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# MEMORANDUM

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Date: July 12, 2018

To: The Honorable Chairman and Members  
Pima County Board of Supervisors

From: C.H. Huckelberry  
County Administrator

A handwritten signature in black ink, appearing to be "CHH", is written over the printed name "C.H. Huckelberry".

Re: **World View Incident Investigation Report**

On December 19, 2017, World View Enterprises experienced a balloon rupture incident during testing activities. An investigation panel was assembled to review the data from this incident to determine a cause and delineate any necessary steps to mitigate any further occurrences of this type.

On February 12, 2018, World View Enterprises assembled an Independent Incident Review Team (IIRT) led by Mr. Wayne Hale, Director of Human Spaceflight for Special Aerospace Services, LLP and comprised of experts in the aerospace field. I appointed Assistant County Administrator John Voorhees, a retired United States Air Force pilot with accident investigation experience to oversee the investigation on behalf of Pima County (Attachment 1).

Shortly after the IIRT's assembly, Mr. Voorhees provided some expected guidance to World View Enterprises for the conduct of the investigation (Attachment 2). For the most part, the expectations listed in the email were met by either the report or telephonic and in-person conversations.

The IIRT conducted a five-day review of the incident site and data associated with the incident, to include interviews with the operators. The IIRT concluded its investigation by providing World View Enterprises at least six "*Findings*" (some are conclusions and some are recommendations) in a publicly releasable Independent Incident Review Team Report dated May 15, 2018 in Attachment 3. The IIRT also compiled a more in-depth report for the internal use of World View Enterprises.

On May 21, 2018, World View Enterprises provided a summary report of their investigation (Attachment 3). Pima County staff have reviewed the attached reports and Mr. Voorhees also relayed his own observations that are included in this memo.

According to Mr. Voorhees, the releasable report contains sufficient information to draw the proper conclusions regarding the mishap sequence, causes, and recommendations. The investigating team provided ample information to World View Enterprises to take the

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appropriate steps to mitigate the risk of any future occurrence of similar type. The report did not recommend any action to be taken by Pima County to mitigate risk to its facilities.

On July 10, 2018, Pima County Facilities Management performed an inspection of the building repairs. This was the final act needed to close out the County's interest in the investigation. The damage to the facility was characterized as significant but superficial. There was no structural damage to the building. The damage to the facility was completely repaired and the building has been restored to full operational capability.

According to Mr. Voorhees, World View Enterprises followed all standard practices for incident reporting. Tucson Fire Department was already on the scene as a safety observer, performed immediate fire-fighting operations and a building safety inspection following the incident. The National Transportation Safety Board (NTSB) and the Occupational Safety and Health Administration (OSHA) were also notified in accordance with workplace mishap regulations.

Mr. Voorhees noted that the timeline to investigate the incident was protracted. Similar aviation mishaps are generally resolved within 30-60 days from the incident date. In spite of this, there was no evidence of wrongdoing in either the mishap, the reporting process, or the investigation timeline.

One of the recommendations of the IIRT was to appoint a fulltime professional safety director for the company. World View Enterprises has hired a fulltime Director of Safety who will focus on the continuous improvement of the company's safety program. World View Enterprises has demonstrated its commitment to be a good neighbor in the Aerospace Parkway by operating a safe and effective aerospace company.

CHH/lab

Attachments

c: Jayne Poynter, CEO, World View Enterprises, Inc.  
Dr. John Moffatt, Director, Economic Development Office

# ATTACHMENT 1



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# MEMORANDUM

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Date: February 8, 2018

To: The Honorable Chairman and Members  
Pima County Board of Supervisors

From: C.H. Huckelberry  
County Administrator

A handwritten signature in black ink, appearing to be "CHH", is written over the printed name "C.H. Huckelberry".

Re: **World View Balloon Rupture on December 19, 2017**

Supervisor Miller placed an item on the Board of Supervisor's meeting agenda for February 6, 2018 regarding the above-referenced matter; unfortunately, she did not request information readily available to answer her questions. This memorandum will respond to her January 12, 2018 written memorandum (Attachment 1) as well as any oral discussion that took place at the meeting.

The President and CEO of World View, Jane Poynter and Chief Technology Officer Taber MacCallum, both attended the February 6, 2018 meeting to answer any questions the Board may have regarding World View.

1. Investigation of Balloon Rupture

World View has commissioned an independent investigation to be conducted by a board of world-class experts in aerospace and aviation incident investigation. The investigation has begun and the County will be a participant to verify the independence of the investigation body. The board is led by Mr. Wayne Hale, a former National Aeronautics and Space Administration (NASA) Space Shuttle program manager and one of the most highly regarded experts in aerospace safety in the world. Additional investigation board members will not be named at this time, in deference to the integrity of the process and will be available upon publication of the final report. Mr. Hale's brief experience associated with this review is as follows:

- Mr. Hale retired from NASA on July 31, 2010 as the Deputy Associate Administrator of Strategic Partnerships, Space Operations Mission Directorate. He has previously served as the Space Shuttle Program Manager and the Shuttle Launch Integration Manager. Wayne was a Space Shuttle Flight Director for 40 Space Shuttle flights, and prior to that a Propulsion Officer for 10 early Space Shuttle flights.
- Mr. Hale has received special honors and awards such as NASA Outstanding Leadership Medals in 1999, 2005, and 2007; NASA

Space Flight Awareness Leadership Award 2002; NASA Exceptional Service Medal 1992; National Space Club Goddard Memorial Astronautics Engineer of the Year 2007; and National Air and Space Smithsonian Achievement Award of the Year 2007.

