UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

B-1B, Tail Number 85-0091

34TH BOMB SQUADRON
28TH BOMB WING
ELLSWORTH AIR FORCE BASE

LOCATION: BROADUS, MONTANA

DATE OF ACCIDENT: 19 AUGUST 2013

BOARD PRESIDENT: COLONEL BRIAN A. HUMPHREY

CONDUCTED IN ACCORDANCE WITH AIR FORCE INSTRUCTION 51-503

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
JOINT BASE LANGLEY-EUSTIS VA

19 DEC 2013

OFFICE OF THE VICE COMMANDER
205 DODD BOULEVARD SUITE 203
JOINT BASE LANGLEY-EUSTIS VA 23665-2788

ACTION OF THE CONVENING AUTHORITY

The Report of the Accident Investigation Board, conducted under the provisions of AFI 51-503, that investigated the 19 August 2013, mishap near Broadus, Montana, involving a B-1B, T/N 85-0091, assigned to the 34th Bomb Squadron, 28th Bomb Wing, Ellsworth AFB, SD, complies with applicable regulatory and statutory guidance; on that basis it is approved.

LORI J. ROBINSON
Lieutenant General, USAF
Vice Commander

EXECUTIVE SUMMARY
AIRCRAFT ACCIDENT INVESTIGATION

B-1B, Tail Number 85-0091
BROADUS, MONTANA
19 AUGUST 2013

On 19 August 2013, at approximately 0916 hours local time (L), the mishap aircraft (MA), a B-1B, Tail Number 85-0091, assigned to the 34th Bomb Squadron, 28th Bomb Wing, Ellsworth Air Force Base (AFB), South Dakota, impacted grass-covered pastureland near Broadus, Montana. The four crewmembers ejected safely and sustained non-life-threatening injuries. There were no injuries to civilians. The MA was destroyed, with the government loss valued at $317,722,980.67. Damage to private property consisted of burnt pastureland.

The MA departed Ellsworth AFB at approximately 0857L on 19 August 2013. Following takeoff, Mishap Pilot 2 (MP2) leveled the MA off at an altitude of approximately 20,000 feet. At that time, the mishap crewmembers (MC) completed an aircraft systems check. MP2 then reduced engine thrust to idle, initiated a descent to 10,000 feet, and swept the wings from the forward to the aft position. During the sweep, the MA developed an undetectable fuel leak in the 4.5-inch main fuel line located in the left overwing fairing. The fairing is a structure that provides a smooth surface for air to flow over portions of the aircraft (e.g., wing) thereby reducing drag. Approximately 7,000 pounds of fuel leaked from the 4.5-inch main fuel line into the left overwing fairing while the MC continued their training mission. Eventually, the fuel contacted exposed portions of the hot precooler duct, ignited, and caused an explosion that separated the left overwing fairing from the MA. Ignited fuel streamed from the exposed left overwing fairing cavity, heated one of the MA's fuel tanks, and ignited the fuel vapors inside the tank. This detonation propagated through the fuel venting system that connects the fuel tanks in the MA, resulted in a cascade of catastrophic explosions and caused a complete and permanent loss of power to the crew compartment.

The efforts of the MC to extinguish the fires were unsuccessful. Mishap Pilot 1 appropriately ordered the MC to eject. Following ejection, the fuselage of the MA split in two and impacted the ground.

The Accident Investigation Board President found by clear and convincing evidence that a displaced fold down baffle in the left overwing fairing caused the mishap. The fold down baffle fills in gaps when the wings are in the forward position to form a fairing under the wing. The fold down baffle became detached for an unknown reason sometime prior to the initiation of the aft wing sweep. During the sweep, the wing pushed the detached fold down baffle into the 4.5-inch main fuel line, resulting in a v-shaped cut to the top half of the fuel line and the subsequent fuel leak. The leaking fuel ignited, caused multiple catastrophic detonations throughout the MA, and ultimately led to the breakup of the MA prior to ground impact.

SUMMARY OF FACTS AND STATEMENT OF OPINION
B-1B, Tail Number 85-0091
19 AUGUST 2013

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

12 AF	Twelfth Air Force
28 BW	28th Bomb Wing
34 BS	34th Bomb Squadron
A1C	Airman First Class
ACC	Air Combat Command
AF	Air Force
AFTO	Air Force Technical Order
AFB	Air Force Base
AFE	Air Flight Equipment
AFI	Air Force Instruction
AFIP	Air Force Institute of Pathology
AFS	Avionics Flight Software
AGL	Above Ground Level
AIB	Accident Investigation Board
AMU	Aircraft Maintenance Unit
APG	Airplane General Mechanic
APU	Auxiliary Power Unit
CAMS	Core Automated Maintenance System
CITS	Central Integrated Test System
CRG	Contingency Response Group
CW	Civilian Witness
DIFM	Due in for Maintenance
DO	Director of Operations
DSO	Defensive Systems Operator
ECS	Environmental Control System
ENG	Engine
EMUX	Electrical Multiplexing
ETAR	Engineering Technical Assistance Report
FDP	Flight Duty Period
FOD	Foreign Object Debris
GX	Gravitational Force Awareness Exercise
IAW	In Accordance With
ICS	Intercom Crew System
I&E	Intake and Exhaust
IDARS	Integrated Data Acquisition Recorder System
IMDS	Integrated Maintenance Data System
IP	Instructor Pilot
JDAM	Joint Direct Attack Munitions
KVA	Kilovolt Amperage
L	Local Time
Lt Col	Lieutenant Colonel
MBW	Multipurpose Ballistics Weapon
MC	Mishap Crew
MICAP	Mission Capable
MIZ	Maintenance Information System
MM	Maintenance Member
MOA	Military Operating Area
MP	Mishap Pilot
MSgt	Master Sergeant
MSA	Minimum Safe Altitude
MSL	Mean Sea Level
MXS	Maintenance Squadron
NOTAMs	Notices to Airmen
OH	Ohio
Ops	Operations
ORM	Operational Risk Management
PCA	Permanent Change of Assignment
PLF	Parachute Landing Fall
SD	South Dakota
SIM	Suppression/Insulation/Migration
TCTO	Time Compliance Technical Order
Tech	Technical
TF	Terrain Following
T/N	Tail Number
T.O.	Technical Order
USAF	United States Air Force
U.S.C.	United States Code
VSD	Vertical Situation Display
VMC	Visual Meteorological Condition
WSO	Weapons System Officer
Z	Zulu

The above list was compiled from the Summary of Facts, the Statement of Opinion, the Index of Tabs, and Witness Testimony (Tab V).

DEFINITIONS

Above ground level	Altitude measurement based on distance from underlying ground surface
Afterburner or augmented thrust	Enhancement of engine power by adding additional oxygen or fuel to the exhaust
Fairing	Structure to provide smooth surface for air to flow over portions of the aircraft (e.g., wing), thereby reducing drag
Flight level	Altitude measurement based on barometric pressure used to normalize measurement of altitude among aircraft
Fuselage	Main body section of aircraft
Fold down baffle	Fills gaps when wings are in forward position to form a fairing under wing
G	A force acting on a body as a result of acceleration
G-Awareness Exercise	A flight maneuver performed prior to high G conditions to ensure crewmembers are capable of coping with increased G
Integrated Data Acquisition System	Compact, solid-state recording system used to collect, process, and store flight data (e.g., accelerometer measurements)
Isochronal inspection	Periodic inspection scheduled according to flying hour utilization rates in specific calendar periods
Mandrel spring assembly	Provides pressure necessary to push fold down baffle into place when wings are in forward position
Mean Sea Level	Altitude measurement based on an aircraft's distance from average height of ocean
Military Power/ intermediate power	Maximum thrust setting of aircraft without afterburner
Military Operating Area	Airspace designated to segregate non-hazardous military activities from non-military air traffic
Nacelle	Structure that contain engines, auxiliary power units, precooler, and other aircraft systems

Overpressure condition	Rapid expansion of combustible materials in a confined area
Overwing fairing cavity	Space below fairing located at wing roots containing 4.5-inch main engine fuel line, 2-inch fuel cooling loop line, and other systems
Preflight	Inspection of aircraft prior to takeoff
Precooler bay	Compartment used to cool engine air for use in aircraft systems
Reconstitution	Post-deployment plan to ensure squadron members be current on training
Sortie	Deployment of aircraft for a particular mission
Technical order	Publication that explains procedures for aircraft operations and maintenance
Wing root	Connection point between the wing and aircraft fuselage
Wing sweep	Movement of the wings forward (15 degrees) or aft (67.5 degrees), allowing increased performance at different airspeeds

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 25 October 2013, Lieutenant General Lori J. Robinson, Vice Commander, Air Combat Command (ACC), appointed Colonel Brian A. Humphrey as Board President (BP) to conduct an aircraft accident investigation of a mishap that occurred on 19 August 2013 involving a B-1B aircraft near Broadus, Montana (MT) (Tab Y-5 to Y-6). The BP conducted the aircraft accident investigation in accordance with Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, at Ellsworth Air Force Base (AFB), South Dakota (SD), from 28 October 2013 through 22 November 2013 (AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010, Incorporating Change 1, 21 June 2010). Board members included a Medical Member, a Pilot Member, a Legal Advisor, a Maintenance Member, and a Recorder (Tab Y-5).

b. Purpose

This is a legal investigation convened to inquire into the facts surrounding the aircraft accident, to prepare a publicly-releasable report, and to gather and preserve all available evidence for use in litigation, claims, disciplinary actions, administrative proceedings, and for other purposes (AFI 51-503, paragraph 1.2).

2. ACCIDENT SUMMARY

On 19 August 2013, at approximately 0916 hours local time (L), the mishap aircraft (MA), a B-1B, Tail Number 85-0091, assigned to the 34th Bomb Squadron (34 BS), 28th Bomb Wing (28 BW), Ellsworth AFB, impacted the ground on civilian owned pastureland near Broadus, Montana. The MA and its crew were conducting a training mission simulating surface attack for post-deployment reconstitution in a Military Operating Area (MOA) (Tabs J-67, J-71, K-7, K-13, CC-11, DD-3, EE-3, EE-25, and FF-7). The purpose of post-deployment reconstitution is to ensure all squadron members become current on training items that expired during deployment (Tab EE-3). All crewmembers ejected safely (Tabs H-2, H-12 to H-13, V-1.9 to V-1.11, V-2.12 to V-2.14, V-3.14 to V-3.15, and V-4.13 to V-4.16). Mishap Pilot 1 (MP1), Mishap Crewmember 1 (MC1), and Mishap Crewmember 2 (MC2) suffered minor injuries (Tabs H-13, V-1.9, V-2.10, V-2.13, V-3.15 to V-3.16, V-4.14 to V-4.16, and X-3 to X-4). Mishap Pilot 2 (MP2) sustained more significant, but not life-threatening, injuries (Tabs H-13, V-4.14 to V-4.16 and X-3 to X-4). There were no injuries to civilians (Tab DD-3 and DD-5 to DD-6). The 28th Bomb Wing Commander responded to media interest following the mishap (Tab DD-3 and DD-5 to DD-6). The MA was destroyed, with the government loss valued at $317,722,980.67 (Tab P-5). There was also damage to private property consisting of burnt pastureland.

3. BACKGROUND

The MA belonged to 28 BW, Twelfth Air Force (12 AF), ACC (Tabs K-7, K-13, CC-5, and CC-7).

a. Air Combat Command

ACC is the primary force provider of combat airpower to America's warfighting commands (Tab CC-3). To support global implementation of national security strategy, ACC operates fighter, bomber, reconnaissance, battle management, and electronic-combat aircraft (Tab CC-3). It also organizes, trains, equips and maintains combat-ready forces for rapid deployment and employment, while ensuring strategic air defense forces are ready to meet emerging challenges (Tab CC-3).

b. Twelfth Air Force

Twelfth Air Force is responsible for the combat readiness of 10 active duty wings and one direct reporting unit (Tab CC-7). It is one of four Numbered Air Forces in ACC (Tab CC-3 and CC-5). Twelfth Air Force includes commands that, in total, operate more than 818 aircraft with more than 65,000 uniformed and civilian personnel (Tab CC-7). It enables combat-ready forces for rapid global deployment to receive, command and control, and employ joint air component assets to meet U.S. strategic objectives across a full spectrum of operations (Tab CC-7).

c. 28th Bomb Wing

The 28th Bomb Wing is located at Ellsworth AFB near Rapid City, SD (Tab CC-5, CC-7, and CC-9). It provides essential base operating support services for Ellsworth AFB and combat support services for an Air Expeditionary Wing (Tab CC-9). It consists of four groups: the 28th Operations Group, 28th Mission Support Group, 28th Maintenance Group, and 28th Medical Group (Tab CC- 9 and CC-11). Its vision is to serve as the backbone of global engagement for the 21st century (Tab CC-9).

d. 34th Bomb Squadron

Known as the Thunderbirds, the mission of 34 BS is to employ the B-1B to defeat America's enemies across the globe at a moment's notice (Tab CC-11). After the 11 September 2001 terrorist attacks on the United States, 34 BS was one of the first units to deploy overseas in support of OPERATION ENDURING FREEDOM (Tab CC-11). Since 2003, the Thunderbirds have completed numerous deployments in support of OPERATIONS ENDURING FREEDOM and IRAQI FREEDOM (Tab CC-11).

e. B-1B

The B-1B carries the largest payload of both guided and unguided weapons in the Air Force inventory (Tab CC-13). It can rapidly deliver massive quantities of precision and non-precision weapons against any adversary, anywhere in the world (Tab CC-13). The B-1B is an improved variation of the B-1A, which was developed in the 1970s as a replacement for the B-52 (Tab CC-13). The wings on the B-1B sweep from a forward position of 15 degrees to and aft position of 67.5 degrees (Tab J-33). The United States first utilized the B-1B in combat to support operations against Iraq during OPERATION DESERT FOX in December 1998 (Tab CC-14). The B-1B played a critical role in OPERATION ENDURING FREEDOM, dropping nearly 40 percent of the total tonnage delivered by coalition forces during the first six months of the operation (Tab CC-13).

