EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION
B-1B, LANCER, Tail Number 86-000138
AT ANDERSEN AIR FORCE BASE, GUAM ON 7 MARCH 2008

On 7 March 2008, at approximately 0203 Zulu (Z), 1203 Guam local time, a B-1B Lancer, tail number 86-000138, assigned to the 37th Bomb Squadron, 28th Bomb Wing, Ellsworth Air Force Base (AFB), South Dakota, collided with two Aircraft Rescue Fire Fighting (ARFF) vehicles after the aircraft began to roll following engine shut down. There were no reported injuries, fatalities, or damage to private property. The Mishap Aircraft (MA) left wing received considerable underwing flight surface damage to the leading edge and flaps. The MA nose radome received deep lacerations on both the left and right sides. Both ARFF vehicles sustained damage as well. Total damage to the aircraft and vehicles was $ 5,773,954.

The MA took off from Andersen AFB, Guam, on a redeployment mission to Hickam AFB, Hawaii. Approximately 24 minutes into the flight, the MA lost hydraulic system #3 and the mishap pilot (MP) declared an in-flight emergency and diverted back to Andersen AFB for landing. The MP executed an uneventful approach and landing, taxied the MA clear of the runway, and stopped on the taxiway with the parking brake set in order for the emergency response crew to visually inspect the MA. The emergency response crew observed a hydraulic leak on the right side of the MA and the MP was advised to shut down the aircraft. Within seconds after engine shutdown, the MA began to roll forward and collided with the two emergency response vehicles.

The Board President found by clear and convincing evidence that the cause of this mishap was a malfunction of the right hand brake metering valve that caused the parking brake to fail following engine shutdown. Failure of the valve caused depletion of associated brake system accumulators, rendering MA brake systems inoperative when the engines shut down. The right hand brake metering valve was the single point failure of both the parking brake system and the backup emergency brake system. Substantially contributing factors include failure of emergency responders to chock the aircraft, a taxiway decline of .8 degrees, and the inability of ARFF vehicles #9 and #11 to clear the path of the rolling B-1B. The loss of hydraulic system #3, due to the separation of a 1.25 inch diameter tubing from a high pressure hydraulic line T-fitting assembly, caused the MA to return to Andersen AFB with an in-flight emergency, and is therefore also a contributing factor to the accident.

STATEMENT OF OPINION

B-1B Lancer S/N 86-000138
7 March 2008

Under 10 U.S.C. 2254(d) any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

1. OPINION SUMMARY

On 7 March 2008, at approximately 0203 Zulu (z), 1203 Guam local time, a B-1B aircraft, tail number 86-000138, assigned to the 37th Bomb Squadron, 28th Bomb Wing, Ellsworth Air Force Base (AFB), South Dakota, collided with two Aircraft Rescue Fire Fighting (ARFF) vehicles at Andersen Air Force Base, Guam, after the aircraft began to roll following engine shutdown. There were no reported fatalities, injuries, or damage to private property. The Mishap Aircraft (MA) left wing received considerable underwing flight surface damage to the leading edge and flaps. The MA nose radome received deep lacerations on both the left and right sides. Both ARFF vehicles sustained damage as well.

The MA took off from Andersen AFB on a redeployment mission to Hickam AFB, Hawaii. Approximately 24 minutes into the flight, the MA lost hydraulic system #3 and the mishap pilot (MP) diverted back to Andersen AFB. The MP executed an uneventful approach and landing, taxied the MA clear of the runway, and stopped on the taxiway with the parking brake set in order for the emergency response crew to visually inspect the MA. The emergency response crew observed a large hydraulic leak on the right side of the MA and the MP was advised to shut down the engines. Within seconds after engine shutdown, the MA began to roll forward and its radome impacted ARFF vehicle #9, pushing it backwards. The MA continued to roll until its left wing impacted ARFF vehicle #11. The MA came to a rest with ARFF vehicle #11 lodged underneath the left wing.

The Board President found by clear and convincing evidence that the cause of this mishap was a malfunction of the right hand brake metering valve that caused the parking brake to fail following engine shutdown. Failure of the valve caused depletion of associated brake system accumulators, rendering MA brake systems inoperative when the engines shut down. The right hand brake metering valve was the single point failure of both the parking brake system and the backup emergency brake system. Substantially contributing factors include failure of emergency responders to chock the aircraft, a taxiway decline of .8 degrees, and the inability of ARFF vehicles #9 and #11 to clear the path of the rolling B-1B. The loss of hydraulic system #3, due to the separation of a 1.25 inch diameter tubing from a high pressure hydraulic line T-fitting assembly, caused the MA to return to Andersen AFB with an in-flight emergency, and is therefore also a contributing factor to the accident.

2. DISCUSSION OF OPINION

Failure of the Parking Brake. When the parking brake is engaged, the MLG emergency accumulator is designed to maintain brake pressure for a minimum of eight hours, independent of normal hydraulic system #3 pressure and power on the aircraft. When the parking brake is selected, the parking brake selector valve opens, allowing MLG accumulator pressure to the right and left hand brake metering valves which apply pressure to the aircraft brakes. Analysis of the MA right hand brake metering valve confirmed that the valve components were seized and the metering valve mechanisms were badly worn. The internally malfunctioning defective right brake metering valve allowed an excessive quantity of hydraulic fluid to bypass the valve and migrate back to the hydraulic reservoir, which ultimately depleted the MLG accumulator and rendered the parking brake system inoperative after engine shut down. If the parking brake had worked properly, the accident would not have occurred.

Failure of the Emergency Brake System. When the emergency brake system is engaged, two emergency brake selector valves open, allowing left and right APU accumulator pressure to the right and left hand brake metering valves. The emergency brake system did not respond due to left and right accumulator pressure depletion. Ground testing of the MA emergency brake system, using only the left APU accumulator, consistently showed left APU accumulator bleed down within 20 seconds of brake application. The likely cause of this rapid accumulator bleed down was the defective right hand brake metering valve for the same reason that it caused the MLG accumulator to bleed down. Sufficient evidence indicates that the right APU accumulator pressure initially bled down in flight after providing pressure for right overwing fairing inflation following the loss of hydraulic system #3. The right APU accumulator could not be recharged in flight due to zero hydraulic system #3 pressure caused by the separation of the T-fitting and tubing. The accumulator recharging electric hydraulic pump motor was inoperative, but its serviceability would not have impacted this event, as system logic prevents it from coming on when quantity is severely low. Any remaining right APU accumulator pressure at the time of emergency brake application depleted due to the defective right brake metering valve. Depletion of both right and left APU accumulators rendered the emergency brake system inoperative. If the emergency brake system had ample pressure to work properly, the aircraft may have been stopped, but would have subsequently needed to be chocked prior to the crew removing their feet from the brake pedals.

