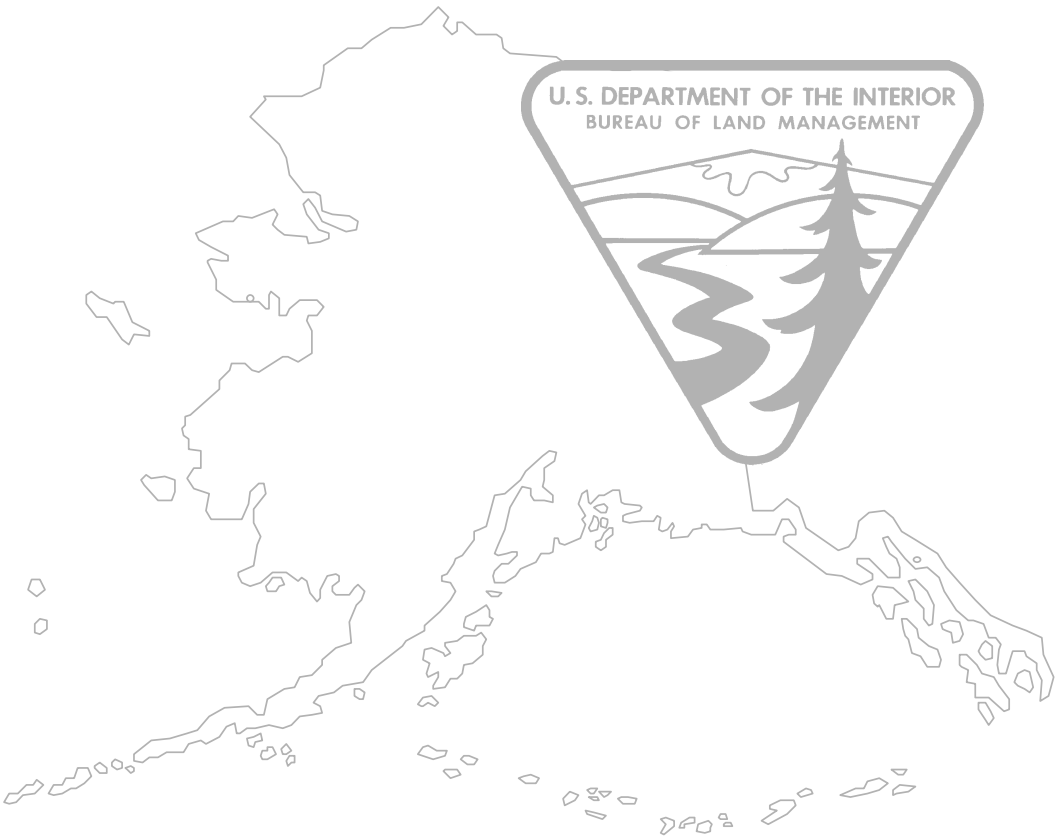


United States Department of the Interior
Serious Accident Investigation Report

# Management Report

David J. Liston
Smokejumper Fatality

Thomas O. Roach
Smokejumper Non-injury
Parachute Malfunction

Bureau of Land Management
Alaska Fire Service
Ft. Wainwright, Alaska

April 29, 2000

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U.S. DEPARTMENT OF THE INTERIOR

**MANAGEMENT REPORT**

FATAL INJURY TO DAVID J. LISTON

SMOKEJUMPER, ALASKA FIRE SERVICE

PARACHUTE MALFUNCTION INVOLVING THOMAS O. ROACH

SMOKEJUMPER, ALASKA FIRE SERVICE

BUREAU OF LAND MANAGEMENT

APRIL 29, 2000

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June 16, 2000
Date

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June 16, 2000
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6-19-00
Date

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BLM Carson City
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June 19, 2000
Date

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U.S. Forest Service, Northern Region
(Interagency Representative)

6.19.2000
Date

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NOTE: The Management Report is prepared for a bureau head and bureau DASHO, by the Serious Accident Investigation Team, which is completed within 45 calendar days of an accident. The Management Report contains all of the essential facts contained in the Factual Report and the results of the investigation; Serious Accident Investigation Team processes, opinions, conclusions and recommendations. Also contained in the report are opinions as to why the management control system did not prevent the accident (if applicable), and recommendations for preventing similar accidents.

# PREFACE

Smokejumpers engage in work that involves risk, including the risks inherent in air operations. These individuals receive training and equipment necessary to mitigate the risks. The incident regarding this fatality involved multiple interactive equipment failures.

The Serious Accident Investigation Team was formed within hours of David Liston's death and assembled at Fairbanks within 24 hours of notification. The team is deeply committed to the objective identification of the causes of Liston's death, and identification of actions that will prevent such an accident from occurring again.

The Investigation Team acknowledges the cooperation of the men and women of the Alaska Smokejumpers and many other individuals at the Alaska Fire Service (AFS), Northern Field Office and Alaska State Office throughout the investigative effort. In the face of a tragic incident involving a colleague, smokejumpers on the scene at the time of the incident took steps to protect the physical evidence. Local office personnel assembled equipment and material while the team traveled to Fairbanks and provided operational support throughout the investigation. The team is grateful for these contributions. The U.S. Army personnel at Fort Wainwright, Fairbanks Police Department, and the Federal Aviation Administration were supportive and cooperative throughout the effort. The team sincerely thanks each person who contributed to the investigation.

The medical examiner's report and the Federal Bureau of Investigation (FBI) video enhancement are pending. Any new information from these items of evidence may change the findings of this investigative report. A negative toxicology report has been verbally provided to the Investigation Team.

This report is presented to the Director, National Office of Fire and Aviation.

# EXECUTIVE SUMMARY

On April 29, 2000, two seasoned BLM smokejumpers, David J. Liston and Thomas O. Roach, experienced main parachute system malfunctions on a refresher training jump at Ft. Wainwright near Fairbanks, Alaska. Both parachute malfunctions precluded opening of the main parachute and are categorized as drogue-in-tow malfunctions. Liston and Roach were making their second jump of the day. On this jump, they were the third and fourth jumpers, respectively, on the last four-person stick of the day. Upon inspection, the aircraft, the parachutes, the packing, and the operational procedures were certified, within specifications, and consistent with manual direction.

Roach successfully deployed his reserve and landed safely. Liston's reserve parachute entangled with the main drogue bridle and both the main and reserve parachutes failed to deploy. Liston died from multiple injuries resulting from a fall of approximately 3,000 feet.

The Investigation Team evaluated Liston's training, proficiency, knowledge, skills, abilities, and attitude, and determined each as non-contributory factors in the fatality. There is no evidence to indicate that the parachute packing (rigging) influenced the outcomes of these incidents. All parachutes, their rigging, and all equipment, including the harness assemblies, were in good repair, packed properly and undamaged.

The contributory factor(s) surrounding this accident cannot be determined with certainty. In both the Liston fatality and the Roach malfunction an equipment failure or multiple, interactive equipment failures were likely involved. Evidence suggests that the 3-ring drogue release mechanism failed on both Liston's and Roach's main parachutes. In Liston's case, the physical evidence indicates that the reserve parachute did not properly deploy because the reserve pilot-chute bridle became entangled with the main drogue bridle, precluding full deployment of either parachute. Liston's accident indicates a multiple, interactive equipment failure, possibly compounding as the jump sequence progressed. Once entanglement occurred, there was no corrective emergency procedure nor other action that could overcome the situation.

From a management perspective, this accident raises serious concerns. It involved a fatality with an experienced jumper. It involved two, back-to-back malfunctions. The evidence indicates it was the result of an equipment failure, involving single components or multiple components interacting in combination. The team was unable to conclusively correlate the cause of the two back-to-back main parachute malfunctions.

The ram-air parachute system is a complex, high-performance design. The ram-air parachutes and the 3-ring release mechanisms are used by the BLM, military, and sport parachute industry. Both are standard within the parachute industry, worldwide.

Configured for smokejumper operations, the ram-air parachute system and 3-ring release mechanism requires close manufacturing tolerances and disciplined performance.

While there is an element of uncertainty surrounding the equipment failure in Liston's fatality, and other possibilities cannot be dismissed, the Investigation Team is concerned with the 3-ring drogue release, as well as the aerodynamic interactions between the drogue and reserve pilot-chute. The team is also concerned with the likelihood of a failed fastener that may have resulted in a separated belly band strap.

At issue, is the deployment reliability in a *systems* context. This apparent back-to-back occurrence of 3-ring release hesitation and other anecdotal reports of these hesitations suggest that there may be a systemic deployment problem. The architecture of the ram-air harness, the 3-ring release mechanism, drogue and pilot parachutes, parachute containers, fasteners, personal gear bag, and related equipment interact mechanically and aerodynamically. The system's engineering dynamics may not be fully understood.

# INTRODUCTION

## Purpose of Investigation

A Department of the Interior Serious Accident Investigation Team's purpose is to investigate serious accidents involving departmental employees, volunteers, contractors, emergency fire fighters, or the public, when departmental property and/or operations are involved. The sole purpose of the investigation is to determine the cause or causes of the accident and to ensure that corrective actions will be implemented to prevent future similar losses.

## Scope

The scope of this investigation covers the fatal accident involving Liston's parachute malfunction and the parachute malfunction of Roach that occurred immediately following Liston's.

# INVESTIGATION METHODOLOGY

The Alaska Fire Service Safety Manager (Team Liaison) ensured that the Agency Administrator's Guide to Critical Incident Management (Office of Fire and Aviation publication) had been implemented, that 24-hour site security had been provided to protect the evidence, and that the aircraft had been secured as evidence. On the morning of May 1, 2000, the Serious Accident Investigation Team received the Agency Administrator's briefing.

The Serious Accident Investigation Team followed an action plan and schedule based upon the following outline to ensure efficient use of time and resources:

1. The Chief Investigator requested a list of documentation from AFS management, the Alaska Smokejumpers and U.S. Army Criminal Investigation Division (CID).
2. The Investigation Team received a briefing from Dalen Romero, Smokejumper Base Manager, on the safety systems in place for smokejumpers to become acquainted with the parachute system and safety management processes.
3. The Team coordinated with the U.S. Army CID, Federal Aviation Administration (FAA) and the Fairbanks Police Department to complete a multi-agency, concurrent-jurisdiction investigation.
4. Viewed video tapes secured as evidence by the U.S. Army CID.

5. Obtained copies of Initial Witness Statements obtained by U.S. Army CID.
6. Made an initial visit to the accident site.
   A. Verified that security was in place at the accident site.
   B. Received a briefing on the site from James Veitch and Gary Baumgartner.
   C. Took photographs of the accident site and made preliminary sketches.
7. Identified, obtained and documented evidence.
   A. Established a Chain-of-Custody Log
   B. Collected supporting documentation.
8. Read initial witness statements from managers, supervisors, employees, members of the public and military personnel. Established a list of follow-up interviews and initial witness interviews for persons identified as eye witnesses and persons of significance.
9. Maintained evidence in place at the site, until the independent parachute systems expert could review the evidence on the ground at the site.
10. Upon arrival at Ft. Wainwright, the Chief Investigator isolated the independent parachute systems expert from the Investigation Team and all other personnel and evidence. The Investigation Team members then took the independent parachute systems expert to the site where he examined the evidence without discussion or comment, to develop an independent analysis.
11. Re-examined Liston's accident site, and performed an initial examination of Roach's equipment in the field.
12. Arranged for an isolated and secured building to conduct a thorough examination of the equipment components.
13. Collected the equipment components from the field, with a minimal disruption of the equipment {placed in-total and arranged on a 4-foot x 8-foot plywood sheet} and transferred the material to the secured building location.
14. The Investigation Team and independent parachute systems expert performed a detailed examination of the parachute equipment components, photographing specific components and noting observations. The Alaska State Director, Fran Cherry, and Alaska Associate State Director, Linda S. C. Rundell briefly observed this process.
15. The accident site was released.
16. Provided an initial briefing to the FAA and U.S. Army CID.
17. Provided an initial briefing to the Alaska State Director and acting Director of Fire and Aviation, with recommendations to establish a team of experts to perform a comprehensive evaluation of the parachute system and equipment in use by the BLM.
18. Performed follow-up witness interviews.

