW CHIEF <u>F. CANDELARIA</u> <u>D. Cobble</u>	2 CSBF PV panels (4)		

K-11 Launch Director's Checklist

National Scientific Balloon Facility	Launch Director's Checklist (Zero Pressure)		
OF-322-10-C	Rev-B	Date- 10-03-05	page 1 of 2
Approved by _____ Victor Davidson _____		date _____ 10/03/2005 _____	

LAUNCH DIRECTOR'S CHECK LIST (Zero Pressure)

FLIGHT # ABJRT 23 NOMINAL ALTITUDE _____ DATE/TIME 29 APR 2010

PRE-BALLOON LAYOUT

- Chocks in place Brakes Set
- Spool and table clean and free of scratches and latched
- B+B Bubble and ground cloths properly deployed
- LF Bubble and ground cloths swept clean
- yes Ethafoam used?

BALLOON

- Properly laid out
- End fitting OK
- Pull or stretched places marked and noted
- MDL Valves installed and working
- 1050 lb Rip line -- Strength or size
- 144' Bubble length inflation complete (Feet)
- 10574' Gross Inflation (lbs.)
- Bubble lengths for cone angle ___ 40% ___ 50% ___ 60% ___

FLIGHT TRAIN ITEMS

- PR Balloon properly mated to parachute and rigging
- Parachute and rigging properly laid out over launch vehicle (cable slack management for parachute/ladder, etc)
- Rigging properly tied into launch vehicle and safeties.
- Special rigging properly done (ballast tubes, swivel or stabilizing devices, ETC)

LAUNCH COLLAR

MDL INSTALLATION CHECK BY CAMPAIGN MANAGER

FLIGHT TRAIN CONTINUED

- Recovery tags
- NSBF instrumentation completed and checked

HELIUM TRAILER AND INFLATION DATA

- MDC ✓ Valves on and off according to inflation sheet
- PAK ✓ Heise gauge valve on
- FE ✓ Final Pressure check
- LF/RW ✓ Inflation tubes tied off

PRE-RELEASE CHECK

- ✓ Scientist ready and OK to launch
- ✓ DIR 7 second delay safety pin pulled
- N/A Terminate fitting safety cable removed

Launch Vehicle:

- ✓ TINY TIM _____ BIG BILL _____ BOSS _____ CRANE _____ X OTHER
- ✓ Communications check with Driver and Electronic personnel B. Maxwell
- DR ✓ Driver ready and engine running
- ✓ Chocks removed (if necessary)
- N/A Safety off (if necessary)
- ✓ Launcher ready
- ✓ Release pi-bal
- ✓ Notify personnel at spool release (radio command or light system)
- ✓ Brake off

Balloon released at 22:38:28 Z By: Frank Candelara

LAUNCH CONDITIONS

Surface Direction & Speed 290 @ 2 Sky conditions CLEAR
Low level Direction & Speed 118 @ 11 Temperature C 11.7
Layout Direction 108 Crosswind(Y/N) N Surface Pressure(MB) 961.4

FRANK CANDELARA LAUNCH DIRECTOR

K-12 Balloon Condition at Launch

National Scientific Balloon Facility OF-329-00-D	Rev - A	Date- 10/28/03	Balloon Condition at Launch Checklist page 1 of 1
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Approved by Mark Cobble date 10-28-03

NOTICE: Copies to Flight Folder and Balloon Engineer: **DOCUMENT FOLLOWS:**

FLIGHT LINE REPORT

BALLOON CONDITION AT LAUNCH

Flight# ABORT 23

Balloon I.D. (1066) W 39.57 - 2 - 76
NSBF I.D. MANUFACTURER VOLUME #CAPS S/N

Launch Date: 29 APR 2010 Time: 0808L Location: ALICE SPRINGS, A.S.

Fully describe any problems found, including location, etc. If damage was caused on launch pad, describe circumstances.

PACKAGING (Balloon box, airing out, condition of protective wrap, markings, folding, etc):

GOOD

BASE & APEX FITTING: (Paint Finish, Connectors, Valve Plates, Bolts.)

GOOD

ACCESSORIES (Inflation tubes, reefing sleeve, valve cables, vent ducts, high slip, etc):

GOOD

DEPLOYMENT (Rope sections, position of valve cables, orientation of inflation tubes, etc):

OK

Report Completed by: Frank Cobble Date: 29 APR 10

K-13 Recovery Information

National Scientific Balloon Facility OF-306-00-D	Recovery Information Data Sheet Rev - A	Date- 10-28-03	page 1 of 1
Approved by <u>Mark Cobble</u>		date <u>10-28-03</u>	

NOTICE: Use to document the recovery information. Copies to **Flight Ops, Pilots, Flight Electronics, and Head of Operations.** Pre-printed "NCR" forms are acceptable. **DOCUMENT FOLLOWS:**

RECOVERY INFORMATION

Scientific Group: NCT / Boggs Scientific Rep, on Recovery: Steve McBride

Aircraft: _____ Vehicle: _____

Payload Dimensions: 11 ft H 5 ft W 15 ft L - Weight 4,289 Lbs.

Batteries: No. 36 Types B-7701-12

Location: Two white boxes on the floor of the electronics bay

Dimensions: 1) _____ H _____ W _____ L, 2) _____ H _____ W _____ L,
3) _____ H _____ W _____ L, 4) _____ H _____ W _____ L,

Removal Inst.: Remove securement straps by loosening bolts. Disconnect power cables on outside edges.

Radioactive Sources: _____ Yes No Type _____

Location: _____

Precautions: _____

Other Hazards: Cryogenic liquid nitrogen (may be evaporated on recovery)

Location: white dewar in instrument cradle.

Precautions: If gondola loads upright, avoid tipping and transport upright.

Special Equipment: Allen + adjustable wrenches

Other Recovery instructions: Remove + safeguard data drives from flight computer. Support gondola on bottom of frame rather than protruding struts.

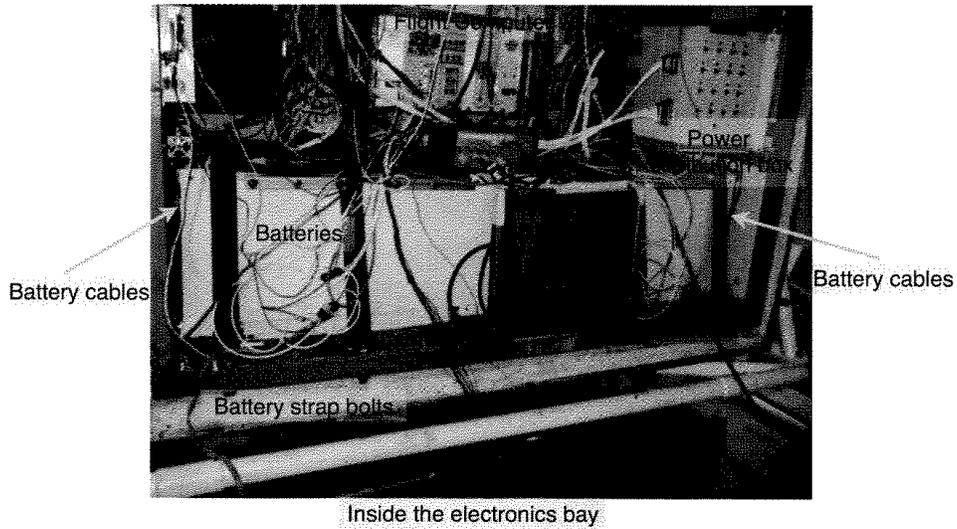
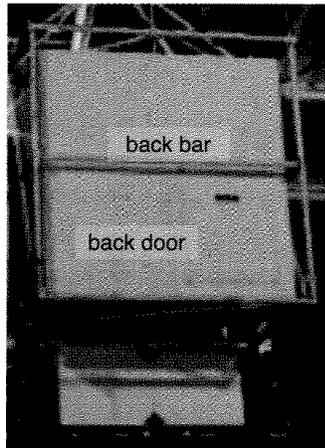
Certification: Ft. Ops.: Flt. Elec.:

NCT Recovery Instructions

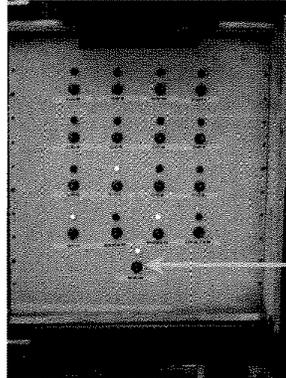
Alice Springs, Australia 2010

I. Battery Removal

1. Remove back bar (5/16" Allen wrench) and back door (latches) to electronics bay.



2. Ensure main power (bottom switch on Power Distribution Box) is off. All LEDs should be off. See supplemental document to shut down solar panel control box.

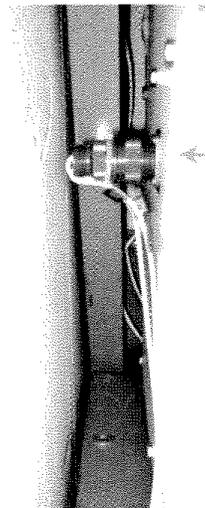


Main power switch

3. Remove battery securement straps with adjustable wrenches.



Remove these bolts to free straps

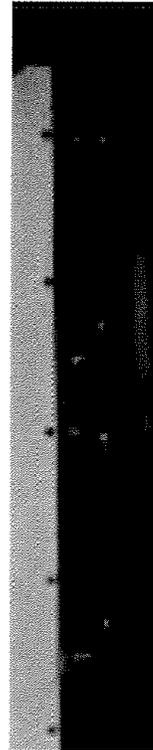
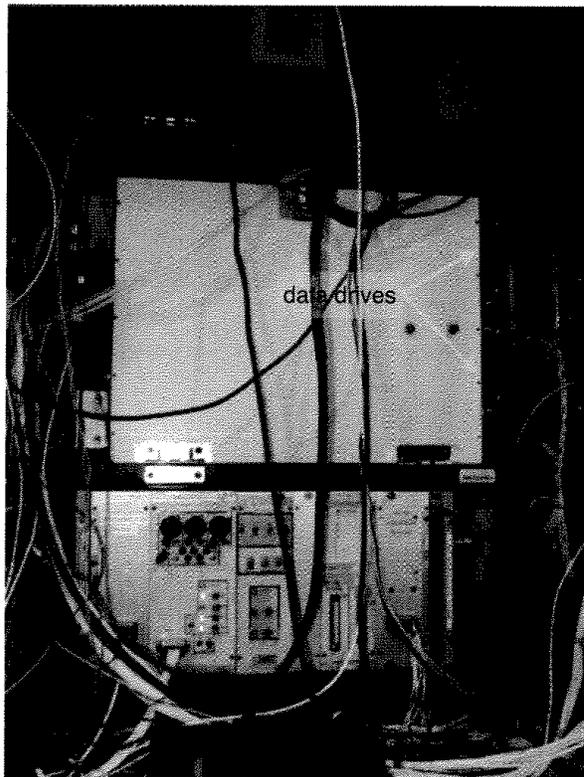


Battery cables are screwed to the outer edges of the batteries

4. Unscrew battery cables. Connectors are on the outside edges of the batteries--it may be necessary to rotate batteries or take off the sides of the electronics bay to access them). For safety, don't cut the cables!
5. Remove batteries from electronics bay.