4. SEQUENCE OF EVENTS

a. Mission

The mission during the 19 August 2013 mishap was a post-deployment training flight in which the mishap crew (MC) would simulate a low-threat surface attack (Tabs V-1.4, V-2.3 to 2.4, V-3.4, V-4.3, EE-3, and EE-16). The MC's objective was to simulate ordnance employment, allowing them to become current on combat-mission readiness training items that could not be accomplished during their recent deployment (Tabs V-1.4, V-2.3, V-3.4, EE-3, and EE-16). The Director of Operations for 34 BS properly authorized the mission on 19 August 2013 (Tab K-13). The mission required the MC to fly in the Powder River MOA (Tabs K-7, and EE-17). It included defensive maneuvers in response to simulated threats, low and medium altitude Modifiable Ballistics Weapon bomb runs, and multiple Joint Direct Attack Munition bomb runs (Tab V-1.4, V-2.3, V-3.4, and V-4.3). The MA and an additional B-1B were the only military aircraft from Ellsworth AFB scheduled to be in the MOA at the time of the mishap (Tabs K-6 to K-7 and EE-25).

b. Planning

The mission planning and briefing were accomplished in accordance with (IAW) 34 BS, 28 BW, and Air Force directives and standards (Tab EE-11 to EE-12). The MC attended 34 BS reconstitution briefings on 16 August 2013, which included the mission briefing for the 19 August 2013 mishap flight (Tab V-1.3 to V-1.4, V-2.3 to V-2.4, V-3.4, and V-4.3). MP1 and MC1 developed the mission plan prior to 16 August 13 (Tab V-2.3 and V-3.3). MC1 briefed 34 BS personnel, including the MC, on the mission scenario, mission execution, emergency procedures, obstructions and high terrain, special interest items, flight administration, training rules, airspace, and forecast weather, IAW the *28th BW In-flight Guide* (Tabs V-1.3 to V-1.4, V-2.3, V-4.4, EE-10 to EE-12, and EE-15 to EE-19). The Commander and Director of Operations for 34 BS attended the mission brief (Tab V-1.4 to V-1.5, V-2.4, V-3.4 to V-3.5, and V-4.3). The MC understood the mission (Tab V-1.5, V-2.4, V-3.5, and V-4.4). Following the mission brief, MP1 briefed the MC, IAW 28 BW guidance (Tabs V-2.4, V-3.3 to V-3.4, V-4.3, and EE-11). The weather flight from the 28th Operational Support Squadron, Ellsworth AFB, developed the weather planning documents for the mission, which included forecasts and observations for

Ellsworth AFB, Powder River MOA, and surrounding airspace, as well as satellite and radar images showing, weather, winds, and other relevant data (Tab F-2 to F-13).

c. Preflight

Prior to departing 34 BS for the MA on 19 August 2013, the MC gathered and inspected their Aircrew Flight Equipment (AFE) gear and received a brief from the operations supervisor (Tab V-1.3, V-1.5 to V-1.6, V-2.4, V-3.5 and V-4.4). This brief concerned aircraft parking locations, maintenance issues, and configurations, and also included a review of the Notices to Airmen (NOTAMS), bird watch conditions, updated information on airfield and weather conditions, and reconstitution guidance from the Commander of 34 BS (Tab EE-12 and EE-21 to EE-29). The flight plan (Department of Defense Form 175) was electronically filed with the Federal Aviation Administration (Tab K-3). The MC departed 34 BS and arrived at the MA at approximately 0730L (Tab V-3.5 and V-4.5). At the MA, the MC conducted a review of the aircraft forms, completed a walk-around inspection, and initiated the engine start sequence and preflight checks (Tab V-1.6, V-2.5, V-3.5 to V-3.6, and V-4.5). Aside from an issue with one of two available radar channels, neither the MC nor maintenance personnel noted anything abnormal during preflight or ground operations prior to takeoff (Tabs R-15, R-19, V-1.6, V-2.5, V-3.6, V-4.5, V-9.3, and V-10.4). The radar issue was resolved prior to takeoff (Tabs R-15, R-19, V-1.6 to V-1.7, V-4.5, V-9.3, and V-10.4).

d. Summary of Accident

The MA departed Ellsworth AFB at approximately 0857L under the call sign THUNDER 21 (Tabs J-66, K-7, K-13, and FF-4). The preflight, engine start, taxi, and takeoff performed by MP2 were uneventful (Tab V-3.6 and V-4.5). The MA proceeded to the training airspace, climbing to 20,000 feet (Flight Level 200) (Tab V-2.6, V-3.6, and 3.11). The MC conducted aircraft system checks, which indicated all systems were operating within normal parameters (Tab V-1.7, V-1.12, V-2.6, V-3.6, V-3.11, and V-4.6).

After arriving in the Powder River MOA at approximately 0905L, MP2 decreased thrust to initiate a descent to 10,000 feet Mean Sea Level (MSL) for a G-Awareness Exercise (Tabs J-66, L-4, V-2.5, V-3.6, and V-4.6). MP2 initiated a sweep of the wings from 25 degrees (the takeoff and climb setting) aft to 67.5 degrees, leveled off at 10,000 feet MSL, and conducted the G-Awareness Exercise (Tabs J-67, V-2.5, V-3.6, and V-4.6).

Soon after the descent to 10,000 feet began, the MA developed an undetectable (see discussion in paragraph 6.a.(4)) fuel leak in the 4.5-inch main fuel line of the left overwing fairing (Tabs J-66, J-78, J-108 to J-110, and FF-4). The leak occurred at a rate of approximately 820 pounds per minute (approximately 120 gallons per minute) for 8.5 minutes totaling approximately 7,000 pounds of fuel (1,000 gallons) (Tab J-78). There were no cockpit indications of a leak (Tab V-1.12, V-2.14, V-3.11 to V-3.12, and V-4.6 to V-4.7). The fuel level indicator located inside the fuel tank was unable to detect a downstream leak (see discussion in paragraph 6.a.(4)).

Unaware of the fuel leak, and following the two G-Awareness Exercise turns, MP2 initiated a descent from 10,000 feet MSL to 1,000 feet Above Ground Level (AGL) (Tabs J-67, V-1.7, V-2.6, V-3.6, V-2.11, V-4.6 to V-4.7, and FF-4). MP2 leveled the MA at 1,000 feet AGL and

began the low altitude unguided bomb run at approximately 0913L (Tabs J-67, V-2.6, V-3.6, V-4.7, and FF-5). After the MC completed the level-off checks, MP2 initiated a defensive left turn maneuver in response to a simulated threat from the northeast announced by MC1 (Tab V-1.7, V-2.6 to V-2.7, and V-3.6). MP2 turned the MA to an approximate heading of 220 degrees and moved the throttles to the maximum augmented thrust (Tabs J-68, V-2.6 to V-2.7, and V-3.6).

At approximately 0914L, the MC heard a loud noise (described as a "bang," "pop," "violent," and "loud explosion"), which some of the MC perceived to be from the left side of the MA (Tabs V-1.7, V-2.9, V-3.6 to V-3.7, V-3.13, V-4.7, and FF-5). The noise was accompanied by an uncommanded left yaw and bank (Tabs J-67 to J-68 and V-3.7). Subsequently, the left overwing fairing fire light illuminated in the cockpit and an alarm sounded, signaling overheat or fire in the left overwing fairing (Tab V-2.8, V-3.7 to V-3.8, V-3.13, and V-4.10). At 0914:30L, MP2 moved the throttles to an intermediate power setting (Tabs J-67, V-2.7 to V-2.8, V-2.11, V-3.7 to V-3.8, V-4.10, and FF-5). At the same time, MP1 informed the MC of the overwing fairing fire indication and began to perform the applicable procedures to extinguish the fire, to include activating the main fire suppression system in the left overwing fairing (Tabs J-67, V-2.7 to V-2.8, V-2.11, V-3.7 to V-3.8, V-4.10, and FF-5).

At 0914:33L, the Engine 2 fire light illuminated in the cockpit, and one second later, the Engine 1 fire light illuminated (Tabs J-67, V-1.7 to V-1.8, V-1.12, V-3.8 to V-3.9, V-4.10 to V-4.11, and FF-5). MP2 then began a climb from the low altitude environment by selecting maximum augmented thrust on all four engines (Tabs J-67, V-1.7 to V-1.8, V-2.7, V-3.8, and V-4.9). Then, in response to the Engine 1 and 2 fire warning lights, MP1 initiated procedures to shut down Engine 1 and Engine 2, IAW technical order (T.O.) procedures (Tabs V-3.8, V-3.12, V-3.18, and T.O. 1B-1B-1). MP2 announced the MA had passed the minimum safe altitude for the airspace, and MP2 continued to climb in anticipation of returning to Ellsworth AFB (Tab V-3.8 and V-4.9). Approximately 30 seconds after the first attempt to extinguish the fire in the left overwing fairing, MP1 activated the reserve fire suppression system (Tab V-3.14). MP1 then called for a turn toward Ellsworth AFB (Tab V-1.8 and V-2.7). MC2 put Ellsworth AFB in the navigation system, and MP2 began a left turn (Tabs J-67, V-1.8, V-2.7, and V-3.8 to V-3.9). The Engine 1 fire light turned off, but the left overwing fairing fire light and the Engine 2 fire light remained illuminated (Tab V-3.8 to V-3.9 and V-4.11).

At approximately 0916L a second explosion occurred and the cockpit of the MA lost all electrical power (Tabs V-1.8 to V-1.9, V-2.7, V-3.9, V-3.13, V-4.11, and FF-7). The nose of the MA pitched down, and the MA experienced an uncommanded left roll (Tab V-2.9, V-3.9, and V-4.12). MP1 called for ejection IAW T.O. guidance for the complete loss of electrical power (Tabs V-1.8 to V-1.9, V-2.7, V-3.15, V-4.14, and T.O. 1B-1B-1). MP1 and MP2 prepared for ejection by pulling the ejection handles on their seats, which initiated the ejection sequence for the MC (Tab V-3.9, V-3.15, and V-4.13). The MC ejected from the MA at approximately 10,700 feet MSL (7,377 feet AGL) and .74 Mach (400 Knots Equivalent Airspeed) (Tabs H-12 and FF-7). All four crewmembers ejected safely and sustained non-life threatening injuries (Tabs H-2, H-12 to H-13, V-1.9 to V-1.11, V-2.10, V-2.12 to V-2.14, V-3.14 to V-3.16, V-4.13 to V-4.16, and X-3 to X-4).

A timeline built from Integrated Data Acquisition Recorder System (IDARS) data, witness testimony, and post-mishap technical reports is included in Tab FF (Tab FF-4 to FF-7). Key points from the timeline are summarized in Table 1 below.

Local Time	Event
0856:50	MA departs Ellsworth AFB
0905:42	MP2 reduces engine thrust to idle
0905:44	MP2 initiates wing sweep
0906:14	MA develops undetectable fuel leak, left overwing fairing
0906:37	MP2 advances throttle to military power
0914:26	Leaking fuel ignites; MP2 moves to intermediate power setting
0914:30	MP1 activates main fire suppression system in left overwing fairing
0914:32	MP2 initiates climb to 10,000 feet MSL
0915:00	MP1 activates reserve fire suppression system in left overwing fairing
0915:59	Detonation of fuel vapors in Tank 1D, Tank 2A, Tank 2B and Tank 4
0916:00	Last data recorded, all power lost in aircraft
0916:07	Crew ejection

Table 1. Summary of Mishap Timeline (Tab FF-4 to FF-7).

e. Impact

The MA impacted the ground at approximately 0916L (Tabs J-67 and FF-7). Debris from the MA spread over a 17-mile area of privately owned, grass-covered pastureland within the MOA, approximately 24 miles east of Broadus, MT (Tab J-53 and J-71). Distinct groups of MA parts were found along a path generally headed in a northwesterly direction, which eventually changed to a southeasterly direction (Tab J-71 to J-72). The debris spanned Site 1 to Site 7 in Figure 1 (Tab J-54). The forward portion of the MA separated and impacted approximately 1.5 miles from the main crash site (see Figure 1) (Tabs H-7, J-54, and J-72).