Related Braking System Valves. Seven hydraulic valves and the APU start module from the critical hydraulic path were analyzed. The tests found that malfunction of the RH brake metering valve was the primary contributor to the loss of brake pressure, while the MLG emergency extend pressure selector valve and other associated valves may also have been contributing factors.

Downward Slope of Taxiway. The MA exited the departure end of Runway 6L at Taxiway Kilo which has a downward slope of .8 degrees. The MA on the slope produced a force of 3400 lbs acting parallel to the taxiway. Without a functional brake system after engine shutdown, there was no way to stop the MA from rolling except for chocks. Thus, the slope of the taxiway was a contributing factor to the accident.

Failure to Chock the Aircraft. There was adequate time to chock the MA nose gear prior to engine shutdown. The Rescue crew had aircraft chocks in their truck, but did not have them in hand when they approached the MA. The MA was stopped on Taxiway Kilo with engines running for approximately two minutes from the time the Rescue crew was standing by the nose gear to the time the aircraft started to roll. The B-1 maintenance team and Andersen Transient Alert had aircraft chocks in their vehicles, but could not reach the aircraft in time because they did not receive timely clearance from Andersen Tower to cross the parallel runway. There is no clear written guidance identifying the responsible agency for chocking an aircraft during an in-flight emergency response. The fire department is the first one on the scene for all aircraft emergencies and the only consistent common denominator in all emergency responses. Furthermore, until the emergency is terminated, the senior fire official on the emergency scene must authorize personnel from other responding agencies to approach the aircraft. If the first task of the initial responding rescue team was to chock the nose gear at the beginning of the initial walk around of the MA, and prior to engine shutdown, the aircraft would not have rolled and the accident would not have occurred.

Inability of ARFF Vehicles to Clear the MA Path. When the MA first started to roll, a call was made for all fire trucks to evacuate the area and approximately thirty seconds later the MA impacted ARFF vehicle #9, followed a few seconds later by the impact of ARFF vehicle #11. ARFF vehicle #11 had sufficient time to clear the path of the rolling MA. ARFF vehicle #9 had very limited time to clear the area. In a desperate attempt to chock the rolling aircraft, the driver of ARFF vehicle #9 exited his vehicle. He would have had more time to move out of the way if he had remained behind the wheel. The driver of ARFF vehicle #11 remained in his vehicle; however, there is substantial evidence that ARFF vehicle #11 was experiencing transmission problems, with slow acceleration which likely contributed to this accident.

Loss of Hydraulic System #3. An inadequate T-fitting swaging task was directly causal in the #3 hydraulic system malfunction. While in flight, the MA lost hydraulic system #3 when a 1.25 inch diameter tubing separated from one end of a high pressure hydraulic line T-fitting assembly. This was the result of deficient installation and inadequate swaging of the T-fitting on 6 Dec 07. Misalignment of the swaging tool and insufficient tool pressure were significant contributors to the deficient swage on the T-fitting, and the primary reason for subsequent tubing separation. Further, it is clear that a properly applied inspection gage (Go/No-Go) by a skilled technician would have deemed this swage operation inadequate. Therefore, improper swaging during installation of the subject T-fitting and an inadequate post-swage inspection allowed the 1.25 inch tube to dislodge over time, causing the in-flight loss of hydraulic system #3 and started the sequence of events ultimately leading to this accident. However, it was not causal to the aircraft rolling into the 2 ARFF vehicles, resulting in this Class A mishap.

6 June 2008

JENNIFER M. FULLMER, Lt Col, USAF
President, Accident Investigation Board

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 7 May 2008, Major General R. Michael Worden, Vice Commander, Air Combat Command (ACC), appointed Lieutenant Colonel Jennifer M. Fullmer president of an Accident Investigation Board (AIB) to investigate the 7 March 2008 accident involving a B-1B "Lancer" aircraft, Tail Number (T/N) 86-000138, at Andersen Air Force Base (AFB), Guam. The investigation was conducted at Ellsworth A FB, South Dakota (SD), from 21 May through 6 June 2008, pursuant to Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, Chapter 11. Technical advisors appointed to the board were Major Sarah Scullion (Legal), Mr. Rick Cantwell (Maintenance) and Technical Sergeant Steve Carter (Recorder). Master Sergeant Bruce Wolf (Emergency Response) was added to the AIB on 4 June 08.

b. Purpose

The purpose of this investigation is to provide a publicly releasable report of the facts and circumstances surrounding this accident; to gather and preserve evidence for claims, litigation, disciplinary and adverse administrative actions; and other proper purposes which may arise from the event in question.

c. Circumstances

The AIB convened to investigate the Class A accident involving a B-1B "Lancer," assigned to the 37th Bomb Squadron (BS) at Ellsworth AFB, (SD) and crewed by members of the 34 BS. On 7 March 2008 the mishap aircraft (MA) and mishap crew (MC) launched from Andersen AFB, Guam, on the second leg of a redeployment mission following attendance at an air show in Singapore from approximately 15 February to 5 March 2008. The accident occurred at Andersen AFB, Guam, on 7 March 2008.

2. ACCIDENT SUMMARY

On 7 March 2008, at approximately 0203 Zulu (z), 1203 Guam local time, a B-1B aircraft, tail number 86-000138, assigned to the 28th Bomb Wing, Ellsworth AFB, collided with two Aircraft Rescue Fire Fighting (ARFF) vehicles at Andersen AFB, Guam, after the aircraft began to roll following engine shutdown. There were no reported fatalities, injuries, or damage to private property. The MA's left wing received considerable underwing flight surface damage to the leading edge and flaps. The MA's nose radome received deep lacerations on both the left and right sides. Both ARFF vehicles sustained damage as well.