- Mr. Hale holds a Bachelor of Science in Mechanical Engineering from Rice University and a Master of Science in Mechanical Engineering from Purdue University.

In addition, Pima County's representative and individual who will closely review this investigation is John Voorhees, Assistant County Administrator. Mr. Voorhees is uniquely qualified to represent the County in this matter, as he is a retired senior United States (US) Air Force officer with significant command experience as well as accident investigation experience. He is a US Air Force training flight safety officer with certification equivalent to National Transportation Safety Board and Federal Aviation Administration investigators.

2. Damages to the leased World View Building owned by Pima County

Immediately after the balloon ruptured, Facilities and Risk Management staff inspected the facilities and documented the damage that is primarily superficial. All damage will be fully repaired at no cost to Pima County. In fact, World View and Pima County received the first check for property damage repair from the insurance carrier for \$200,000. An architectural firm and an engineering firm have been retained by World View to identify repairs required as a result of the accident. Both firms will monitor the repair work until completed and final approval issued by the insurance company, World View and Pima County. There have been no claims filed by any other party for damage that may have been sustained due to the rupture. Attachment 2 is a Facilities Management Report of the damages. Attachment 2A is a field report from Schneider Structural Engineers. Attachment 2B is a summary report from Swaim Associates LTD, of the damage to the building.

3. Damages to Surrounding Properties

The County has not received any claims of damages from surrounding property owners.

The Raytheon Airport Site facilities sustained minor damage and disruptions in business operations as a result of the incident. Additionally, Raytheon continues to be concerned about the World View "Test Planning" process and the safety reviews/oversight of those test plans for activities on the "Launch Pad". We have committed to work directly with the World View team to communicate and address

Raytheon's concerns and World View leadership has been supportive of that partnership.

4. Injuries

There were no reported injuries based on the balloon rupture. As is standard World View practice both the Tucson Fire Department and Tucson Police Department were onsite for the testing activity that led up to the balloon rupture. Following standard protocol, World View had also notified the Tucson Airport Authority, Federal Aviation Administration and Raytheon among others, of the test. We understand three employees complained of ringing in their ears, however there have been no other reported injuries at the time of the accident nor any since. Any expenses related to the employees would be covered by World View's workers' compensation insurance. No medical claims or referrals have been made to any medical provider by Pima County as a result of the balloon rupture.

5. State Review

The Arizona Division of Occupational Safety and Health (ADOSH) conducted an investigation of the incident and issued no citations or violations of safety regulations. The case review by ADOSH closed on January 4, 2018. Risk Management contacted ADOSH to confirm that the listed Inspection Detail (Attachment 3), Inspection Number 1285260.015, is available on the US Department of Labor-OSHA website at <https://www.osha.gov/pls/imis/establishment.html>.

6. Hazardous Materials Stored on Property or used in the Operations, including hydrogen gas

The Environmental Protection Agency (EPA) and Arizona Department of Environmental Quality (ADEQ) regulations do not apply to storage, use, or release, of hydrogen gas. Their regulations pertain to air quality and management of hazardous waste. Hydrogen gas is not subject to these regulations and is not considered an air pollutant or a hazardous waste.

The Clean Air Act regulates the accidental release, prevention/risk management plan rule to hydrogen and is applicable if hydrogen is stored or used at the facility if the total quantity of hydrogen exceeds 10,000 pounds. This would require at least 13 fully loaded standard hydrogen tube trailers to exceed this weight of hydrogen. Photos available show less than this quantity of hydrogen present at the site.

Department of Transportation hazardous material regulations apply to the transportation of materials to the site and therefore are not applicable under the use or storage section of the County contract, Section 7.3.1, requires written consent for hazardous materials, "other than such hazardous materials that are necessary or

useful to WV's business..." Hence, written consent for the use of hydrogen is not required; as it is used as part their business.

We are not aware of any regulated hazardous materials present at the site that would require written consent from the County.

7. Insurance

The following information is regarding certificates and/or evidence of insurance (Attachment 4), both liability and property, that are in place for World View Enterprises:

- Commercial General Liability Insurance is listed as \$5 million for each occurrence; including no-fault medical expense coverage for \$5,000 per person; and personal and injury insurance t \$3 million per occurrence.
- Workers Compensation Insurance as required by Arizona statue for coverage by employer for any employee's work related injury and Employers' Liability Insurance with policy limits of \$1 million for each accident and for each employee.
- Property Insurance coverage for replacement cost of the building with the insurance value of \$12.2 million and the SpacePort insured at \$2.2 million. Pima County is also a loss payee. Policy also includes insurance coverage for World View's business personal property with limits of \$3 million.

In addition, the replacement cost of the building is insured at \$12.2 million; SpacePort insured at \$2.2 million; and Business Personal Property insured at \$3 million with Pima County as a Loss Payee on the policy.