At the time the MC ejected, the MA was at approximately 10,700 feet MSL, making a left hand turn, and in a slight descent (Tabs H-12, J-68, and V-3.9). The exact configuration and flight parameters of the MA at the time of impact are unknown because data from IDARS concerning the moments immediately prior to impact could not be recovered (Tabs H-12, J-67, and L-2 to L-5). Electrical power to IDARS was lost prior to ejection (Tabs H-12, J-67, L-2 to L-5, V-1.8 to V-1.9, V-2.7, V-3.9, V-3.13, and V-4.11).

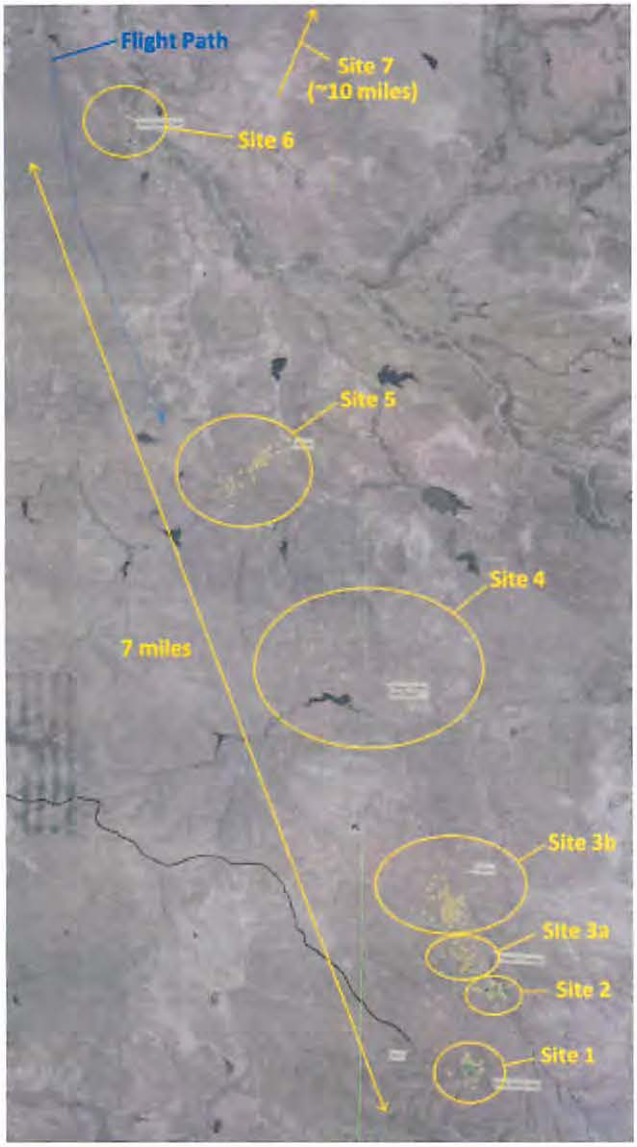


Figure 1. Crash Sites (Tab J-53 to J-64).

SITE 1: Wing carry-through box structure, wings, main landing gear, engine nacelles, engines, and aft fuselage (Tabs J-61 to J-64 and Z-3 to Z-13)

SITE 2: Forward equipment bay, cockpit, nose landing gear, and central equipment bay (Tabs J-61 and Z-13 to Z-14)

SITE 3A: Bottoms of Tanks 2A and 2B, nose radome, crew entry ladder, and pieces of intermediate weapons bay doors (Tabs J-60 and Z-15 to Z-17)

SITE 3B: Sections of intermediate weapons bay and Tank 2 side walls, approximately 15 feet of tunnel bay above intermediate weapons bay, and pieces of intermediate weapons bay doors (Tab J-59)

SITE 4: Ejection seats, escape hatches, refueling tube from Tank 2, and an access panel from the tunnel bay above Tank 3 (Tab J-58)

SITE 5: Tops of Tanks 2A and 2B, numerous frames from Tanks 2A and 2B, and pieces comprising a section from the top of Tank 1D (Tabs J-56 to J-57 and Z-17 to Z-18)

SITE 6: Aft half of panel from the left overwing fairing (Tab J-55 to J-56)

SITE 7: Overwing fairing bumper, bottom of left aft nacelle, and the left aft overwing fairing (Tab J-55)

f. Egress and Aircrew Flight Equipment

The MC successfully ejected within the performance parameters of the Advanced Concept Ejection Seat II (Tab H-2 and H-12 to H-13). The ejection occurred at approximately 10,700 feet MSL (7300 feet AGL) and .74 Mach (400 KEAS), which places the ejection sequence near the boundary between the Mode II to Mode III (see Chart 1) (Tab H-6 and H-12 to H-13). In Mode III, once the seat drogue chute deploys, the deployment of the personnel recovery parachute is delayed until the conditions (altitude and airspeed) of Mode II are satisfied (Tab H-7).

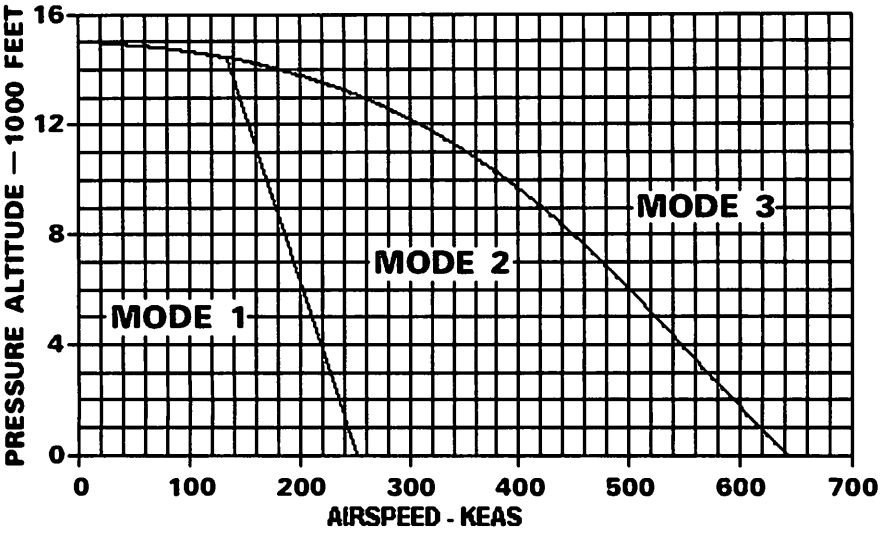


Chart 1. Digital Recover Sequencer Mode Selection Criteria (Tab H-6).

The MC landed within 2,000 feet of each other and approximately three miles north of the main impact site (Tab H-8). MP2 injured his left knee during ejection, possibly because the leg restraints failed to retract fully (Tab H-13). The left leg restraints on both forward ejections seats had not been properly installed during maintenance performed in August 2012 (Tab H-6, H-10, and H-13). In addition, the leg restraint shear rivets failed at loads lower than designed due to improper fabrication (Tab J-136).

The aircrew flight equipment inspections were all current (Tabs H-18 and FF-3). The MC had current training in aircrew flight equipment and wore their equipment properly (Tabs H-18, T-3 to T-5, V-1.9, V-2.10, V-4.13, and FF-3). The helmets of all four crewmembers came off during the ejection sequence (Tabs H-18 to H-19 and V-4.14). Although the helmets appeared to be properly configured, each helmet had multiple failures, likely caused by windblast during the ejection sequence (Tabs H-19, J-174, and J-198 to J-214).

Three of the MC's personal locator beacons transmitted as designed. One beacon did not transmit because the battery was dead (Tab H-21). The ejection survival kits appeared to be properly serviced and configured (Tabs H-21 to H-22). The MC used the following items from the kits: (1) water, (2) PRC-90 survival radios, (3) flares and pen gun flares, (4) life rafts (used for shade), (4) knife, (5) wool glove, and (6) signal mirror (Tabs R-4, R-6, R-10, H-21 and H-22, V-1.10, V-2.12 to V-2-13, and V-3.16).

g. Search and Rescue

Shortly after the MA impacted the ground (approximately 0916L), the Denver Air Route Traffic Control Facility contacted the second B-1B flying in the Powder River MOA to provide notification of an explosion in southeast Montana observed on satellite (Tabs J-67, N-3, and FF-7). MP1 and MC2 also contacted the airborne B-1B's crew and informed them that the MC had ejected (Tab V-1.10, V-2.12, and V-3.16). The remaining airborne B-1B crew became the initial

on-scene commander (Tab V-1.10 and V-3.16). MP2 and MC2, who were physically separated from each other, contacted the operations desk at 34 BS to inform the squadron of the situation and to initiate recovery efforts (Tab V-1.9, V-2.12, and V-3.16). The point of contact at 34 BS advised MC2 to call local emergency services (Tab V-1.10). Two local ranchers approached the MC to assist with medical needs (Tab V-1.10, V-2.13, V-3.16, and V-4.16). Both ranchers remained with the MC until two ambulances arrived approximately two hours after MP2's initial call to local emergency services (Tab V-1.11, V-2.13, V-3.17, and V-4.16). The two-hour delay resulted from the MC's remote location (Tab V-1.10). All crewmembers were transported by ambulance to nearby hospitals to be treated for their injuries (Tabs V-1.1, V-1.11, V-2.13, V-2.14, and X-3 to X-4).

h. Recovery of Remains

There were no fatalities during the mishap.

5. MAINTENANCE

a. Forms Documentation

(1) General Definitions

Air Force maintenance and inspection histories are documented through Air Force Technical Order (AFTO) 781 series forms and the Integrated Maintenance Data System (IMDS). In addition to scheduling and documenting routine maintenance actions, these tools allow aircrew to report discrepancies and maintenance personnel to document actions taken to resolve any reported discrepancy (T.O. 00-20-1).

AFTO 781 series forms are divided into active forms and inactive forms. The active forms are those currently in use by maintenance personnel to record aircraft inspections, conditions, and repair actions. The inactive forms consist of historical forms, but all unresolved discrepancies are moved onto the active forms (T.O. 00-20-1).

Time Compliance Technical Orders (TCTOs) are used to process aircraft system changes (e.g., parts upgrades), which must be accomplished within a specific timeframe, depending on the severity of the issue as indicated by the TCTO. A TCTO may also direct inspections or adjustments to parts or equipment already installed on aircraft. Time change items are routine maintenance actions involving the removal and replacement of parts at a given interval (e.g., flight hours, engine operating hours, engine cycles, calendar days) (T.O. 00-5-1 and T.O. 00-5-15).

(2) Documentation Review

A review of the MA's IMDS information, maintenance logbooks, and active and inactive AFTO 781 series forms did not reveal any issues that contributed to the mishap. There were no significant recurring maintenance issues.

(a) Active Forms

The physical AFTO 781 forms binder was on the MA at the time of the mishap, was not recovered, and is presumed lost. Thus, the most recent forms could not be reviewed. The physical AFTO 781 series forms that remained at Ellsworth AFB had a few documentation errors, none of which contributed to the mishap (Tabs D-3 to D-22 and GG-6).

On 19 August 2013, there were seven open discrepancies in the active AFTO 781 series forms (Tab D-3 to D-22). None of the open discrepancies contributed to the mishap. The ejection seat for MC1 had a waiver for an overdue inspection (Tab D-4). All other inspection items were current, and there were no TCTOs or time change items pending that were relevant to the mishap (Tabs D-3 to D-22 and GG-5 to GG-6).

Maintenance personnel completed the preflight inspection prior to 0600L on 19 August 2013, documenting the inspection on the physical AFTO 781 and placing it on the MA (Tab V-5.6, V-6.5, V-7.4, and V-8.2). The preflight inspection remained valid for 72 hours (T.O. 1B-1B-6). The Exceptional Release was completed at 0600L, indicating the MA had a valid preflight inspection and had been released for takeoff (Tabs R-15, R-21, V-9.4 to V-9.5, and V-11.3 to V-11.4; T.O. 00-20-1).

(b) Inactive Forms

The MA's inactive AFTO 781 series forms had several documentation errors; however, none of the errors contributed to the mishap (Tab GG-5 to GG-6). The MA's 12-month historical files, including TCTOs, AFTO Form 95's (*Significant Historical Data Form*), major inspection packages, and archived IMDS data, revealed nothing relevant to the cause of the mishap (Tab GG-5 to GG-6).

b. Inspections

Maintenance personnel conducted inspections on the MA according to schedule and documented the inspections IAW applicable T.O.s. All inspections were completed satisfactorily (Tab GG-5 to GG-6). At the time of the mishap, there were no past-due inspections (Tab GG-5 to GG-6).