19. Packaged the documentation evidence for which the Chief Investigator assumed Chain of Custody, and packaged the physical evidence, for which the Technical Specialist assumed Chain of Custody responsibilities.
20. Prepared a draft version of the Factual Report.
21. Analyzed evidence and witness statements.
22. Formulated opinions and recommendations and prepared the Management Report.
23. Conducted a briefing for the Director, National Office of Fire and Aviation, Acting Associate Director, National Office of Fire and Aviation, Alaska State Director, AFS Manager, Chief, Fire Operations, AFS, NIFC Director.
24. Cataloged evidence and transferred it to the BLM National Safety Office.

## Investigation Techniques

The Chief Investigator established two concurrent case investigations into the incidents that occurred on April 29, 2000, for Liston's fatal accident and Roach's parachute malfunction. In both cases, the Chief Investigator briefed the Investigation Team on the use of two system safety applications, *Linear Sequencing* and *Fault Tree Analysis*. See Appendix ? for an explanation of each method.

## Sources of Expertise

Team expertise included an experienced and qualified Department of the Interior Serious Accident Investigation Team Leader and Chief Investigator, a qualified Accident Safety Advisor, two Technical Specialists familiar with smokejumper operations and the ram-air parachute system, and an interagency representative experienced in managing regional fire management staff and whose responsibilities include management of smokejumper

operations.

## Listing of Serious Accident Investigation Team Members

Timothy M. Murphy, Field Manager
BLM Miles City Field Office
(Team Leader)

Kathy Hull, State Safety Manager
BLM Utah State Office
(Accident Investigation Advisor)

Kipp Wagner, District Safety Manager
BLM Eugene Field Office
(Chief Investigator)

Jim Olson, Loft Manager
BLM Boise Smokejumpers
(Technical Specialist)

Leonard Wehking, Fire Management Officer
BLM Carson City
(Technical Specialist)

Jerry Williams, Director, Fire Management
U.S. Forest Service, Northern Region
(Interagency Representative)

## Selection Criteria

Department of the Interior Serious Accident Investigation Team members are selected in such a manner as to eliminate any perception of bias. The objective is to obtain an accurate investigation, without any real or perceived improper management influence of the investigation results. As such, Investigation Team members are not selected from the state experiencing the serious accident. This does not preclude, however, a local state safety professional (in this case, Vince Mazzier) from observing the investigative process.

The Team Leader is a senior bureau management official. The team leader directs the investigation and serves as the immediate point of contact with the Director, National Office of Fire and Aviation. Tim Murphy is an

experienced Department of the Interior Serious Accident Investigation Team Leader. In 1999, he was the team leader of the BLM Smokejumper Program Review.

The Accident Investigation Advisor is an experienced safety and occupational specialist or manager, who acts as an advisor to the team leader, to ensure that the investigation focus remains on safety and health issues. The Accident Investigation Advisor also works to ensure strategic management issues are examined. Kathy Hull is a state safety manager with the BLM. She was a qualified accident investigator with the Department of Defense.

The Chief Investigator is a qualified accident investigation specialist responsible for the direct management of all investigation activities. The chief investigator reports to the team leader. Kipp Wagner is an experienced Department of the Interior Serious Accident Investigation Team Chief Investigator.

The Technical Specialists are personnel who are qualified and experienced in addressing specific technical issues such as weather, terrain, specialized occupations, activities, skills and equipment. Jim Olson is the loft manager with the BLM Boise Smokejumpers and is an FAA Certified Master Rigger. He has worked 22 years in smokejumper operations. Leonard Wehking has been the fire management officer with the BLM, Carson City Field Office since June 1998. He has worked 14 years with the Alaska Smokejumpers, including six years as smokejumper lead spotter.

The Interagency Representative is a representative from the Department of Agriculture, Forest Service and serves on Serious Accident Investigation Teams involving accidents occurring to personnel participating in wildland fire suppression or prescribed burning operations, or to personnel working in direct support of those activities. The Interagency representative is appointed by the Bureau Fire Director and serves as liaison between agencies and as an advisor to the Team Leader. Jerry Williams was a supervisory smokejumper for two years and a smokejumper for seven years (1972-1979). He is presently the Director of the Fire and Aviation, Northern Region, Missoula, Montana.

**Independent Expert**

Independent Experts are utilized by the Investigation Team to assist in the determination of causal factors of the accident. Independent Experts are personnel who are qualified and experienced in addressing specific technical, legal, managerial or analytical skills in a certain area applicable to the accident situation.

Mark Schlatter BS, MS (Purdue 1984) is an independent parachute systems expert. Schlatter is a professional parachute jumper and co-author of *Parachute Rigging Course* (Para-Publishing, 1985). He has worked in the sport parachute industry since 1975. He holds FAA certificates for Master Parachute Rigger, Airframe & Powerplant Mechanic and Private Pilot. He served as an FAA designated parachute rigger examiner in Indiana from 1987 to 1996. He conducted parachute rigger training courses in Indiana from 1985 through 1997. He now serves as Course Director for the U.S. Academy of Parachute Rigging in Eloy, Arizona. He is proprietor of Mark Schlatter Skydiving, a professional exhibition jumping service based near Houston, Texas. He writes for the parachute industry press on parachute rigging topics.

**Team Liaisons**

The Alaska State Office, Northern Field Office, and the AFS supported the Serious Accident Investigation Team. The following personnel were assigned as liaisons:

- Vince Mazzier, AFS safety manager;
- Ed Lee, BLM law enforcement ranger; and
- Anne Jeffery, BLM public information officer.

Additional sources of expertise were used in the investigation and included expertise from the work unit that had the accident. Experts who were utilized throughout the investigation, but are not considered to be part of the Serious Accident Investigation Team include:

- Larry Brosnan, Accident Safety Investigator, Office of Aircraft Services (OAS);
- Gary R. Davis, OAS technical services;
- Dale Linden, Federal Bureau of Investigation, forensics laboratory; and,
- Jim Veitch, Alaska smokejumper.

# SUMMARY OF ACCIDENTS

Brief Description of Accident Event

The factors surrounding David Liston's fatality cannot be determined with certainty. It is clear that in both Liston's fatality and Thomas Roach's malfunction, an equipment failure or multiple interactive failures likely occurred. The physical evidence and witness statements do not conclusively indicate what happened. The investigators have agreed on the following sequence as the most probable.

Liston made a stable exit and pulled the drogue release handle on time. The drogue did not release. Next Liston implemented emergency procedures and pulled the main canopy release and the reserve activation handle. The Investigation Team suspects the reserve belly band may have been separated at this time due to possible pre-existing cracks in the Fastex snap. If this happened, the team members believe that the separated belly band could have allowed a misdirected launch of the reserve pilot-chute by allowing movement of the reserve container. The separation of the belly band could also allow the main container to ride up and block the 3-ring mechanism. It is also considered possible that turbulence around the falling jumper and the inflated drogue had a significant effect on the behavior of the pilot-chute during its launch.

The reserve pilot-chute entangled with the drogue bridle by encircling two times around the base or sail of the drogue. The reserve deployment bag was apparently lifted against the drogue sail where it also encircled the drogue bridle forming a knot with the reserve suspension lines and preventing further deployment of the reserve parachute. The drogue released sometime thereafter. The entanglement remained unchanged until impact except for six twists that resulted from rotation of the entangled systems.

The investigators note that this is the first known BLM reserve deployment into a zero porosity (ZP) drogue-in-tow malfunction. A factor that separates Liston's fatality and Roach's malfunction is that Liston used a ZP drogue while Roach used the F-111 drogue that was tested during development of the drogue system. The difference is the fabric used in their manufacture. When new, the two fabrics (F-111 and Zero-P) have similar performance. Multiple jumps increase the fabric permeability of the F-111 drogue. Consequently, the turbulent "burble" and other performance parameters change. The ZP drogue fabric is considered superior due to its consistent performance over time.

The separation between Liston's handles, relative to the separation between Roach's handles, and based on witness accounts, indicates that Liston may have pulled the main release and reserve handles late in the jump sequence. This delay may be attributable to a distraction or pre-occupation with a problem. The cracked belly band Fastex snap may have separated and allowed the personal gear (PG) bag to interfere with handle pulls. The Team has not received the Federal Bureau of Investigation's video enhancements, which may clarify this issue.

# DETAILED NARRATIVE OF ACCIDENT EVENT

Chronology

**Pre-Incident**

January 26, 2000 - Liston was selected from Position Announcement AK-353-34-OH-012 selectees list, for Position Description OSJ961-2 10104AM.

February 14, 2000 - Drug testing was initiated.

February 27, 2000 - Liston acknowledged Conditions of Temporary Employment, Standards of Ethical Conduct Booklet, Inventions Made by Employees, Unemployment Insurance Benefit Payments, Drug Testing and Security Program.

April 23, 2000 - Liston and Roach began employment with the Alaska Smokejumpers.

April 24, 2000 - Liston and Roach began Smokejumper Refresher training. The April 29, 2000, jump schedule was posted.

April 25, 2000 - Liston and Roach completed tower evaluations.

These evaluations indicate that Liston performed "Great" on Drogue-in-Tow; "Feet apart, need to get head down to look at handles" on Spinning; "Good" on Streamer; "Good" on Horseshoe; and "Good" on last column titled Good.

These evaluations indicate that Roach performed "Excellent" on Drogue-in-Tow; " Left hand not on butt, Feet apart, OK" on Spinning; "Good" on Streamer; the space on Horseshoe was blank; and "Good" on last column titled Good.

April 27, 2000 - Liston and Roach completed two practice jumps.

11:30 a.m. - Jump Objectives 4,000-foot, two-man sticks, 1) Good A/C Procedures, 2) Good after canopy opening checks, 3) Good PLF. Liston's evaluation comments are "Cross wind. Good. Feet apart on roll." Roach's evaluation comments are "X wind. Feet Apart on roll."

2:45 p.m. - Jump Objectives 3,500-foot, two-man sticks, 1) Good Pattern, 2) On final by 300-foot, 3) Good PLF. Liston's evaluation comments were not found.

3:30 p.m. - Jump Objectives 3,500-foot, two-man sticks, 1) Good Pattern, 2) On final by 300-foot, 3) Good PLF. Roach's evaluation comments were "LHP. OK final; arms out, FA on PLF" "Not real good separation."

April 28, 2000 - Liston and Roach completed one practice jump.

3:45 p.m. - Jump Objectives 3,000-foot, two-man sticks, 1) Get Good Vertical Separation, 2) Use sink, mushing on high final 3) Good PLF. Liston's evaluation comments were "Too far downwind" and Roach's evaluation comments were "Too far downwind." The Practice Jump Evaluator Notes indicate Liston and Roach switched jump order.

**The Day of the Accident - April 29, 2000**

Times are approximate.

9:00 a.m. - Second refresher group, trainers, spotters, operations, etc. start work.

9:01 a.m. - Roll call, morning briefing, start workday in loft, rigging, inspecting gear/parachutes until 1030.

10:30 a.m. - Group meets in Smokejumper lounge to critique previous days' jumps and watch jump video.

11:30 a.m. -1:00 p.m. - Review Bowl Mountain, Montana incident.

1:00 -2:00 p.m. - Lunch.

2:00 -2:30 p.m. - Group briefed on the afternoon jump criteria. Ground crew personnel were assigned to video tape and critique the jumps.

2:30 p.m. - First smokejumper load, consisting of eight employees, suited up.

2:43 p.m. - Aircraft pilot (PIC) Chris Eisele, and aircraft pilot (second PIC) Stoney Bauer started the jump ship, a Casa 212, Call Sign J 17.

Smokejumper Action Report indicated Request #24 Practice Jump. The aircraft, a Casa 212, Call Sign J 17 (Jump ship), was piloted by Eisele and Bauer, and crewed by BLM spotters Melvin Tenneson and Assistant Mitch Decoteau.

2:45 p.m. - Jump ship (J-17) contacted AICC (Fairbanks Dispatch), "Off (FBK) en route Birch Hill with 12 SOB (souls-on-board), 2 FOB (fuel-on-board), 45 ETE (estimated time en route)."