8. Vehicles

There were no County vehicles used at the World View facilities. World View vehicles are all gasoline or diesel, with internal combustion engines.

9. Related Economic Development benefits of World View

The location of World View kicked off a number of space related businesses seeking to relocate or expand in Pima County. Vector Space was a direct attraction initiated by World View senior management's meetings with Vector that included positive comments on the County's support and the development of the Aerospace Research Campus. World View's customer list includes the "Who's Who" of the space business with many coming to Spaceport Tucson to collaborate on and participate in mission development and launches.

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World View's industry presence and reputation has generated numerous visits to Tucson for technical and operational discussions. The Federal Aviation Administration's Office of Commercial Space Transportation held a discussion related to the management of the airspace at World View with a wide range of attendees.

The annual meeting of the Commercial Spaceflight Federation (CSF) was held at World View in 2017 exposing World View, Spaceport Tucson and the Aerospace Research Campus to the world's leaders in space exploration. Executive members of the CSF include commercial spaceflight developers, operators and spaceports. Associate members include suppliers supporting commercial spaceflight, with recent members including suppliers of mission support services and suppliers of training, medical and life-support products and services.

One of the CSF Associate Members is BRPH, an engineering and consulting firm based in Florida with contracts across a wide range of space-oriented facilities. BRPH has referred a number of space-focused companies and investors to the Aerospace Research Campus including two national developers that proposed to build the Vector headquarters and manufacturing facility as well as other prospects.

Since announcing World View, Pima County and Sun Corridor, Inc. have proposed the Aerospace Research Campus to seven space related companies. More importantly, we are currently in discussions with a microsatellite and rocket manufacturing company looking to expand in the West. The concentration of space related companies like Raytheon, World View, and Vector, as well as the leadership of The University of Arizona in space exploration, and our excellent workforce, make the Aerospace Research Campus an attractive location for other companies. World View's international reputation has been a major source of attraction and awareness for the Aerospace Research Campus.

#### Summary

I have visited the World View headquarters at least twice since the accident and can confirm that the reports of superficial damage are accurate and that repairs are either underway or have been completed and financed with insurance proceeds. Upon completion of the independent investigation, the accident review board will submit details of its findings and recommendations to World View to ensure no such incident can or will occur in the future. This report will be made available to Pima County for our information and comment. World View staff and personnel have always demonstrated a significant commitment to safety and professionalism, in particularly how they have handled this incident. We very much appreciate having an innovative aerospace company such as World View call Tucson home.

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World View is a high economic development source. They have grown rapidly from 44 employees in March of 2017 to 72 employees earning an average wage of \$73,738 in December of 2017 with 20 unfilled positions ready for qualified employees. Finding software, mechanical and electrical engineers continues to be a challenge for World View.

CHH/lab

Attachment

c: Jane Poynter, President and CEO, World View Enterprises, Inc.  
Taber MacCallum, Chief Technology Officer, World View Enterprises, Inc.  
Dr. John Moffatt, Director, Economic Development  
Tom Burke, Deputy County Administrator for Administration  
Lisa Josker, Director, Facilities Management  
Lauren Eib, Risk Manager, Finance and Risk Management

# ATTACHMENT 2

## John Voorhees

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**From:** John Voorhees  
**Sent:** Thursday, February 15, 2018 12:27 PM  
**To:** Maricela Solis  
**Cc:** John Moffatt  
**Subject:** Investigation of 19 December 2017 incident  
**Attachments:** bd-WV Balloon Rupture.pdf

Maricela,

Hope all is well in World View. I apologize for missing the Feb 6 Board of Supervisors' meeting (had a family issue). Sounds like things went very well and all of the Supervisors' questions were answered adequately. Per the memo attached Mr. Huckelberry has tasked me to 'ride shotgun' on your internal investigation on behalf of Pima County. I have absolutely no desire to influence the outcome of the investigation (or even get involved in the investigatory process). However, I believe there are certain touchpoints where Pima County as the landlord should have awareness. With that, here are some County expectations:

1. I will liaison with the senior investigator on any investigatory matter related to the County's interest. In other words, if there are findings in the investigation that might impact the County's business (something was wrong with the building, infrastructure, launch pad,...) I'd like the investigator to out-brief the County before the final report is released. As long as we're kept in the loop about any developments I will maintain a passive role and await an out-brief.
2. I would expect the County to receive a written publicly releasable (ie sanitized) incident investigation report. The report should cover:
  - a. investigator qualifications
  - b. investigation methodology (what did they examine and why)
  - c. mishap crew details (no names, but years of experience, qualifications/certifications hours on shift at the time of the mishap)
    - i. supporting crew details (how many fire fighters, notifications to other agencies)
  - d. mishap vehicle details (no proprietary information-just a description of the mishap balloon and servicing equipment [time in service, inspection currency-as applicable])
  - e. mishap supporting equipment details (servicing history, certifications,...)
  - f. mishap timeline/sequence
    - i. planning
    - ii. briefings (to include any safety briefing topics discussed prior to the mishap)
    - iii. mission operations (what time was the balloon inflated, any non-proprietary information about how the testing went)
    - iv. deflation timeline
    - v. incident time
    - vi. post incident safety measures (notifications, cleanup, securing of evidence,...)
    - vii. immediate debrief and aftermath
  - g. injuries
  - h. damage to facilities
  - i. mishap observations – without divulging "safety privileged information" explain the basic cause and effect of the mishap
  - j. Findings – (usually "privileged" information and not included in a basic mishap report). I would expect the investigator to provide this to you for mishap prevention