(1) Aircraft Inspections

Isochronal (ISO) inspections are scheduled based on flying hour utilization rates in specific calendar periods. The B-1B has a 900-hour ISO inspection cycle (T.O. 1B-1B-6). The MA underwent a routine 1,800-hour major ISO inspection on 19 March 2013 when the MA reached 8,300 flying hours (Tab GG-5). The overwing fairing cavity was inspected as part of the major ISO inspection, and deficiencies were corrected, to include sheet metal repairs, replacement of minor parts (e.g., cotter pins, chafe wrap), and fire bottle line repairs (Tabs V-12.3 to V-12.5, V-16.2 to V-16.4, V-17.2 to V-17.4, and GG-5). At the time of the mishap, the MA was scheduled to begin a 60-month Programmed Depot Maintenance on 9 September 2013 (Tab GG-5).

Prior to 0600L on 19 August 2013, maintenance personnel concluded the last minor inspection on the MA—a preflight inspection that lasted approximately five hours (Tabs V-5.5 to V-5.6 and

GG-5 to G-6). The preflight inspection includes fluid servicing, inlet and exhaust inspection, and a complete walk around inspection of the aircraft for panel and fastener security (T.O. 1B-1B-6). The overwing fairings were checked as part of the preflight inspection (Tabs R-12, V-8.2 to V-8.4, and V-8.6 to V-8.7). The preflight inspection does not require a specific check of the fold down baffles to ensure proper attachment or function (T.O. 1B-1B-6). The preflight inspection was valid at the time the MA departed Ellsworth AFB (Tabs J-66 and FF-4; T.O. 1B-1B-6).

The IMDS data confirmed that, with the exception of the inspection for MC1's ejection seat check (which had a waiver), all inspections were accomplished IAW applicable maintenance directives (Tab GG-5).

(2) Engine Inspections

Maintenance personnel visibly inspect the B-1B engine inlets and exhausts before and after every flight (Tab GG-6; T.O. 1B-1B-6). In addition, the engines are inspected before and after every engine maintenance run. Each engine also requires an inspection every 100, 200, and 300 flight hours (Tab GG-6; T.O. 00-20-1). All engine inspections were current for the MA at the time of the mishap (Tab GG-5 to GG-6).

Engine components and modules have limited lifetimes that are tracked by engine operating time and cycles (Tabs J-2; T.O. 00-20-1). IMDS did not show any modules or components due for time change at the time of the mishap (Tab GG-5).

c. Maintenance Procedures

AFTO 781 series forms and IMDS reflect all maintenance actions conducted on an aircraft's systems and subsystems (T.O. 00-20-1). Aside from a few minor documentation discrepancies, which were not causal to the mishap, all maintenance procedures on the MA were performed IAW applicable T.O.s and AFIs (Tab GG-5 to GG-6).

d. Maintenance Personnel and Supervision

Maintenance procedures are specific to Air Force Specialty Code and consistent with the member's Career Field Education and Training Plan, require personnel to be trained and qualified on: theory of operations, system schematics, isolation of malfunctions, performance of operational checks, and parts removal and installation, (AFI 36-2232, *Maintenance Training*, 22 February 2006, Incorporating Change 1, 21 June 2010, Attachment 1). Training and qualifications for maintenance personnel are tracked and monitored electronically in the Training Business Area system (AFI 36-2232, Chapter 4).

All personnel assigned to the 28th Maintenance Group, Ellsworth AFB, who maintained the MA were qualified (Tab GG-6). The training records (i.e., AF Forms 623, *Individual Training Record Folder,* and AF Forms 797, *Job Qualification Standard Continuation/Command JQS*), and special certification rosters (i.e., staff progress records and staff certification records) for all personnel performing maintenance on the MA reflected proper training and full qualifications on all tasks accomplished (Tab GG-6). The operations supervision engaged with maintenance

leadership on a daily basis and saw no issues with maintenance practices and procedures (AFI 21-101, *Aircraft and Equipment Maintenance Management*, 26 July 2010, incorporating Change 1, 16 August 2011, including Air Force Guidance Memorandum 4, 19 April 2013, paragraph 3.2.1; Tab K-6 to K-8).

There was no evidence that the actions or omission of actions of maintenance personnel or supervision substantially contributed to the mishap.

e. Fuel, Hydraulic, and Oil Inspection Analyses

Following the mishap, fuel samples were taken from the fuel tank that supplied fuel to the MA (Tab U-4 to U-7). These samples were tested at Wright Patterson AFB, Ohio (OH) (Tab U-4 to U-7). The fuel analysis report shows the fuel used on the MA met specification requirements (Tabs U-4 to U-7 and GG-6).

Hydraulic fluid and oil samples taken post-mishap were sent to Mid-Continent Testing Laboratories for analysis (Tab U-8 to U-21). The hydraulic fluid and oil analyses reported high on water content but were within the acceptable operating standards (Tab U-8 to U-21 and GG-6).

No fluid samples were taken from the MA post-accident.

There was no evidence that abnormalities in the fuel, hydraulic fluid, or oil contributed to the mishap.

f. Unscheduled Maintenance

Review of the 90-day history in IMDS and historical AFTO 781 series forms reflected numerous unscheduled maintenance actions, including structural repairs and part replacement. Maintenance members completed the corrective actions for all of the unscheduled maintenance items (Tab GG-5 to GG-6).

There was no evidence that unscheduled maintenance contributed to the mishap.

6. AIRFRAME SYSTEMS

a. Structures and Systems

Figure 1 details the location of debris from the MA. Upon impact at Site 1, the main portion of the MA disintegrated, resulting in the immediate release of the remaining fuel and other combustibles (Tabs J-61 to J-64, J-72, and Z-3 to Z-13). Burning at the north end of Site 1, where the wings and main carry-through box impacted, was more intense than at the south end (Tab J-72). The fires self-extinguished because of the remote location of the crash site (Tab J-72).

The maintenance history of the components reflect nothing different from post-mishap analyses (Tabs J-2, J-81, J-107 and GG-5 to GG-6).

(1) Overwing Fairing

The overwing fairings are located at the left and right wing roots—the connection point between the body of the aircraft and the wing (T.O. 1B-1B-2-27GS-00-1). The purpose of the overwing fairings is to reduce turbulent airflow between the wing and fuselage surfaces (T.O. 1B-1B-2-27GS-00-1). The fairings accommodate contour changes from the varying wing sweep angles and deflections from aerodynamic loads (T.O. 1B-1B-2-27GS-00-1). The cavities formed by the overwing fairings contain the main engine fuel feed lines, fuel cooling loop lines, fuel cooling blower, fire detection loops, multiple aircraft wire harnesses and hydraulic lines (T.O. 1B-1B-2-27GS-00-1).

The overwing fairings are positioned up during ground operations, providing airflow for the fuel cooling blowers and auxiliary power units (1B-1B-2-27GS-00-1). The fairings shift from ground mode to airborne mode when airspeeds exceed 60 knots (1B-1B-2-27GS-00-1). When the wings are swept between 15 degrees and 61 degrees in flight, the overwing fairings are held in the down position (1B-1B-2-27GS-00-1). At wing sweep positions greater than 61 degrees, the fairings move automatically in response to wing flex (1B-1B-2-27GS-00-1). The fairings automatically open when the airspeed is less than 60 knots (1B-1B-2-27GS-00-1).

The outer edges of the overwing fairings have forward and aft inflatable seals, ensuring that gaps between the wings and the overwing fairings are minimized to reduce aerodynamic drag (1B-1B-2-27GS-00-1). The gap between the bottom of the wing and the nacelle also has an inflatable seal (T.O. 1B-1B-2-53GS-00-1).

The lower seal is attached to left and right nacelle, which contain the engines, auxiliary power units, hydraulic pumps, accessory drive gearboxes, and other aircraft systems (T.O. 1B-1B-2-53GS-00-1). It seals the bottom surface of the wing when the wings are swept back (T.O. 1B-1B-2-53GS-00-1). When the wings are swept forward, the seal and the underwing fold down baffle form the underwing fairing, working together to seal the cavity above the nacelle (T.O. 1B-1B-2-53GS-00-1 and T.O. 1B-1B-2-54GS-00-1). The fold down baffle, which is manufactured by the Boeing Company, is broad at the front and tapers to an acute, v-shaped angle at the aft end (see Figure 2) (Tab U-24 to U-25). Two mandrel spring assemblies, also manufactured by the Boeing Company, provide positive pressure against the fold down baffle to keep the seal in place (Tab U-23 and U-25; T.O. 1B-1B-2-54GS-00-1).

See Figure 2 for a depiction of the overwing fairing.

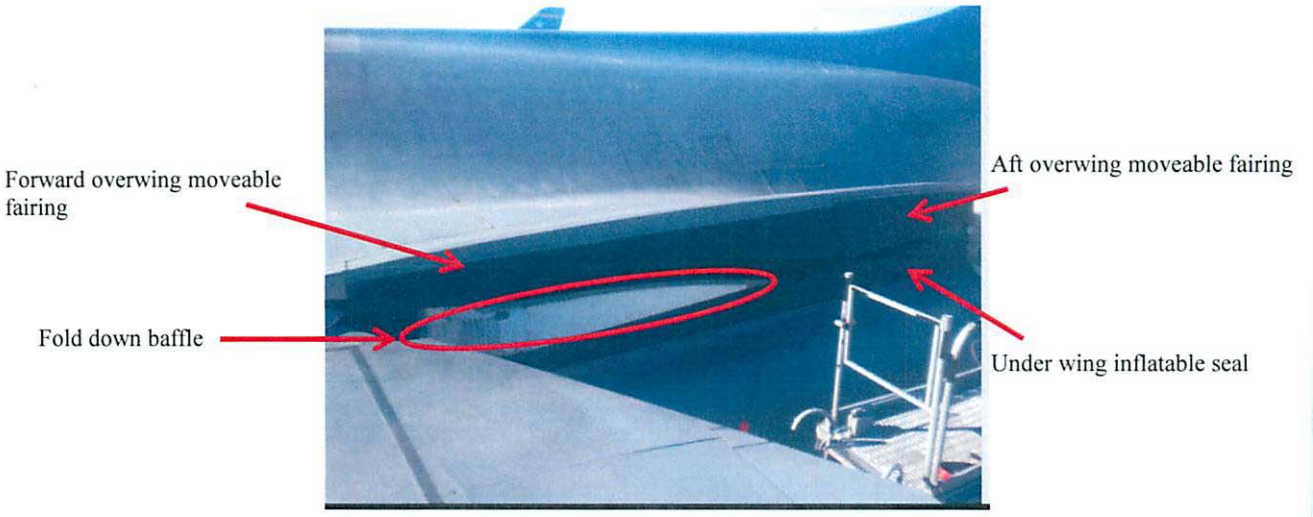


Figure 2. Side View of Left Overwing Fairing (Wing Forward).

During aft wing sweep, only the wing and the fold down baffle move inward into the overwing cavity (see Diagram 1). The overwing fairings house the 4.5-inch main fuel line, the 2-inch fuel cooling loop line, the fuel cooling blower, the overwing fairing fire detection loops, multiple aircraft wire harnesses, and hydraulic lines (Tabs J-38 to J-39 and J-47 to J-49; T.O. 1B-1B-2-27GS-00-1).