The MA took off from Andersen AFB on a return mission en route to Hickam AFB, Hawaii. Approximately 24 minutes into the flight, the MA lost hydraulic system #3 and the mishap pilot (MP) diverted back to Andersen AFB. The MP executed an uneventful approach and landing, taxied the MA clear of the runway, and stopped on the taxiway with the parking brake set in order for the emergency response crew to visually inspect the MA. The emergency response crew observed a large hydraulic leak on the right side of the MA and the MP was advised to shut down the engines. Within seconds after engine shutdown, the MA began to roll forward and its radome impacted ARFF vehicle #9, pushing it backwards. The MA continued to roll until its left wing impacted ARFF vehicle #11. The MA came to a rest with ARFF vehicle #11 lodged underneath the left wing. Total damage to the aircraft and vehicles was $ 5,773,954. (Tab P-3 to P-7)

3. BACKGROUND

a. The 28th Bomb Wing (28 BW) includes the 34th and 37th Bomb Squadrons. They provide rapid, decisive and sustainable combat air power and expeditionary combat support anytime, anywhere. The wing flies B-1B Lancers and serves as the host unit for Ellsworth AFB, providing all essential base operating support services for Ellsworth and combat support services for an Air Expeditionary Wing. The wing consists of four groups: the 28th Operations Group, 28th Mission Support Group, 28th Maintenance Group and 28th Medical Group. The 28 BW is under the command of Air Combat Command.

b. Air Combat Command (ACC) is the primary force provider of combat airpower to America's warfighting commands. To support global implementation of national security strategy, ACC operates fighter, bomber, reconnaissance, battle-management and electronic-combat aircraft. It also provides command, control, communications and intelligence systems, and conducts global information operations. As a force provider, ACC organizes, trains, equips and maintains combat-ready forces for rapid deployment and employment while ensuring strategic air defense forces are ready to meet the challenges of peacetime air sovereignty and wartime air defense. ACC numbered air forces provide the air component to U.S. Central and Southern Commands with Headquarters ACC serving as the air component to U.S. Northern and Joint Forces Commands. ACC also augments forces to U.S., European, Pacific and Strategic Commands.

c. The B-1B "Lancer"

(1) Mission: Carrying the largest payload of both guided and unguided weapons in the Air Force inventory, the multi-mission B-1B is the backbone of America's long-range bomber force. It can rapidly deliver massive quantities of precision and non-precision weapons against any adversary, anywhere in the world, at any time.

(2) Background: The first production B-1 flew in October 1984, and the first B-1B was delivered to Dyess Air Force Base, Texas, in June 1985. Initial operational capability was achieved on 1 October 1986. The final B-1B was delivered 2 May 1988.

The B-1B was first used in combat in support of operations against Iraq during Operation Desert Fox in December 1998. In 1999, six B-1s were used in Operation Allied Force, delivering more than 20 percent of the total ordnance while flying less than 2 percent of the combat sorties. Eight B-1s were deployed in support of Operation Enduring Freedom (OEF). B-1s dropped nearly 40 percent of the total tonnage during the first six months of OEF. This included nearly 3,900 precision guided bombs, or 67 percent of the total. All of this was accomplished while maintaining an impressive 79 percent mission capable rate. The B-1 continues to play an active role in Operations Enduring Freedom and Iraqi Freedom.

4. SEQUENCE OF EVENTS

a. Mission

The mission was a planned flight from Guam to Hawaii for refueling and final stop over prior to the third leg of a redeployment mission to Ellsworth AFB, SD. (Tab C-3)

b. Planning

The aircrew conducted mission planning for the flight in accordance with established Technical Orders, Air Force Instructions, and squadron policy guidance. The MP thoroughly briefed his crew, and everyone on the crew had a clear understanding of all aspects of the mission. The AIB conducted an Operational Risk Management (ORM) evaluation utilizing all applicable data and conditions that were current during pre-flight on 7 March 2008. The ORM calculation for this mission was "Low." Mission planning and ORM were in accordance with regulation and were adequate for the mission. (Tab T-15)

c. Pre-Flight

Pre-flight procedures were normal and crew testimony confirmed there were no significant issues with the MA during pre-flight checks or ground operations. (Tab R-10, R-17, Tab V-35 to V-38)

d. Summary of Accident

All MA systems appeared normal until approximately 24 minutes after takeoff, when the MP and crew heard a loud "bang" and experienced a sudden loss of hydraulic system #3. (Tab R-10, R-15, R-18, R-21, Tab V-35 to V-38) The MP declared an emergency with Approach Control after the MA lost hydraulic system #3. Shortly after the hydraulic system #3 failure, the MP noticed the illumination of "forward compartment hot," "crew/central avionics hot," and "oxygen" caution lights, indicating an overheat condition in two avionics bays. These lights are not usually associated with a hydraulic system #3 failure and raised the level of concern among the crew. (Tab R-4, R-10, R-11, R-15, R-18, R-21, Tab V-35 to V-38) The MP selected the backup oxygen switch, directed a descent to ten thousand feet, and began to adjust gross weight in preparation for an emergency landing at Andersen AFB. The MP asked Approach Control to

relay a request to Andersen Tower to coordinate for the fire department, B-1 maintenance personnel, and the flight surgeon to meet the MA after landing. (Tab V-35) The MP and crew ran all appropriate related emergency checklists, executed all appropriate procedures, utilized effective Crew Resource Management (CRM), and effective Air Traffic Control (ATC) coordination while handling this in-flight emergency. (Tab V-35 to V-38)

e. Impact

Approximately ten minutes after the MA lost hydraulic system #3, fire crews assigned to Andersen AFB received notification via the primary crash phone that a B-1 would be landing in approximately fifteen minutes on runway six left (Rwy 6L) with #3 hydraulic system failure. Fire crews responded to their standby locations and waited for the arrival of the MA. (Tab N-4, Tab V-11)