- k. Contributing factors – (again usually privileged) not directly related to the cause and effect of the mishap sequence, but may have impacted the characteristics of the mishap or contributed to the mishap sequence development.
  - l. Other areas of note – sometimes an investigation into one area reveals deficiencies in other areas.
  - m. Conclusions and recommendations – (usually falls into the ‘safety privileged’ arena). Again the County would expect a sanitized version of the investigator’s recommendations.
3. If there are procedures and processes already in place to mitigate any new risk to life or property, the County would like to see those measures.
  4. If there are privileged items that are not publicly releasable but pertinent to our lease relationship the County would expect to be briefed on these findings/items of interest. Having held a formal certification as a mishap investigator I fully understand the need to safeguard and maintain the confidentiality of safety privileged information. I can be a liaison for this information.
  5. Unless it has a direct relationship to our tenant agreement I have no expectation of World View to reveal proprietary information. Our interest is not to know everything World View does. But, like you, we wish to protect our investment.
  6. Though the report will probably not reach the depth of the reports traditionally accomplished by the FAA, NTSB, or military; there are templates and examples available that may provide a decent backdrop from which to write a report. Let me know if I can help provide anything.

Our goal is to mitigate any and all identified risks to Pima County. To that end I wish to work with you and the involved staff. Thanks for your accommodation.

V/R,

**John “Dutch” Voorhees**

Assistant County Administrator

Pima County, Arizona

# ATTACHMENT 3



May 21, 2018

Chuck Huckleberry  
Pima County Administrator  
130 W. Congress St.  
Tucson, AZ 85701

Dear Administrator Huckleberry:

World View Enterprises has concluded the formal review of the incident that took place on December 19, 2017, at the Tucson Spaceport facility, and has implemented a number of organizational and procedural changes based on the findings and recommendations of an Independent Incident Review Team.

On December 21, 2017 World View management-initiated plans for a thorough and independent review of the technical and organizational causes by a panel of independent aerospace experts led by N. Wayne Hale. Beginning on February 12, 2018, the Independent Incident Review Team (IIRT) conducted a five-day intensive review consisting of on-site data collection, hardware review, and personnel interviews. In addition to finding the proximate technical and organizational causes of the mishap, the IIRT was mandated to review company safety practices and culture to provide recommendations for improvements in those areas.

In response to the incident review and the report of the team detailing key findings and recommendations, World View has enacted several organizational and operational changes necessary for safe and reliable utilization of its evolving operation and capability. Principally among those changes was the hiring of a full-time, globally recognized Director of Safety, Dr. Tony Kern. Dr. Kern has already begun his employment with World View and is responsible for the continuous improvement and implementation of all safety programs and processes, instilling World View with the highest culturally safety standards, and ensuring the organization's overall commitment to safety excellence during all activities and operations. Dr. Kern is one of the world's leading authorities on human performance in time constrained, error intolerant environments. He has authored seven books on human performance, has previously served as the Chairman of the U.S. Air Force Human Factors Steering Group, the National Aviation Director for the U.S. Forest Service, and as the CEO of Convergent Performance, a think-tank dedicated to reducing human error and improving performance in, among other fields, aviation safety and operations.



**WORLD VIEW**

In addition to hiring Dr. Kern, World View has already implemented numerous changes to its safety culture and operations. World View is working diligently to improve its risk assessment models for all future mission operations, utilizing industry standard tools and peer review methodology. World View has engaged with an independent consultant to improve its already disciplined and rigorous safety standards and training procedures for employee handling of lift gas. World View is expanding corporate safety training, procedures, and the strict enforcement of all standards surrounding the use of Personal Protective Equipment (PPE) for all appropriate personnel. World View has already implemented accountability processes, work time rules, and human resources policies for all mission operations. In addition, and in line with the overall maturing of our organization following our most recent financing round, we have implemented the IIRT's recommendation to establish a Mission Operations organization separate from R&D, which is now formally led by retired NASA Astronaut Col. Ron Garan, who has decades of experience in aviation and spaceflight operations excellence. He is Senior Vice President of Mission Operations and reports to the CEO of World View.

With guidance and oversight from the IIRT, World View management has worked diligently and objectively to fully dissect and understand the cause and various effects of December's operations mishap and how we might prevent such an event from occurring again in the future. Our team is committed to and already well on its way to implementing the recommendations of the IIRT in pursuit of operational and safety excellence.

In addition to addressing the specific recommendations of the IIRT, World View swiftly responded to all surrounding neighbors who reported property damage as a result of the operation. Our team ensured that all claims were handled quickly and appropriately. The damage to the county-owned building has been completely repaired and returned to its original state. World View is proud to be a member of the Tucson community and we are committed to the safe operation of Spaceport Tucson.

The following report documents the results and recommendations of the IIRT Report. World View is confident that these findings will only help progress this unique technology and the organization, safely and effectively.