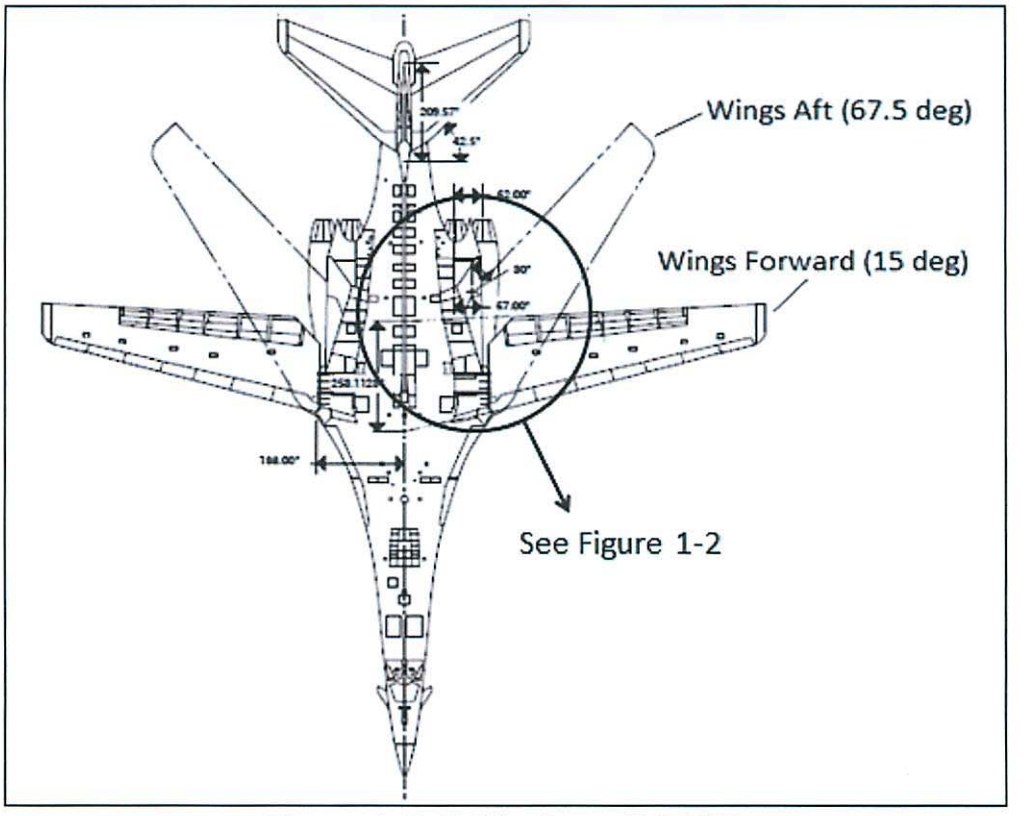
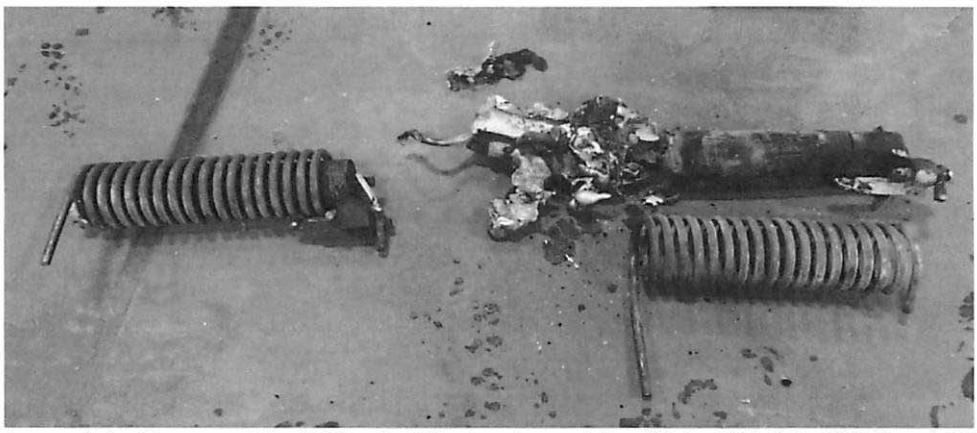


Diagram 1. B-1B Wing Sweep (Tab J-33).

The MA's left aft overwing fairing was found 17 miles north of the main impact site (see Site 7 of Figure 1) (Tab J-54 to J-55). It showed no signs of damage from inflight or ground fire (Tab J-77). As detailed below, a significant fuel leak developed in the left overwing fairing due to a puncture in the 4.5-inch main fuel line (Tab J-78). This leaking fuel detonated when it came into contact with a hot precooler duct, resulting in an over pressure condition in the left overwing fairing (Tab J-78 to J-80). The force from the over pressurization and wind stream caused the left aft overwing fairing to detach from the MA (Tab J-79).

The left forward and aft mandrel spring assemblies from the MA were severely damaged (see Photograph 1) (Tab GG-3 to GG-5).



Photograph 1. Recovered Left Mandrel Spring Assemblies (Tabs GG- 3 to GG-5 and Z-22).

(2) Aircraft Engines

The B-1B is powered by four F101-GE-102 engines attached to the nacelles just aft of the wing pivot (T.O. 1B-1B-2-70GS-00-1). Engine 1 and Engine 2 are located on the left side of the aircraft, while Engine 3 and Engine 4 are located on the right side of the aircraft (T.O. 1B-1B-2-70GS-00-1). The engines are augmented, mixed-flow turbofans, with low and high-pressure sections and a variable exhaust nozzle (T.O. 1B-1B-2-70GS-00-1). The engines produce 15,000 pounds of non-augmented thrust and 30,000 pounds of augmented thrust (T.O. 1B-1B-2-70GS-00-1).

None of the engines from the MA exhibited any evidence of in-flight mechanical or thermal non-containment (Tab J-11 and J-31). In addition, there was no evidence of uncommanded, non-recoverable engine shutdown during flight (Tab J-31). The fire damage found between Engine 1 and Engine 2 is consistent with an in-flight fire, originating *external* to the engines (Tab J-31). All other engine damage is consistent with ground impact and post-impact fire (Tab J-31). The location of the fire external to Engine 1 is marked in Figure 3.

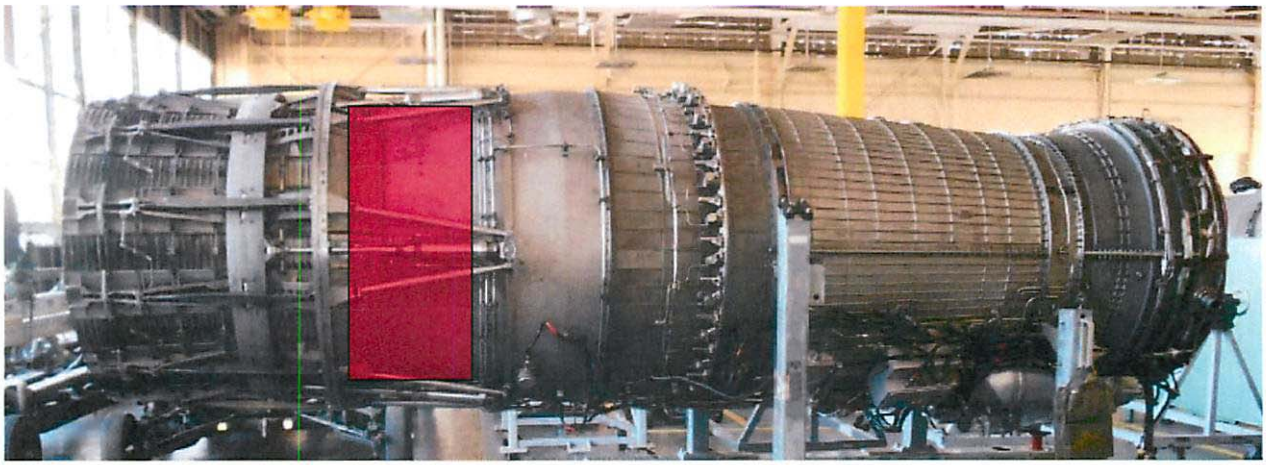


Figure 3. Location of Apparent In-flight Fire Outside of Engine 1 Highlighted in Red on Sample Engine (Tab J-32).

(3) Aircraft Fire Protection System

(a) Fire Detection

The fire detection system indicates overheat or fire conditions in any of the four engine bays, the left or right auxiliary power units, or the left or right overwing fairings (Tab J-47). The overwing fairing sensing elements will indicate a fire when the average element temperature is 350 to 450 degrees Fahrenheit (Tab J-48). The engine sensing elements will indicate a fire when the average element temperature is 1100 degrees Fahrenheit over a 4-inch section inside the engine nacelle (Tab J-48). Crewmembers are notified of a fire via fire warning lights located on the forward crew station center instrument panel (T.O. 1B-1B-2-26GS-00-1).

Shortly after the explosion in the left overwing fairing of the MA, the fire warning light illuminated in the cockpit (Tab V-2.8, V-3.7, V-3.13, and V-4.10). MP1 initiated in-flight emergency procedures IAW the T.O., while MP2 focused on flying the MA (Tab V-2.8, V-3.7, and V-4.10). A few seconds later, at 0914:33L, Engine 2 fire warning illuminated (Tabs J-67, V-1.7, V-1.12, V-3.8 to V-9, V-4.10 to V-4.11, and FF-5). The Engine 1 fire warning illuminated one second later (Tab V-1.8, V-1.12, V-3.8 to V-3.9, and V-4.10 to V-4.11).

(b) Fire Suppression

The B-1B has eight fire extinguishers—two located in each nacelle and two in each overwing fairing containing a fire suppressant agent (T.O. 1B-1B-2-26GS-00-1). All are part of an active fire protection system that provides high discharge rates through pressurization, short feed lines, and large agent container discharge valves (T.O. 1B-1B-2-26GS-00-1). When activated, 90 percent of the fire suppression agent will be discharged in less than one second (T.O. 1B-1B-2-26GS-00-1). The system is designed to operate in a closed environment by shutting fuel valves, air inlets, and exhaust doors, and then using a chemical suppressant to displace air, thereby extinguishing the fire by starving it of oxygen (T.O. 1B-1B-2-26GS-00-1).

Crewmembers arm the fire extinguishers by depressing the associated switch light on the fire warning panel in the cockpit and activate the system by movement of the agent discharge switch

(T.O. 1B-1B-2-26GS-00-1). When the fire suppression system in an overwing fairing is activated, the overwing fairing closes and the associated fuel shutoff valve shuts off, preventing the continued flow of fuel into the overwing fairing (T.O. 1B-1B-2-26GS-00-1).

Both the left nacelle and overwing fire suppression systems of the MA were found empty and damaged at Site 1 (Tab J-77). Analysis of the left overwing fire suppression system showed the main and reserve extinguishers were activated during flight (Tab J-77 to J-78). In addition, analysis of the main left nacelle fire suppression system shows it was activated during flight (Tab J-77 to J-78).

(4) Aircraft Fuel Subsystems

(a) Engine Feed

The engine feed system supplies fuel from the main fuel tanks to the engines (T.O. 1B-1B-2-28GS-00-1). Two boost pumps in each main fuel tank supply positive pressure flow to the cooling loop pump and the two engines on that tank's side of the aircraft (T.O. 1B-1B-2-28GS-00-1). The boost pumps from Tank 6—the main fuel tank—have a rate of 8,000 rotations per minute, with an output pressure of 10 pounds per square inch at 72,000 pounds per hour (T.O. 1B-1B-2-28GS-00-1). These pumps send fuel through the firewall shutoff valves into a 4.5-inch main fuel line that passes through the overwing fairing and connects to the engine feed lines (T.O. 1B-1B-2-28GS-00-1). Because fuel is pumped from the tank, a downstream fuel leak cannot be detected from inside the tank, where fuel quantity is monitored (T.O. 1B-1B-2-28GS-00-1).

The 4.5-inch main fuel line from the MA's left overwing fairing was recovered from the crash site and exhibited extensive damage (Tab J-108 to J-110). Specifically, the line had a v-shaped cut to the top half of the fuel line (Tab J-108 to J-110 and J-122). Analysis suggests the v-shaped cut resulted from impact from an external object (Tab J-109).

An analysis of fuel quantities and IDARS data determined that a fuel leak of approximately 820 pounds per minute (120 gallons) began at 0906:14L, shortly after MP2 began sweeping the wings (Tab J-67, J-78, and FF-4). The fuel leak continued at about the same rate for at least 8.5 minutes, at which time fuel quantity data became unreliable (Tab J-78).

A Suppression/Insulation/Migration (SIM) modification package was previously implemented on the B-1 B fleet (Tab J-47). It included the following: (1) an active fire suppression system in the overwing fairing cavity and bleed air precooler compartment; (2) additional fuel-resistant thermal insulation installed on the engine bleed air ducting, on the bleed air precooler and ancillary hardware, and around the suppression agent bottles and associated wiring; and (3) barriers on the top of the nacelle, which forms the floor of the overwing fairing cavity, and additional drain holes along the inboard boundary layer control walls (Tab J-47). The drain holes attempt to minimize the accumulation of spilled fuel on the top of the nacelle (Tab J-47). The barriers try to direct spilled fuel away from the precooler compartment cover to prevent leakage onto potential hot spots (Tab J-47). The SIM modifications proved ineffective in the MA due to the quantity of fuel that leaked into the left overwing fairing cavity (Tabs J-78 and J-80).

Aircraft fuel ignites at 437 degrees Fahrenheit (Tab J-80). Engine bleed air entering the precooler bay, which can be accessed through the overwing fairing, can exceed this temperature (Tab J-80). Fuel leaking from the 4.5-inch main fuel line in the left overwing fairing could leak into the precooler bay through gaps and seams in the plating above the precooler and ignite if the fuel comes into contact with the hot precooler duct (Tab J-79 to J-80). Unprotected ducting and exposed joints in the precooler bay were observed on the MA wreckage. Ignition of fuel in the precooler bay would likely result in an overpressure condition (Tab J-80).

Fire emanated from the left side of the MA (Tabs J-80, R-29, R-34 to R-35, R-37, R-39 to R-45, and V-4.11). In-flight fire damage was found on the engines, left aft nacelle, Tank 4 (aft portion of aircraft), and the left side of the horizontal stabilizer (Tabs J-74 to J-75 and Z-8 to Z-12).