The MP executed an uneventful approach and landing, taxied the MA clear of Rwy 6L at approximately 0158:47z, and stopped on taxiway Kilo with the parking brake set in order for the emergency response crews to visually inspect the MA. (Tab N-4, Tab V-35, V-36) When the MA landed and exited Rwy 6L onto taxiway Kilo the fire crews accomplished standard set-up on the MA. (Tab R-29)

At approximately 0159:33z, about 46 seconds after the MA came to a stop on taxiway Kilo, Andersen Transient Alert (TA), call sign "Andy 2," accompanied by a truck with two B-1 maintainers, called Andersen Ground Control to request permission for two to cross Rwy 6R at Kilo, to provide the MA any needed B-1 maintenance support. (Tab N-4, R-44 to R-47, Tab V-10)

The first firefighter on the scene, call sign "Rescue 3," was the first person to approach the MA to accomplish a 360 degree inspection of the aircraft. When Rescue 3 approached the nose of the MA, at approximately 0200:47z, he noticed a large hydraulic leak coming from the right side of the MA under the engines, and passed this information to the senior fire official on scene, call sign "Chief 2." (Tab R-23, R-24, Tab S-17) Unable to contact the MP directly, Chief 2 advised the Air Traffic Control Tower to pass to the MP a request to shut down engines due to the hydraulic leak. (Tab N-11, N-14, Tab R-35, R-40, Tab S-17) The MP had all engines shut down at approximately 0202:30z and approximately twenty seconds after engine shutdown, the MA started to roll forward with the parking brake engaged. (Tab S-17) Realizing that the parking brake failed, the MP applied the back-up emergency brakes. The emergency brakes did not respond, leaving the MP with no way to stop the aircraft. (Tab R-35, R-36) ARFF vehicles #9 and #11 were in the path of the rolling MA and were unable to get out of the way prior to impact. At approximately 0203:30z the MA radome impacted ARFF vehicle #9, followed a few seconds later by the left wing of the MA impacting ARFF vehicle #11. (Tab S-17) The MA came to a stop with the left wing resting on top of ARFF vehicle #11.

directives. The most recent scheduled aircraft inspection of the MA was a major isochronal inspection (ISO) completed on 10 Dec 07. (Tab U-148, U-169)

c. Maintenance Procedures

There was improper installation and inspection of a hydraulic T-fitting on 6 December 07 during the ISO inspection. Details are recorded in Section 12.b.3. (Tab J-23, Tab R-50, R-51)

d. Maintenance Personnel and Supervision

No discrepancies were discovered in the training or qualifications of maintenance personnel. However, irregularities were found in the documentation of maintenance actions. Relevant to this mishap was an entry in the aircraft AFTO Form 781A that a 7-level maintenance technician signed off an aircraft repair task as the "Inspected By" technician after having completed the actual task. A maintenance technician not associated with the repair task signed off the "Corrected By." The aircraft repair was ultimately inadequate and directly led to the MA In Flight Emergency (IFE), 7 March 2008 that led to the MA's collision with two responding aircraft rescue fire fighting vehicles. (Tab J-23, Tab R-11, Tab S-15) Additional details are recorded in Section 12.b.3 of this document.

e. Fuel, Hydraulic, and Oil Inspection Analyses

Post-mishap fuel analysis and engine oil analysis returned no positive findings of contamination or abnormal indications. Hydraulic fluid analysis was not conducted. Serviced aircraft fluids were not pertinent to the accident. (Tab U-170)

f. Unscheduled Maintenance

Aircraft forms were reviewed for the period 10 December 2007 through the accident day of 7 March 2008. No documentation irregularities or maintenance actions pertinent to the accident were discovered in this time frame. In the 30 days prior to the accident, forms review did discover the MA received 18 hydraulic system write-ups and/or follow-on maintenance form entries in a 7-day time frame in February 2008 (5 Feb-11 Feb). (Tab U-47, U-68 to U-73, U-88) From 12 February until the time of the incident the aircraft had several flap and slat write ups, but none associated with hydraulic problems. (Tab U-119 to U-121, U-130, U-134 to U-138) The MA experienced no documented hydraulic or brake malfunctions from 12 February 2008 to the mishap day of 7 March 2008. (Tab U-138 to U-169)

There is no indication in the maintenance forms that a hydraulic system 3 failure was a recent concern or had received maintenance in recent days leading up to the mishap. (Tab U-2 to U-169) The same is true for the APU accumulators, although early in February 2008, the accumulators received routine servicing on February 5th and 8th (Tab U-45 to U-48) The MA

had flown (and parked) successfully five times in the 30 days prior to the incident. (Tab U-77, U-124)

6. AIRCRAFT, AIRFRAME, SYSTEMS

a. Conditions of Systems and Structures

The MA is fully recoverable and repairable. The left wing received considerable underwing flight surface damage to the wing leading edge and flaps. The nose radome received deep lacerations on both the left and right sides. Failed hydraulic and brake components included an inoperable right hand brake metering valve and a detached hydraulic pressure line. (Tab J-5, J-6, Tab S-6 to S-9, S-15)

b. Repair

The only aircraft component receiving repairs prior to and relevant to the accident was the #3 hydraulic pressure line, specifically the T-fitting on the line in the right hand (RH) APU start module bay. This repair action was completed 6 December 2007, during the last scheduled ISO inspection of MA. (Tab U-168)

c. Functionality

Prior to the loss of hydraulic system #3, approximately 24 minutes after departure, all flight systems appeared operational. (Tab V-35)

d. Testing

Related Braking System Valves: The following eight aircraft components from the critical hydraulic path were removed post mishap from the MA and analyzed by depot engineers and overhaul technicians. Analysis was conducted at the responsible depot overhaul facility for these components at the Ogden Air Logistics Center (OO-ALC). Each component was subjected to depot level serviceability tests. Further physical disassembly was accomplished for components that failed these tests for determination of failure mode. (Tab J-13 to J-18)

- Right Hand (RH) Brake Metering Valve
- Left Hand Brake Metering Valve
- Parking Brake Selector Valve
- Right Emergency Brake Selector Valve
- Left Emergency Brake Selector Valve
- Main Landing Gear (MLG) Emergency Extend Pressure Selector Valve
- Main Landing Gear (MLG) Emergency Extend Accumulator Dump Valve
- Right Hand Auxiliary Power Unit (APU) Start Module