Sincerely,

Jane Poynter

Co-Founder and CEO, World View Enterprises

# **Independent Incident Review Team Report**

**May 15, 2018**

## **I. Introduction**

On December 19, 2017 World View Enterprises incurred an unexpected explosion during testing activities of a large hydrogen filled balloon at their Tucson, AZ flight facility. On December 21, 2017 World View management-initiated plans for an incident review by a panel of independent aerospace experts to provide a thorough review of the technical and organizational causes of the mishap. The Independent Incident Review Team (IIRT) held its initial meeting at World View Enterprises headquarters in Tucson, AZ on Monday February 12, 2018. Five consecutive days of on-site data collection, hardware review, and personnel interviews were accomplished. In addition to finding the proximate technical and organizational causes of the mishap, the IIRT was mandated to review company safety practices and culture to provide recommendations for improvements in those areas. This report documents the results of that IIRT investigation.

## **II. Executive Summary**

The IIRT recognizes World View as an enterprising and innovative company focused on the development and exploitation of high altitude (stratosphere) balloon technologies for diverse applications including earth observation, near-space science, and communication. The company has been aggressively pursuing advances in performance, manufacturability, power, subsystems, and operations to provide safe and cost-effective operations for their clients. World View leadership expressed their sincere desire to utilize the unexpected explosion as a catalyst for developing organizational and operational changes necessary for safe and reliable utilization of this evolving capability. As such, they requested identification of any issues, concerns, or observations “holding no punches.”

Development of high performance cost effective balloon systems led World View to examine the use of hydrogen gas as the lift medium. World View correctly recognized that use of highly flammable hydrogen gas is a hazard and safety risk. World View instituted numerous changes to the balloon operations including the addition of Personal Protective Equipment (PPE) for exposed personnel, hydrogen safety training, and the analysis of potential ignition scenarios. Special efforts were implemented by World View to minimize hazards and potential of all ignition sources. Some of these were the banning of cell phones or other electronic devices in the test area and the electrical grounding of the balloon load tapes to reduce the likelihood of electrostatic discharge.

The IIRT recognizes the meticulous and methodical approach the World View operations and planning team utilized in developing detailed procedures for the initial filling and lift including the conduct of subscale tests to further refine these procedures. The primary objective of the tests was to demonstrate large balloon fill operations with hydrogen gas. During pre-test hazard

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assessment, the safety review process incorrectly assessed both the probability and possible consequences of an explosive event during deflation.

The primary objective of the test series was met successfully in the final test. Immediately following successful fill of the balloon, the planned termination of the test required deflating the balloon. This was to be accomplished through a destructive gore or tearing process. The IIRT confirmed that the upper balloon outer skin and upper fill tube demonstrated significant motion (flapping) which most likely resulted in static electricity generating a spark and igniting the hydrogen/air mixture.

The IIRT concludes that ground facilities (which were disconnected at the time), vehicles in the area, or other causes were not contributors to the explosion.

The explosion that followed resulted in a pressure wave that impacted the World View facility and caused some property damage and several personnel experienced ear ringing. The operations ground crew all felt some radiant heat from the explosion but did not experience any overpressure or blast effects and were unharmed. Following the incident and appropriate safing operations, the World View team began an orderly shutdown for the previously scheduled seasonal break.

The IIRT conducted five consecutive days of on-site data collection, hardware review, and personnel interviews. In addition to finding the proximate technical and organizational causes of the explosion, the IIRT's review of company safety practices, operations and organizational culture revealed opportunities to improve, mature, and formalize procedures and process such that hazardous operations can be conducted with appropriate rigor, protocol, and contingency planning. The result was six key findings and several recommendations.

**Finding #1:** The board finds that escaping hydrogen gas from the planned balloon deflation interacted with the fragmented plastic balloon shell and/or balloon accessories (inflation tube) in such a manner as to build up an electrostatic potential which discharged and caused the hydrogen gas which had mixed into atmospheric air to ignite.

**Finding #2:** The board finds that the pre-test safety review process incorrectly assessed both the probability and possible consequences of an explosive event during deflation.

**Finding #3:** The use of hydrogen gas in large balloons can be done safely and has been demonstrated worldwide. If World View determines to continue the use of hydrogen gas in large balloons, the board recommends rigorous additional safety measures be implemented.

**Finding #4:** Current safety practices at World View should be improved commensurate with other relevant hazardous operations. Changes to culture, practices, procedures, protocols, documentation, accountability and communication will be required.

**Finding #5:** The World View organization has been evolving and growing rapidly and is expected to continue rapid growth for some time. World View transitioning from an R&D/prototyping type organization to a production and operations organization. To ensure both

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company success and safety, changes must be made including internal communications. These changes must be appropriate to the organization to maintain creativity and flexibility

**Finding #6:** Ops tempo with the staffing level available in the last quarter of 2017 resulted in excessive workloads on some personnel. Human factors concern, crew rest rules, and realistic planning and scheduling processes are being matured at World View and must be made rigorous for future operations.

Key IIRT recommendations include: hiring a formal safety manager for World View operations, improving hazard assessment and risk management processes, procuring additional hydrogen gas operations and analysis support, refining operations crew scheduling rules, recommending design enhancements for the balloon system, and items regarding the transitioning of the organization culture so that the company can include both innovative development and highly reliable production operations.