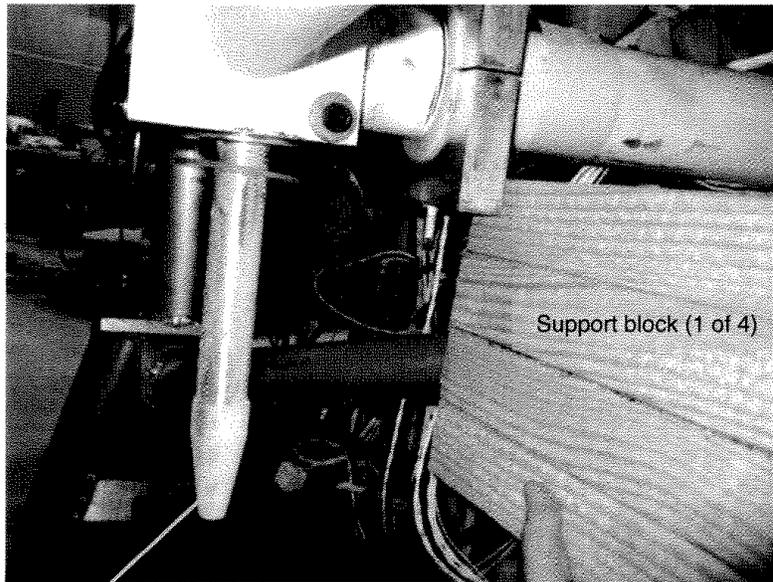
II. Data drive removal

1. Unscrew thumb screws holding in the two data drives into the flight computer and pull them out. Remove the cables attached at the back by pulling gently.



III Transport

The SIP cage is secured to the gondola by metal pegs which protrude from the bottom of the gondola. Whether or not the pegs bend on landing, it will likely be easier to support the gondola on blocks (supplied) during transit than on the pegs.



Remove the tapered peg tip by unscrewing it.

K-14 Quality Control Information

National Scientific Balloon Facility	Quality Control Balloon Information Data
OF-330-00-D Rev - A	Date- 10-27-03 page 1 of 1
Approved by <u>Mark Cobble</u>	date <u>10-27-03</u>

NOTICE: This sheet is to be attached to Launch Director's Checklist for eventual placement into Flight Folder. Balloon rigging information is captured, transferred to this sheet and sent to the Balloon Engineer. **DOCUMENT FOLLOWS:**

QUALITY CONTROL INFORMATION

TO:	Balloon Engineer
FM:	Operations Department
Flight #:	<u>ABORT 23</u>
Balloon type:	<u>W39.57-2-76 (1066)</u>
Gross lift:	<u>10574</u> lbs
Collar ID:	<u>21</u>
Foam ID:	<u>NA</u>
Collar Location:	<u>166</u> Ft. from top
Was polyethylene used between foam?	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
Signed:	<u>Frank Cobble</u>
Date:	<u>29 APR 2010</u>

K-15 Collar Flight Record

National Scientific Balloon Facility OF-328-00-C	Collar Flight Record Rev - A	Date- 10-27-03	page 1 of 1
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Approved by Mark Cobble date 10-27-03

NOTICE: This sheet is to be attached to Launch Director's Checklist for eventual placement into Flight Folder. Collars are to be inspected after each flight according to the above guideline and tagged. Tag is to be removed upon collar installation. Any information on tag should then be transferred to this sheet. **DOCUMENT FOLLOWS:**

COLLAR FLIGHT RECORD

FLIGHT NO. ABORT 23 LAUNCH DATE ALICE SPRINGS
 INSTALLED BY F. CANDELARIA COLLAR LOCATION 166
 COLLAR FIT LOOSE _____ MODERATE X TIGHT _____
 COLLAR RELEASE ON LAUNCH X ASCENT _____
 COLLAR RELEASE ANGLE _____ BALLOON SIZE W39.57-2
 COLLAR SIZE LARGE COLLAR ID NO. 21

COLLAR INSPECTION RECORD

COLLAR INSPECTED BY: DR
 COLLAR INSPECTION DATE: 19 APR 2010
 CLEAN OF DEBRIS, ETC.: ✓
 MATERIAL TEARS REPAIRED: OK
 LINK BELTS CHECK/REPAIR: REPLACE 1 LINK
 TAPE ON BRADS OR ROPE: OK
 BUNGEE CHECKED/REPAIRED: OK
 BUNGEE EYEBOLTS CHECKED: ✓
 O RINGS CHECK BURRS/RUST: ✓
 CLEVIS PIN ATTACHMENT OK: ✓
 VELCRO STRAPS CHECK/REPAIR: ✓

K-16 Flight Operations – Rigging Job Assignments

Columbia Scientific Balloon Facility OF-318-00-D	Rev-B	Date: 06-12-2006	CSBF Ft. Ops. - Rigging Job Assignments Page 1 of 1
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Approved by Victor M. Davison Date 6/12/2006

NOTICE: DOCUMENT FOLLOWS

FLIGHT OPERATIONS – RIGGING JOB ASSIGNMENTS

29 APR 2010 ABORT 23
SCIENCE GROUP: BOGGS/NCT UC BERKELEY LAUNCH @ 0700

RELEASE DRIVER: DON

Pick up package, Help scientists on line, Connect rip line, Connect parachute,
Choke, Pull line cutter pin and check Terminate Safety Cable, Drive on Release

HELIUM TRAILER(S):

Trailer #: ISO-2 Tubes: 8 RANDALL

Trailer #: ISO-1/ISO-3 Tubes: 8/8 LARRY/COBBLE/CANDELARIA/RH
 (Larry drive prime mover) (Mark monitor helium)

BALLOON VEHICLE: Balloon # 1066 ROBIN

Drive balloon to pad and during layout. Inflate balloon and Pick up red poly.

GROUND CLOTH VEHICLE: Bubble + 8 LARRY

Drive to pad, Drive for layout, Inflate balloon, drive on cloth pick up

LAUNCH SPOOL: Pibal 1000 ft RANDALL

Drive to pad, inflate & position tethered pibal, Raise bubble
Drive during inflation, Release balloon from spool

LIGHT PLANT(S): (1) _____ (2) X (BOTH BY SPOOL) ROBIN

SPECIAL EQUIPMENT: KAWASAKI MULE/CHUTE CART MARK

RECOVERY CREW: Show Time: N/A SULLIVAN

SAO Show Time: N/A

- *****
 1. Mark Cobble 2. Victor Davison 3. Frank Candelaria 4. Keith Parkes 5. Randall Henderson
 6. Marty Crabill 7. Joe Masters 8. Robin Whiteside 9. Derek Dolbey 10. Nathan McCabe
 11. Don Roberts 12. Curtis Frazier 13. Reid Chambers 14. Larry Fox

K-17 Rigging Weight Sheet

Flight Folder

RIGGING FLIGHT REQUEST RESPONSE

Flight Request Number
C1000-09 Revised

Scientist
Steven Boggs/Un. Cal Berkeley (NCT)

<u>Desired Float</u>	Minimum Float	Desired Alt.	Minimum Alt.	Valving Required
4 days	24 hours	130 kft	120 kft (day) 100 kft (nite)	no

Flight Profile
evening launch desired

Float Stability
Desired: 10 kft Minimum: 20 kft

Payload		3100	
Electronics		356	
Parachute Size	130	500	
Misc.		225	
Sustaining Ballast		157	
Sunset Ballast		677	
Drive Up Ballast	morning	366	
SUSP. WEIGHT		5381	
Est. Balloon Wt.		4124	
GROSS LOAD		9505	
Free Lift %	10	951	
GROSS INFLATION		10456	
CU FT. HELIUM		158924	
			Location Australia 2010
			Ballast Type Total Ballast
			SAND 1200

Balloon Size W39.57-2 0

Max Payload 6000 Min Payload 100

Alt w/Ballast 128 kft Alt w/o Ballast 130.5 kft

Comments:

APPENDIX L: WEATHER DOCUMENTATION

L-1 Davis Weather Station 8 Hour

L-2 Flight Forecast Data

L-3 Pilot Balloon (PIBAL) Data

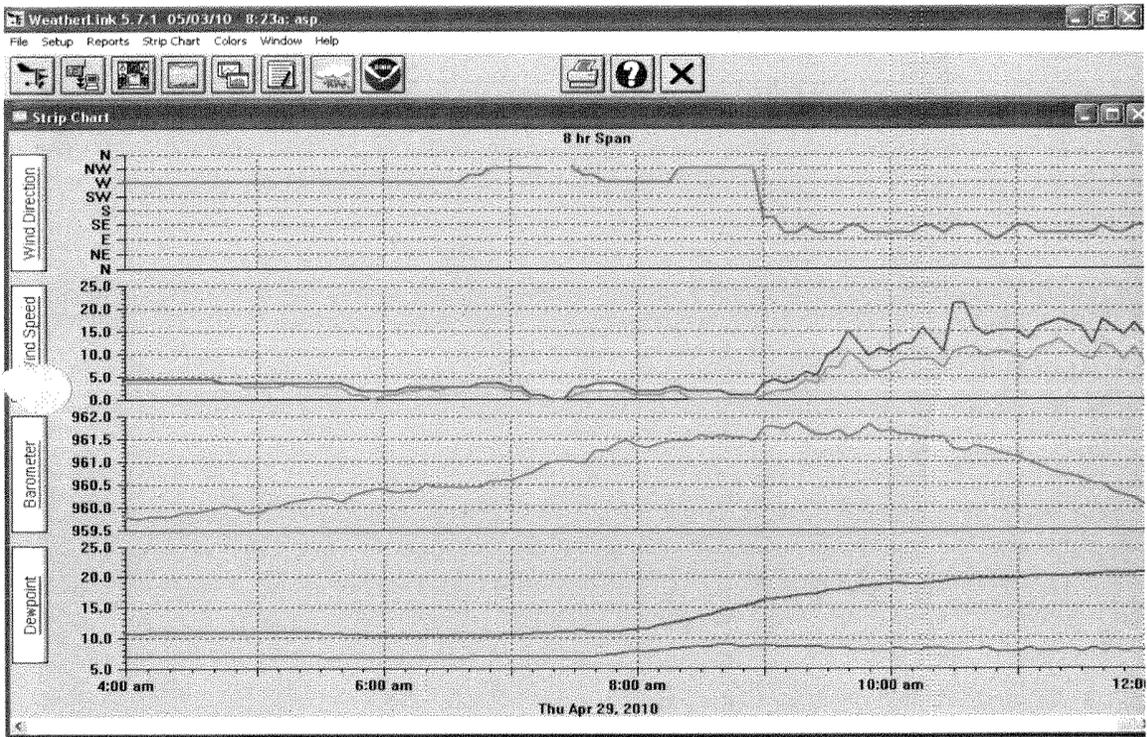
L-4 Climbout and Descent Trajectory Forecast

L-5 ABORT 23 Meteorologist Observation Report

L-6 Rawinsonde Data (radiosonde systems that measure winds, along with pressure, temperature and humidity)

L-7 Surface Observations

L-1 Davis Weather Station 8 Hour



L-2 Flight Forecast Data

Flight Forecast Data

Group: NCT

Launch Date/Time(UTC):28 Apr 2010/2200Z
Launch Date/Time(Local):29 Apr 2010/0730L

Synopsis

High pressure to the south will continue to dominate.