Testing and evaluation found the right hand brake metering valve was defective as detailed in the following paragraph. The MLG emergency extend pressure selector valve was found to have an intermittent failure condition that contributed to or exacerbated the depletion of the MLG extend accumulator. The remaining components tested were found to be operational within design tolerances. (Tab J-13 to J-18)

Right Hand Brake Metering Valve (Tab J-13, J-14):

Depot Physical Analysis:
The right hand brake metering valve was received in good visual condition. During manual actuation of the mechanical valve lever with no hydraulic pressure applied, the lever would not return to the full off position. The original equipment manufacturer lead seals and lack of depot overhaul stickers suggest that this metering valve has never been overhauled, is original aircraft equipment, and has never been removed from the aircraft. (Tab J-13)

Depot Test Analysis:
System 3 supply pressure was closed to isolate at 4000 psi while system 2 supply pressure was reduced to zero to simulate power down of the APU/engine. This particular test aids the explanation of rapid pressure depletion on the left hand APU accumulator during post-mishap ground checks of the emergency brake function. Test analysis produced the following results:

- Pressure drops were indicated immediately on system 3 and system 2 brake pressures following system 2 supply pressure to 0 psi.

- Priority valve failed to shuttle fully to single system mode. This prevented hydraulic pressure from system 2 to aircraft braking.

- System 3 brake pressure bled to < 320 psi (brake actuation pressure) in 2 min 24 sec, and to < 150 psi in 4 min 30 sec. (, J-14)

This test was conclusive in that the right hand brake metering valve removed from MA on 22 March 2008 (post-mishap) was defective to the point of inoperability. (Tab J-5, J-6, J-13, J-14)

Depot Teardown Analysis:
Teardown analysis of the RH brake metering valve confirmed valve components were seized and the metering valve mechanisms badly worn. This failure mode allowed hydraulic fluid to bleed back through the hydraulic return path to the reservoir, depriving the APU accumulators of hydraulic fluid and pressure. (Tab J-13, J-14)

e. Other Analyses

Additional Leak Sources: There is a direct path from the APU start accumulators to the Overwing Fairing (OWF) actuators, the fuel heat sink scoops and the emergency brake selector valves. If any or all of these valves leak internally it can contribute to or cause the

depletion of the corresponding accumulator after the loss of a hydraulic system. (Tab CC-3, CC-4) There can also be internal leakage in the start module that can contribute to depletion of the accumulator. Cumulative, excessive hydraulic fluid bypass through some of these other system components may have resulted in a more rapid depletion of the RH APU accumulator pressure (following over wing fairing actuation) such that minimal pressure would have been available at the time of emergency brake engagement. (Tab CC-4)

#3 Hydraulic System Pressure Line T-Fitting: Post-mishap analysis of a hydraulic line fitting is contained in the Materials Engineering Report dated 22 April 08; *Analysis of a Failed B-1B High Pressure Hydraulic Line "T" Fitting & Associated Tube Segments*. Metallurgical analysis of the T-fitting concludes inadequate swaging was applied to the T-fitting, creating a weak mechanical union between the titanium hydraulic tubing and T-fitting. (Tab J-23)

7. WEATHER

a. Forecast

Weather at Andersen AFB, Guam, was forecast as sky condition of few clouds at 2,000 feet, scattered clouds at 6,500 feet, and seven miles visibility. Temperature was 79 degrees Fahrenheit with surface winds of 080 at 10 knots. No forecast weather hazards. (Tab F-3 to F-6)

b. Observed Weather

Weather observed at the time of the mishap was sky condition of scattered clouds at 2,000 feet, broken clouds at 7,000 feet, broken clouds at 12,000 feet, and seven miles visibility. Temperature was 77 degrees Fahrenheit with surface winds of 050 at 11 knots. (Tab F-7 to F-8)

c. Space Environment

Not applicable.

8. AIRCREW QUALIFICATIONS

a. Mishap Pilot (MP)

The MP was a current and qualified experienced B-1 instructor pilot with over 2,000 flying hours, including more than 1,300 B-1 hours. (Tab G-3) As an experienced Combat Mission Ready (CMR) crewmember, the MP is required to fly a minimum of three sorties per month. (Tab BB-2) The following table illustrates he met this requirement: (Tab T-10)

Flying Lookback	Hours	**Sorties**
Previous 30 Days	27.3	**3**
Previous 60 Days	43.6	**10**

Previous 90 Days	52.4	**15**

The MP passed his most recent aircrew mission evaluation on 4 Jan 08 and was current in emergency procedures training. (Tab G-20 to G-21)

b. Mishap Co-Pilot (MC)

The MC was a qualified inexperienced B-1 pilot with over 650 B-1 hours. (Tab G-4) He was non-current in night air refueling. However, he was flying with an instructor pilot and night air refueling was not scheduled on this mission. (Tab K-6, Tab T-15) As an inexperienced CMR crewmember, the MC is required to fly a minimum of four sorties per month. (Tab BB-2) The following table illustrates that the MC met his requirement for the previous two months and he was flying with a current and qualified instructor pilot. (Tab G-11 to G-13, Tab T-12, T-13, T-15)

Flying Lookback	Hours	**Sorties**
Previous 30 Days	29.3	**4**
Previous 60 Days	39.5	**9**
Previous 90 Days	44.5	**11**

The MC passed his most recent aircrew mission evaluation on 19 Jan 07 and was current in emergency procedures training. (Tab G-22, G-23)

c. Mishap Offensive Systems Officer (MO)

The MO was a current and qualified experienced B-1 Instructor Weapons Systems Officer (WSO) with over 800 B-1 hours. As an experienced CMR crewmember, the MO is required to fly a minimum of three sorties per month. (Tab BB-2) The following table illustrates he met this requirement: (Tab T-12)

Flying Lookback	Hours	**Sorties**
Previous 30 Days	30.2	**4**
Previous 60 Days	49.4	**12**
Previous 90 Days	56.5	**15**

The MO passed his most recent aircrew mission evaluation on 17 Oct 07 was current in emergency procedures training. (Tab G-24, G-25)

d. Mishap Defensive Systems Officer (MD)

The MD was a qualified inexperienced B-1 WSO with over 700 B-1 hours. As an inexperienced CMR crewmember, the MD is required to fly a minimum of four sorties per month. (Tab BB-2) The following table illustrates that the MD did not meet his flight lookback requirement because

he could not fly for two months due to back surgery; however, he was flying with a current and qualified instructor WSO. (Tab K-5, Tab T-11)

Flying Lookback	Hours	**Sorties**
Previous 30 Days	8.6	**3**
Previous 60 Days	8.6	**3**
Previous 90 Days	8.6	**3**

The MD passed his most recent aircrew mission evaluation on 18 Jan 07 and was current in emergency procedures training. (Tab G-26, G-27)

The aircrew was qualified for the mission.