(b) Fuel Tank Pressurization and Venting System

Pressure control and venting of internal fuel tanks occurs through a common vent line (T.O. 1B-1B-2-28GS-00-1). Overboard venting to accommodate for changes in altitude is controlled by the primary vent manifold in Tank 4 (T.O. 1B-1B-2-28GS-00-1). A valve controlled by engine bleed air senses tank and atmospheric pressure to maintain a safe pressure differential (T.O. 1B-1B-2-28GS-00-1). When the differential is within safe limits, the primary vent valve closes (T.O. 1B-1B-2-28GS-00-1). When pressure differential limits are exceeded, the climb and dive valves remove bleed air to the vent valve, enabling the vent valve to open and thus allowing tank pressure to return to tolerable limits (T.O. 1B-1B-2-28GS-00-1). Vent connections also provide air induction to the engine feed system and relief in the aerial refueling line (T.O. 1B-1B-2-28GS-00-1). The common manifold for Tanks 1 to 4 and Tank 6 have no valves or other obstructions connecting the tanks (Tab J-41).

The ruptured upper skin of Tank 2A, Tank 2B, and Tank 1D found at Site 5 (see Figure 4) indicate an in-flight overpressure condition in the fuel vent system (Tab J-80). Over 90 pieces of Tank 2A and Tank 2B were recovered at Site 5 (J-76). Site 5 is located just under 4.5 miles from the main impact site and approximately 12.5 miles from Site 7 where the left overwing fairing was located (Tab J-54). There was no evidence of ground fire at Site 5, and all of the recovered pieces were relatively clean, lacking any evidence of being involved in a typical hydrocarbon-fed in-flight fire (Tab J-56).

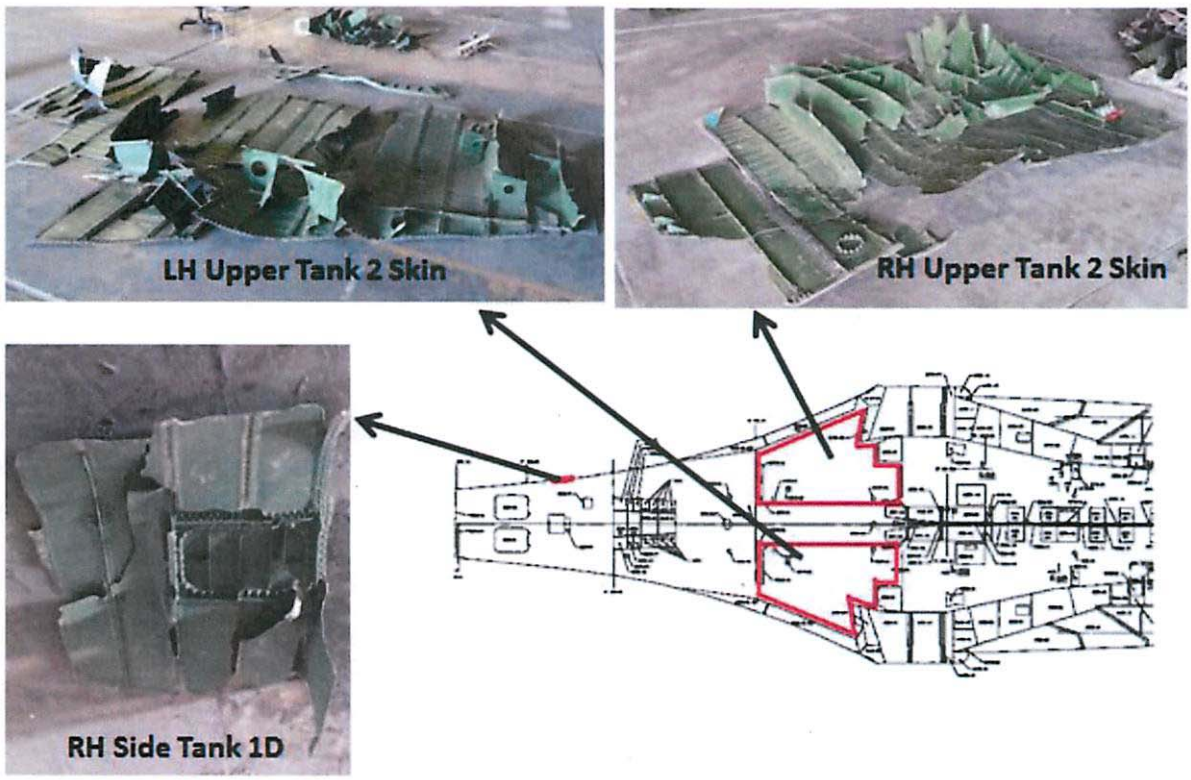


Figure 4. Debris from Tops of Tank 2A and Tank 2B (Tab J-57).

The MC heard a second explosion immediately prior to loss of electrical power, and approximately 1.5 minutes after the first explosion (Tab V-1.8 to V-1.9, V-2.7, V-3.9, V-3.13, and V-4.11). Given the type and condition of debris located at Site 5 and the distance between debris from Site 7 and Site 5, this second explosion was likely from an overpressure condition in Tank 1D, Tank 2A, and Tank 2B (Tab J-80).

(5) Electrical Power Supply Systems

The main electrical power supply comes from three primary alternating current (AC) generators (Generator 1, Generator 2, and Generator 4) (T.O. 1B-1B-2-24GS-00-1). The B-1B has one emergency generator. Under normal conditions, all three primary generators are online (T.O. 1B-1B-2-24GS-00-1). The emergency generator provides a backup source of power for the aircraft (T.O. 1B-1B-2-24GS-00-1). The electrical cables for distributing power to the crew compartment run along the tops of the fuel tanks (T.O. 1B-1B-1 and T.O. 1B-1B-2-24GS-00-1).

The three primary generators convert variable input power from the associated aircraft engine through an accessory drive gearbox (T.O. 1B-1B-2-24GS-00-1). During normal operation, each generator supplies 230 volts/115 kilovolt amperage (KVA) alternating current; the outputs are paralleled and synchronized to supply power to the five distribution buses (T.O. 1B-1B-2-24GS-00-1). Thus, when an engine is shutdown, the associated generator goes offline (T.O. 1B-1B-2-24GS-00-1). The emergency generator is hydraulically driven with an output of 15 KVA (T.O. 1B-1B-2-24GS-00-1).

For a detailed schematic of the electrical system, see Diagram 2.

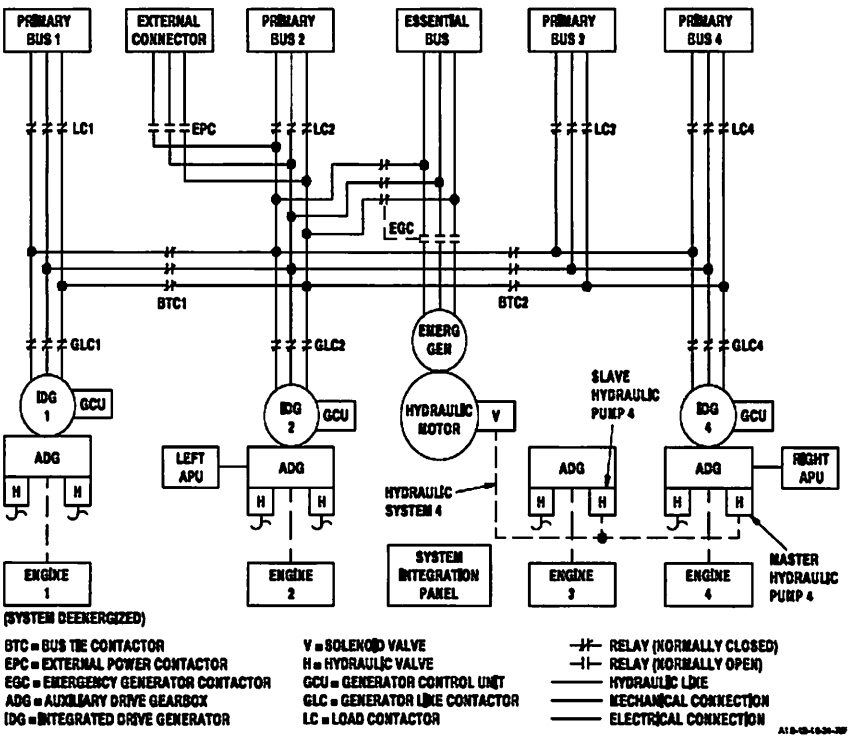


Diagram 2. AC Power Generation (T.O. 1B-1B-1).

After MP1 initiated procedures to address the fires in the left overwing fairing, Engine 1, and Engine 2, the number one and number two AC generators were rendered inoperative, leaving the MA to rely on the number four and emergency AC generators (Tabs J-67, V-3.8, V-3.12, and V-3.18; T.O. 1B-1B-1 and T.O. 1B-1B-2-24GS-00-1). The rupturing of the MA's fuel tanks resulted in the severing of the electrical cables running through the tops of the fuel tanks, causing a complete and permanent loss of electrical power in the crew compartment (Tabs V-1.8 to V-1.9, V-2.7, V-3.9, V-3.13, V-4.11, and FF-7; T.O. 1B-1B-2-24GS-00-1). The loss of electrical power degraded MP2's ability to control the MA (Tabs V-2.9, V-3.8 to V-3.9, and FF-3; T.O. 1B-1B-1 and T.O. 1B-1B-2-24GS-00-1).

(6) Integrated Data Acquisition Recorder System

IDARS is a compact, solid-state recording system used for collecting, processing, and storing a variety of flight data on the aircraft, including inputs from strain gages, accelerometers, flight control surface position conditioning units, and the central integrated test system. The data provides a time-history file stored in the IDARS until processed for analysis (Tab J-78).

The MA's IDARS data started at 00:00:08.906 and ends at 01:30:25.906 (Tab J-66). Overwing fairing fires are not recorded by IDARS (Tab J-78). Table 2 below is a summary of the information obtained from IDARS (Tab J-66 to J-67).

IDARS Time	Comments
01:10:50.906	Takeoff
01:11:48.906	Wings positioned forward (25 degrees)
01:20:07.906	Throttle back for descent
01:20:09.906	Begin wing sweep aft to 67.5 degrees
01:20:48.906	Wings full aft (greater than 65 degrees)
01:21:02.906	Military Power
01:25:53.906	Begin descent to low level
01:27:14.906	Arrived at low level (approximately 1,000 feet AGL)
01:28:42.906	Full afterburner on all four engines
01:28:51.906	Uncommanded left hand bank
01:28:55.906	Engines drop to intermediate power level
01:28:57.906	Begin climb
01:28:58.906	Engine 2 fire
01:28:59.906	Engine 1 and Engine 2 fire lights illuminate
01:29:10.906	Engine 3 and Engine 4 to maximum augmented thrust
01:29:29.906	Generator 2 offline
01:29:30.906	Fuel data becomes erratic
01:29:35.906	Engine 1 oil pressure low
01:29:40.906	Left hand turn to Ellsworth AFB, right wing begins sweeping forward
01:29:41.906	Generator 1 and Generator 2 offline
01:29:43.906	Hydraulic 2 low pressure
01:29:45.906	Engine 1 oil pressure low, Hydraulic 1 low pressure
01:29:47.906	Engine 2 oil pressure low
01:29:48.031	Lost wing sweep strain gauge (went invalid)
01:30:11.906	Right wing holds for a few seconds at 45 degrees
01:30:20.906	Right wing starts sweeping forward again
01:30:25.906	Last data recorded

Table 2. IDARS Information Summary (Tab J-66 to J-67).

b. Evaluation and Analysis

(1) Engine Investigation Report

All four engines were recovered from the crash site and sent for analysis at the Air Force Life Cycle Management Center at Tinker AFB, Oklahoma (Tab J-5 to J-30). Analysis results for each engine is as follows:

Engine 1. Engine 1 was operating at sub-idle speed at impact. Fire damage to Engine 1 indicated in-flight fire originating outside of the engine. All other damage to Engine 1 was

consistent with high-speed impact. The analysis revealed no in-flight mechanical problems (Tab J-5 to J-11).

Engine 2. Analysis revealed Engine 2 was operating at sub-idle speed at impact. Similar to Engine 1, fire damage to Engine 2 indicated in-flight fire originating outside of the engine. All other damage was consistent with high-speed impact. No evidence of in-flight mechanical problems was found (Tab J-11 to J-17).

Engine 3. Engine 3 was operating at idle to high-idle speed at impact. There was no indication of in-flight fire in or around Engine 3. The damage to Engine 3 is consistent with high-speed impact. The analysis revealed no in-flight mechanical problems (Tab J-17 to J-21).