2:45 p.m. - Jump ship took off for first load. Jumps occurred at River Road jump spot, with two four-person sticks, with 300 yards drift cross wind pattern.

3:00 p.m. - Mark Musitano, BLM smokejumper, arrived at the landing zone near Ski Hill Lodge to observe the scheduled refresher training jumps.

3:03 p.m. - Jump ship (J-17) contacted AICC, en route back to FBK for more smokejumpers.

3:05 p.m. - Jump ship (J-17) contacted AICC, "On FBK."

3:06 p.m. - Jump ship (J-17) contacted AICC, "will load up more smokejumpers."

3:10 -3:13 p.m. - Jump ship landed and returned to standby shack (Alaska Smokejumper Building 1513) for second smokejumper load.

Smokejumper Action Report indicated Request #25 Practice Jump, including Liston as the third person and Roach as the eighth person on the list. The aircraft, a Casa 212, Call Sign J 17 (Jump ship), piloted by Eisele and Bauer, and BLM spotters Decoteau and Tenneson. Comments indicated cross wind pattern. Evaluated as a good job by all.

3:06 p.m.- Jump ship (J-17) contacted AICC, "On FBK, 12 SOB, 1 plus 30 FOB, Practice, 20 minute ETE, River Road Jump."

3:15 - 3:16 p.m. - The Jump ship took off for second smokejumper load to River Road jump spot, with two four-person sticks.

3:30 p.m. - Practice Jump Evaluator Notes indicate: Objectives 3,000-foot above ground level (AGL), four-man sticks, 1) Good plan in A/C, 2) Good

vertical separation 3) Use "lanes" if vertical separation fails. The first four-man stick, Smith, Veitch, Liston, and Bruce Ford's Evaluator Comments were, "RHP. Kind of forced issue would have been better to switch into a LHP. Worked out but not much margin. The second four-man stick, Bradley, Brown, Taylor, Roach's Evaluator Comments are, "LHP. Pattern choice worked well. Third and fourth guys had to work a bit to get back to spot. 3- Could have turned into wind earlier and landed into wind. 4- Raised toggles low on final and hit harder than necessary."

Musitano observed Liston's first jump with his main parachute deployed as it should, and observed Liston landing on the landing zone without any problems.

After Liston and Roach were on the ground they gathered their gear, and with the ground crew, Cramer, Bloemker and Lambright, were transported to the standby shack where they readied their equipment to board the jump ship for the next scheduled jump.

3:34 p.m. - Jump ship (J-17) contacted AICC, "en route FBK."

3:41 p.m. - The jump ship landed and returned to standby shack and waited for smokejumpers to return from River Road jump spot to reconfigure and, those on the last load, get their gear ready.

BLM smokejumpers Charlie Brown, Paul Lenmark, Michael Bradley and Murray Taylor stayed at the jump spot to become ground crew for the next jump. Bruce Ford was at the jump spot. James Veitch acted as an observer during the jump.

At the standby shack, David Hade, BLM smokejumper, observed Liston and Roach and the other jumpers scheduled for the third planeload as they prepared for the next jump.

Cramer observed that the pre-jump procedures were routine. Hade observed that each jumper received a buddy check, which is a major check of all smokejumper equipment by another smokejumper. The buddy check does not routinely include the personal gear bag. Cramer performed both Liston's and Roach's buddy checks. Liston's belly bands were not routed through the d-rings of his harness. Cramer routed them correctly, then went back a previous step, which is required by procedures, and found everything in order. Roach's equipment was checked by Cramer and found in order with no mistakes.

Following the equipment check, the spotter (Cramer) called out the load in reverse order to board the aircraft and lined up all of the jumpers in a single

line. Prior to boarding the aircraft, all jumpers received a final 3-ring and main container pin check performed by the spotter and the assistant spotter (Hade) by having the jumpers walk between them. On this final check, the spotter inspected the left riser 3-ring and the main container pin, and assistant spotter inspected the right riser 3-ring and the drogue 3-ring. No problems were noted with the 3-rings (main riser 3-rings and drogue 3-rings) or the main container pin. After all of the jumpers were checked and approved for their jump, all jumpers then proceeded immediately to the aircraft and boarded.

3:54 p.m. - Jump ship (J-17) contacted AICC, "On FBK."

4:15 p.m. - Ivan Smith arrived at the jump spot to observe the proficiency jumps.

Before boarding the jump ship, Liston and Roach changed the jump order due to differences in weight, and to gain vertical separation.

4:17 p.m. - All of the smokejumpers were on board the jump ship.

4:26 - 4:27 p.m. - Jump ship took off with third smokejumper load.

4:27 p.m. - Jump ship (J-17) contacted AICC (Fairbanks Dispatch), "off FBK, 12 SOB, 2 FOB, 30 minutes ETE, River Road Jump."

4:30 - 4:40 p.m. - The Jump ship proceeded to the drop zone, where at 1,500 feet AGL the jump spot size-up was completed and found to be routine, and then the initial streamers were dropped to establish wind conditions. The initial set of streamers showed a fair amount of "up" air and approximately 100 yards of drift to the ESE. The check set of streamers made it into the spot with a normal descent rate. The spotter communicated with the ground crew, Lenmark, to inquire of wind conditions on the ground. The spotter was informed that the winds were light and variable, but generally in line with the streamers. Then the aircraft climbed to jump level 3,000 feet AGL. The spotter then briefed the first stick on wind speed and direction. After the briefing was completed, the pilot informed the spotter of a potential airspace conflict. The jump ship circled the jump spot waiting for the airspace to clear. The pilot informed the spotter that the potential conflict was gone, and the spotter contacted the jump spot to see if they had noted any changes in wind direction or speed. No changes were noted, so the spotter resumed jump operations.

Jump progressed at River Road jump spot with two four-person sticks. The first stick jumped.

The Smokejumper Action Report indicates Request N/A Practice Jump - second Refresher. The aircraft, a Casa 212, Call Sign J 17 (Jump ship), piloted by Eisele and Bauer, and BLM spotters Cramer and Hade. Smokejumpers listed in the following order, 1. Tenneson, 2. Decoteau, 3. Lambright, 4. Bloemker, 5. Humphery, 6. Shalom, 7. Roach ID #6740 Main A-209 Reserve A169R, 8. Liston ID #1232 Main A-227 Reserve A224R. Comments indicated streamers showed 100 yards of drift, check set made it in. Kicked jumpers out in two four-man sticks. No problems with first stick. Third and fourth jumper of second stick had malfunctions. J 17 stayed near spot until Liston was found and emergency medical service (EMS) personnel were on scene.

The jump spots' Practice Jump Evaluator Notes indicate: A time of 1630. Objectives 3,000' AGL, four-man sticks, 1) Good plan in A/C, 2) Good vertical separation 3) Use "lanes" if vertical separation fails. Winds 5-10 out of SW. Critiquer: Lenmark. Emergency medical technician (EMT): Bradley **(Investigator's Note: Bradley also was operating a video camera).** Video: Charlie Brown.

The spotter gave the first jumper the command, "Get in the Door" as the jump ship turned onto final. The jumpers of the first stick performed their four point checks (drogue release handle, main release handle, reserve handle, and lower reserve static line snap shackle). The assistant spotter moved into position so that the first two men at the door could hand him their static lines to hold as they exited the aircraft. The spotter confirmed with the jump stick that they were, "on final, at 3,000 feet AGL, and the static line were clear." The smokejumpers then waited until the spotter gave the command to exit the aircraft.

No problems were noted inside the aircraft or with canopy openings. The assistant spotter, once the second man exited the aircraft, pulled both the first and second man's drogue deployment bags back into the aircraft. This was repeated for the third and fourth man of the first stick. The spotter ensured that each static line was clear before giving the smokejumper in the door a slap to exit out of the aircraft. The exits appeared normal.

## Incident

4:40 p.m. - The aircraft circled around for the second stick. The pilot stated that all operations throughout the practice jump were normal. The airplane was in smokejumper configuration: Boost pumps on, pulse light on, flaps set 25 percent.

The four smokejumpers of the second stick were briefed.

4:41 p.m. - The pilot made the standard calls to the spotter: Down wind, base leg, on final, 3,000 feet. On final the airplane was at 3,000 feet above the ground and traveling at 103 knots, north by northwest and the wind line was a northwesterly heading.

The jumpers hooked up their static lines, and the jump briefing was routine. The spotter noted that Liston and Roach had traded places from the load list which put Liston out as number three in the stick and Roach out as a number four. All jumpers were attentive during the briefing. The spotter put the first jumper, Humphrey, in the door as the jump ship turned on final and the jumpers completed the four-point checks. The spotter notified the jumpers of the second stick that they were, "On final, 3,000 feet, static lines clear."

4:42 - 4:43 p.m. - BLM spotter signaled smokejumpers Humphrey, Shalom, Liston and Roach to exit aircraft with a slap on the back.

None of the jumpers experienced any difficulties getting in the door and the exits appeared normal. The spotter had positive sight of each static line before giving the jumpers a slap to exit the aircraft. Once the second smokejumper, Shalom, exited the aircraft, the assistant spotter pulled both the first and second smokejumpers' drogue deployment bags back into the aircraft. Then the assistant spotter grabbed Liston's and Roach's static lines and held them until they exited the aircraft, then pulled the drogue deployment bags back into the aircraft.

Several witnesses saw these smokejumpers exit the aircraft. This is synopsis of the witness statements.

Humphrey exited the aircraft, went through his main deployment parachute procedure, then turned to watch Shalom exit the aircraft and deploy his parachute. Humphrey then saw Liston exit the aircraft and only saw his drogue parachute deploy. Humphrey watched Liston fall to the ground, but could not see any movement nor hear any sound from Liston.

Shalom watched Liston's jump under his drogue, which is normally a five-second ride, but in this case did not end. Shalom could not see any movement and did not hear anything from Liston. Shalom yelled at Liston to pull the handle, and then lost sight of him below his feet.

Roach watched Liston exit the aircraft, and noticed no problems as Liston exited the aircraft. Approximately two to three seconds after Liston exited the aircraft, Roach was given the signal and exited the aircraft.

The spotter notified the pilot, "Jumpers Away."

Upon the last jumper leaving the aircraft, the spotter looked toward the ground to check the exit point and then turned his attention to the jumpers. The spotter had a clear view of the last jumper, Roach, and saw the other canopies in his peripheral field of vision. Roach was stable under a fully inflated drogue and appeared normal. Roach's back was to the spotter, with a normal feet-to-earth position.

The spotter noticed Roach's right arm moving as if to pull his drogue release handle, approximately three to four seconds after Roach exited the aircraft.

After a five count (approximately four to five seconds), Roach pulled his drogue release handle. Roach's main parachute did not deploy, and during the next few seconds, Roach fell past Shalom.

Roach then reached behind his head to check and did not feel any lines. Then he pulled his main release handle and nothing happened. Roach then pulled his reserve handle, which deployed the reserve parachute and the reserve opened successfully.

The spotter could see Roach moving his right arm in a manner consistent with initiating emergency procedures. Approximately eight to ten seconds after exiting the aircraft, the spotter saw Roach's reserve parachute deploy over the inflated drogue. Shortly after line stretch, the drogue 3-ring released and pulled the main deployment bag out of the main container. The reserve parachute inflated fairly fast and the main's line deployment slowed. The main deployment bag and lines reach a maximum angle of 45 degrees before falling in trail behind Roach. No main canopy material ever deployed.

Ten seconds elapsed between the time the spotter notified the pilot "jumpers away," and the spotter notified the pilot, "had a drogue-in-tow malfunction on the last out."

Roach then looked around and saw the first two jumpers who were 300 feet above him, and 300 feet away from him horizontally. Roach did not see Liston fall.

When Shalom turned back to look for Liston, he saw a reserve parachute deployed (**Investigator's Note: Roach's reserve parachute**). Then he looked up for Roach, but could not find him.

The spotter radioed Paul Lenmark, BLM smokejumper, at the jump spot that the last smokejumper had a drogue-in-tow malfunction on the last stick, and

asked the ground crew to secure the equipment on the malfunction. The spotter did not know that Liston also experienced a malfunction. The spotter notified the pilot that a jumper had a malfunction but had successfully pulled his reserve.