The Board is extremely encouraged by the receptive posture and openness to feedback of World View as demonstrated by their immediate adoption of these recommendations. The IIRT believes that with comprehensive implementation of the recommendations, World View can be both a safe and extremely effective organization in this unique field of practice.

### **III. Background**

#### Incident Description and Timeline

The test took place on December 19, 2017. The systematic detailed timeline was by all accounts followed as designed.

All the operations and inflation steps defined in the test plan were successfully completed just before 1 PM local time. The inflation and fill of the balloon demonstrated that the design could successfully hold the lift gas which was the primary test objective. Included in the test plan was disconnection of all ground hydrogen gas loading equipment to put the balloon into a 'launch ready' configuration. The IIRT notes that the inflation tubes were sealed, the hydrogen gas diffusers, hydrogen gas lines to the tube trailers, and all other associated loading equipment was removed from the area near the balloon to what was considered a safe distance.

The only steps remaining were to gore the balloon which would vent the hydrogen gas and post-test clean up.

Shortly before 12:48 PM local time the call was made for the planned deflation and to gore the balloon. The balloon's destruct line functioned as expected and the balloon envelope was successfully split open and started to vent gas.

When gored, most large balloons will peel open with the balloon film rapidly rolling back resulting in a rapid discharge of the lift gas. This destruct system worked as planned in that it opened the balloon, but the balloon fabric did not peel back in the typical manner. Video recordings of the event show the balloon fabric folding back in over the gore tear and

constricting the gas flow out of the balloon. Video recordings show clearly that the gas did not vent from the balloon in the very short amount of time that was expected.

At 12:48 PM the escaping hydrogen ignited, exploded, and set fire to the balloon fabric.

The only credible source for ignition is static electricity discharge which caused the hydrogen gas mixed into air to ignite.

The actual timing of all the test event were recorded by the Test Director but these notes were destroyed in the explosion.

The Tucson fire department was at the test site as a pre-planned safety precaution. Fire fighters delayed action until all the falling burning plastic had reached the ground and it was clear that there was no additional hydrogen gas trapped in the balloon fabric. At that point, the fire department addressed the residual fire, which was contained to the launch pad.

Many of the test operations team who were at ground level reported feeling a radiative heat pulse but no large pressure wave or loud report.

The sound, shock wave interacted with the building causing alarms and fire suppression water activation. In short order, the World View personnel evacuated the building.

Reentry into the building was not allowed until the fire department had checked the building. There was water leakage in balloon production area of the building. A brief structural integrity inspection was performed by Tucson Fire Department, and then the workforce was allowed back into the areas to start the cleanup process.

Three World View employees experienced hearing issues and all received appropriate medical attention. These medical issues were reviewed per OSHA workplace mishap regulations and reported as required in compliance with those regulations. Additionally, counseling services were provided to any World View employee experiencing emotional trauma from the event.

The IIRT notes that no ground facilities were involved in the initiation of the fire and explosion. The IIRT notes that no vehicles in the area (e.g., hydrogen tube trailers, forklift) were involved in the initiation of the fires and explosion. The IIRT did not find any exceptions to reporting requirements for hazardous materials at the facility. The IIRT did not find that schedule pressure, worker fatigue, or other related issues contributed incident.

Following the incident and appropriate cleanup and safing operations, the World View team began a previously scheduled shut down. The IIRT noted that the World View team did not execute some post-mishap procedures which the IIRT expected: only some witness statements were taken, the data sources were collected but not impounded, and the equipment used in the incident were not preserved in a coherent manner. The balloon fabric was placed in a recycle receptacle and the leased vehicles were returned to their owners. Initiation of a review team was not immediately made. The IIRT does not believe that there was any consequence of significance associated with any of these observations.

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Property damage to the Pima County owned building is being evaluated with initial estimates on the order of \$200,000.00. There was also some minor breakage in surrounding non-World View buildings. In the NASA parlance with which the IIRT is familiar, this event would have been categorized as a Mishap Class C. (reference **NPR 8621.1C**  
<https://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=8621&s=1C>)

### Investigation Board Process

The independent investigation board was assembled by World View to provide both a technical assessment of the explosive event on Dec 19, 2017 and to assess the overall operating environment including test hardware, software, planning, procedures, decision processes and safety management. World View leadership expressed their sincere desire to utilize this unexpected event as a catalyst for developing organizational and operational changes necessary for safe and reliable utilization of this evolving capability. As such, they requested identification of any issues, concerns, or observations, “holding no punches” and to provide specific recommendations for improvements.

The board consisted of three senior engineering managers with a breadth of experience in conducting hazardous test and flight operations and associated incident and failure investigations. The board also has considerable experience with the management and organizational culture required to perform high reliability operations in hazardous fields.

The five-day onsite review initiated on February 12, 2018. The planned review process included formal technical presentations, hardware inspection, integrated engineering and operations team debriefings, and private interviews of all individuals directly involved in test and any employee indirectly affected who requested an interview.

After introductions on February 12, briefings began with a company overview followed by detailed presentations of the test objectives, operations planning, setup, major event timelines, risk and hazardous analysis, and results. Inspection of ground and flight hardware manufacturing, integration, operation and test facility followed. Some of the hardware directly involved in the incident was no longer available for the investigation team to examine. However, similar type equipment was made available for the investigation team to review.