Engine 4. Analysis showed Engine 4 operated near the intermediate power setting at impact. Similar to Engine 3, there was no sign of in-flight fire damage in or around Engine 4. The damage to Engine 4 was consistent with high-speed impact, and analysis did not reveal any in-flight mechanical issues (Tab J-21 to J-30).

Although the Engine 1 and Engine 2 warning lights came on during flight, analysis of the engines revealed that the fire was external to the engines and not a result of engine failure (Tabs J-31, J-67, V-1.7 to V-1.8, V-1.12, V-3.8 to V-3.9, and V-4.10 to V-4.11).

(2) Overwing Fairing Attachment Fractures Report

The left aft overwing fairing was recovered at Site 7, which was located 17 miles north of the main impact site (Tab J-54 to J-55). Analysis of the overwing fairing by the Air Force Research Laboratory at Wright-Patterson AFB, OH, revealed evidence of overload. However, the analysis failed to reveal any pre-existing defects (e.g., fatigue, corrosion) that would have compromised its ability to function properly (Tab J-86). It showed no signs of being involved in a fire, inflight or ground (Tab J-77).

At approximately 0914L, the MA experienced an initial explosion followed by an uncommanded left bank (Tabs J-67 to J-68, V-1.7, V-2.9, V-3.6 to V-3.7, V-3.13, V-4.7, and FF-5). Shortly after the explosion, the left overwing fairing fire light illuminated (Tab V-2.8, V-3.7 to V-3.8, V-3.13, and V-4.10). The uncommanded left bank likely resulted from the detonation of leaked fuel in the precooler bay, causing an overpressure condition that separated the left aft overwing fairing components (Tab J-79 to J-80). The combination of the over pressurization force and the wind stream caused the overwing fairing to detach from the aircraft (Tab J-79).

(3) Flexible Fuel Line Examination Report

The 2-inch fuel cooling loop line and 4.5-inch main fuel line (see Diagram 3) from the left wing root bay were submitted to the Air Force Research Laboratory at Wright-Patterson AFB, OH, for analysis (Tab J-107). The 2-inch fuel cooling loop line showed evidence of line collapse due to thermal exposure (Tab J-107 to J-108, J-113, and J-115). The 4.5-inch main fuel line showed multiple fractures and melting of the inner layers of the line, likely due to thermal exposure (Tab J-108 to J-109). In addition, the 4.5-inch main fuel line had a v-shaped cut (see Photograph 2) through the exterior braiding and into the inner layers of the line (Tab J-109).

This type of damage suggests the 4.5-inch main fuel line had been cut by impact with an external object (Tab J-109).

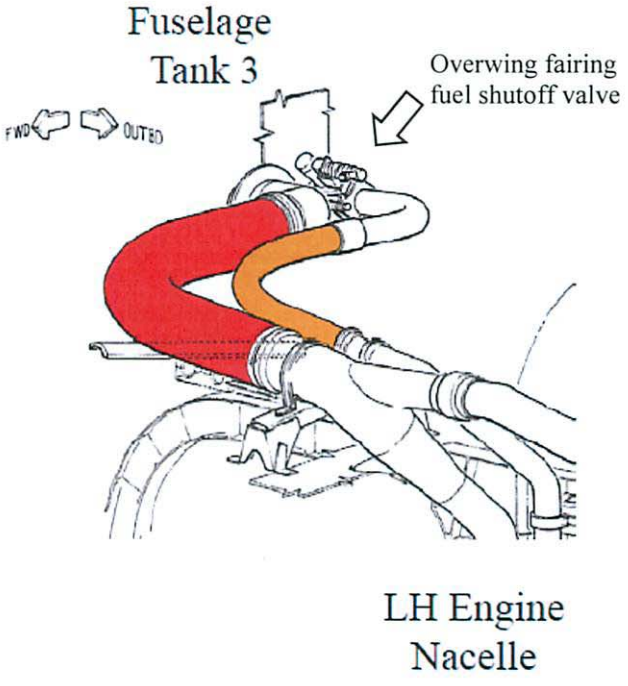
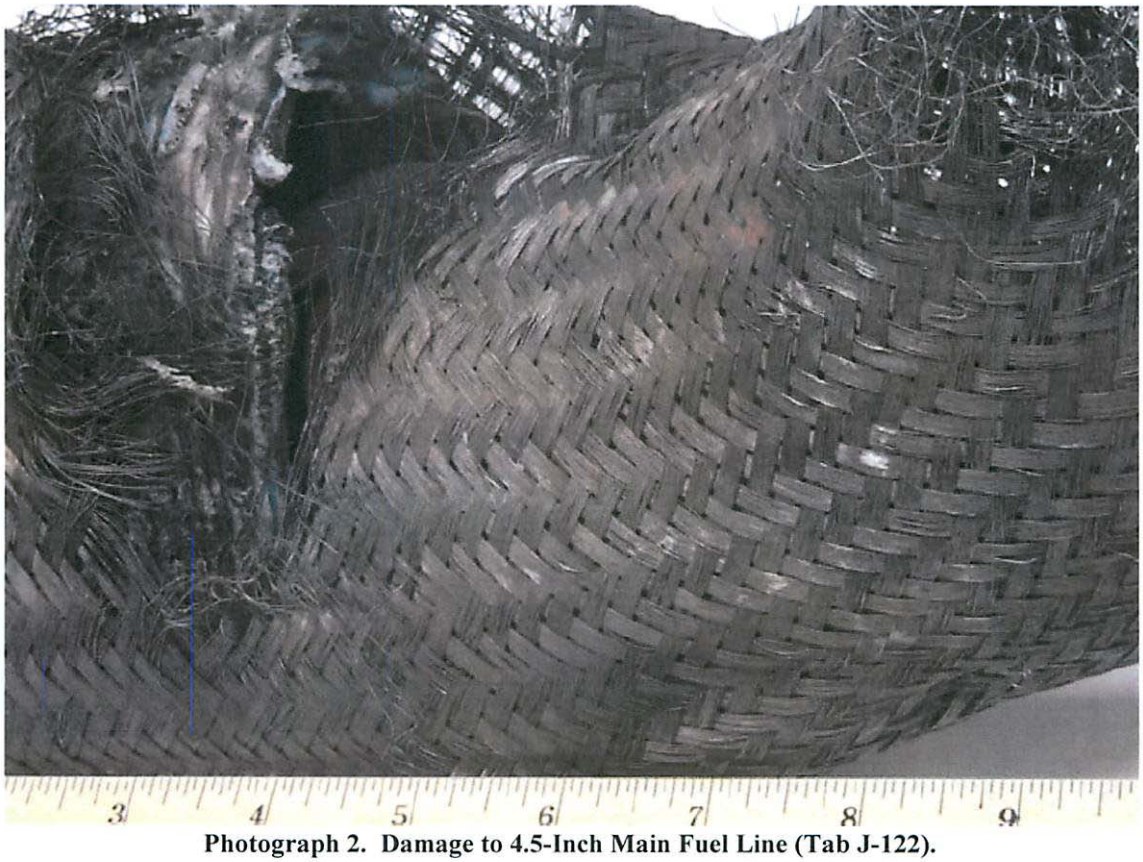


Diagram 3. Two-Inch Fuel Cooling Loop Line (Orange) and 4.5-Inch Main Fuel Line (Red) (Tab J-113).



Photograph 2. Damage to 4.5-Inch Main Fuel Line (Tab J-122).

7. WEATHER

a. Forecast Weather

On the day of the mishap, the forecasted weather for takeoff of the MA at Ellsworth AFB, SD, was clear skies, unlimited visibility, and winds variable at five knots (Tab F-3 to F-4). The forecast surface temperature was 73 degrees Fahrenheit, with a freezing level at 13,000 feet AGL (Tab F-3). The altimeter setting was 29.96 inches of mercury and pressure altitude was 3,239 feet MSL (Tab F-3).

The forecasted weather for the Powder River MOA for the date and time of the mishap was clear skies, unlimited visibility, and surface winds 160 degrees at seven knots (Tab F-3 and F-4). The freezing level was 15,000 feet MSL (Tab F-3 and F-4).

b. Observed Weather

Observed weather at the mishap location at the time of the mishap was clear skies, unrestricted visibility, surface winds 160 degrees at seven knots, and freezing level at 15,000 feet MSL (Tab F-5 and F-6). The MC did not report any weather conditions prior to the mishap.

c. Operations

The mission complied with weather requirements (AFI 11-202, Volume 3, *General Flight Rules*, dated 22 October 2010, ACC Supplement, 28 November 2012, paragraph 8.11 and Table 7.1; AFI 11-214, *Air Operations Rules and Procedures*, dated 14 August 2012, paragraph 4.2.7.2; and AFI 11-2B-1, Volume 3, *Flying Operations: B-1 Operations Procedures,* 7 January 2011, paragraph 7.10.2).

There was no evidence that weather contributed to the mishap.

8. CREW QUALIFICATIONS

a. Mishap Pilot 1

MP1 was a fully qualified B-1B Instructor Pilot (IP) and United States Air Force (USAF) Weapons School graduate (Tab G-105). MP1 was also an experienced flight lead in the B-1B (Tab G-103). With the exception of instrument approach, day and night air refueling, night landing, and terrain following at night or in instrument meteorological conditions, MP1 was current in all flight areas, IAW AFI 11-2B-1, Volume 1, *Flying Operations: B-1 Aircrew Training*, 23 December 2011, Table 4.1 (Tabs K-4 to K-5 and FF-3). MP1 completed his most recent instrument and mission qualification checkride in the B-1B on 29 March 12 (Tab G-63). MP1 completed graduation from the Air Force Weapons Instructor Course with outstanding performance on 1 June 2013 (Tab G-105). MP1 had 1,782.4 total flight hours and 1,567 B-1B flight hours (Tab G-4).

At the time of the mishap, MP1's recent flight times were as follows (Tab G-5):

	Hours	Sorties
Last 30 Days	0.0	0
Last 60 Days	4.2	2
Last 90 Days	4.2	2

Table 3. MP1's Flight Times (Tab G-5).

b. Mishap Pilot 2

MP2 was a qualified IP who was an experienced flight lead in the B-1B (Tab G-103). With the exception of unguided bomb hit and visual contour, MP2 was current in all flight areas, IAW AFI 11-2B-1, Volume 1, Table 4.1 (Tabs K-4 and FF-3). MP2 completed his most recent instrument and mission qualification checkride in the B-1B on 30 July 2012 (Tab G-72, G-75 and G-76). MP2 had 2,254.9 total flight hours and 2,013.1 B-1B flight hours (Tab G-20).

At the time of the mishap, MP2's recent flight times were as follows (Tab G-21):

	Hours	Sorties
Last 30 Days	24.2	2
Last 60 Days	97.5	9
Last 90 Days	186.7	16

Table 4. MP2's Flight Times (Tab G-21).

c. Mishap Crewmember 1

MC1 was a qualified Instructor Weapons System Officer (WSO) and USAF Weapons School graduate who was an experienced Multi-Ship Mission Lead in the B-1B (Tab G-104 and G-107). MC1 was current in all flight areas, IAW AFI 11-2B-1, Volume 1, Table 4.1 (Tabs K-5 and FF-3). MC1 completed his most recent mission qualification checkride in the B-1B on 9 August 2012 (Tab G-83 to G-85). MC2 had 1,872.3 total flight hours and 1,696.6 B-1B flight hours (Tab G-34).

At the time of the mishap, MC1's recent flight times were as follows (Tab G-35):

	Hours	Sorties
Last 30 Days	18.5	6
Last 60 Days	18.5	6
Last 90 Days	18.5	6

Table 5. MC1's Flight Times (Tab G-35).

d. Mishap Crewmember 2

MC2 was a qualified Instructor WSO who was an experienced Single-Ship Mission Lead (SML) in the B-1B (Tab G-104). With the exception of unguided bomb hit and Terrain Following, MC2

was current in all flight areas, IAW AFI 11-2B-1, Volume 1, Table 4.1 (Tabs T-5 and FF-3). MC2 completed his most recent qualification checkride in the B-1B on 22 October 2012 and mission qualification on 31 May 2013 (Tab G-92 to G-93 and G-96 to G-97). MC2 had 1,828.2 total flight hours and 1,651.6 B-1B flight hours (Tab G-49).

At the time of the mishap, MC2's recent flight times were as follows (Tab G-50):

	Hours	Sorties
Last 30 Days	25.6	2
Last 60 Days	97.8	8
Last 90 Days	221.6	19

Table 6. MC2's Flight Times (Tab G-50).

There was no evidence that insufficient crew qualifications contributed to the mishap.