Several persons observed the fall from various vantage points.

(**Investigator's Note: The approximate time of the fall, from the time Liston exited the aircraft and the time of impact with the ground, is 23-26 seconds).**

At the jump spot, Veitch watched Liston, then turned away, then looked back and saw a smokejumper with a drogue-in-tow. He waited the normal cadence (about five seconds) for a smokejumper to go through the emergency procedures for this type of malfunction and deploy his reserve parachute. He could see that the drogue appeared normal, but could not see any arm or leg movement, and saw the smokejumper in an upright position and not spinning. He saw something flapping or floating above the head of the smokejumper.

At approximately nine seconds before Liston disappeared behind the treeline, Veitch at the jump spot was heard on the video shouting "Look at this, drogue-in-tow, drogue-in-tow, get a camera on it."

From the jump spot, BLM personnel, Kenneth Perry, Matt Lyons, Ivan Smith, Bruce Ford and Mark Musitano observed the fall from the jump spot, and saw the jumper with the malfunction and under drogue about 1,500 feet above the ground, and 3,000 feet away falling feet first headed straight down. From this distance, some of the observers could not determine if Liston made any movement in an attempt to implement his emergency procedures. Some of the observers could not tell if Liston was spinning, or the reserve pilot-chute was deployed. To other observers he appeared conscious and attempting malfunction procedures. No observers heard any sounds. Bradley saw a portion of Liston's fall and tried to capture it on video. Brown also filmed Liston's fall. The camera was set on wide angle and does not show sufficient detail. (This footage has been sent to the FBI forensics laboratory for enhancement.)

From the northwest corner of the Ft. Wainwright football field across the street from the AFS, Bryan Combs, BLM employee, saw one of the smokejumper's parachute not open, and the jumper falling at a high rate of speed. Near the tree level, he saw an opened yellow and white chute. Standing next to Combs, Justin Houston, BLM employee, observed the fall and stated that as Liston reached the tree line, something yellow deployed and then disappeared.

Sergeant First Class Fredrick Kregel and Captain Deborah Crawford were standing in the Birchwood Subdivision, later determined to be 6,560 feet west of the accident site. Several adults and children were watching the smokejumpers exit the aircraft. Kregel watched as the first three jumpers exited the aircraft flying between 2,500 and 3,000 feet. He watched as the fourth jumper was falling out of the airplane and observed that it did not look right. He watched as three of the four parachutes deployed between 250 and 500 feet below the plane. At about 100 feet below the aircraft, it appeared the pilot-chute (light in color) on the fourth jumper opened and that pulled something dark in color, was suspended five to 10 feet above the jumper. It appeared to Kregel that this jumper fell in a standard fall, feet first, without any apparent attempt to fight open the parachute or the reserve. As the smokejumper fell, he appeared to be spinning, and from Kregel's perspective, that he was going to land on the third jumper's parachute. Kregel stated that the third jumper's parachute, which was light in color, probably white, appeared to be released, and a new (reserve) parachute was deployed in two to three seconds. Kregel then watched as the unopened chute (**Investigator's Note: Roach's reserve deployment bag**) continued to fall to the ground. The witnesses from the Birchwood Subdivision watched until they lost sight of the individuals about 750-1,000 feet off the ground when they went behind the tree line.

Crawford observed Liston's fall and just before disappearing from view, she saw the jumper spiraling. **(Investigator's Note: The trees near the housing area obscure the last 1,000 feet of the descent.)**

David Fischer, private citizen, observed Liston fall. Fischer was the closest witness, standing approximately 200 meters west of the intersection of Birch Hill Road, and the Ski Lodge Entrance, and was closing up the skeet range. Fischer heard a flapping sound, and saw a parachute that looked like a streamer. Sergeant Major Bert Thomas was inside his vehicle, with his engine running, at the skeet range talking to Fischer.

Gregory Lavryk, private citizen, was driving on the dirt road (Birch Hill Road) and observed that Liston had a red parachute open as he went behind the tree line.

At the jump spot, a BLM employee was heard on the two cameras video taping the smokejumper operations, "Pull that (expletive deleted), Pull that (expletive deleted), ah (expletive deleted)," approximately the time Liston disappeared behind the tree line.

Fischer turned to Thomas and said that he thought one of the smokejumpers just hit the ground. Thomas heard the flapping noise, and then they heard the impact. Thomas then drove his truck over to the intersection of Birch Hill Road and the ski lodge entrance.

**(Investigator's Note: Death was instantaneous upon impact due to traumatic aortic disruption according to the Admitting Physician.)**

## Post Incident

Thomas and Fischer began to search for the smokejumper whose parachute failed to deploy and who landed approximately 75 yards east of the intersection of Birch Hill Road and ski lodge entrance.

Several smokejumpers at the jump site that watched Liston's fall (Perry, Veitch, Musitano, Bradley, Smith, and Lyons) ran to vehicles to drive west down River Road, and then north to the intersection of Birch Hill Road and the ski lodge entrance.

There was confusion on the jump spot with other personnel, who were focused on Roach, as to whether there were one or two malfunctions. Personnel who watched Roach under reserve began to count the seven visible parachutes, and then realized a jumper was missing. Ford watched Roach coming down on his reserve parachute, trailing a fully inflated drogue and another unidentifiable object. Roach landed without injury, and got out of his harness and jump suit. Roach noticed that his main parachute and drogue were still attached, and that some of the lines from the main parachute had come out. Ford observed that Roach had been trailing the undeployed main parachute in its deployment bag. Roach stated that his reserve static line did not appear to deploy. Ford observed that the upper reserve static line snap shackle was connected to the main riser, and that the reserve static line was not completely deployed from its pocket, and that at least six feet of the lanyard connected the riser to the harness.

Roach left all his gear at the jump site with the exception of his personal gear bag.

4:46 - 4:47 p.m. - Thomas found Liston, and yelled that he had found him. Thomas observed parachute material on the ground and that the reserve parachute did not open. Fischer approached the scene as several smokejumpers entered the woods. Perry ran over to Liston's location, and checked for a pulse. Fischer returned to the Ski Lodge to call 9-1-1.

Bradley, EMT, took over the medical response as EMTs Perry, Smith, and Lyons, and Musitano assisted with CPR/emergency procedures. No pulse was obtained. Veitch took command of the scene.

4:47 p.m. - Lenmark, at the jump spot, informed the pilot and the spotter that there was an additional problem.

4:48 p.m. - Lenmark then gave the aircrew directions to Liston's estimated location, and the jump ship began searching to see where Liston had landed.

4:50 p.m. - Jump ship (J-17) contacted AICC, "Over River Road - Canopy Malfunction."

4:56 p.m. - Ft. Wainwright Fire and Emergency Services were contacted by the Birch Hill Operator and Engine E6, Emergency C2 and Ambulance M212 was dispatched.

The jump ship searched for a deployed canopy. The pilot then turned around and followed the same line of flight to the exit point. The spotter then asked the pilot to fly the same pattern, but off the wind line so the spotter and assistant spotter could have a better view of the exit point and also the flight path from the exit point to the drop zone.

4:58 p.m. - Humphrey arrived where Liston was lying, and asked for a trauma kit from jump ship.

Hernandez and Lenmark drove down the road, stopped near the site, and ran to Liston. Thomas returned to the road to guide the ambulance. Tenneson, EMT, arrived on the scene and assisted with CPR.

4:59 p.m. - The jump spot personnel recommended notifying EMS personnel and contacted the jump ship.

5:00 p.m. - The jump ship radioed AICC to request EMS response towards Ski Hill Lodge with one serious injury.

AICC dialed 9-1-1, informed the 9-1-1 operator of the report from J-17, and was told an ambulance was on the way to that location (Ski Lodge).

5:01 p.m. - Ft. Wainwright Fire and Emergency Services Ambulance arrived on scene.

The spotter in the jump ship located Liston's landing site. The spotter could see only a small amount of material from the air.

EMS personnel from Ft. Wainwright Fire and Emergency Services arrived at Liston and Erik Jones, EMT-paramedic, assumed control of the medical response.

5:02 p.m. - Jump ship was informed by Fairbanks Dispatch that EMS had already been dispatched to the Ski Lodge. The pilot informed AICC that they were responding to the right location.

5:03 p.m. - The jump ship asked AICC to contact Dalen Romero, Chief, Smokejumper Operations at home.

AICC left a message on Dalen Romero's answering machine.

5:04 p.m. - The jump ship confirmed that EMS had reached Liston and then returned to Ft. Wainwright.

Roach arrived at the scene and helped other BLM personnel carry gear and clear a trail with chainsaws.

Ford arrived at the scene just before Liston was transported to the hospital.

5:05 p.m. - Medical personnel began to move Liston on a stretcher to the ambulance.

5:05 p.m. - AICC notified Dave Dash, Chief, Fire Operations.

5:07 p.m. - AICC notified that the ambulance and EMS were on scene.

5:08 p.m. - Jump ship (J-17) contacted AICC, and informed them that "Jump -17 is landing, and EMS and smokejumper EMTs were on scene."

AICC leaves message on AFS Manager Scott Billing's answering machine.

5:09 p.m. - Jump ship returned to standby shack.

5:10 p.m. - Bert Mitman, assistant smokejumper base manager, was notified at home of a possible fatality. Mitman called Dash to give him the information. Dash had already been informed by AICC. Mitman attempted to contact Romero, but was unsuccessful.

AICC left message on AFS Aviation Manager Gil Eggleston's pager.

Togie Wiehl, BLM smokejumper, and Hade went to Liston's accident site, and then proceeded to the drop zone to look at Roach's parachute.

Ford returned to the scene of Roach's parachute equipment and examined it in detail. He noted that the reserve static line lanyard was still partially in its pocket; the lower reserve static line snap shackle was open, but the loop of the Velcro assembly was hooked over the arm of the open shackle. The Velcro was detached from the reserve, and the reserve handle was not in sight. There were about three to four inches of lanyard between the reserve static line pocket and the lower snap shackle. The main suspension lines were fully stretched out, but the center and right locking stows were still in the rubber bands. Half the lines appeared to be pulled out of the center locking stow. The left locking stow was pulled open and the slider was visible on that side. The remaining stows had approximately two-inch bights. All the other main line stows were deployed. Main toggles were stowed in their keepers and the brakes set. The drogue was un-killed and appeared to have no extra kill line slack.

5:12 p.m. - AICC identified Scott Billing's pager was not in service.

5:18 p.m. - AICC notified Adrian Benett, Office of Aircraft Services (OAS) who would notify Lee Svoboda, OAS.

5:20 p.m. - Ft. Wainwright Fire and Emergency Services Ambulance M212, with Liston and Bradley aboard, Emergency C2 and Engine E6 departed scene for Basset Army Community Hospital.

5:27 p.m. - Veitch video taped scene. Lenmark took photographs of scene.

5:28 p.m. - Ft. Wainwright Fire Department Ambulance arrives at Bassett Army Community Hospital, Urgent Care Center (BACH-UCC), 1060 Gaffney Road, Building #7420, Ft. Wainwright, AK 99703, with CPR in progress. Patient had no vital signs; advanced life support and medical procedures were initiated, with no results.

BLM EMTs departed scene.

BLM personnel arrived and taped off the area.

5:32 p.m. - AICC contacted Andy Williams, public affairs officer, to come in.

5:34 p.m. - AICC notified Joe Ribar, fire staff officer.

5:35 p.m. - Mitman arrived at standby shack, where he talked to Dash and overhead.

5:36 p.m. - Liston was pronounced dead by Dr. Peter G. Deveaux, Captain, M.D.

5:38 p.m. - AICC notified the Chief of Support Services Terry O'Connell, who called the Chief of Financial Services Veronica Belton.

5:40 p.m. - AICC notified Vince Mazzier, AFS safety manager, who would respond.

5:45 p.m. - Specialist (SPC) George A. Dominguez and Sergeant Dalton, Military Police arrived at scene, and notified the Military Police Desk Sergeant, Provost Marshall's Office (PMO) of a training accident, who then notified Special Agent Sonny Siebert, U.S. Army Criminal Investigation Division.