Launch Conditions

Surface Winds: ESE-SE 2-5 kts, G9 kts by 0820-0850L

Low Level Winds:

400ft:100-120/8-10 kts

700ft:090-110/12-14 kts

1000ft:090-110/13-15 kts

1300ft:090-110/14-16 kts

Clouds and Weather: 50 SCT

Climbout and Enroute

Tropopause: -76.0C @ 51.9kft Min Temp: TROP

Max Wind: 270 deg/55 kts at 45kft

Initial Position at Float: 085/20nm from Alice Springs

Estimated Time at Float: 27 hrs staying at 105kft minimum,

Clouds and Weather: 60 SCT 100 SCT 300 SCT-BKN

Impact Conditions

Forecast Descent Vector: 080 deg/10 nm

Estimated Impact Position: 150nm E of Longreach

Clouds and Weather: 50 SCT 100 SCT 300 SCT

Surface Winds: VRBL 5-10 kts

Remarks

Fri AM: Sfc: VRBL 2-5 kts, L/L winds..080-100/12-14 kts

Estimated float time: 21-28 hours (depending on min alt)

Sat AM: Sfc: VRBL 1-3 kts, L/L winds..070-090/10-12 kts

Estimated float time: 24-30 hours (depending on min alt)

Sunday..increasing easterly flow

L-3 Pilot Balloon (PIBAL) Data

20100428161050.txt
Starting PiBall Run 2010/04/28 16:10:50
150ft 3.2 knots from 90.1 deg
450ft 10.7 knots from 82.4 deg
750ft 14.6 knots from 91.0 deg
1050ft 12.4 knots from 99.2 deg
1350ft 11.6 knots from 101.2 deg
1650ft 10.3 knots from 109.9 deg
1950ft 10.7 knots from 112.5 deg
2250ft 11.2 knots from 117.4 deg
2550ft 9.1 knots from 129.1 deg
2850ft 9.8 knots from 147.0 deg
3150ft 9 knots from 156.6 deg
3450ft 10 knots from 169.3 deg
3750ft 10.5 knots from 155.0 deg
4050ft 12.7 knots from 126.2 deg

01 / 01:41 AOST
(L)

20100428164807.txt

Starting PiBall Run 2010/04/28 16:48:07

150ft 1.9 knots from 80.6 deg
450ft 9.7 knots from 81.7 deg
750ft 12.5 knots from 93.5 deg
1050ft 11.9 knots from 98.3 deg
1350ft 9.7 knots from 111.0 deg
1650ft 10.9 knots from 112.5 deg
1950ft 11.2 knots from 116.7 deg
2250ft 11.5 knots from 125.1 deg
2550ft 12.6 knots from 128.3 deg
2850ft 12.9 knots from 133.3 deg
3150ft 12.7 knots from 127.6 deg
3450ft 9.4 knots from 121.1 deg
3750ft 9.5 knots from 130.6 deg
4050ft 11.3 knots from 135.5 deg

02/02:18(6)

20100428172841.txt
Starting PiBall Run 2010/04/28 17:28:41

150ft 2.2 knots from 128.7 deg
450ft 6.7 knots from 80.1 deg
750ft 11.3 knots from 101.7 deg
1050ft 11.2 knots from 113.3 deg
1350ft 12.5 knots from 114.5 deg
1650ft 11.9 knots from 118.3 deg
1950ft 13.5 knots from 117.1 deg
2250ft 12.6 knots from 117.6 deg
2550ft 12.3 knots from 119.2 deg
2850ft 12.4 knots from 116.1 deg
3150ft 13.4 knots from 114.9 deg
3450ft 14.2 knots from 122.7 deg
3750ft 12.5 knots from 136.8 deg
4050ft 12.5 knots from 136.6 deg

03 | 02:59 (w)

20100428175847.txt
Starting PiBall Run 2010/04/28 17:58:47
150ft 1.2 knots from 230.4 deg
450ft 5.7 knots from 92.3 deg
750ft 8.5 knots from 109.6 deg
1050ft 10.9 knots from 118.4 deg
1350ft 12.5 knots from 117.9 deg
1650ft 13.8 knots from 118.4 deg
1950ft 13.2 knots from 119.0 deg
2250ft 9.1 knots from 116.0 deg

04/03:32(L)

20100428183651.txt
Starting PiBall Run 2010/04/28 18:36:51
150ft 0.9 knots from 209.2 deg
450ft 4.5 knots from 113.2 deg
750ft 10.1 knots from 120.5 deg
1050ft 10.5 knots from 119.6 deg
1350ft 11.4 knots from 121.5 deg
1650ft 11.4 knots from 118.6 deg
1950ft 12.9 knots from 119.6 deg
2250ft 12.7 knots from 118.6 deg
2550ft 13.8 knots from 120.6 deg
2850ft 14 knots from 123.7 deg
3150ft 14.3 knots from 125.5 deg
3450ft 13.6 knots from 136.6 deg

05/04: 18(L)

20100428191755.txt

Starting PiBall Run 2010/04/28 19:17:55

150ft 4.3 knots from 249.0 deg
450ft 4.3 knots from 101.5 deg
750ft 8.9 knots from 113.9 deg
1050ft 10.3 knots from 118.3 deg
1350ft 10.9 knots from 122.3 deg
1650ft 12.2 knots from 118.5 deg
1950ft 11.8 knots from 123.0 deg
2250ft 14 knots from 121.0 deg
2550ft 14.9 knots from 123.1 deg
2850ft 14.7 knots from 119.0 deg
3150ft 15.3 knots from 123.5 deg
3450ft 13 knots from 128.4 deg
3750ft 15.8 knots from 138.7 deg
4050ft 13 knots from 131.3 deg

06/04:48(LW)

20100428194757.txt
Starting PiBall Run 2010/04/28 19:47:57
150ft 2.7 knots from 252.4 deg
450ft 4.3 knots from 93.6 deg
750ft 8.4 knots from 108.4 deg
1050ft 10.3 knots from 119.6 deg
1350ft 12.1 knots from 117.3 deg
1650ft 11.7 knots from 118.4 deg
1950ft 11.7 knots from 121.0 deg
2250ft 11.7 knots from 118.8 deg
2550ft 13.2 knots from 118.4 deg
2850ft 13.6 knots from 118.6 deg
3150ft 16.3 knots from 120.0 deg
3450ft 34.2 knots from 124.7 deg
3750ft 55.5 knots from 119.4 deg

07/05/18 (L)
Delayed NOTAM



20100428202336.txt

Starting PiBall Run 2010/04/28 20:23:36

150ft	3.4 knots	from 235.3 deg
450ft	3.1 knots	from 120.7 deg
750ft	9 knots	from 111.5 deg
1050ft	10.5 knots	from 116.5 deg
1350ft	11.8 knots	from 114.3 deg
1650ft	12 knots	from 115.9 deg
1950ft	11.8 knots	from 114.6 deg
2250ft	12.3 knots	from 115.2 deg
2550ft	12.5 knots	from 118.2 deg
2850ft	13.6 knots	from 117.6 deg
3150ft	15.1 knots	from 125.6 deg
3450ft	16.2 knots	from 131.2 deg
3750ft	13.9 knots	from 138.6 deg
4050ft	12.7 knots	from 131.7 deg

08/05:54(L)
Balloon layout



20100428205943.txt
Starting PiBall Run 2010/04/28 20:59:43
150ft 2.7 knots from 229.2 deg
450ft 5.1 knots from 111.9 deg
750ft 10.8 knots from 109.6 deg
1050ft 12.8 knots from 111.6 deg
1350ft 14.4 knots from 112.6 deg
1650ft 14 knots from 116.3 deg
1950ft 14.4 knots from 120.0 deg
2250ft 14.8 knots from 120.7 deg
2550ft 13.1 knots from 122.9 deg
2850ft 13.7 knots from 122.6 deg
3150ft 15.1 knots from 129.2 deg
3450ft 15.3 knots from 128.9 deg
3750ft 12.6 knots from 129.2 deg
4050ft 12.6 knots from 122.6 deg

09/ 06:30 (L)

20100428211230.txt
Starting PiBall Run 2010/04/28 21:12:30
150ft 2 knots from 246.3 deg
450ft 4.6 knots from 115.4 deg
750ft 10.6 knots from 109.8 deg
1050ft 12.9 knots from 115.2 deg
1350ft 15.1 knots from 116.3 deg
1650ft 14.6 knots from 117.1 deg

10/06:43(L)
Go for inflation

20100428220956.txt
Starting PiBall Run 2010/04/28 22:09:56
150ft 2.9 knots from 199.0 deg
450ft 7.5 knots from 121.6 deg
750ft 11.6 knots from 114.9 deg
1050ft 13 knots from 113.6 deg
1350ft 12.6 knots from 114.6 deg

11/07:40 (L)
Inflation check

20100428224023.txt

Starting PiBall Run 2010/04/28 22:40:23

150ft	0.7 knots	from 187.5 deg
450ft	8.1 knots	from 110.8 deg
750ft	12.2 knots	from 110.6 deg
1050ft	13.4 knots	from 111.2 deg
1350ft	13.6 knots	from 109.9 deg
1650ft	13.5 knots	from 109.6 deg
1950ft	14.4 knots	from 109.4 deg
2250ft	15.2 knots	from 111.9 deg
2550ft	17.2 knots	from 112.8 deg
2850ft	19.1 knots	from 125.3 deg