9. MEDICAL

a. Qualifications

MP1, MP2, MC1, and MC2 were medically qualified for flight duty without restrictions at the time of the mishap. All mishap crewmembers had current annual flight physical examinations (Tab X-3 to X-5).

b. Health

All members of the MC were in good health and had no performance-limiting conditions or illnesses prior to the mishap (Tabs V-1.3, V-1.13, V-2.3, V-3.3, V-4.2 to V-4.3, and X-3 to X-5). The MC sustained injuries consistent with the mishap and were treated at local emergency rooms (Tabs V-1.9, V-2.10, V-3.15 to V-3.16, V-4.14 to V-4.15, and X-3 to X-5).

c. Toxicology

Toxicology tests were conducted on the MC and maintenance members following the mishap. The relevant results were within the Department of Defense limits or consistent with post-mishap treatment (Tab X-3 to X-5).

d. Lifestyle

No lifestyle factors were found to be relevant to the mishap.

e. Crew Rest and Crew Duty Time

Air Force crewmembers must have proper crew rest, as defined in AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010, ACC Supplement, 9 March 2012, prior to performing in-flight duties. Crew rest is defined in paragraph 9.4.5 and 9.8 as a minimum 12-hour non-duty period before the flight duty period (FDP) begins. Its purpose is to ensure crewmembers are

adequately rested before flight or performing flight related duties (paragraph 9.4.5 and 9.8). During this time, a crewmember may participate in meals, transportation, or rest, as long as he or she has the opportunity for at least eight hours of uninterrupted sleep (paragraph 9.4.5 and 9.8). MP1, MP2, MC1, and MC2 had adequate crew rest prior to the mishap (Tabs R-2 to R-11, V-1.3, V-2.3, V-3.3, V-4.3, and X-3 to X-5).

There was no evidence that medical issues contributed to the mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

The 34 BS has a total of 41 assigned and attached pilots, 24 of whom are experienced (Tab G-103 and G-104). To be considered "experienced," B-1B pilots must meet an AFI mandated level of 1,500 total flight hours and 300 B-1B hours, 1,250 total flight hours and 500 B-1B hours, or 1,000 total flight hours and 750 B-1B hours (AFI 11-2B-1, Volume 1, Table 1.1). The 34 BS has thirty seven WSOs, 24 of whom are experienced (Tab G-103 and G-104). To be considered "experienced," B-1B WSOs must have 1,300 total flight hours and 200 B-1B hours, 1,000 total flight hours and 300 B-1B hours, or 750 total flight hours and 500 B-1B hours (AFI 11-2B-1, Volume 1, Table 1.1). Eighteen of the 41 pilots are qualified as instructors, and 21 of the 37 WSOs are instructors (Tab G-103 and G-104). The 34 BS recently returned from a deployment and had initiated post-deployment reconstitution training (Tab EE-3).

The Operational Risk Management (ORM) level of the mission was eight (Tab EE-5). ORM is a decision-making process to systematically evaluate possible courses of action, identify risks and benefits, and determine the best course of action for any given situation (Air Force Pamphlet 90-803, *Risk Management Guidelines and Tools: Special Management*, 11 February 2013, paragraph 1.1). A score of eight is in the lowest risk category and places the authority to continue the mission with the aircraft commander or flight lead (Tab EE-5 and EE-7). Specific items considered in the ORM assessment included: (1) non-current crewmembers, (2) days since last low altitude flown, (3) days since last flight, (4) mission profile type, (5) defensive maneuvering, and (6) bird condition (Tab EE-5). The operations supervisor on duty was experienced and qualified, IAW the 34 BS Letter of Certification (Tab G-103).

The operations tempo at the time of the mishap was low (Tab G-21, G-35, and G-50).

b. Supervision

The 34 BS Director of Operations reviewed and authorized the mission on the day of the mishap (Tab K-13). In addition, the Commander and Director of Operations for 34 BS attended the mission brief on 16 August 2013 because the mishap mission was the first squadron flight since returning from deployment (TabV-1.4 to V-1.6, V-2.4, V-3.4 to V3.5, and V-4.3). Squadron supervision briefed the MC immediately prior to the MC's departure to the MA on 19 August 2013 (Tabs V-1.5 to V-1.6, V-2.4, V-4.4, and EE-21 to EE-29).

There was no evidence that squadron operations or supervision contributed to the mishap.

11. HUMAN FACTORS

There was no evidence that human factors contributed to the mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 11-2B-1 Volume 1, *Flying Operations: B-1 Aircrew Training*, 23 December 2011

(2) AFI 11-2B-1, Volume 3, *Flying Operations: B-1 Operations Procedures,* 7 January 2011

(3) AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010, Air Combat Command Supplement, 9 March 2012

(4) AFI 11-214, *Air Operations Rules and Procedures*, 14 August 2012

(5) AFI 21-101, *Aircraft and Equipment Maintenance Management*, 26 July 2010, incorporating Change 1, 16 August 2011, including Air Force Guidance Memorandum 4, 19 April 2013

(6) AFI 36-2232, *Maintenance Training*, 22 February 2006

(7) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010, Incorporating Change 1, 21 June 2010

(8) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010, Air Combat Command Supplement, 5 September 2013

(9) Air Force Pamphlet 90-803, *Risk Management Guidelines and Tools: Special Management*, 11 February 2013

(10) T.O. 00-5-15, *Air Force Time Compliance Technical Order Process*

(11) T.O. 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*

NOTICE: All directives and publications listed above are available digitally on the Air Force Departmental Publishing Office website at http://www.e-publishing.af.mil.

b. Other Directives and Publications Relevant to the Mishap

The following T.O.s are not publically available and are subject to the Arms Export Control Act of 1976.

(1) T.O. 1B-1B-1, *USAF Series B-1 Aircraft*

(2) T.O. 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*

(3) T.O. 00-5-1, *AF Technical Order System*

(4) T.O. 1B-1B-2-24GS-00-1 and T.O. 1B-1B-2-24GS-00-2, *Electrical Power*

(5) T.O. 1B-1B-2-26GS-00-1, *Fire Protection*

(6) T.O. 1B-1B-2-27GS-00-1, *Flight Controls*

(7) T.O. 1B-1B-2-28GS-00-1, *Fuel*

(8) T.O. 1B-1B-2-53GS-00-1, *Fuselage*

(9) T.O. 1B-1B-2-54GS-00-1, *Nacelles/Pylons*

(10) T.O. 1B-1B-2-70GS-00-1, *Propulsion*

(11) T.O. 1B-1B-6, *Scheduled Inspection and Maintenance Requirements*

c. Known or Suspected Deviations from Directives or Publications

There were no known or suspected deviations from directives or publications.

13. ADDITIONAL AREAS OF CONCERN

There were no additional areas of concern.

22 November 2013

BRIAN A. HUMPHREY, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

B-1B, Tail Number 85-0091
Broadus, Montana
19 August 2013

Under 10 U.S.C. § 2254(d) the opinion of the accident investigator as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, 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

I find by clear and convincing evidence that a displaced fold down baffle in the left overwing fairing caused the mishap. The underwing fairing fold down baffle became detached for an unknown reason at one or more points sometime prior to the initiation of an aft wing sweep. During the sweep, the wing pushed the detached fold down baffle into the 4.5-inch main fuel line, resulting in a v-shaped cut to the top half of the fuel line. The leaking fuel ignited and caused multiple catastrophic detonations throughout the aircraft.

I developed my opinion by analyzing factual data from Air Force directives and guidance, engineering technical analysis, witness testimony, flight data, flight simulations, animated simulations, technical analysis of post-crash aircraft components, and information provided by subject matter experts.

2. BACKGROUND

On 19 August 2013 at 0856:50L hours the mishap aircraft (MA), a B-1B,Tail Number 85-0091, assigned to the 34th Bomb Squadron, 28th Bomb Wing, Ellsworth Air Force Base (AFB), and containing four crewmembers, departed Ellsworth AFB on a training mission.

Following takeoff, Mishap Pilot 2 (MP2) leveled off at an initial altitude of 20,000 feet (Flight Level 200), and the mishap crew (MC) performed a level off check to ensure normal aircraft system performance. At 0905:42L, MP2 initiated a descent to 10,000 feet Mean Sea Level and swept the wings from the forward to the aft position. During this wing sweep, the MA developed a fuel leak in the 4.5-inch main fuel line found in the left overwing fairing cavity. Due to the location of the fuel leak and the duration of the sortie, the MC could not detect the fuel leak. Approximately 7,000 pounds (1,000 gallons) of fuel leaked into the overwing fairing while the MC continued their training mission.

At 0914:26L, the leaking fuel migrated through seams in the precooler bay access panels and detonated following contact with exposed portions of a hot precooler duct. The MC perceived the detonation as a loud noise from the left hand side of the MA. The detonation caused an uncommanded left bank of approximately 15 degrees. The left overwing fire light illuminated in

the cockpit. Ignited fuel streamed down the left side of the MA, extending one to two times the length and four times the width of the MA.

MP2 pulled the throttles back to an intermediate power setting, and Mishap Pilot 1 (MP1) activated the main left overwing fairing fire suppression system. The left overwing fire light remained illuminated. Thirty seconds after the first attempt to extinguish the fire, MP1 activated the reserve fire suppression system. MP1's efforts to extinguish the fire failed for two reasons: (1) the fire suppression agent was no longer being discharged into a closed system (the high velocity airflow entering the exposed overwing fairing prevented the fire suppression chemicals from being effective), and (2) the fire had extended beyond the reach of the fire suppression system, trailing down the side of the MA.

Two engine fire lights also illuminated in the cockpit. However, the fire lights were not the result of engine fire but, instead, were activated in response to the intense heat generated by ignited fuel streaming near the engines. Following MP1's attempts to extinguish the apparent fire in Engine 1, the fire light went out for unknown reasons. The Engine 2 fire light remained illuminated.

The ignited fuel streaming down the left side of the MA heated fuel Tank 4, located in the aft portion of the MA, to a temperature that exceeded 437 degrees Fahrenheit, the temperature at which jet fuel will automatically ignite. As MP2 began a climbing left turn to execute an emergency return to Ellsworth AFB, the fuel tank detonated, resulting in an overpressure condition that propagated through the MA fuel venting system. This initiated a cascade of catastrophic detonations in additional MA fuel tanks. The explosions severed the electrical cables, cut power to the crew compartment and severely degraded MP2's ability to control the MA. With no options left to remedy the situation, and with marginal control over the MA, MP1 ordered the crew to eject.

The forward fuselage separated from the MA due to compromised structural integrity resulting from the multiple fuel tank explosions. The forward fuselage came to rest embedded in a ravine wall approximately 0.5 miles from the aft portion of the fuselage. The aft fuselage impacted 24 miles east of Broadus, Montana.

3. CAUSE

The wings of the B-1B move from a forward position to an aft position to increase the aircraft's performance at different speeds. During a wing sweep, the only moving parts in the overwing fairing cavity are the wing and the fold down baffle. The wing normally sweeps clear of the fuel lines located in the overwing fairing cavity, and I found no evidence to suggest that the wing of the MA came in contact with the fuel line. The fold down baffle helps provide a smooth surface for air to pass over the wing. During an aft wing sweep, the fold down baffle folds flat, allowing the wing to sweep over the top.

At some time prior to MP2's initiation of the wing sweep, the left fold down baffle became detached at one or more points, preventing it from folding as the wing swept aft. Because the fold down baffle was detached, the wing pushed the fold down baffle into the overwing fairing

cavity where the tapered edge of the fold down baffle cut a v-shaped hole in the 4.5-inch main fuel line.

I considered whether the left underwing fold down baffle may have detached due to the failure of the forward mandrel spring assembly, as a possible substantially contributing factor but could not so conclude. The fold down baffle attaches to the underwing fairing at four points. Mandrel spring assemblies (forward and aft) form two of the attachment points, providing the pressure necessary to push the fold down baffle into place as the wings sweep. A forward and an aft mandrel spring assembly recovered at the crash site are consistent in form and fit with those found in the left overwing fairing cavity. Both assemblies showed evidence of structural overload, along with significant damage from exposure to fire. Of note, the forward mandrel spring assembly was missing the spring component, the interior tube was gouged and crushed, and the sheared forward mounting plate was co-mingled with a mass of melted aluminum. Thus, the cause and timing of the detachment of the left fold down baffle remains unknown.

Despite minor documentation irregularities, I found no evidence that maintenance personnel, practices, or procedures substantially contributed to the mishap. My review of the MA's maintenance records showed that all inspections of the MA were completed in accordance with technical orders. My interviews with maintenance members who worked on the MA immediately prior to takeoff on 19 August 2013 and during the last major inspection on 19 March 2013 did not reveal any issues related to the cause of the mishap.

In addition, I found no evidence that the MC caused, could have prevented, or substantially contributed to the loss of the MA. My interviews of the MC and review of information from the Integrated Data Acquisition Recorder System showed that the MC responded appropriately to the known conditions on the MA.

4. CONCLUSION

I find by clear and convincing evidence that a displaced fold down baffle in the left overwing fairing cavity caused the mishap.

22 November 2013

BRIAN A. HUMPHREY, Colonel, USAF
President, Accident Investigation Board

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