9. MEDICAL

a. Qualifications

All MA aircrew members were medically qualified for flight. This information for all MA aircrew members was confirmed by documentation on Air Force Forms 1042, *Medical Recommendation for Flying or Special Operational Duty* before it was entered into the Aviation Resource Management System (ARMS) currency tracking database. (Tab CC-2, Tab T-2 to T-4)

b. Health

The mishap aircrew did not have any significant, ongoing medical conditions. (Tab CC-2)

c. Pathology

Toxicological examination of the blood and urine from the mishap aircrew, the MA maintenance personnel, and emergency response team was performed by the Armed Forces Institute of Pathology. The MD's urine tested positive for Oxymorphone, a byproduct of a previously prescribed medication. The level of Oxymorphone in his system was not sufficient to affect his performance of flight duties, or otherwise contribute to the cause of the accident. (Tab FF-2) Toxicological tests for all other MA aircrew members, MA maintainers, and emergency response personnel tested negative and did not contribute to this accident. (Tab FF-3)

d. Lifestyle

There is no evidence that unusual habits, behavior, or stress on the part of the mishap crew, MA maintenance personnel, or emergency response team members contributed to this accident.

e. Crew Rest and Duty Time

The Air Combat Command Supplement to Air Force Instruction 11-202, Vol 3, para. 9.7.1. states that Air Force aircrews require at least 10 hours of continuous restful activities including an

opportunity for at least 8 hours of uninterrupted sleep during the 12 hours immediately prior to the flight duty period. (Tab BB-3) All members of the mishap aircrew had adequate crew rest prior to the accident. (Tab V-35)

10. OPERATIONS AND SUPERVISION

a. B-1 Operations

The 34th Bomb Squadron has a high operations tempo primarily due to the ongoing Global War on Terrorism. The squadron returned from their last six month deployment in July 2007, is preparing to deploy again shortly, and underwent Air Combat Command Operational Readiness Inspections in November 2007 and April 2008. The B-1 has been continually deployed since October 2001; however, there is no evidence that current operations tempo contributed to this accident.

b. B-1 Supervision

There was no B-1 operations supervision on duty at Andersen AFB because the MA was only at Andersen AFB for a layover after the first leg of a three leg redeployment mission to Ellsworth AFB. There was no evidence that supervision was a factor in this accident.

c. Supervisor of Flying (SOF)

There is no evidence that the SOF or SOF procedures were a factor in this accident.

11. HUMAN FACTORS INVOLVED

a. Mishap Pilot

When the MP heard Tower tell him that Chief 2 recommended MA shutdown due to a significant hydraulic leak on the right side of the MA, he was compelled to expedite engine shut down to preclude any subsequent fire due to hydraulic fluid coming into contact with hot brakes or other heated aircraft systems or parts. (Tab N-11, Tab V-35) Ordinarily there is no B-1 maintenance support at Andersen AFB. The reason the B-1 maintenance team was present was to repair another B-1 that sustained severe damage after a hydraulic system leak led to a fire. After the MP stopped the MA on taxiway Kilo, the brakes registered under 300 degrees (well below emergency temperatures); however, the B-1 brake fire incident on Guam was still fresh in the minds of the crew members. (Tab V-35 to V-38) Although there is no written procedure to specifically ensure the aircraft is chocked before shutdown, the MP's memory of the recent hydraulic leak and fire mishap contributed to his immediate shutdown without confirmation that the MA was chocked. (Tab V-35)

b. ARFF Vehicle #9 Driver

The AIB perceived that the vehicle #9 driver was distracted when the ARFF vehicle #9 crew chief began "screaming for a chock," (Tab R-24, Tab S-17, Tab V-22) which led the #9 driver to exit his vehicle in a desperate attempt to find a chock and stop the rolling MA as it was picking up speed. This distraction used up valuable time and when the vehicle #9 driver got back into his vehicle to move it, the MA was so close that there was nothing the vehicle #9 driver could do to move the truck out of the way. (Tab R-33, Tab S-17, Tab V-22)

c. Air Traffic Control Ground Controller

TA and B-1 maintenance personnel could not chock the MA in time due to lack of clearance by the Air Traffic Control (ATC) Ground Controller (GC). The AIB perceived that the GC was distracted by multiple radio calls from multiple agencies while monitoring three frequencies at once; the crash net, the ramp net, and ground frequency. The crash net on the normal ATC radio console was inoperative, causing the ATC crew to monitor the crash net on a hand-held Land Mobile Radio (LMR) which was sitting between the GC and the Local Tower Controller (LC). (Tab V-17 to V-20) There were multiple agencies talking to GC and to each other over the ramp net, while Chief 2, the aircrew, and other agencies were making calls to LC over the crash net. (Tab N-3 to N-15, Tab R-46, Tab V-16 to V-20) GC was listening to a congested ramp net and the crash net simultaneously because the LMR did not have an ear piece. GC did not answer the first three requests that TA made on the ramp net to cross Rwy 6R. On the fourth call, GC replied "Calling ground, say again," and finally responded for TA to proceed across Rwy 6R on the fifth call, more than five minutes after TA's first request. (Tab N-5, Tab R-44 to R-46, Tab V-7, V-9 to V-10, V-14-V-16) Task saturation due to multiple auditory inputs may have caused GC to miss TA's calls, thereby delaying TA and maintenance personnel from reaching the MA before it started to roll.