12/08:10(L)
Post launch

L-4 Climbout and Descent Trajectory Forecast

Flight Folder

climb_20100428_153802.txt

Science Group: NCT
 Balloon Type: ZP
 Balloon Size: 39.5
 Chute Size: 130
 Weight with Ballast: 5489
 Weight without Ballast: 3289

Trop
 -TBC
 @ 94.8kft

Calculations based on the following ascent rates:
 Surface-50kft: 1050.
 50kft-70kft: 600.
 Above 70kft: 675.

altitude	dir	spd	bearing	distance(nm)	time(min)
3.	100	14	280.	0.2	1.0
6.	135	11	305.	0.7	3.8
9.	185	7	323.	0.9	6.7
12.	240	5	338.	0.9	9.5
18.	290	5	8.	0.7	15.2
24.	275	11	62.	1.3	21.0
30.	280	14	81.	2.5	26.7
34.	280	18	87.	3.6	30.5
39.	265	31	86.	6.0	35.2
45.	275	46	90.	10.4	41.0
53.	245	30	80.	16.7	54.3
60.	205	12	74.	18.1	66.0
70.	85	8	73.	15.9	82.6
80.	90	15	68.	12.4	97.4
90.	100	15	56.	9.5	112.2
100.	270	5	59.	10.6	127.1
110.	270	15	67.	13.9	141.9
120.	270	20	73.	18.5	156.7
128.	270	35	78.	25.2	168.5

MinTemp
 Trop

Descent Vectors Without Ballast

altitude	dir	spd	bearing	distance(nm)	time(min)
3.	100	14	280.	0.2	0.9
6.	135	11	305.	0.7	3.6
9.	185	7	323.	0.9	6.3
12.	240	5	336.	0.9	8.8
18.	290	5	3.	0.7	13.8
24.	275	11	56.	1.0	18.3
30.	280	14	78.	1.9	22.8
34.	280	18	85.	2.8	25.7
39.	265	31	85.	4.7	29.4
45.	275	46	89.	7.8	33.5
53.	245	30	84.	9.8	37.7
60.	205	12	81.	10.1	40.7
70.	85	8	81.	9.6	44.0

Page 1

climb_20100428_153802.txt

80.	90	15	80.	9.0	46.7
90.	100	15	79.	8.5	48.8
100.	270	5	79.	8.6	50.4
110.	270	15	79.	8.9	51.6
120.	270	20	80.	9.2	52.5
128.	270	35	80.	9.6	53.2

Descent Vectors with Ballast

altitude	dir	spd	bearing	distance(nm)	time(min)
3.	100	14	280.	0.2	0.7
6.	135	11	305.	0.5	2.8
9.	185	7	323.	0.7	4.9
12.	240	5	336.	0.7	6.8
18.	290	5	3.	0.5	10.7
24.	275	11	56.	0.8	14.2
30.	280	14	78.	1.5	17.6
34.	280	18	85.	2.1	19.9
39.	265	31	85.	3.6	22.8
45.	275	46	89.	6.0	25.9
53.	245	30	84.	7.6	29.2
60.	205	12	81.	7.8	31.5
70.	85	8	81.	7.5	34.1
80.	90	15	80.	6.9	36.1
90.	100	15	79.	6.6	37.8
100.	270	5	79.	6.7	39.0
110.	270	15	79.	6.9	39.9
120.	270	20	80.	7.1	40.6
128.	270	35	80.	7.4	41.2

L-5 ABORT 23 Meteorologist Observation Report

Campaign Meteorologist Observation Report for Abort #23

I was the campaign meteorologist on duty during this abort during the 2010 Australia Campaign. Weather conditions at time of balloon release from the spool were as follows:

Surface wind: 290 deg/2 kts (note that during inflation surface winds were 250-300 deg/1-4 kts)
Pressure: 961.4 mb
Temperature: 11.7C
Sky Condition: Clear
Layout direction: 110 degrees

Pilot Balloon measurement taken 2209Z:

150ft: 199 deg/2.9 kts
450ft: 122 deg/7.5 kts
750ft: 115 deg/11.6 kts
1050ft: 114 deg/13 kts
1350ft: 115 deg/12.6 kts

Pilot Balloon measurement taken after abort at 2240Z:

150ft: 188 deg/0.7 kts
450ft: 111 deg/8.1 kts
750ft: 111 deg/12.2 kts
1050ft: 111 deg/13.4 kts
1350ft: 110 deg/13.6 kts

I have also separately sent YBAS radiosonde data taken by the Alice Springs Met Office (from 12Z 28 Apr and 00Z 29 Apr), Flight Forecast Data Sheet, and emergency terminate descent corridor data. Please note that the emergency terminate descent corridor data was based on the 12Z 28 Apr YBAS radiosonde up to 80kft.

L-6 Rawinsonde Data (radiosonde systems that measure winds, along with pressure, temperature and humidity)

SNPARM = PRES;TMPC;DWPC;DRCT;SKNT;HGHT;HGFT

STID = YBAS STNM = 94326 TIME = 100428/1200
 SLAT = -23.80 SLON = 133.88 SELV = 546.0
 STIM = 1100

	PRES	TMPC	DWPC	DRCT	SKNT	HGHT	HGFT
	961.00	15.60	7.60	130.00	6.99	546.00	1791.00
	1000.00	-9999.00	-9999.00	-9999.00	-9999.00	204.00	669.00
	955.00	18.80	7.80	128.25	10.50	599.65	1967.00
	950.00	19.00	7.00	126.77	13.45	644.88	2116.00
	944.00	18.57	6.81	125.00	17.00	699.32	2294.00
	925.00	17.20	6.20	125.00	16.01	874.00	2867.00
	863.00	11.78	4.89	120.00	12.00	1458.19	4784.00
	850.00	10.60	4.60	125.00	12.00	1586.00	5203.00
	818.00	7.60	4.00	133.39	10.33	1904.48	6248.00
	812.00	8.00	4.40	135.00	10.00	1965.30	6448.00
	805.00	10.40	-14.60	138.21	9.65	2037.08	6683.00
	799.00	12.60	-36.40	140.98	9.35	2099.50	6888.00
	775.00	12.40	-33.60	152.28	8.12	2354.73	7725.00
	707.00	8.00	-31.00	186.31	4.40	3117.11	10227.00
	700.00	7.40	-25.60	190.00	4.00	3199.00	10495.00
	659.00	3.60	-22.40	238.29	2.86	3692.58	12115.00
	617.00	2.40	-35.60	290.98	1.62	4226.22	13866.00
	566.00	-2.73	-36.73	0.00	0.00	4913.93	16122.00
	542.00	-5.30	-37.30	323.31	1.74	5259.30	17255.00
	523.00	-5.90	-41.90	293.09	3.18	5539.39	18174.00
	500.00	-8.90	-44.90	255.00	4.99	5890.00	19324.00
	474.00	-11.50	-53.50	257.90	6.45	6300.12	20670.00
	416.00	-19.96	-51.96	265.00	10.00	7276.58	23873.00
	400.00	-22.50	-51.50	275.00	10.99	7570.00	24836.00
	398.00	-22.82	-51.62	275.00	10.99	7606.71	24956.00
	390.00	-24.10	-52.10	270.67	11.69	7755.43	25444.00
	354.00	-28.94	-58.71	250.00	15.00	8446.84	27713.00
	313.00	-35.10	-67.10	278.92	12.52	9325.62	30596.00
	305.00	-36.69	-68.08	285.00	12.00	9505.29	31185.00
	300.00	-37.70	-68.70	285.00	13.00	9620.00	31562.00
	279.00	-42.14	-70.92	290.00	16.01	10114.71	33185.00
	272.00	-43.70	-71.70	286.53	16.93	10287.92	33753.00
	250.00	-48.10	-73.10	275.00	20.01	10850.00	35597.00
	239.00	-50.30	-74.30	266.46	22.56	11145.16	36565.00
	225.00	-53.25	-73.97	255.00	25.99	11535.98	37848.00
	222.00	-53.90	-73.90	256.95	26.97	11622.88	38133.00
	210.00	-54.96	-73.37	265.00	31.00	11978.11	39298.00
	200.00	-55.90	-72.90	260.00	38.00	12290.00	40322.00
	191.00	-56.48	-75.13	255.00	37.00	12580.55	41275.00
	160.00	-58.70	-83.70	273.32	45.06	13698.12	44941.00
	156.00	-59.90	-84.90	275.94	46.21	13856.40	45461.00
	150.00	-61.50	-9999.00	280.00	48.00	14100.00	46260.00
	149.00	-61.73	-9999.00	280.00	48.00	14141.15	46395.00
	133.00	-65.70	-9999.00	274.95	42.44	14839.99	48688.00
	119.00	-68.21	-9999.00	270.00	37.00	15507.59	50878.00
	107.00	-70.62	-9999.00	245.00	31.99	16145.59	52971.00
	102.00	-71.70	-9999.00	245.00	28.67	16432.83	53913.00
	101.00	-71.50	-9999.00	245.00	27.99	16491.12	54105.00

100.00	-71.70	-9999.00	250.00	25.99	16550.00	54298.00
96.80	-72.70	-9999.00	260.00	24.01	16740.98	54924.00
88.50	-71.30	-9999.00	260.00	26.82	17267.91	56653.00
88.00	-70.88	-9999.00	260.00	27.00	17301.63	56764.00
86.00	-69.18	-9999.00	255.00	29.00	17438.44	57213.00
84.30	-67.70	-9999.00	242.42	23.97	17557.26	57603.00
82.00	-67.88	-9999.00	225.00	17.00	17722.85	58146.00
79.00	-68.12	-9999.00	220.00	8.00	17945.96	58878.00
76.00	-68.37	-9999.00	235.00	15.00	18177.71	59638.00
72.00	-68.72	-9999.00	205.00	12.00	18501.37	60700.00
70.00	-68.90	-9999.00	200.00	12.00	18670.00	61253.00
68.00	-69.54	-9999.00	200.00	15.00	18843.30	61822.00
67.50	-69.70	-9999.00	193.82	14.26	18887.42	61967.00
66.00	-68.63	-9999.00	175.00	12.00	19022.70	62410.00
62.60	-66.10	-9999.00	97.79	11.33	19341.07	63455.00
61.00	-66.67	-9999.00	60.00	10.99	19497.54	63968.00
58.00	-67.79	-9999.00	45.00	10.99	19802.29	64968.00
57.20	-68.10	-9999.00	29.03	8.61	19886.22	65244.00
57.00	-67.84	-9999.00	25.00	8.00	19907.48	65313.00
54.30	-64.30	-9999.00	281.62	4.66	20202.01	66280.00
53.00	-63.66	-9999.00	230.00	2.99	20350.87	66768.00
51.90	-63.10	-9999.00	222.80	4.08	20479.70	67191.00
50.00	-62.10	-9999.00	210.00	6.00	20710.00	67946.00
48.00	-61.20	-9999.00	145.00	10.00	20963.14	68777.00
47.00	-60.74	-9999.00	110.00	10.00	21093.70	69205.00
46.50	-60.50	-9999.00	104.32	9.52	21160.02	69423.00
44.70	-62.50	-9999.00	83.38	7.71	21404.60	70225.00
44.00	-62.13	-9999.00	75.00	6.99	21502.76	70547.00
43.00	-61.60	-9999.00	85.00	13.00	21645.72	71016.00
41.00	-60.49	-9999.00	55.00	10.99	21941.91	71988.00
39.00	-59.32	-9999.00	80.00	12.00	22252.91	73008.00
38.30	-58.90	-9999.00	67.96	12.00	22365.54	73378.00
37.00	-58.73	-9999.00	45.00	12.00	22582.41	74089.00
36.00	-58.59	-9999.00	60.00	6.99	22754.48	74654.00
35.00	-58.45	-9999.00	130.00	8.00	22931.40	75234.00
34.00	-58.30	-9999.00	-9999.00	-9999.00	23113.45	75832.00