Twenty-six individual interviews of approximately half hour duration each were conducted. These interviews of key World View employees provided detailed understanding and perspective of every aspect of company operations including design, development, production, integration, operations and flight. Insight into company culture and norms especially regarding safety processes were elicited during these interviews.

The anonymous safety reporting system previously put in place by World View also provided additional information on employee concerns and company safety culture.

Much of the data relevant to the immediate explosive event was in the form of photography and videos from various vantage points including a drone video from above and to the east of the balloon during the deflation/explosion.

At the end of the week, initial findings, observations and recommendations were consolidated and presented to the senior leadership team with expectation for final report within several weeks. The board has made themselves available for follow up or clarifying discussion over the next several months.

### Investigation Team Biographies

#### **N. Wayne Hale, Jr.**

##### ***Academic Background***

Master of Science in Mechanical Engineering, Purdue University, 1978.

Bachelor of Science in Mechanical Engineering, Rice University, 1976.

##### ***Employment History:***

**2010 to present: Director of Human Spaceflight**, Special Aerospace Services, LLP, of Boulder, Colorado. Provides services in technical consulting, management coaching, technical analysis, safety processes, technical seminars, and advising on organizational culture change. Has served as leader or member of several incident review boards. Clientele includes aerospace, energy sector, and other high reliability organizations concerned with safety, management, culture change, and operations in high risk environments.

**2008 to 2010:** NASA Deputy Associate Administrator for Strategic Partnerships. Established and coordinated new collaborative activities with national space programs of various foreign countries, other government agencies, commercial space flight entities, and academic institutions. Provided critical support to the 2009 President's Blue-Ribbon commission on the future of space exploration, the "Augustine" Commission. Developed the management plans and philosophy for NASA to encourage the development of a commercial human space launch industry to low earth orbit which became the Commercial Crew Program Office. Provided support to national leadership in the development of national space policy.

**2003 to 2008: NASA Space Shuttle Program: Program Manager, Deputy PM, and Launch Integration Manager.** Executive responsibility for the \$5.1 billion, 20,000 employee program. Overall responsibility for returning the Space Shuttle to regular flight following the Columbia accident including safety, technical content, budget development and adherence, schedule establishment and adherence. Extensive media interaction, inter-organizational conflict resolution, interface with legislative and independent oversight organizations. Chief accomplishments while Deputy PM included response to the Columbia Accident Investigation Board (CAIB) and implementation of management restructuring and culture change, served as Mission Management Team chairman with final technical responsibilities for STS-114 flight execution. As Launch Integration Manager coordinated disaster response to Columbia accident at the Kennedy Space Center; interfaced with the CAIB during its investigation and reporting.

**March 1988 to January 2003: NASA Flight Director.** Operational responsibility for 40 space shuttle flights including 28 launches, 26 landings. Lead Flight Director responsible for overall shuttle mission success on three flights including the first logistics flight to the ISS. Extensive international interfaces required for many flights. Served on the Shuttle-Range Safety Panel; International Space Station Independent Advisory Panel; Space Flight Safety Panel; Mars

#### **World View**

#### **Incident report for Pima County**

Surveyor Program Architecture Peer Review; Recoverable Entry Flight Safety Review Board (X-38). Served on several mishap/incident review boards associated with Space Shuttle Flight Operations incidents.

**June 1978 to March 1988: NASA Space Shuttle Systems Flight Controller** and supervisor of Shuttle Propulsion and Communications Flight Controllers.

***Significant Professional Activities post Government service:***

Member At Large for the NASA Advisory Council providing advice to the NASA Administrator and senior US leadership on space policy.

Member of the FAA Commercial Space Transportation Commercial Space Transportation Advisory Committee providing advice to the FAA Deputy Administrator

National Academy of Sciences Committee on Applications of Real Time Monitoring to Offshore Oil and Gas Operations 2014-2016

President, JSC chapter of the NASA Alumni League

Board of Advisors for the Coalition for Deep Space Exploration (CDSE)

Standards Chairman for the Commercial Spaceflight Federation (CSF). 2011-2013

***Professional Awards and Honors:***

AIAA Associate Fellow, 2015

NASA Exceptional Service Medal, 1992

Three times awarded the NASA Outstanding Leadership Medal, 1999, 2005, 2007

National Space Club, Astronautics Engineer of the Year, 2007

Smithsonian National Air and Space Museum, Current Achievement of the Year, 2007

## **Christopher E. Singer**

Christopher (Chris) Singer recently retired as NASA Deputy Chief engineer and is currently an independent space launch systems consultant and executive coach. He is a proven, dynamic leader with over 34 years of experience in developing innovative solutions for human space flight, design, thru flight and has lead numerous failure and accident investigation teams.

### **Perspective**

For over 34 years, I had the honor and privilege to serve NASA, providing strategic vision, discipline technical leadership, motivational energy creating an innovative environment to advance high performance space systems from propulsion to Life Support.

### **Career Highlights**

**NASA Deputy Chief Engineer, March 2016-June 2017**, - Lead Engineering integration across 10 field Centers. Created effective relationships and strategies for new partnerships within NASA, other agencies, commercial industry and academia. Infused behavior changes needed to effectively embrace innovation, risk and failure tolerance. Provided expert analysis for catastrophic events including Commercial Crew Development ground and flight systems failures.