In addition, GC received word from his supervision that, because Rwy 6R was not technically a Controlled Movement Area (CMA) at the time because it was closed, vehicles were not required to coordinate with ATC to cross that runway. (Tab V-17 to V-20) Runway 6R had been closed for a few weeks prior to this accident and GC's understanding that vehicles did not need to coordinate to cross, compounded by the congested radio traffic, may have conditioned GC not to consciously listen for Rwy 6R crossing requests.

d. Maintenance Technician

During the December 2007 ISO of MA, there were management pressures to expedite and finalize the remaining ISO tasks in an effort to return the MA to the operational fleet as soon as possible. This weighed heavily upon the "Inspected By" maintenance technician's mind and may have exacerbated the inadequate inspection of the improperly swaged T-fitting, described in paragraph 12.(b) below. (Tab V-1.13 to V-1.16)

12. GOVERNING FACTORS AND PUBLICATIONS

a. Relevant Directives and Publications

(1) Air Force Instruction (AFI) 11-202, Vols 3 & 5, 5 Apr 06, *General Flight Rules*

(2) AFI 11-202, Vol 2, 8 Dec 06, *Aircrew Standardization/Evaluation Program*

(3) AFI 11-2B-1, Vol 1, 16 Dec 06, *B-1 Aircrew Training*

(4) AFI 11-2B-1, Vol 3, 20 Jul 05, *B-1 Operations Procedures*

(5) AFI 11-418, Andersen AFB Supplement 1, 15 May 07, *Operations Supervision*

(6) 36 OG SOF Checklist, 24 Jul 07

(7) 36 WGI 13-201, 1 Aug 06, *Andersen Air Force Base Flight Line Driving Instruction*

(8) 36 WGI 13-202, 10 Apr 06, *Airfield Operations*

(9) Andersen Fire Department, AFTO 88, 2007

(10) FAA JO 7110.655S, 14 Feb 08, *Air Traffic Control*

(11) Air Force Manual 15-129, 21 Jun 04, *Air and Space Weather Operations – Processes and Procedures*

(12) AFI 51-503, 16 Jul 04 (incorporating through change 2, 11 Feb 08) *Aerospace Accident Investigations*

(13) AFI 51-503, 16 Jun 04, Air Combat Command Supplement, 27 Jun 07, *Aerospace Accident Investigations*

(14) AFI 91-204, 14 Feb 06, *Safety Investigations and Reports*

(15) Technical Order (TO) 1B-1B-2-51GS-00-1, *General Systems, Organizational Maintenance, Structures*, 1 Jul 07

(16) TO 1-1A8, 1 Feb 08, *Technical Manual, Engineers Manual Series, Aircraft and Missile Repair, Structural Hardware*

(17) TO 1B-1B-2-32GS-00-1, 1 Dec 07, *Technical Manual, General Systems, Organizational Maintenance, Landing Gear, B-1B Aircraft*

(18) TO 1B-1B-2-29GS-00-1, 1 Jun 06, *Technical Manual, General Systems, Organizational Maintenance, Hydraulic Power*

(19) Technical Manual (TM) 00-20-01, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, And Procedures,* 30 Apr 2003

(20) TO 1B-1B-1, Change 6, 14 Feb 08, *B-1 Flight Manual*

b. Known or Suspected Deviations from Directives or Publications

(1) Crew: None

(2) Supervision/Training: None

(1) Maintenance: Aircraft Maintenance TO, 1B-1B-2-51GS-00-01, pages 7-8, step 14, and preceding "Caution," requires the alignment of upper and lower die retainers of the swaging tool, and the tube fitting. (Tab DD-3) In addition, step 20 and associated Caution requires application of recommended hydraulic pressure. (Tab DD-3) The restrictive location of the RH APU accumulator start module bay, where the subject T-fitting is located, increased the likelihood of misalignment of the swaging tool, resulting in an inadequate swage operation.

(i.) Insufficient Inspection: An insufficient follow-on inspection of the T-fitting swaging task failed to discover the inadequate T-fitting swage operation. (Tab R-57, Tab V-1.8, V-1.16 to V-1.17) Aircraft Maintenance TO, 1B -1B-2-51GS-00-01, page 7-9, step 24, requires the inspection of a completed swage using Figure 7-3 as guidance to determine quality of swage operation. (Tab DD-3) The "Go/No-Go" tool, referred to as the Inspection Gage in Figure 7-3 must be utilized to make this determination. (Tab DD-3) The "Inspected by" maintenance technician failed to use the Go/No go tool to inspect swages and T-fitting. (Tab U-168, Tab V-1.8 to V-1.10)

(ii.) Incorrect Forms Sign-Off: During the period that the MA underwent isochronal inspection in December 2007, the "Corrected by" and "Inspected by" block of the specified task of removing and replacing #3 hydraulic pressure line in the right hand APU start module bay was accomplished in MA AFTO Form 781A, From 20071109 To 20071211, page 199 of 244, Block 3. (Tab U-168) The "Inspected by" maintenance technician stated he accomplished 65% to 70% of the work in this area, and he had a recollection of the subject T-fitting. (Tab R-53) There is reasonable evidence to indicate that the "Inspected by" maintenance technician removed and replaced subject T-fitting and subsequently signed the post task inspection, contrary to the requirement defined in Air Force Technical Order 00-20-01. (Tabs DD-5, Tab R-50 to R-58, Tab V-1.10, V-1.17)

Air Force TO 00-20-1, 4.2.6.1, states, "Inspectors who participate in accomplishment of the repair work and who are authorized to clear Red X symbols will enter their minimum signature

in the "INSPECTED BY" block, provided that another member of the maintenance crew accomplishing the work signs the "CORRECTED BY" block with their minimum signature. (Tab DD-5) This maintenance technician must be involved in the work required to complete the task. In addition, the inspector and the maintenance technician who signs the "CORRECTED BY" block must have the opportunity to accomplish, monitor, or verify the correct completion of the work. (Tab DD-5) Work accomplished by an inspector, in any other way, will not be verified in this manner and will require a check by another inspector." (Tab DD-5)

Additionally, the "Corrected by" maintenance technician stated that he was not familiar with the 51GS tech order section concerning the swaging of tubes and fittings. He also had not installed or swaged hydraulic lines in the past. (Tab V-33)