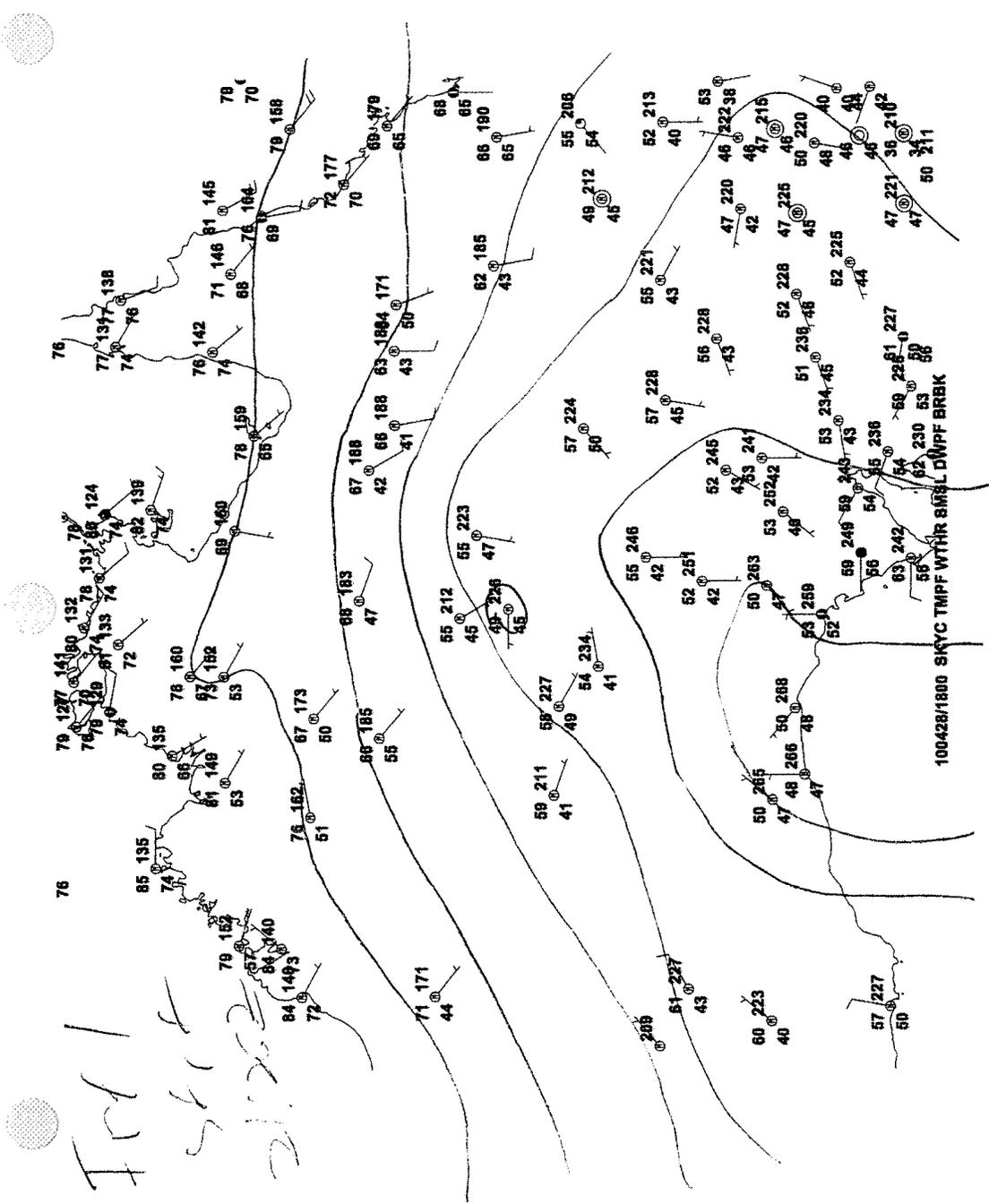
SNPARM = PRES;TMPC;DWPC;DRCT;SKNT;HGHT;HGFT

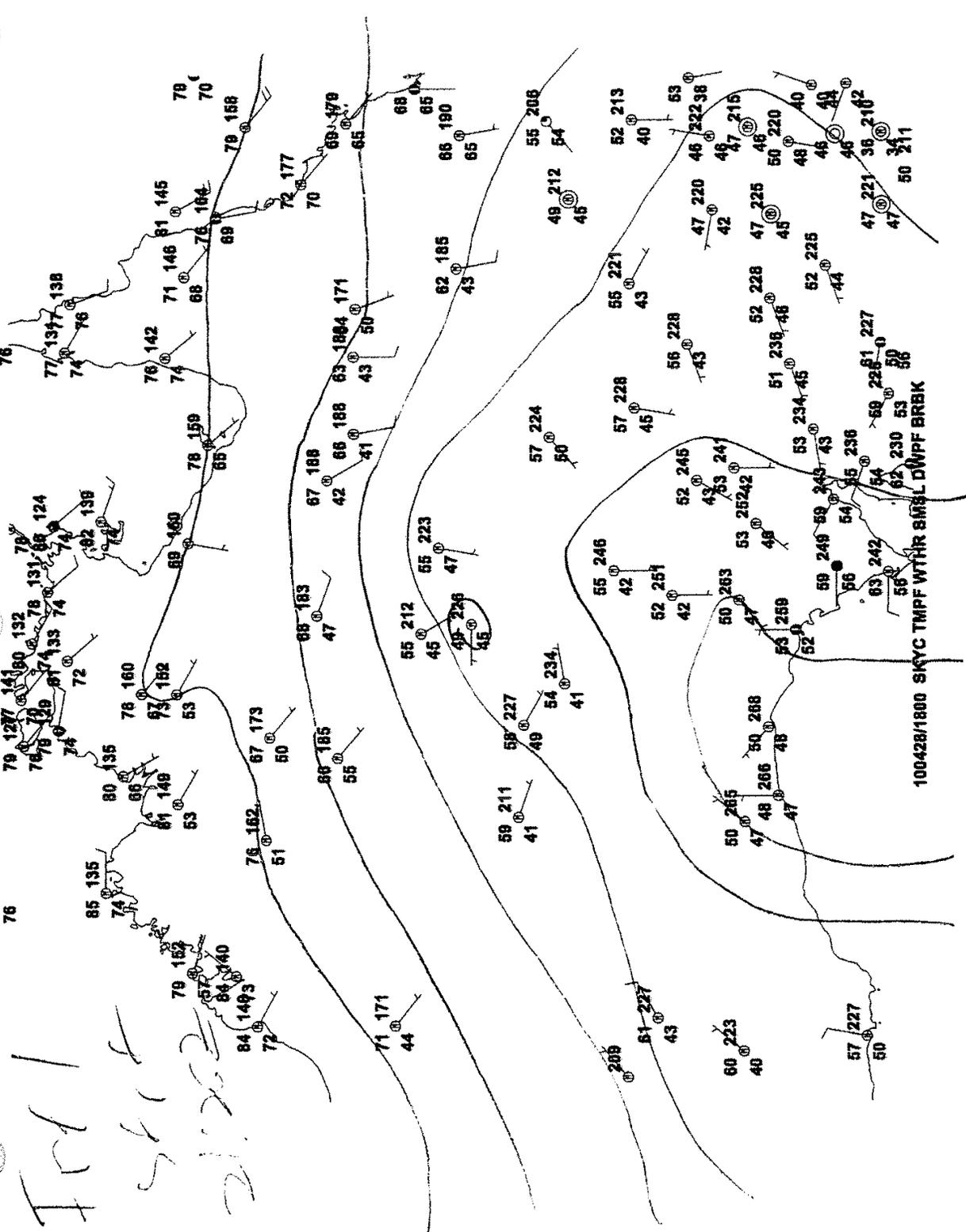
STID = YBAS STNM = 94326 TIME = 100429/0000
SLAT = -23.80 SLON = 133.88 SELV = 546.0
STIM = 2300