BLM Personnel reviewed emergency procedures, and discussions occurred. Bradley was at the hospital with  Liston.

5:50 p.m. - AICC paged  Scott Billing.

5:51 p.m. - AICC paged Gill Eggleston.

6:00 p.m. - The Alaska Smokejumpers decided to send another employee to the hospital to aid  Bradley, then were informed of Liston's death. Crew was instructed to meet at 8:00 p.m.

6:10 p.m. -SPC James Lawton, Military Police arrived on site and assisted SPC Dominguez.

6:14 p.m. - Special Agent (SA) Clarence Joubert III, U.S. Army Criminal Investigation Division arrived on scene and was briefed.

6:16 p.m. - SA Sonny Siebert, arrived on scene and was briefed by SPC Dominguez. SA Siebert requested SPC Dominguez and another patrol to remain on site and help secure the scene.

Military Investigators (MPI) Eastwood and Yeatts arrived on scene.

6:20 p.m. - SA Joubert, SA Siebert and Veitch entered the scene and took photos and video documentation of the scene.

6:22 - 6:40 p.m. - List of all persons on scene was taken by the Military Police, and scene was secured by Military Police.

7:00 p.m. - Mitman was informed by Dash that Military CID (U.S. Army Criminal Investigation Division) would want to interview the jumpers on the load and at the jump spot.

7:20 p.m. - SPC Lawton, Military Police, was assigned by Sgt. Dawton to guard the body at the hospital.

8:00 p.m. - The smokejumpers started their crew meeting, and passed on what information was known. Romero arrived about this time.

9:00 - 10:00 p.m. - AFS started sending people to building 1051 to be interviewed by CID. Confusion existed as to who would guard gear in the field, who had jurisdiction, and who would maintain gear in undisturbed condition. Many people had gone home.

9:15 p.m. - The Office of Fire and Aviation was notified and activated the Serious Accident Investigation Team.

9:20 p.m. - Siebert continued his investigation at the hospital.

11:00 p.m. - Smokejumpers pulled parachutes from racks and bins and stored them in round tower.

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12:00 a.m. - AFS personnel were still going to CID for interviews.

1:00 a.m. - Romero stayed at the standby shack with the night operations shift. Mitman departed for a few hours. Weihl returned from the jump spot with information that MPs and Fairbanks Police would patrol the road and the jump spot and protect gear.

4:00 p.m. to 12:00 a.m. - Serious Accident Investigation Team members arrived in Alaska.

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8:30 a.m. - Investigation began.

David J. Liston's Fatality Findings

# Determination of Causal Factors

## Primary Causes

Liston experienced a parachute malfunction when his reserve parachute's pilot-chute and suspension lines entangled with the main parachute's drogue (pilot-chute). This entanglement prevented either parachute from deploying. The entanglement overcame the ability of the employee to manage the event. Liston suffered massive blunt force injuries due to a fall from height (failure of parachute to open).

## Secondary Causes

Liston's main parachute did not properly deploy because the main drogue did not release at the correct time in the deployment sequence.

Liston's reserve parachute did not properly deploy because the reserve pilot-chute bridle was entangled with the drogue bridle.

Physical evidence indicates that once the reserve pilot-chute was deployed by Liston initiating emergency procedures, it encircled (twisted with) the main parachute drogue bridle thus preventing full elongation of the reserve suspension lines. The twists caused the reserve deployment bag to stop against the drogue bridle where the bag and lines formed a knot with the drogue bridle. At some point thereafter the main parachute drogue released. At this point, the load (tension) was transmitted between the main parachute drogue bridle and the reserve droop risers precluding full deployment of either parachute.

Neither the main parachute canopy nor the reserve parachute canopy came out of their deployment bags due to the entanglement between the reserve suspension lines and main drogue bridle.

The Investigation Team focused on employee performance, smokejumper operational procedures, environmental factors on the day of the accident, materials used in construction of equipment, and BLM ram-air parachute equipment.

The factors surrounding Liston's fatality cannot be determined with certainty. It is clear, however, that in Liston's fatality an equipment failure or multiple interactive failures were likely involved.

**Employee Performance** - The Investigation Team evaluated Liston's training, proficiency, knowledge, skills, abilities and attitude and determined each as non-contributory factors in the fatality. The toxicology report on Liston was negative. Riggers were certified and parachutes were packed properly. Aircraft and pilots were carded and flew normally. The spotters performed standard equipment checks before the jump and performed jump operations correctly.

**Smokejumper Operational Procedures** - The Investigation Team evaluated all relevant policies, procedures, practices, instructions and management controls. These smokejumper operational procedures were examined. Specific development protocols for the introduction of new equipment and modifications were found inadequate. The team members evaluated the training and refresher training curricula and procedures and determined that they had no causal bearing on the accident. As a result of this investigation, new information can be added to the *Ram-Air Parachute Training Manual* to address heretofore unknown malfunction scenarios (e.g. debris in the 3-ring locking loop, freezing or stiffening of the locking loop.)

**Environmental Factors -** The weather conditions at the time of accident were mostly clear and sunny, with few clouds at 5,500 feet, and scattered clouds at 20,000 feet. Ground winds were light and variable (1-3 mph). Winds at jump altitude were reported at 190 degrees (south to southwest) at eight knots. The temperature recorded at AFS Fairbanks Remote Area Weather Station (altitude 454 feet), was 57 degrees Fahrenheit (F), with 25 percent relative humidity. The temperature at 3,450 feet MSL recorded by weather sounding 30 minutes before the accident was 29-31 degrees F.

Minimum flight conditions for ram-air smokejumper jump operations are: 3,000 feet minimum AGL, Visual Flight Rules (VFR) conditions (500 feet below, 1000 feet above, and 2,000 feet horizontally from clouds). The conditions at the time of the incident were within minimum standards.

On the first jump both jumpers landed in a wet area. One or both of the 3-ring locking loops may have been wet during the second jump(s). At exit altitude, the temperature was below freezing. Testimony from 3-ring inventor Bill Booth indicates that freezing of the locking loop can increase the force required to release the 3-ring mechanism. John P. Zarling, Ph.D., professional engineer submitted documentation that states if the locking loops were wet

and frozen and if the load on the assembly was low "because of pulling the release within seconds of exiting the aircraft," then this could explain why both jumpers experienced hesitations in the release of the drogue 3-ring mechanism. Dr. Zarling's report indicates that freezing the 3-ring locking loop and assembly raises the release force. Testing and simulations produced both a release failure and a release hesitation. There are no equipment standards that address temperature or moisture limitations. See Appendix ?.

The "River Road" jump spot was on flat terrain, approximately 450 feet elevation (MSL). The ground cover vegetation is tussocks tundra with scattered mixed spruce and hardwoods. The ground is generally swampy, with standing water 3-12 inches deep, between the individual tussocks. The fatality site was wooded with patches of snow. Both sites are located south of the ridge that includes the Birch Hill Ski Area at Fort Wainwright. The fatality site and the jump spot are located approximately 3,000 feet apart.

**Materials Used in Construction -** The parachute system components designed and manufactured by BLM are the harness, main and reserve container, main deployment bag, personal gear bag, static line and drogue deployment bag, separable reserve risers, and occasionally the main risers. This equipment was designed and built in accordance with existing industry standards and practices. Materials complied with applicable Military Specifications and industry standards at the time of construction.

**BLM ram-air parachute equipment** - Liston's main and reserve parachutes, his containers and harness met all specification standards as developed by the BLM. The equipment was constructed properly and the parachutes were packed properly. Although all of the equipment was constructed according to bureau specifications and was in serviceable repair, the interaction of the various components has received the critical attention of the Investigation Team. Attention is specifically focused on the following most plausible factors involved in this accident:

- 3-ring drogue release mechanism and its position on the harness relative to the main container.
- Zero porosity (ZP) drogue and aerodynamic interactions during reserve deployment.
- Reserve container belly band attachment hardware.
- Personal gear bag size, shape and weight, its position relative to the reserve container, and its attachment hardware.
- Environmental conditions and the possibility of freeze-related stiffening of the 3-ring release locking loop.

Two main drogues are used in BLM ram-air applications. They have different fabric porosity characteristics. The F-111 drogue was the first in use and was tested in emergency reserve deployment simulations. The Team was unable to determine if the ZP drogue was tested in emergency reserve deployment simulations before it was brought into service. The distinct differences in porosity between these two drogues suggest that there may be important aerodynamic differences that can influence the trajectory of the reserve pilot-chute. This is the first known incident involving emergency deployment of a reserve under a ZP drogue with the BLM ram-air system.

***During the investigation of the equipment malfunction, the Investigation Team considered all of the following scenarios. Using expert opinions of the investigators, the possibilities in each subject area are subjectively ranked from most likely to least likely.***

# Drogue-in-Tow

It is certain that the drogue did not release at the correct time in deployment sequence. Therefore, the investigators focused considerable attention on the 3-ring release mechanism. For the purposes of this discussion, a "drogue-in-tow" is defined as a failure of the 3-ring mechanism to release the drogue parachute and then, act as a pilot-chute and deploy the main parachute.

**3-Ring Drogue Release Mechanism**

The 3-ring release mechanism is an internationally used system. It is used in BLM smokejumper operations, military operations, and sport applications. It is standard within the parachute industry worldwide.

It is important to understand that relatively little force is required to release the mechanism (about five pounds); however, the same small force, if opposing, can prevent it from functioning properly. Several construction specifications must be observed in the manufacture of the 3-ring release assembly. Several important precautions must also be observed in 3-ring use. In drogue release applications, the 3-ring design and construction, with respect to the harness and its maintenance, may be especially critical.

The 3-ring mechanism's inventor has identified two ways in which the assembly may not release:

1. Anything that comes into contact with the locking loop or the rings might block its action. As described above, relatively little

force is required to hold the small ring in an un-releasable position. In this case, for example, the main parachute container bag may have ridden up allowing it or one of its parts to block the operation of the mechanism. Whereas very little force is required to hold the locking loop, it is conceivable that foreign matter (e.g. twigs or splintered cable coating) was present which prevented the release action of the mechanism. While it is impossible to be certain that foreign matter was not present, there was no evidence to support this theory, as well as the fact that the assembly was inspected before exit.

2. A hardened locking loop that precludes release of the first, smallest ring. In this case, as an example, a wetted locking loop that subsequently froze is possible.

During the course of this investigation, two other factors have been identified that may, also, cause the 3-ring mechanism to fail.

3. The main drogue bridle can accidentally wrap around the drogue bridle ring.

4. The first, smallest ring can release off of its design path.

The inventor of the 3-ring system was consulted and confirmed that these last two scenarios were improbable on the BLM system. Although any or all of these four factors can be demonstrated and replicated in a static environment, the first two are considered as possible secondary causes for this fatality.

The possibility that the hard pad at the back top of Liston's jumpsuit interfered with the 3-ring was discounted following suspended harness tests.

The 3-ring interference that could possibly result from bad body position (e.g. tumbling) was discounted by testimony from the spotter and other witnesses who saw Liston's exit and/or drogue fall. He had a good exit and was in an upright position following drogue deployment.

The existing records of previous drogue-in-tow malfunctions include four scenarios that were discounted after review by the investigators:

- 3-rings hooked up incorrectly;
- wrong cable used to hook up drogue;
- swedge came loose on drogue handle; and,
- drogue bridle broke

The standard pre-jump inspection procedures include three separate visual inspections of the 3-ring assembly. All three inspections were verified by testimony of the participants in this jump operation.

**Out-of-sequence Pulls**

The investigators considered the possibility that the three handles were not pulled in the correct sequence. The correct sequence is : 1) Drogue Release; 2) Main Canopy Release; 3) Reserve Activation.

All three handles were pulled. The drogue release handle was found seven feet from Liston's body. The main release handle and the reserve activation handle were found 49 feet apart. The main release handle was found about 212 feet from Liston's body, and the reserve handle was 197 feet away. This evidence does not indicate whether or not the handles were pulled in the correct order. Training procedures direct disposal of the drogue release handle during emergency procedures before pulling the main release and reserve activation handles. It is common for smokejumpers to omit this step because the drogue release handle fits unobtrusively over the hand and does not impede operation of the other handles. Standard practice is to hold onto the drogue release handle until landing on normal jumps.