**Director/Deputy MSFC Engineering, 2004-2016** - Strategic leadership and technical direction to organization of over 2500 engineers responsible for the design, testing, and operation of space transportation, spacecraft systems, and payloads including Space Shuttle Propulsion and Space Launch System (SLS) development. *Columbia* Tragedy/Recover, Led the External Tank Bipod failure scenario recreation and debris mitigation efforts. Shuttle Mission Management representative for final 21 Flights. Provided senior review for numerous ground and flight systems failures including: Commercial Crew Propulsion Systems (Boeing and Space X), Commercial Resupply Launch Vehicle (Orb-3, Engine), Taurus Fairing, Peregrine Solid Rocket Nozzle and many others.

**Deputy Director/Chief Engineer MSFC Space Transportation, 2000-2004** - Led 600 person, full-lifecycle organization (Research, Engineering, Test thru Flight Demonstration), responsible for numerous advanced technology space flight projects including Fastrac Engine, X-33, X-34, X-37. Defined Mission Success protocol, Flight Readiness, Contingency/Failure Investigations, systems engineering methods to embrace risk posture for advanced technology development.

**Space Shuttle Propulsion Leadership, MSFC & NASA HQ, 1992-2000-** Defined and implemented numerous safety and performance upgrades for space shuttle main engine including advanced health monitoring and high pressure turbopumps, enabling 2 times increase in reliability. Led 11 catastrophic ground test engine failure investigations and 3 Space Shuttle on-pad aborts providing systems analysis, fault tree development, hazards and root cause analysis. Rapidly developed mandatory corrective actions including hardware changes, inspection requirements, test, process controls or additional operational health management diagnostic algorithms. Led Safety Review Team for advanced Hydrogen Cold flow facility activation.

**Honors & Awards** - AIAA Associate Fellow, numerous awards including Distinguished Service, Outstanding Leadership medals and Presidential Rank Award — the highest honors for career federal employees and the coveted Astronaut Corp Silver Snoopy Award.

A native of Nashville, Tennessee, Mr. Singer earned a bachelor's degree in mechanical engineering in 1983 from Christian Brothers University in Memphis, Tennessee.

### **Henry M. Cathey, Jr.**

Henry M. Cathey, Jr. is the Interim Deputy Director of the New Mexico State University's (NMSU), Physical Science Laboratory (PSL) and serves as the manager of the FAA approved NMSU UAS Flight Test Site. His responsibilities also include support for scientific ballooning, Unmanned Aircraft Systems, other suborbital efforts, and PSL Business Development. He has worked for PSL for over 25 years with his core concentrations focused on research and new technology implementation. Mr. Cathey has leadership experience in managing a staff of engineers, R&D efforts, test programs, projects, and flight campaign efforts.

For over 25 years he has supported the NASA Scientific Balloon Program with a focus on the NASA Super Pressure Balloon development effort. He has design, analysis, performance

analysis, balloon production/fabrication, and flight operations experience with numerous balloon test flights. He currently supports other national and international ballooning efforts.

He manages one of the seven FAA approved UAS Flight Test Sites supporting different UAS missions. These include testing of new flight vehicles, qualification of flight systems, new sensor development, and operational planning. UAS R&D efforts focus on applying this new technology to various scientific research activities. He serves as the lead for PSL's efforts related to the FAA Center of Excellence (COE) for UAS research. As part of the ASSURE (Alliance for System Safety of UAS through Research Excellence) team, PSL is helping safely integrate UAS's into the national airspace. Specific efforts focus on small UAS Detect and Avoid Requirements Necessary for Limited Beyond Visual Line of Sight Operations and detection of UAS near airports. He is also leading an FAA Minority STEM education outreach effort that focuses on UAS's as the central learning platform. Events have targeted middle school students across New Mexico through UAS Roadshows and summer camps.

He previously worked on the NASA's first Discovery mission the Near Earth Asteroid Rendezvous (NEAR) spacecraft, the Rossi X-Ray Timing Explorer (XTE), the Tropical Rainfall Mission (TRMM), the first Hubble Space Servicing Mission, and other spaceflight missions. He has experience in design, packaging, and thermal analysis of spacecraft electronics, spectrophotometers, colorimeters, radio receivers, test equipment, and other electronic assemblies. He has designed, planned, managed, and implemented numerous balloon and balloon subsystem tests.

He received his Bachelor of Engineering Degree in Mechanical Engineering from Vanderbilt University in Nashville, TN in 1983, and his Master's Degree from the George Washington University in Washington, DC in 1993. In July of 2015 he was awarded a NASA Exceptional Public Service Medal for his contributions to NASA's mission. In January 2016, he was presented with a NMSU 2016 Research Discovery Award. Mr. Cathey is an Associate Fellow member of the American Institute of Aeronautics and Astronautics (AIAA) and past Chair the AIAA Balloon Systems Technical Committee. He has organized technical conferences, has authored over 45 technical papers, and has served as a technical article reviewer for international refereed journal publications. He has managed and directed nearly 20 co-op students. He actively participates in educational outreach activities speaking to thousands of students over the past 25 years.