	PRES	TMPC	DWPC	DRCT	SKNT	HGHT	HGFT
	962.00	14.80	8.80	0.00	0.00	546.00	1791.00
	1000.00	-9999.00	-9999.00	-9999.00	-9999.00	214.00	702.00
	954.00	13.80	7.80	25.55	2.98	616.24	2022.00
	940.00	15.00	7.00	70.78	8.26	740.61	2430.00
	925.00	14.20	6.20	120.00	14.01	876.00	2874.00
	914.00	13.41	5.96	120.00	14.01	976.16	3203.00
	863.00	9.60	4.80	130.00	17.00	1456.85	4780.00
	855.00	9.60	3.60	133.07	16.39	1534.17	5033.00
	850.00	11.60	-4.40	135.00	16.01	1583.00	5194.00
	847.00	12.60	-16.40	135.45	15.47	1612.59	5291.00
	840.00	14.00	-23.00	136.49	14.21	1682.27	5519.00
	824.00	14.20	-21.80	138.92	11.30	1844.19	6050.00
	817.00	13.95	-23.29	140.00	10.00	1915.83	6286.00
	780.00	12.60	-31.40	154.99	7.90	2305.04	7562.00
	709.00	6.80	-22.20	185.87	3.57	3096.19	10158.00
	700.00	6.60	-19.40	190.00	2.99	3201.00	10502.00
	629.00	3.20	-33.80	334.05	0.46	4072.28	13361.00
	617.00	2.26	-35.15	0.00	0.00	4226.25	13866.00
	546.00	-3.70	-43.70	308.99	7.85	5203.43	17072.00
	528.00	-6.06	-44.16	295.00	10.00	5464.94	17930.00
	508.00	-8.78	-44.68	300.00	10.00	5766.17	18918.00
	500.00	-9.90	-44.90	280.00	10.99	5890.00	19324.00
	495.00	-10.45	-44.35	270.00	12.00	5967.10	19577.00
	491.00	-10.90	-43.90	270.55	12.00	6029.34	19781.00
	460.00	-13.92	-51.06	275.00	12.00	6521.04	21394.00
	435.00	-16.50	-57.20	230.00	15.00	6942.35	22777.00
	413.00	-18.90	-62.90	217.25	18.19	7333.64	24060.00
	401.00	-20.93	-64.01	210.00	20.01	7551.55	24775.00
	400.00	-21.10	-64.10	210.00	20.01	7570.00	24836.00
	362.00	-27.07	-64.17	215.00	16.01	8281.31	27170.00
	346.00	-29.77	-64.20	235.00	18.01	8603.44	28227.00
	300.00	-38.30	-64.30	230.00	19.00	9620.00	31562.00
	293.00	-39.90	-65.90	234.48	20.79	9781.93	32093.00
	270.00	-43.61	-68.58	250.00	27.00	10332.08	33898.00
	250.00	-47.10	-71.10	240.00	23.00	10850.00	35597.00
	248.00	-47.34	-71.31	240.00	22.01	10902.19	35768.00
	226.00	-50.18	-73.72	255.00	27.00	11505.82	37749.00
	200.00	-53.90	-76.90	240.00	31.99	12300.00	40354.00
	185.00	-57.30	-78.30	231.06	37.81	12798.51	41990.00
	168.00	-58.61	-82.33	220.00	45.01	13406.64	43985.00
	155.00	-59.70	-85.70	220.00	39.32	13914.77	45652.00
	150.00	-60.70	-9999.00	220.00	37.00	14120.00	46325.00
	119.00	-67.89	-9999.00	215.00	27.99	15518.90	50915.00
	100.00	-73.30	-9999.00	230.00	21.00	16570.00	54364.00
	97.30	-73.90	-9999.00	225.00	24.01	16729.10	54885.00
	82.00	-71.30	-9999.00	190.00	16.01	17730.48	58171.00
	78.00	-70.54	-9999.00	125.00	10.00	18023.21	59131.00
	77.80	-70.50	-9999.00	123.23	10.00	18038.23	59181.00

71.00	-71.54	-9999.00	60.00	10.00	18576.52	60947.00
70.00	-71.70	-9999.00	55.00	8.00	18660.00	61220.00
68.70	-72.10	-9999.00	9.73	4.76	18770.71	61584.00
68.00	-70.19	-9999.00	345.00	2.99	18831.80	61784.00
67.10	-67.70	-9999.00	318.42	5.06	18911.27	62045.00
65.00	-68.30	-9999.00	255.00	10.00	19102.70	62673.00
61.90	-64.50	-9999.00	232.29	13.03	19399.19	63646.00
59.00	-65.14	-9999.00	210.00	16.01	19691.59	64605.00
55.00	-66.08	-9999.00	150.00	13.00	20119.39	66009.00
53.30	-66.50	-9999.00	140.12	11.68	20310.72	66636.00
50.00	-64.70	-9999.00	120.00	8.99	20700.00	67913.00
41.00	-59.17	-9999.00	75.00	12.00	21927.14	71939.00
40.90	-59.10	-9999.00	72.80	11.96	21942.24	71989.00
39.00	-58.97	-9999.00	30.00	10.99	22240.56	72968.00
37.00	-58.82	-9999.00	80.00	10.00	22570.71	74051.00
35.50	-58.70	-9999.00	-9999.00	-9999.00	22830.25	74902.00

L-7 Surface Observations





Handwritten notes:
 I-1
 site
 site

100428/1800 SAGYC TMPPF WTHR SAGY SAGY DWPFF BRBK

APPENDIX M: Quest for Quotation

M-1 – Request for Quotation

M-2 – Crane Selection Process

M-3 – Purchase Order

**BALLOON LAUNCHING STATION – ALICE SPRINGS AIRPORT
UNIVERSITY OF NEW SOUTH WALES**

CRANE HIRE FOR BALLOON LAUNCHING STATION, ALICE SPRINGS

REQUEST FOR QUOTATION

Description:

The University of New South Wales is seeking to hire a crane for the purpose of launching a series of stratospheric balloon flights carrying scientific instruments, from the Balloon Launching Station, Alice Springs Airport. The balloon launch is a specialised procedure requiring the involvement of a highly trained professional team, one of whom will drive the crane during the launch process. The launches are carried out from the secured area of Alice Springs airport runway 17/35. Up to eight balloon flights will take place between approximately mid-March and end of May 2010. The maximum suspended payload for any flight will be 3.5 tonnes. Because of stringent weather condition requirement, several attempts are sometimes necessary before a successful launch is achieved. Because of the sporadic nature of balloon launches, it is envisaged that the crane will be operated only for short periods. However, it will be required to be on-site for the whole duration of the hire period. The launch area is 600 metres away from the Balloon Launching Station. The picture below shows a DEMAG AC265J crane used in a previous launch from Alice Springs airport.



It will be necessary to fit two pieces of hardware (a) a pair of stabiliser bars, and (b) a launch head unit, to the hired crane to modify it for the launch process. These pieces of hardware were previously constructed to be fitted to a DEMAG AC265J crane without the need for welding or bolting into the chassis of the hired crane. These pieces of hardware will be supplied by the University of NSW, and the fitting will be carried out at the Balloon Launching Station. However, if the existing units do not fit

the hired crane, they will be altered or new ones will be fabricated on site. They are described below:

1. **Stabiliser bars:** The hired crane will be fitted with two stabiliser bars with swivel wheels, one bar on each side and parallel to the crane body. A stabiliser bar is shown in the picture below.



The stabiliser bar is designed so that it can be clamped to the outriggers of the hired crane as shown in the pictures below. The existing stabiliser bars were fabricated for outriggers of cross-section dimensions as follows:

- **Front outrigger** 225 mm wide, 450 mm high, 950 mm distance from top of outrigger to ground;
- **Rear outrigger** 250 mm wide, 600 mm high, 1250 mm distance from top of outrigger to ground. Distance between mid-points of front and rear outrigger: 8520 mm.



2. **Launch head unit:** A specially designed launch head unit is fitted to the end of the boom of the crane. It is designed to be pinned to the crane head using the existing pins and pin holes used for the light boom extension. It has a launch pin at the end pointing away from the crane boom, from which the scientific payload is suspended. It also has a release arm mechanism to release the payload from the launch head unit at launch. The complete unit is shown (on its side) in the pictures below.



The launch head unit is shown in the pictures below in the orientation in which it will be mounted on the boom of the hired crane (left hand picture looking along the boom towards the crane cab, right hand picture looking towards the end of the crane boom).



The stabiliser bars and the launch head unit will be available for inspection at the Balloon Launching Station as per the schedule given below.

Crane vehicle Specifications:

- The crane vehicle must be in very good mechanical condition, and must have good acceleration.
- Vehicle wheelbase length from front axle to rear axle: 6130 mm minimum
- Total vehicle weight: 50 tonnes minimum
- Crane lifting capability: 59 tonnes
- Crane boom: The boom must extend out at least 3.2 metres from the front of the vehicle when at a height of 12.2 metres from the ground
- Period of hire: 1 March 2010 to 15 May 2010, with the option of an extension of hire to 15 June 2010, and of early termination of contract in the event of early completion of the campaign.

- Crane/vehicle operation: A crane/vehicle operator will not be required. The crane will be operated and driven by suitably qualified NASA personnel.
- Amount of anticipated usage: A total crane operation time of 150 hours is anticipated for the hire period, with an average usage of 1.5 hours a day.

Payment terms:

Payment will be made on the submission of fortnightly invoices.

Selection criteria:

Criterion no.	Description	Weighting
1.	Total cost of hire, including delivery to and pickup from site, and options for extending the hire period or for early termination of hire contract	60%
2.	Crane/vehicle technical details, including acceleration and capability	10%
3.	Crane/vehicle history (age, past use, service history)	10%
4.	Maintenance requirements and availability of local technical support in Alice Springs during the hire period.	10%
5.	Ability to use existing stabiliser bars and launch head unit without modification	10%

Quotation Process Schedule:

DATE	ACTIVITY
26 Oct 09	Issue of limited Request for Quotation
9 Nov 09	Meeting from 9.00 a.m. to 10.00 a.m. at the Balloon Launching Station, Alice Springs for questions and any further required clarification, with the opportunity to inspect the stabiliser bars and launch head unit on-site.
20 Nov 09	Deadline for Quotation to be received at UNSW@ADFA
27 Nov 09	Award of contract to successful vendor

Address for site of balloon operations and for delivery of crane:

Balloon Launching Station
 Off Maryvale Road
 Alice Springs Airport
 Alice Springs NT 0870
 Phone: 08 8952 6315
 Fax: 08 8955 5007

Contact for further information and for delivery of your quotation:

Associate Professor Ravi Sood
Station Director, Balloon Launching Station
School of PEMS
UNSW@ADFA
Northcott Drive
Canberra ACT 2600

Phone: 02 6268 8765

Fax: 02 6268 8786

Mobile: 0420 278 508

Email: r.sood@adfa.edu.au (preferred mode of contact)

R. Sood
26 October 2009

MEMORANDUM

TO: MARK VAN POPPEL
MANAGER, FINANCIAL SERVICES
UNSW@ADFA

FROM: RAVI SOOD
SCHOOL OF PEMS

SUBJECT: **HIRE OF LAUNCH CRANE FOR BALLOON LAUNCHES**

27 NOVEMBER 2009

Five companies (see Attachment A) were each invited to quote for the supply of a crane to carry out a series of eight balloon launches from the Balloon Launching Station, Alice Springs during the NASA/CSBF campaign which will take place from Feb to May 10. The specifications, selection criteria and the timetable that were sent out to each company are shown in Attachment B.

Two quotes were received by the deadline of 22 November 09. These were assessed by the selection committee which consisted of the following:

1. Ravi Sood (UNSW@ADFA)
2. Erich Klein (CSBF)
3. Frank Candelaria (CSBF)
4. Jim Rotter (CSBF)
5. Danny Ball (CSBF).

The selection process included a one hour long teleconference on 25 Nov 09. A summary of the submissions is shown as Attachment C.