Out-of-sequence pulls would result if the drogue release handle was inaccessible to the jumper. If the release handle was inaccessible, Liston would have had no choice but to activate the reserve out of sequence. The drogue release handle was pulled at some point.

The investigators could not eliminate the possibility that the reserve container moved out of position and blocked access to the drogue release handle during some part of the descent. Microscopic inspection of the left side reserve container belly band Fastex snap showed a distinct possibility of pre-existing fractures in the female component that would affect the tensile strength of the snap. A fracture of this strap is difficult to see. If the Fastex snap released during exit, then the reserve container and or the main container may have changed positions. In a high position, the main container may impede 3-ring release. Additionally, pressure between the personal gear bag and the reserve container would likely affect the position of the reserve by shifting it upward.

Out-of-sequence pull could also be caused by the drogue release handle slipping out of its retainer pocket to a position out of reach. If the release handle was inaccessible, Liston would have had no choice but to activate the reserve out of sequence. The investigators deemed this improbable because

inspection of the elastic release handle pocket was found to be in good condition and the handle was inspected repeatedly before exit. The handle was pulled at some point.

**On-time 3-ring Release / Drogue still towed**

The investigators considered that the 3-ring may have functioned normally and on time but the drogue still did not open the main container and lift the main deployment bag as designed. Such occurrence would follow if the rubber bands that stow the drogue bridle did not release or if the main container closing pin was not extracted. All investigators agree that the rubber bands were not a factor. The recommendations that follow in this report will suggest an improvement to the drogue bridle system to further reduce the unlikely chance that the main closing pin was not pulled at the correct time.

**Horseshoe / Bridle Under Arm**

A horseshoe malfunction is defined by the BLM training manual as any entanglement of the deployment system with any part of the jumper body or equipment. An example in this case would have occurred if Liston had tumbled out of the aircraft and trapped the drogue bridle under one arm. The investigators discounted a horseshoe malfunction based on testimony from the spotter and other witnesses who saw Liston's exit and/or drogue fall and based on the absence of typical friction burn or tear damage on his equipment.

## Reserve Entanglement

It is not normal that the reserve pilot-chute encircles or tangles with a drogue-in-tow malfunction. Private industry has conducted extensive tests and determined the risk to be low. The investigators in Liston's fatality identified the following factors that may upset the normal function of the reserve deployment and may have contributed to this entanglement.

**Misdirected launch**

The investigators could not eliminate the possibility that the reserve container moved out of position. Microscopic inspection of the left-side reserve container belly band Fastex snap showed a possibility of pre-existing fractures in the female component that would lower the tensile strength of the snap. If the Fastex snap released inadvertently during exit, the reserve container may have changed positions. Pressure between the personal gear

bag and the reserve container would likely affect the position of the reserve by shifting it upward. The reserve pilot-chute is designed to launch forward out and away from the jumper with a spring force exceeding 20 pounds. (Liston's pilot-chute spring measured 24.3 pounds.) The design is intended to keep the reserve pilot-chute clear of any possible obstruction or interference. The separation of the belly band could be critical during deployment of the reserve because it could lead to movement of the reserve container resulting in misdirected launch of the reserve pilot-chute.

**Aerodynamics**

It is known that reserve pilot-chutes launch in close proximity to the drogue. Liston's reserve was deployed while under an inflated ZP drogue-in-tow. The aerodynamics of this interaction are not known. The Investigation Team believes that the pressure zones around a ZP drogue are different than those around an F-111 drogue. The F-111 drogue was tested in emergency reserve deployment simulations during the course of ram-air development. The recently introduced ZP drogue may not have been tested in emergency simulations with the BLM configuration. The investigators suspect that the difference in turbulence of the drogues made from two fabric types warrants further investigation.

**Personal Gear (PG) Bag Effect**

Liston used a prototype PG bag cover under development at the Alaska Smokejumper facility.

The personal gear bag is designed to ride below the reserve deployment bag. Presently, there are no weight, shape or size specifications to the personal gear bag or bag cover. The personal gear bag is attached with Fastex snaps routed underneath the reserve belly band to prevent the personal gear bag from riding up over the reserve container. The attachment of the personal gear bag is sometimes difficult. It is left to the smokejumper and is not a standardized checklist item.

Pressure between the PG bag and the reserve container could possibly affect the pilot-chute launch trajectory or pilot-chute bridle deployment. Lifting the reserve container would cause the trajectory to travel closer to the drogue bridle where the entanglement occurred. Pressure between the PG bag and the reserve container could impede the reserve pilot-chute bridle thereby restricting the pilot-chute from launching to its desired trajectory distance from the drogue bridle.

The position of the stiff, round hardhat inside the bag may act as a fulcrum causing the bag to more easily ride up over the reserve container bag. This could impede the launch of the reserve pilot-chute.

The PG bag handle is sized, shaped and positioned in a way that it could conceivably release the reserve handle if the PG bag rolls up and completely over the reserve container. Microscopic inspection and the location of the handles does not support this theory.

**Pilot-chute / drogue collision (Tear in drogue)**

A small 2-inch tear in the outer perimeter of the drogue canopy is unexplained after microscopic inspection. It may have resulted from the collision of the reserve pilot-chute with the drogue, but more likely occurred as the drogue descended through the trees just prior to landing. It is also possible that the damage was preexisting and went unnoticed during packing. The tear in and of itself would not be a causal factor of the accident.

**Hands in the way**

The possibility exists that Liston may have inadvertently misdirected the pilot-chute launch with his hands. No evidence exists to support or discount this possibility.

**Premature reserve deployment**

Investigators considered the possibility that the reserve deployed prematurely without Liston's input. One example is described above in the PG bag interaction with the reserve activation handle. No evidence is present to substantiate the PG bag cover's handle released the reserve parachute. The investigators discounted the probability that the PG bag handle snagged the reserve handle because of the distance of the reserve handle and the main release handle away from the accident site.

Another scenario considered was that Liston's grip on the drogue release handle may have captured the reserve static-line (RSL), subsequently activating the reserve prematurely. The investigators deemed this improbable because the RSL tackings were not broken.

The reserve pack was studied to ascertain whether an ineffective hesitator loop may have allowed the reserve deployment bag to escape the container without being lifted by the pilot-chute or its bridle. Manufacturing instructions call for the hesitator loop to be one and one-eighth inches long.

The measured length of the hesitator loop on Liston's reserve was one and seven-eighth inches. Loop length increases commonly due to tightening of the knot during packing. The investigators deemed this as inconsequential because the entanglement did not indicate bag-first deployment.

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## Contributory Causes

One component that is used in the construction of the BLM parachute system for which Mil-spec standards do not exist is the Fastex snaps that secure the PG bag and the reserve container belly band.

Microscopic inspection of the left side reserve container belly band Fastex snap showed distinct possibility of pre-existing fractures in the female component that would affect the tensile strength of the component. If the Fastex snap released during exit the reserve container and/or the main container may have changed positions. The reserve container may have moved up and blocked access to the drogue release handle. This change may have been aggravated by the affect of the PG bag that presses against the bottom of the reserve container. The movement of the reserve container could also contribute to misdirected launch of the reserve pilot-chute. The separated belly band could also allow the main container to move up and contact the 3-ring release mechanism blocking its release. The investigators consider this as a possible contributory factor.

BLM has not established size, shape and content weight limitations for the PG bag or bag cover. The bag's close proximity to the reserve container may have influenced deployment of the reserve pilot-chute and or pilot-chute bridle.

Thomas O. Roach's Incident Findings

# Determination of Causal Factors

## Primary Causes

Roach's main parachute did not properly deploy because the drogue failed to release when the drogue release handle was pulled. This malfunction is known as a drogue-in-tow. Roach implemented his emergency procedures, and successfully deployed his reserve parachute that functioned as designed.

## Secondary Causes

Roach's main parachute did not properly deploy because the main drogue did not release at the correct time in the deployment sequence.

The Investigation Team focused on Employee Performance, Smokejumper Operational Procedures, Environmental factors on the day of the incident, Materials used in construction of equipment, and BLM Ram-air Parachute Equipment.

The statement given by Roach and the corroborating witness statement of the spotter indicate an equipment malfunction.

**Employee Performance** - The Investigation Team has evaluated Roach's training, proficiency, knowledge, skills, abilities and attitude and determined each as non-contributory factors in the incident. Riggers were certified and parachutes were packed properly. Pilots were carded and flew normally. The spotters checked equipment before the jump and performed jump operations correctly.

**Smokejumper Operational Procedures** The Team evaluated policies, procedures, standard operating procedures; specific operating practices; exact procedures and operating instructions; safety precautions, malfunctions, emergency procedures, and hazard identification; management involvement and control. The procedures were examined and were adequate and had no causal effect on the incident. The Investigation Team evaluated the training and refresher training curricula and procedures and determined that they had no causal bearing on the accident. As a result of this investigation, new information can be added to the *Ram-Air Parachute Training Manual* to address heretofore unknown malfunction scenarios (e.g. debris in the 3-ring locking loop, freezing or stiffening of the locking loop.)

**Environmental Factors -** The weather conditions at the time of accident were mostly clear and sunny, with few clouds at 5,500 feet, and scattered clouds at 20,000. Ground winds were light and variable (1-3 mph). Winds at jump altitude were reported at 190 degrees (SSW) at eight knots. The temperature recorded at AFS Fairbanks Remote Area Weather Station (Alt. 454 Ft), was 57 degrees Fahrenheit, with 25 percent Relative Humidity. The temperature at 3450 feet MSL recorded by weather sounding one half hour before the accident was 29-31 degrees F.

The weather conditions may have been a significant factor given that both Liston and Roach were the only jumpers to make two jumps that day. On the first jump both jumpers landed in a wet area. One or both of the 3-ring locking loops may have been wet during the second jump(s). At exit altitude, the temperature was below freezing. Testimony from 3-ring inventor Bill Booth indicates that freezing of the locking loop can increase the force required to release the 3-ring mechanism. Dr. Zarling submitted documentation that states if the locking loops were wet and frozen and if the load on the assembly was low "because of pulling the release within seconds of exiting the aircraft," then this could explain why both jumpers experienced hesitations in the release of the drogue 3-ring mechanism.

Minimum flight conditions for ram-air smokejumper jump operations are: 3,000 feet minimum AGL, Visual Flight Rules (VFR) conditions (500 feet below, 1000 feet above, and 2,000 feet horizontally from clouds). The conditions at the time of the incident were within minimum standards.

The "River Road" jump spot was on flat terrain, approximately 450 feet elevation (MSL). The ground cover vegetation is tussock tundra with scattered mixed spruce and hardwoods. The ground is generally swampy, with standing water 3-12 inches deep, between the individual tussocks. The jump spot was located about 3,000 feet apart.

**Materials Used in Construction -** The parachute system components designed and manufactured by BLM are the harness, main and reserve container, main deployment bag, personal gear bag, static line and drogue deployment bag, separable reserve risers, and occasionally the main risers. This equipment was designed and built in accordance with existing industry standards and practices. Materials comply with Military Specifications and industry where applicable.

**BLM ram-air parachute equipment** - Roach's main and reserve parachutes, his containers, and his harness met all specification standards as developed by the BLM. The equipment was constructed properly and the parachutes were packed properly. Although all of the equipment was constructed according to bureau specifications and was in serviceable repair,

the interaction of the various components has received the critical attention of the Investigation Team. Attention is specifically focused on the following most plausible factors involved in this accident:

- 3-ring drogue release mechanism and its position on the harness relative to the main container.
- Environmental conditions and the possibility of freeze related stiffening of the 3-ring release locking loop.

# RECOMMENDATIONS

**Operational:**

Update the BLM *Smokejumper Operations Manual* to include 3-ring release precautions. Include these precautions in parachute training.

Specifically address freezing of a wet 3-ring assembly, 3-ring alignment, and debris in mechanism in the Drogue-In-Tow Malfunction section of the *Ram-Air Training Manual*.

Establish visual inspection for these hazards in established equipment checks, buddy checks, and spotter checks.