(iii.) Causal Factors of Hydraulic System #3 loss: Inadequate swage operation was performed on subject hydraulic T-fitting. (Tab J-12, J-23, J-24)

The "Inspected by" maintenance technician trusted other 7-level technicians, on other shifts, when they reported the in-process work accomplished was satisfactory. Failed to verify with adequate post task 7-level inspection. (Tab V-1.8, V-1.16)

The "Inspected by" maintenance technician did not use swage Go/No-Go gage in post task final 7-level inspection – though, there is no requirement in written guidance or policy. (Tab V-1.17)

There is convincing evidence that the #3 hydraulic pressure line in the right hand APU start module bay, specifically the "T"-fitting on the line, was installed incorrectly and a post task inspection failed to discover the inadequate installation of the "T"-fitting. The failure of this "T"-fitting was the direct and sole cause of MA IFE and return to Andersen AFB, Guam, on 7 March 2008.

(iv.) Mitigating Factors: The task to remove and replace subject hydraulic lines took 4 days, requiring multiple shifts and multiple technicians to complete the job. (Tab V-1.13, V-1.14) The task consumed many hours over several days; therefore, it was inspected for quality along the way and the aircraft was put back together as the task progressed. This precluded an adequate "final" 7-level inspection of the entire task once the work was complete, as many of the areas worked were inaccessible at the point of final inspection. (Tab V-1.14, V-1.16, V-1.17)

13. NEWS MEDIA INVOLVEMENT

There has been no apparent media interest regarding this accident.

14. ADDITIONAL AREAS OF CONCERN

a. Failure to Chock the Aircraft

(1) Lack of Clear Chocking Guidance: There is no clear written guidance identifying the

responsible agency for chocking an aircraft during an in-flight emergency response.

(2) MP: Approximately twenty minutes before landing, the MP asked Guam Approach Control to coordinate with Andersen Air Traffic Control Tower to have the fire department, B-1 maintenance, and the flight surgeon standing by to meet the MA after landing. The MP assumed that maintenance would be bringing chocks.(Tab V-35, V-36)

(3) Rescue 3: Rescue 3 was the first responder to the MA emergency. Rescue 3 had aircraft chocks in his truck, but did not carry them to the aircraft for initial response. (Tab V-2, V-8) The MA was stopped on Taxiway Kilo with engines running for approximately two minutes from the time Rescue 3 was standing by the MA nose gear to the time the aircraft started to roll. (Tab S-17) Rescue 3 had time to chock the aircraft. However, they were not directed to do so by Chief 2. Rescue 3 had relied on TA or maintenance personnel in the past to perform this task.

(4) Transient Alert: It is common practice at Andersen AFB for Transient Alert (TA) or the aircraft maintenance team to chock an aircraft when the area is declared fire safe by the senior fire official. (Tab V-16) Andersen AFB TA, along with a B-1 maintenance crew in a second truck, arrived at the hold line to cross Rwy 6R and called GC approximately 46 seconds after the MA came to a stop on Taxiway Kilo after turning off Rwy 6L. Ground Control did not answer TA or approve TA and the B-1 maintenance team to cross Rwy 6R for approximately five minutes, and crossing approval was not received by TA until after the MA impacted the ARFF vehicles. There were approximately two minutes and forty seconds from the time TA requested approval to cross Rwy 6R to the time the MP shut down the MA. (Tab N-5, N-14, Tab S-17) TA and/or the B-1 maintainers would have had time to chock the aircraft, if GC had approved TA to cross Rwy 6R after TA's first request, and the senior fire official cleared them to chock the aircraft.

b. Unmanned Fire Trucks

The driver of ARFF vehicle #9 momentarily exited his vehicle in a desperate attempt to chock the rolling MA with the ARFF vehicle chocks. When he got back into his vehicle, there was not enough time to move ARFF vehicle #9 out of the path of the MA. (Tab V-4, V-13, V-14, V-22) There is no written guidance on manning a fire truck during emergency response.

c. Fire Truck Maintenance

(1) Forms Documentation: Every USAF fire fighting vehicle has dedicated written maintenance forms used to record all maintenance activity. Air Force Form 1800 collectively provides a record of operator's inspection and trouble report. (Tab EE-2, EE-3, EE-22 to EE-29) There is no evidence of negative maintenance trends for ARFF vehicles #9 and #11.

(2) Inspections: Every fire vehicle undergoes a daily inspection/operational check.

Documentation confirms that all inspections were satisfactorily accomplished in accordance with applicable driver operator inspection and trouble report requirements. The most recent vehicle inspection of ARFF vehicles #9 and #11 was completed on the morning of the mishap. (Tab V-22, V-24)

(3) Maintenance Procedures: ARFF vehicle #11 experienced intermittent transmission problems (slow accelerator response) en route to the mishap scene. (Tab R-36, R-41, Tab V-23, V-24) This did not affect the firefighting capability of the vehicle and therefore it was not taken out of service. The transmission problems hampered the ability of the ARFF vehicle #11 to clear the path of the MA.

d. Airfield Management – Information Control

The AIB conducted many interviews with the Andersen AFB work force, firefighters, TA, and ATC personnel. The AIB determined that there was no collective knowledge that Rwy 6R was closed on the day of the mishap. There was unclear and conflicting guidance and lack of associated procedures for coordination to cross a closed runway. There is an absence of clear airfield management methodology to timely distribute or disseminate airfield status, i.e. runway closures, to provide those accessing the airfield an unambiguous understanding of airfield status and associated coordination variances. (TAB V-16 to V-20)

e. B-1 Aircraft Maintenance Inspection Tracking

There is no clear method to track or identify which connections or fittings on long tube run replacements, encompassing several access bays, have or have not been inspected. There was no reference during follow-up supervisor inspections on a job or task that spans an extended period of time over multiple work shifts.

f. Single Point Failure Components

Single point failure aircraft components, such as the right hand brake metering valve, have a maintenance concept of "fly-to-failure," meaning these components never had either a periodic field level test/inspection procedure or a programmed depot maintenance replacement program. The right hand brake metering valve was never previously replaced.

6 June 2008

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