The DEMAG AC100/4 crane proposed by Tasmanian Heavy Lift was **rejected** due to its insufficient wheel base length (5791 mm vs. 6130 mm minimum specified length)

The LTM 1080/1 proposed by Wanna Lift Crane Hire was **rejected** due to its insufficient wheel base length (5700 mm vs. 6130 mm minimum specified length)

The LTM 1100/2 proposed by Wanna Lift Crane Hire was **accepted** because the crane meets all the requirements for wheel base length, gross vehicle weight and acceleration performance.

I would appreciate it if a Purchase Order could be raised to Wanna Lift Crane Hire as per the attached Request for Purchase Order. Insurance cover for the hire will be provided by CSBF and a copy will be submitted to your office prior to the commencement of the hire period. We will need to wait for the crane details from the supplier before the insurance cover is established.

Thank you for your assistance in this matter.

CRANE HIRE AT THE BALLOON LAUNCHING STATION, ALICE SPRINGS

A. COMPANIES THAT HAVE EXPRESSED AN INTEREST IN BIDDING:

National Crane Hire / McAleese Transport¹

P: 08 8347 4322 08 8347 4602
M: 0418 600 450
19 Opala St, Regency Pk, SA, 5010
Ron Holman [Ron.Holman@mcaleese.com.au]

Wanna Lift? Crane Hire

Russell Delme Enterprise
19 Price St, Alice Springs NT 0870
(08) 8953 5900; 0418 899 916
rdelme@bigpond.net.au

Freo Cranes

1 Mandurah Road
Kwinana WA 6167
NW Area Manager
Ben Pieyre; 08 9419 5444
ben.pieyre@freomachinery.com.au

B. OTHER COMPANIES IN ALICE SPRINGS THAT HAVE THE CAPABILITY OF RESPONDING TO OUR REQUEST FOR QUOTE/TENDER

Sitzler Bros²

52 Smith Street
Alice Springs NT 0870
Tel: +61 8 8952 1855
Email: admin@sitzlerbros.com.au
Managing Director: Michael Sitzler
General Manager: Trevor Jacobs

C. OTHER COMPANIES IN ALICE SPRINGS THAT MAY HAVE THE CAPABILITY OF RESPONDING TO OUR REQUEST FOR QUOTE/TENDER

R & D NT Crane Hire

4 Goyder St
Alice Springs NT 0870
0402 336 516; 08 8953 1907

Ross Engineering³

46 Elder St Alice Springs NT 0870
Ph: (08) 8952 1132
Neil Ross [neil.ross@rossengineering.com.au]

¹ This company supplied the crane previously

² This company was an unsuccessful bidder for Project 2008/4962

³ This company won the contract for Project 2008/4962

ATTACHMENT B

**BALLOON LAUNCHING STATION – ALICE SPRINGS AIRPORT
UNIVERSITY OF NEW SOUTH WALES**

CRANE HIRE FOR BALLOON LAUNCHING STATION, ALICE SPRINGS

REQUEST FOR QUOTATION

Description:

The University of New South Wales is seeking to hire a crane for the purpose of launching a series of stratospheric balloon flights carrying scientific instruments, from the Balloon Launching Station, Alice Springs Airport. The balloon launch is a specialised procedure requiring the involvement of a highly trained professional team, one of whom will drive the crane during the launch process. The launches are carried out from the secured area of Alice Springs airport runway 17/35. Up to eight balloon flights will take place between approximately mid-March and end of May 2010. The maximum suspended payload for any flight will be 3.5 tonnes. Because of stringent weather condition requirement, several attempts are sometimes necessary before a successful launch is achieved. Because of the sporadic nature of balloon launches, it is envisaged that the crane will be operated only for short periods. However, it will be required to be on-site for the whole duration of the hire period. The launch area is 600 metres away from the Balloon Launching Station. The picture below shows a DEMAG AC265J crane used in a previous launch from Alice Springs airport.



It will be necessary to fit two pieces of hardware (a) a pair of stabiliser bars, and (b) a launch head unit, to the hired crane to modify it for the launch process. These pieces of hardware were previously constructed to be fitted to a DEMAG AC265J crane without the need for welding or bolting into the chassis of the hired crane. These pieces of hardware will be supplied by the University of NSW, and the fitting will be carried out at the Balloon Launching Station. However, if the existing units do not fit

the hired crane, they will be altered or new ones will be fabricated on site. They are described below:

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2. **Launch head unit:** A specially designed launch head unit is fitted to the end of the boom of the crane. It is designed to be pinned to the crane head using the existing pins and pin holes used for the light boom extension. It has a launch pin at the end pointing away from the crane boom, from which the scientific payload is suspended. It also has a release arm mechanism to release the payload from the launch head unit at launch. The complete unit is shown (on its side) in the pictures below.



The launch head unit is shown in the pictures below in the orientation in which it will be mounted on the boom of the hired crane (left hand picture looking along the boom towards the crane cab, right hand picture looking towards the end of the crane boom).



The stabiliser bars and the launch head unit will be available for inspection at the Balloon Launching Station as per the schedule given below.

Crane vehicle Specifications:

- The crane vehicle must be in very good mechanical condition, and must have good acceleration.
- Vehicle wheelbase length from front axle to rear axle: 6130 mm minimum
- Total vehicle weight: 50 tonnes minimum
- Crane lifting capability: 59 tonnes
- Crane boom: The boom must extend out at least 3.2 metres from the front of the vehicle when at a height of 12.2 metres from the ground
- Period of hire: 1 March 2010 to 15 May 2010, with the option of an extension of hire to 15 June 2010, and of early termination of contract in the event of early completion of the campaign.

- Crane/vehicle operation: A crane/vehicle operator will not be required. The crane will be operated and driven by suitably qualified NASA personnel.
- Amount of anticipated usage: A total crane operation time of 150 hours is anticipated for the hire period, with an average usage of 1.5 hours a day.

Payment terms:

Payment will be made on the submission of fortnightly invoices.

Selection criteria:

Criterion no.	Description	Weighting
1.	Total cost of hire, including delivery to and pickup from site, and options for extending the hire period or for early termination of hire contract	60%
2.	Crane/vehicle technical details, including acceleration and capability	10%
3.	Crane/vehicle history (age, past use, service history)	10%
4.	Maintenance requirements and availability of local technical support in Alice Springs during the hire period.	10%
5.	Ability to use existing stabiliser bars and launch head unit without modification	10%

Quotation Process Schedule:

DATE	ACTIVITY
26 Oct 09	Issue of limited Request for Quotation
9 Nov 09	Meeting from 9.00 a.m. to 10.00 a.m. at the Balloon Launching Station, Alice Springs for questions and any further required clarification, with the opportunity to inspect the stabiliser bars and launch head unit on-site.
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Address for site of balloon operations and for delivery of crane:

Balloon Launching Station
 Off Maryvale Road
 Alice Springs Airport
 Alice Springs NT 0870
 Phone: 08 8952 6315
 Fax: 08 8955 5007

Contact for further information and for delivery of your quotation:

Associate Professor Ravi Sood
Station Director, Balloon Launching Station
School of PEMS
UNSW@ADFA
Northcott Drive
Canberra ACT 2600

Phone: 02 6268 8765
Fax: 02 6268 8786
Mobile: 0420 278 508
Email: r.sood@adfa.edu.au (preferred mode of contact)

R. Sood
26 October 2009

SUMMARY OF CRANES OFFERED BY VENDORS

Tasmanian Heavy Lifts Pty Ltd: DEMAG AC100

- Wheel base: 5740 mm compared to 6130 mm minimum requirement
- Vehicle weight: 48 tonnes min (12 tonnes per axle); can be loaded to 72 tonnes
- Cost: \$2143 per day
- Mob/demob cost: \$36,000
- History of crane: Date of manufacture ranges from 2001 to 2006. Three cranes available.
- Service and Maintenance : Not included (extra if needed)
- Minimum crane hire period: Hire duration quoted 1 Mar to 15 May, i.e. 76 days. Therefore minimum cost will be \$198,868, plus service costs, plus insurance
- Extension of hire period: not addressed.

Wanna Lift Crane Hire Liebherr LTM1100/2

- Wheel base: 7240 mm compared to minimum 6130 mm
- Vehicle weight: 60 tonnes minimum, 12 tonnes per axle, can be loaded to > 70 tonnes
- Cost: \$2200 per day
- Mob/demob cost: \$60,000
- History of crane: Average age of 4 years, hired from Melbourne
- Maintenance: day to day check-up included. Service not required during hire period
- Minimum hire: 8 weeks. Therefore, minimum cost for 8 weeks (56 days) would be \$183,200. Comparative cost for 76 days would be \$227,200.

Wanna Lift Crane Hire Liebherr LTM1080/1

- Wheel base: 5700 mm compared to minimum required 6130 mm
- Vehicle weight: 48 tonnes (12 tonnes per axle), can be loaded to > 55 tonnes
- Cost: \$2000/day
- Mob/demob costs: \$48,000
- History of crane: Average age of 4 years, hired from Melbourne
- Maintenance: day to day check-up included. Service not required during hire period
- Minimum hire: 8 weeks. Therefore, minimum cost for 8 weeks (56 days) would be \$160,000. Comparative cost for 76 days would be \$200,000.