Replace Fastex snaps with strength rated hardware appropriate for loads experienced in smokejumper operations to prevent reserve/main container movement.

Require the personal gear bag attachments as a pre-jump checklist item.

Establish size, shape, loaded weight, and other design specifications for the personal gear bag, and bag cover if it is utilized. Consider attaching the personal gear bag to paracargo.

**Programmatic:**

Smokejumpers have contributed design innovations to the evolution of parachute systems. These contributions have been widely adopted in sport and military applications. Senior managers have the responsibility to evaluate and oversee smokejumper operations. The smokejumpers' continued involvement, both operationally and programmatically, is viewed as essential by the Investigation Team, outside experts, and the smokejumper community.

Conduct a systems safety assessment (comprehensive design evaluation) of parachute equipment used in the smokejumper program. Address the integration and dynamics of individual components within the entire parachute system.

Specifically address suggestions forwarded by Bill Booth for improvements to the 3-ring release and main container closing pin. **(Attachment ?)**

Specifically address the aerodynamic differences of the ZP and F-111 drogues in the BLM ram-air configuration.

Analyze the engineering of the 3-ring drogue release as configured in smokejumper ram-air operations. Include a certified professional engineer in the assessment process. Use results to update the smoke jumper manual.

Create a management process to document and report parachute malfunctions and anomalies (e.g. drogue release hesitation). Implement this on an interagency basis similar to the National Interagency Safe-com or the FAA Malfunction or Defect Reports.

Formalize a management process to evaluate, analyze, and correct deficiencies identified in malfunction or anomaly reports. The process should address employee recommendations for improvements. Implement this on an interagency basis.

While encouraging new ideas and innovation from smokejumpers, develop a systems-based process to test, evaluate, and document modifications to the existing parachute systems. Include parachute engineering experts from industry in the process. Every component improvement must be developed, tested, and implemented, in the context of how it integrates with and affects existing systems and related operational procedures.

# APPENDIX

APPENDIX A

INVESTIGATION DOCUMENTATION (Utilizing OSHA CPL 2.113 Format)

1. **PERSONAL DATA - VICTIM.**

a. Name - David J. Liston

b. Address(es)

1513 Gaffney Road (Ft. Wainwright duty station)
Ft. Wainwright, Alaska 94703

c. Telephone -
907-356-5540 (Ft. Wainwright duty station)

d. Age - 28. Date of Birth - April 17, 1972. Height: 5' 7". Weight: 190 pounds.

e. Sex - Male

f. Job Title - Forestry Technician (Smokejumper)

Grade/Series - GS-0462-06 (180 Day Appointment)

g. Date of Employment - April 23, 2000

Service Computation Date (April 30, 1996) Indicates total time in Federal Employment. Entered Federal Employment May 16, 1993.

h. Time in Position - Six (6) Days

Employed as a Smokejumper since April 22, 1998

i. Training for Job being performed at time of accident

**David J. Liston Training and Experience:**
Forestry Aid (GS-0462-03) - Fire Fighter position
U.S. Forest Service. May 16, 1993- November 11, 1993

Forestry Aid (GS-0462-03) - Fire Fighter position
U.S. Forest Service - May 1, 1994 - October 16, 1994
FTN Status October 16, 1994 - April 4, 1995

Forestry Aid (GS-0462-03) - Fire Fighter position
U.S. Forest Service - April 16, 1995 - May 13, 1995

Forestry Technician (GS-0462-04) - Fire Crew Member Midnight Suns Hot Shots (Seasonal Appointment)
BLM, AFS - May 22, 1995 - November 15, 1995
The following is an excerpt from Position Description HS9435:
"Participates in fire and safety training in the techniques, practices, and methods of fire suppression and in the safe, efficient operation and use of tools, equipment and vehicles used in fireline activities, with emphasis on those used in the particular function to which assigned. Participates in crew proficiency checks and drills. Participates in safety sessions and fire critiques. Ensures own and others' welfare and safety in all aspects of the assignments."

Knowledge Required by the Position: Must have the knowledge, skills and abilities specified in the IGS qualifications standard for this position and grade level.

This firefighting position requires strenuous physical exertion on a recurring basis. The employee must meet the established physical requirements for the position. This position is subject to the arduous physical requirement of the GS-462/455 standards."

Forestry Technician (Fire Crew) -(GS-0462-05)
(Seasonal Appointment) - Position No. HS9502
BLM, AFS, Hot Shot Crew - May 12, 1996 - September 27, 1996
(Experience commensurate with GS-0462-04 position with one year experience at that level, with two seasons completed on the Hot Shot Crews).

Lead Range/Forestry Technician (Fire Suppression)(GS-0462-06)
(Seasonal Appointment) - Position No. HS9605
BLM, AFS, Hot Shot Crew - April 13, 1997 - August 29, 1997
(Experience commensurate with GS-0462-05 position with one year experience at that level, with one season completed on the North Star Hot Shot Crew).

Forestry Technician (Smokejumper) (GS-0462-05)
(Seasonal Appointment) - Position No. SJ9518
BLM, AFS, Smokejumper Operations - April 22, 1998 - September 21, 1998.

The following is an excerpt from Position Description FSS10103:

"INTRODUCTION This position description is intended for use throughout the BLM for temporary seasonal positions.

MAJOR DUTIES Primary purpose is to parachute into inaccessible areas for the purpose of suppressing wildfires...

Receives extensive training in the use of parachutes in jumping over forest and mountainous terrain landing in timber, open, or on rough ground. Learns the use of smokejumper parachute equipment, parachute deployment, emergency procedures, and techniques of parachuting into rugged timber terrain...

1. Knowledge Required by this Position Must have the knowledge, skills and abilities specified in the IGS qualifications standard for this position and grade level. The incumbent of this position is required to have prior firefighting experience as stated in the smokejumper standards...

2. Supervisory Controls Works under the close supervision of skilled smokejumpers and squad leaders. Work guidance and direction is provided requiring the use of standard procedures and practices...

4. Complexity The employee must be able to carry out a variety of parachuting and firefighting operations following establish procedures and precedents...

5. Physical Demands the work involves extreme physical exertion in parachuting to fires, carrying 110-pound packs for up to 10 miles through rugged terrain, and for working up to 20-hour shifts on fire lines. This position is subject to the arduous physical requirements for smokejumpers included in the GS-462 standards...

6. Work Environment The majority of the work is performed out-of-doors in a wide variety of weather and terrain conditions or in a crowded smokejumper airplane without seats or seatbelts. Employee is often assigned to field sites in isolated locations often in primitive conditions. This work requires a variety of safety gear and precautions."

Forestry Technician (Smokejumper)(GS-0462-06)
(Seasonal Appointment) - Position No. ~~SJ9612~~ 10104AM
BLM, AFS, Smokejumper Operations - April 25, 1999 - September 27, 1999.

The following is an excerpt from Position Description FSS10104:

INTRODUCTION This position description is intended for use throughout the BLM for temporary seasonal positions...

MAJOR DUTIES ... Serves as a highly trained and skilled member of a parachuting fire suppression squad which jumps over forest and mountainous terrain, landing in timber, open, or on rough ground...may supervise one or more firefighters who accompany him on fires... Completes forms connected with parachute jumps... When not involved in fireline activities, participates in a wide range of fire support activities including parachute rigging and repair, paracargo rigging, and construction and repair of assorted smokejumper equipment.
Receives training in basic smokejumper skills including aircraft exits, parachute manipulation, landing techniques, and tree letdown procedures. Participates in a daily physical conditioning program maintain a physical condition necessary to perform the duties of the position... May receive advance training in various specialties that include paracargo, fireline explosives, emergency medical technician, and parachute loft.

1. Knowledge Required of the Position Must have the knowledge, skills and abilities specified in the qualifications standard for this position and grade level. Prior firefighting experience and at least one season of smokejumping experience is required. Must be experienced in the use of smokejumper parachute equipment, parachute deployment, emergency procedures, and techniques of parachuting into rugged timbered terrain...

2. Supervisory Controls Work assignments are generally given by the supervisor through a work leader in terms of current plans and polices existing for the use of smokejumpers. Explicit instructions on work methods and procedures to be used are not given unless technical problems of an unprecedented nature occur. The employee works independently as an experienced team member, often serving as a squad leader for several inexperienced team member. Work is reviewed in process and upon completion for adequacy of the efforts expended and the results obtained.

3. Guidelines Guidelines include training exercises, past experiences, equipment handbooks, BLM and USFS manuals, and Operations Handbooks. Since every fire is unique, the employee must typically select from a number of guides and adapt procedures to meet field conditions.

4. Complexity The work requires carrying out a variety of operations following establish procedures and precedents making adaptations as necessary. Parachuting into rugged terrain is a complex skill requiring 120 hours of training and practice in aircraft procedures, exiting, parachute steering, landing, timber let-down, and parachute malfunctions .

5. Work Environment The majority of the work is performed out-of-doors in a wide variety of weather and terrain conditions or in a crowded smokejumper airplane without seats or seatbelts. Employee is often assigned

to field sites in isolated locations often in primitive conditions. Employee risks death or serious injury during parachutes jumps, low flying cargo dropping, or firefighting. This work requires a variety of safety gear and precautions."

Forestry Technician (Smokejumper) (GS-0462-06)
(Seasonal Appointment) - Position No. ~~SJ9612~~ 10104AM
BLM, AFS, Smokejumper Operations - April 23, 2000 - .

**Chief Investigators Note:** A current Job Description was not found in the employee's Official Personnel Folder. It is noted that the Supervisor was currently working on a revision and Position Description number 10104AM was in effect according to the Notification of Personnel Action (Standard Fore 50-B) effective April 23, 2000. Documentation was found to indicate employee was qualified as an experienced Smokejumper with the BLM.

Liston was Red Card Qualified:
- WF-FFT1 Advanced Firefighter/Squad Boss
- TS-HESM Helispot Manager
- TS-SMKJ Smokejumper

Liston had completed 64 successful jumps with the BLM ram-air parachute system, and had successfully managed and deployed his reserve parachute on jump 28 following parachute malfunction. Liston's records indicate that he had completed 43 practice jumps and 21 operational or initial attack jumps. Liston had completed four successful jumps since his recent date of hire (April 23, 2000), including two on April 27, one on April 28, and one on the afternoon of April 29.

Liston completed his tower evaluations on April 25, 2000. These evaluations indicated that Liston performed "Great" on Drogue-in-Tow; "Feet apart, need to get head down to look at handles" on Spinning; "Good" on Streamer; "Good" on Horseshoe; and "Good" on last column Good.

Documentation reviewed included:
- Official Personnel File
- Application for Federal Employment (SF-171) dated November 3, 1998.
- Liston's Jump Records
- Employee Incident Qualification System
- Tower Evaluations

Physical Capacity: No Medical Alert Conditions indicated on Liston's Medical Records. Liston signed his Health Screen Questionnaire (Instruction Memorandum OF&A 98-011, Attachment 1-8) on April 25, 2000, and passed the Work Capacity Record (Attachment 1-10) with a Arduous

Performance Level and a test result time of 42:55 minutes. Liston's Smokejumper Physical Training records indicate complete of the 1.5 mile run in 9:17 minutes, 10 pull-ups, 35 pushups, and 60 sit-ups.

j. Employee Status
David J. Liston **Deceased**

k. Nature of Injuries -
David J. Liston -- Multiple fatal injuries resulting from fall from 3,000 feet (Pending report from Medical Examiner, State of Alaska Report).

2. **ACCIDENT DATA.**

a. How and why did accident occur.

Liston experienced a parachute malfunction when his reserve parachute's pilot-chute and suspension lines entangled with the main parachute's drogue (pilot-chute). This entanglement prevented either parachute from deploying. The entanglement overcame the ability of the employee to manage the event. Liston suffered multiple fatal injuries resulting from a fall from approximately 3,000 feet (pending report from Medical Examiner, State of Alaska report).

b. Physical Layout - N/A

c. Sketches/Drawings - See Attachment F

d. Measurements - N/A

e. Video/Photos - See Attachment D

3. **EQUIPMENT INVOLVED OR PROCESS.**
a. Machine Type - See below.
b. Manufacturer - See below.
c. Model - See below.
d. Manufacturer's Instructions - See below.