Requested By: <u>R. Sood</u>		Date Requested: <u>27 Nov 09</u>		Room number: <u>110</u> Phone Extn: <u>88765</u>					
Job Number: _____		Budget No: _____		Supervisors signature: _____					
Availability: Ex Stock _____ Days/Weeks		Delivery Date: <u>1 Mar 2010</u>		Are Material Safety Data Sheets Required YES <input type="checkbox"/> NO <input checked="" type="checkbox"/> _____ <small>(signature required)</small>					
QUOTATIONS <small>(PER PURCHASING GUIDELINES)</small>				If quotation procedures haven't been met per UNSW Accounting Manual Section 11.2.4 please tick reason(s)					
Supplier		Price		Date					
1. See attached Memo.									
2.									
3.									
Other									
Brief justification for purchase when quotation procedures haven't been met:									
Item	Business Unit	Account Code	Fund Source	Dept ID	Program	Class	Budget Yr.	Project/Grant	
1	UNSWA		RE949	Z7001	0 0 0 0	0 0	2009	RM01538	
2					0 0 0 0	0 0			
3					0 0 0 0	0 0			
4					0 0 0 0	0 0			
5					0 0 0 0	0 0			
6					0 0 0 0	0 0			
7					0 0 0 0	0 0			
8					0 0 0 0	0 0			
9					0 0 0 0	0 0			
10					0 0 0 0	0 0			
Comments:									
FUNDING APPROVAL						Asset: YES <input type="checkbox"/> NO <input checked="" type="checkbox"/>		Location:	
This request approved and declared free of any conflict of interest (as defined in the UNSW Staff Code of Conduct and quotation requirements have been met:						Build in to existing asset:		Disposal of asset:	
Delegates Signature:						Location:		Asset Description	
Surname (Print):						Tag #		Serial #	
Date:						Comments:		Tag # NB: Asset Disposal form to be lodged	
FUNDING: Tick one box only <input type="checkbox"/> Central <input type="checkbox"/> Admin <input type="checkbox"/> Education <input checked="" type="checkbox"/> Research <input type="checkbox"/> Other Name: <u>R. Sood</u>									

Appendix N: Evidence Listing

ITEM	LOCATION	ACTION	DATE	Reason
TM GSE CONFIGURED FOR NCT	OLD PAYLOAD BUILDING	Released		Video shows functional/DBR
MINI-SIP WORKSTATION	OLD PAYLOAD BUILDING	Released		Video shows functional
85' BI-FILAR FLIGHT CABLE LADDER (STEEL)	NEW PAYLOAD BUILDING	Released		Video shows functional
TRUCK PLATE ASSEMBLY W/PARTIAL SAFETY CABLE	NEW PAYLOAD BUILDING	Send to Goddard		
SAFETY CABLE PEAR RING AND CABLE REMNANTS	LAUNCH CRANE HEAD	Send to Goddard		
LAUNCH CRANE W/SAFETY CABLE PEAR RING ATTACH	SECURE YARD AS BLS	Send to Goddard		
TRI-PLATE (ATTACHMENT TO SCI ROTATOR)	NEW PAYLOAD BUILDING	Released		
BALLOON COLLAR AND RECEIVER	NEW PAYLOAD BUILDING	Released		
120 PARACHUTE (INTACT)	NEW PAYLOAD BUILDING	Released		
REMOTE FIRING UNIT (UTP)	PARACHUTE TOP	Released		Video shows functional
MINI-SIP (SUPPORT INSTRUMENT PACKAGE)	NEW PAYLOAD BUILDING	Released		Video shows functional
UNIVERSAL TERMINATE PACKAGE (UTP)	NEW PAYLOAD BUILDING	Released		Video shows functional
PARACHUTE CUTAWAY MECHANISM	NEW PAYLOAD BUILDING	Released		Video shows functional
GONDOLA AUTOMATIC PARACHUTE RELEASE (GAPR)	NEW PAYLOAD BUILDING	Released		
EXTERNAL CABLING (UTP/MINI SIP/CIP/PARACHUTE)	NEW PAYLOAD BUILDING	Released		
VIDEO DATA TRANSMITTER (CSBF)	NEW PAYLOAD BUILDING	Released		
SCIENCE DATA TRANSMITTER (CSBF)	NEW PAYLOAD BUILDING	Released		
CONSOLIDATED INSTRUMENT PACKAGE (CIP)	NEW PAYLOAD BUILDING	Released		
ACCELEROMETER (TOP PAYLOAD MOUNTED)	NEW PAYLOAD BUILDING	Find data		
BATTERIES: UTP/M-SIP/CIP	NEW PAYLOAD BUILDING	Determine damage		
PV PANELS (2EA) PIGGYBACK FOR MPT CHG. CONT.	NEW PAYLOAD BUILDING	Released		
3 HELIUM TUBE RACK UNITS W/HEISE GAUGES	SECURE YARD AS BLS	Released		Readings verified
NCT INSTRUMENT COMPONENTS	SEA CONTAINER AS BLS	Released		
NCT GONDOLA REMNANTS	NEW PAYLOAD BUILDING	Released		
DOCUMENT - DAVIS WX SURF. OBS.	WX FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - SURFACE CHARTS	WX FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - PIBAL READINGS (1-4)	WX FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - WX FORECAST & METEOROLOGIST OBS	WX FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - (MECHANICAL) RIGGING RECORDS	OPERATIONS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - RECOVERY INSTRUCTIONS	OPERATIONS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - RECOVERY FORM	OPERATIONS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - ADD'L RIGGING DATA	OPERATIONS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - POST FLIGHT HELIUM TRAILER MEASURE	OPERATIONS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - POST FLIGHT GAGES & SCALES CHECK	OPERATIONS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - 01 CIP PACKING LIST & COMPAT CHECK	ELECTRONICS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - 02 ELECTRONICS PRE-FLIGHT CHECK L	ELECTRONICS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - 03 TM GSE CONFIGURATION SHEET	ELECTRONICS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - 04 FLIGHT LINE CHECKLIST	ELECTRONICS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - 05 UTP PACKING / CHECK LIST	ELECTRONICS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - 06 UTP/GAPR PRE-FLIGHT CHECK LIST	ELECTRONICS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - 07 UTP/RFU ENVIRONMENTAL RECORD	ELECTRONICS FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - REVISED FLIGHT PLAN	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - PRE-FLIGHT MINIMUM SUCCESS	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - LOAD ALTITUDE CURVE	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - GONDOLA CERTIFICATION	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - FLIGHT REQUIREMENTS	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - ELECTRONIC CERTIFICATION	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - RISK ANALYSIS REVIEW	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - BALLOON SPECIFICATION (AEROSTAR)	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - LAUNCH EQP. CONFIG. CERT. (LECC)	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - QUICK LOOK REPORT - POST ABORT	CAMPAIGN MANAGER FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - AUSTRALIA CONTACT / WITNESS LIST	BPO FILES FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - GROUND SAFETY PLAN	BPO FILES FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - PROCEDURES, ELECTRONICS FAILURE	BPO FILES FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - KEY PERSONNEL LIST	BPO FILES FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - BALLOON MISHAP APPOINTMENT MEMO	BPO FILES FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - NCT MISSION PROJECT PLAN	BPO FILES FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - NCT QUICK LOOK REPORT (POST ABOR	BPO FILES FOLDER	Send to Goddard	5/15/2010	
DOCUMENT - FLIGHT APPLICATION, NCT	BPO FILES FOLDER	Send to Goddard	5/15/2010	
VIDEO DOCUMENT - ALL AVAILABLE VIDEO FILES	VIDEO FOLDER	Send to Goddard	5/15/2010	
STILL PHOTOS - ALL AVAILABLE PHOTOGRAPH FILES	PICTURES FOLDER	Send to Goddard	5/15/2010	
WITNESS STATEMENTS (UP TO 5/7/10)	SECURE FOLDER	Send to Goddard	5/15/2010	

Appendix O: Export Control Evaluation

Export Control Review

August 26, 2010

Columbia Scientific Balloon Facility

1510 E FM 3224, Palestine, Texas 75803, 903-729-0271

The Columbia Scientific Balloon Facility (CSBF), located in Palestine, Texas, is a NASA facility managed by the Physical Science Lab of New Mexico State University. The contract to manage the facility is administered by the Balloon Program Office at Wallops Flight Facility of Goddard Space Flight Center (GSFC).

CSBF provides the services of launching large (400 ft. diameter), unmanned, high altitude (120,000 ft.), research balloons; tracking, and recovering the scientific experiments suspended beneath them, for NASA centers and universities from all over the world. Scientists use scientific data collected during balloon flights to help answer important questions about the universe, atmosphere, the Sun and the space environment. Questions such as "How did the universe, galaxies, stars, and planets form and evolve?" and "Are there Earth-like planets beyond our solar system?" are being answered by NASA with the help of experiments flown on these scientific balloons.

Standard NASA scientific balloons are constructed of polyethylene film; the same type material used for plastic bags. This material is only 0.002 centimeters (0.0008 inches) thick, about the same as an ordinary sandwich wrap. The film is cut into banana-peel shaped sections called gores and heat sealed together to form the balloon. Up to 180 gores are used to make NASA's largest balloons. These standard, zero-pressure, balloons are open to the atmosphere at the bottom to equalize the internal pressure with the surroundings. The balloon system includes the balloon, the parachute and a payload that holds instruments to conduct scientific measurements.

Helium, the same gas used to fill party balloons, is used in NASA balloons. These very large balloons can carry a payload weighing as much as 3,600 kilograms (8,000 pounds), about the weight of three small cars. They can fly up to 42 kilometers (26 miles) high and stay there for up to two weeks. The balloon is launched by partially filling it with helium and launched with the payload section suspended beneath it. As the balloon rises, the helium expands, filling the balloon until it reaches float altitude in two to three hours.

The CSBF contracted with the University of New South Wales to operate the Alice Springs Balloon Launching Centre at the Alice Springs International Airport. The balloon launch campaign in question was conducted in April 2010. The payload for the launch attempt on April 29th, 2010 was the Nuclear Compton Telescope (NCT). The NCT is a balloon-borne soft gamma-ray (0.2-15 MeV) telescope designed to study astrophysical sources of nuclear line emission and gamma-ray polarization. The NCT Program was sponsored by NASA and by

NSPO of Taiwan in collaboration with the Space Science Laboratory of University of California (UC) Berkeley.

Analysis

These scientific balloons are expansive balloons filled with helium and are not listed under the ITAR (Category VIII) or under any specific ECCN on the CCL; they are therefore classified as EAR 99. They are commercially available products. The NASA Sounding Rocket Program contracts with the Columbia Scientific Balloon Facility (CSBF) in Texas, which purchases these balloons for NASA. CSBF manages the balloon launching operations and contracted with the University of New South Wales (NSW) in Australia for the launch operations for the Nuclear Compton Telescope (NCT). NSW manages the balloon launch facility in Australia and provided the commercially available crane that was used for this balloon launch. The interface between the balloon, the payload, and the crane was provided by the CSBF. The payload was provided by the University of California at Berkeley under a NASA Grant. The Grant stipulated no pre-review requirements and encourages the public distribution of the science from these missions, without controls. The payload was developed with international students and extensive information concerning the payload has been published in the open literature. The balloon launch operations are conducted in an open forum and the public is able to photograph these operations. In fact, a documentary on the balloon launch operations that shows the details of the launch operations was shown in 2006/2007 on the Discovery Channel.

Summary

These balloons are commercially available, the crane is commercially available, the scientific payload was developed at a university in a publicly available forum, and the launch operations are not secluded and are available for public viewing. There is minimal information about the balloons, the crane, and the NCT in this report; there is far more extensive information publicly available on the NCT than is included in this report. The interface between the crane, the payload, and the balloon uses standard industrial design, involving a pin and cables, with no high technology involved. The report details launch operations and procedures, which have been extensively documented and photographed, with both still photography and videos.

Therefore, I do not believe that there is any export control concerns with this Mishap Investigation Board (MIB) Report. I recommend that from an export control perspective that this report is approved for public release; this only speaks to the export control concerns and does not address other reasons that the report may be limited in its distribution, which must be addressed separately. Proprietary information must be protected and only released upon approval of the owner.