**AIRCRAFT INFORMATION**
Contract Aircraft owned by Bighorn Airways, Box 4037, Sheridan, WY 82801 (307-672-3421) under contract/ARA No. 81-0784, hired on April 5, 2000 (0800) to U.S. Department of the Interior, Office of Aircraft Services, PO Box 15428, Boise, ID 83715-5428 (208-387-5781) / 4837 Aircraft Drive, Anchorage, AK 99502-1052 (907-271-3700/3935)

Make and Model - Casa 212
Aircraft FAA Registration No. - N117BH
Pilot Name (PIC) - Chris Eisele
Pilot Name (PIC) - Stoney Bauer

On April 30, 2000, the Chief Investigator requested that the aircraft be taken out of service. The aircraft returned to service on May 5, 2000.

On May 1, 2000, the Serious Accident Investigation Team requested the Office of Aircraft Services to provide an Air Safety Investigator to determine airworthiness and evaluate smokejumper equipment within the aircraft. On May 1, 2000, the Serious Accident Investigation Team requested the Anchorage Office, of the Office of Aircraft Services to provide the Technical Inspector of this aircraft to evaluate the current condition of the aircraft.

On May 2, 2000, Gary R. Davis, OAS Tech Services, Anchorage, AK 99502, (907-271-3728), Lawrence P. Brosnan, Air Safety Investigator, OAS, Boise, ID 83705 (208-387-5804), Kipp Wagner, and Leonard Wehking inspected the aircraft and smokejumper equipment.

The aircraft was found to be in good condition. All of the installed smokejumper equipment was in good working order. The cabin was clean and all equipment was secure with no sharp edges. The static line was in good condition and properly tensioned. The seats and seat belts were in serviceable condition. The jump door opening is well protected with tape. The jump door opening, airframe handle is secure. The cable mounted static lines were in serviceable condition. The outside of the aircraft was in good condition with just a few small chips in the paint just aft of the door opening, they appeared to have been caused by a fabric strap or plastic buckle.

The Investigation Team members took several pictures of the interior and exterior of the aircraft, and installed smokejumper equipment. The investigation members performed a close search of the floor area, behind and under the seats, and tail of the aircraft searching for any debris or materials from the incident (specifically pieces from broken FASTEX snap), none was located.

The aircraft cockpit voice flight recorder was removed under a Chain-of-Custody and taken to Seattle, Washington, by Brosnan, for down-loading and transferred to audio cassette by American Avionics, 7023 Perimeter Road, Boeing Field, Seattle, Washington 98108.

**PARACHUTE EQUIPMENT INVOLVED (NOTE: "Z" after the number denotes the Top Skin of the canopy is zero porosity) :**

**David J. Liston's Parachute equipment**

Parachute System Series - 200
Ram-air Harness Number - 9012
Ram-air Harness Model- 8801
Ram-air Harness - Manufactured 1990

Drogue Riser or Container Number - A324Z
Drogue Serial Number - 34984
Drogue Model - B2002
Drogue Type - ZP
Drogue manufactured by - Paramedics Technology June 1998
Placed in Service - July 5, 1998
Drogue packed by - Doug Carrol
Drogue pack date - March 15, 2000

Main Canopy Riser or Container Number - A277
Main Canopy Serial Number - BLM-7-0611
Main Canopy Model Number - 8910
Main Canopy Type - Trilobe
Main Canopy manufactured by - Quantum Parachutes on June 7, 1991
Place in Service - June 13, 1991
Main Canopy packed by - Lance Clouser
Main Canopy packed date - March 22, 2000

Reserve Canopy Riser or Container Number - A224R
Reserve Canopy Serial Number - MRS 9234
Reserve Canopy Model - MT-1S
Reserve Canopy manufactured by - Paraflite February 1998
Placed in Service - June 25, 1998
Reserve Canopy packed by - Lance Clouser
Reserve Canopy packed date - March 28, 2000

e. Kind of Process

Training / Parachute Jump / Wildland Fire Suppression Training / Natural Resource Protection / BLM Smokejumper Refresher Training / Government Activity / Federal Government

f. Condition

Aircraft condition is in good condition and serviceable, no defects noted. Smokejumper equipment in aircraft is in good condition and serviceable, no defects noted.

Liston's harness, drogue, main parachute, reserve pilot-chute and reserve parachute are in good condition and meet specifications; defects noted are due to contact (minor friction burns on reserve pilot-chute bridle and suspension lines and drogue parachute bridle) and post-contact causes (impact and EMS) a small two- inch tear was found on the drogue outer perimeter.

g. Misuse - No evidence of equipment misuse was identified.

h. Maintenance Program

The maintenance program of the aircraft was not evaluated by the Investigation Team since it was determined not be a factor.

Inspection records were not requested by the Investigation Team for the harness. There are no requirements for maintenance records.

Liston's main parachute was inspected and packed on March 22, 2000, within the 120 days before the date of its use as required by 14 CFR 105.43(a)(1).

Liston's reserve parachute was inspected and packed on March 28, 2000, within the 120 days before the date of its use as required by 14 CFR 105.43(a)(2)(i).

i. Equipment Inspection (Logs, Reports)

LOFT MASTER LOG (4 pages)
Loft Record Rigging Log Book of Lance Clouser (4 pages)
Parachute Repair Record (BIFC Form 9210-15) for BLM Riser or Container Numbers.

j. Warning Devices (Detectors)

Not Applicable

k. Tasks Performed

Training Refresher for Parachute Smokejumper Operations.

l. How often equipment used

The BLM began researching an alternate parachute to the FS-10 round canopy for smokejumping in 1978. Equipment development and testing began in 1979 and continued through 1981. Smokejumper training and field testing started in 1982. The first operational fire jumps began in 1982. Further refinements in the ram-air equipment took place from 1982 through 1990. By 1990, the current harness design was finalized resulting in the ram-air harness model 8801. Rookie BLM smokejumper classes trained exclusively on the ram-air system for the first time in 1991. BLM smokejumpers currently use the system finalized in 1990 (BLM ram-air parachute system series 200). Approximately 30,000 BLM ram-air jumps have been completed.

The main parachute used is the Trilobe, a 330-square foot, seven-cell ram-air parachute. The ram-air parachute is a semi-rigid, airfoil-shaped canopy designed for maneuverability and target accuracy. The ram-air main parachute follows this sequence when opening:

1. Static line deploys drogue.
2. Drogue gives smokejumper an upright stable body position.
3. Drogue release handle is pulled by smokejumper. Released drogue pulls main parachute deployment bag (D-bag) off smokejumper's back.
4. Lines pay out (rubber retainer bands keep deployment bag closed until line stretch is complete).
5. D-bag is pulled off canopy.
6. Canopy inflates.

The reserve parachute, MT-1S by Paraflite, is a 270-square foot, five-cell ram-air canopy. This model was originally used as a main parachute during the research and development of the ram-air system from 1981 through 1984. The attachment of the reserve to the ram-air harness using "droop risers" allows the parachute to ride in the same position as the main when deployed.

The drogue parachute has two primary functions. First, the drogue serves to stabilize the smokejumper in an upright position after exit. The upright position avoids suspension line entanglements with the smokejumper during deployment of the main parachute. Secondly, the drogue serves as a pilot-chute for the main canopy. After the smokejumper pulls the drogue release handle, the drogue parachute is designed release from the harness and pull the main parachute out of its container.
The 3-ring *drogue* release system allows parachutists to release the drogue by pulling a single handle. The 3-ring *main* release system allows the parachutists to jettison a malfunctioning main canopy.

m. Energy sources and disconnecting means identified

Not Applicable

n. Supervision or instruction provided to employees involved in accident

See BLM *Ram-Air Training Manual*.

4. **Witnesses (**Public, Fellow Employees, Management)

5. **Safety and Health Program.**

Does employer have a safety or health program -

Yes, in place.

Does the program address the type of hazard which resulted in the fatality/catastrophe -

The smokejumper program address parachute malfunctions but not dual malfunction of main and reserve system

APPENDIX C

INVESTIGATION MODELS AND ANALYSES

Linear sequencing is the arrangement of the time line sequence in which

events occurred, starting with the first employment of Liston and Roach by the BLM. It establishes experiences (commonalties, variations and differences) between both cases. It defines and analyzes the use of safety gates (management procedures and practices in use to control adverse outcomes and accidents). It identifies the conditions and events that occurred on the day of the accident. The purpose of linear sequencing is to identify what events, conditions, and standard practices must occur to ensure a safe outcome for the employees, and to identify any deviation from the accepted practice. This process requires detailed analysis of documentation to identify any deficiencies in management controls or adherence to established management controls. The linear sequence follows that the employee using equipment follows procedures to process a job task or materials within an environment.

On the third day of the investigation following initial data collection, initial development of the linear sequencing chart began to identify missing gaps in the evidence collected by the team. The team then formulated and executed a plan to obtain the missing information.

On the fourth day of the accident investigation, the team began the initial development of the Fault Tree Analysis due to the extremely complex and detailed system and processes involved. This was particularly important due to the comprehensive safety systems (personnel selection, training, equipment, materials, and procedures) in place to prevent parachute malfunctions by the BLM smokejumpers.

The fault tree analysis utilizes the deductive method of logic (i.e., moves from the general to the specific). Since Liston's accident clearly resulted from more than one initiating factor (failure of the main parachute deployment, and failure of the emergency reserve parachute to successfully deploy) and the circumstances of Roach's parachute malfunction, a systematic process was necessary to analyze each potential causal factor. As the team identified specific events, which may have contributed to the accident, the team had to identify whether supporting evidence upholds or contradicts various possibilities in the likely series of events. By placing each possible contributing factor in its respective location on the fault tree, the Investigation Team can accurately identify where any breakdowns in the system, task, process or work operation occurred, or did not occur as the case may be.

Although the fault tree analysis implies that it is a tool primarily for analyzing faults in the system or process, it is important to note that fault tree analysis also was used by the team to evaluate the actions necessary to result in desired events or a successful outcome.

The use of fault tree analysis is a very organized, meticulous, and versatile type of analysis. It is organized because it evaluates each event with consideration for that event's specific purpose, function, or place within a system or process. It is meticulous because it attempts to describe the relationship of any and all events that may have acted upon a system that resulted in the accident. This method is versatile in its ability to evaluate hypothetical events, which the accident investigators may introduce into the fault tree to determine potential effects on the resulting event.

On the seventh day of the investigation, the Interagency Representative, Jerry Williams, developed a comprehensive fault tree analysis, which the Investigation Team utilized for evaluating each event separately or in combination with other events on the tree. With the identification of more than one contributing events (or possibilities), each interacting or possibly interacting event is placed into a set. Essentially, the set isolates specific events in the system and allows for a qualitative examination of the relationship between the set and, as a whole, on its effect of the resulting event.

The team then assigned a probability value to each event, and then through analysis of these events, yielded quantitative results which describe the most likely scenario of events to the least likely scenario.

## APPENDIX D

## PHOTOGRAPHIC EVIDENCE

Site Photographs
Page

#1 Front View of Parachute Equipment

#2 Back View of Parachute Equipment

#3 Close up of handles and equipment

#4 Close up of personal gear bag attachment & reserve belly band

#5 Liston accident site

#6 Liston's drogue and reserve parachute bag

#7 Line entanglement at Liston's site

#8 Close up of line entanglement

#9 Liston's main parachute in deployment bag

#10 Liston's reserve parachute in deployment bag

#11 Knot (Liston site)

#12 Close up of knot (Liston site)

#13 Drogue at Liston's site

#14 View of Roach's reserve parachute & landing site

#15 Roach's main parachute deployment bag

#16 Roach's main riser w/upper RSL attached

#17 View of RSL attached by Velcro to Roach's harness

#18 Birch Hill signAPPENDIX E

MAPS, SKETCHES, DRAWINGS
APPENDIX F

DEFINITIONS, ACRONYMS, ABBREVIATIONS

AICC -
FAA
OAS
OSHA
TSO

APPENDIX H

MISCELLANEOUS INFORMATION