UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

E-4B, T/N 73-1676

55th WING
OFFUTT AIR FORCE BASE, NEBRASKA

LOCATION: OFFUTT AIR FORCE BASE, NEBRASKA

DATE OF ACCIDENT: 12 MAY 2010

BOARD PRESIDENT: COLONEL SCOTT A. FOREST

Conducted IAW Air Force Instruction 51-503 (26 May 2010)

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION BOARD (AIB)

E-4B, T/N 73-1676
OFFUTT AIR FORCE BASE, NEBRASKA
12 MAY 2010

On 12 May 2010, at approximately 2310 local time, an E-4B aircraft, tail number (T/N) 73-1676, struck its tail approximately 1,300 feet past the threshold of runway 30 at Offutt Air Force Base (AFB), Nebraska (NE), after completing a National Airborne Operations Center (NAOC) Alert weather avoidance mission. No injuries or lost work were incurred by the Mishap Crew (MC). The mishap aircraft (MA) is based at Offutt AFB, NE, and assigned to the 1st Airborne Command and Control Squadron of the 55th Operations Group, 55th Wing, to provide the President and Secretary of Defense with a survivable command center for directing United States forces during all conditions of peace and war, and for supporting the federal government during military, national, and natural emergencies. The MA was damaged on the underbody of the tail section upon impact, and the mishap caused no damage to the runway. Damage was estimated at $3.1 million.

Two hours and 32 minutes after takeoff, Mishap Pilot 1 (MP1) flew an uneventful, stable, on speed precision approach to short final. Digital flight data recorder (DFDR) information and testimony reveal that on short final, MP1 flew a slightly low glide path with a higher than normal descent rate. MP1 applied a large pitch-up control movement to the yoke at approximately 30 feet above touchdown, culminating in a firm touchdown at a 9-degree pitch angle and a subsequent bounce. During the bounce, MP1 applied back pressure to the yoke, increasing the aircraft pitch angle to 11 degrees as the aircraft settled back to the runway about 800 feet past the first touchdown point, resulting in the tail of the aircraft impacting the runway 2-3 feet right of the centerline, approximately 1,300 feet past the threshold. MP1 and the MC brought the MA to a stop on the runway, ensured the MA was safe for taxiing, and exited the runway uneventfully.

The Aircraft Investigation Board (AIB) president found by clear and convincing evidence the cause of the mishap was pilot error by MP1 and Mishap Pilot 2 (MP2). During the bounce, MP1 increased the pitch angle of the MA to more than twice the pitch angle specified by the flight manual for landing, resulting in the tail striking the runway nearly simultaneously to the landing gear. As the Aircraft Commander for the sortie, MP2 did not ensure the safe and effective conduct of the flight, giving no input to MP1 during the landing, bounce, and second touchdown. Additionally, the AIB president found as contributing factors that the E-4B flight manual and training programs did not state, discuss, or address any risk of tail strikes during landings or bounce recovery and that the manufacturer did not provide the Air Force information concerning risks of tail strikes for 747 aircraft during landing or bounce recovery. Weather, crew rest, fatigue, personal, professional, mission, or flight distracters, navigational aids and lighting systems, maintenance, and the MA were not factors.

TABLE OF CONTENTS

TABLE OF CONTENTS ii
COMMONLY USED ACRONYMS AND ABBREVIATIONS iv
SUMMARY OF FACTS 1
1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES 1
a. Authority 1
b. Purpose 1
c. Circumstances 1
2. ACCIDENT SUMMARY 1
3. BACKGROUND 2
a. 55th Wing 2
b. 55th Operations Group 2
c. 1st Airborne Command Control Squadron 2
d. E-4B 2
4. SEQUENCE OF EVENTS 3
a. Mission 3
b. Planning 3
c. Preflight 3
d. Summary of Accident 3
e. Impact 6
f. Life Support Equipment, Egress and Survival 6
g. Search and Rescue (SAR) 7
h. Recovery of Remains 7
5. MAINTENANCE 7
a. Forms Documentation 7
b. Inspections 7
c. Maintenance Procedures 8
d. Maintenance Personnel and Supervision 8
e. Fuel, Hydraulic and Oil Inspection Analysis 9
f. Unscheduled Maintenance 9
6. AIRCRAFT AND AIRFRAME 9
a. Condition of Systems 9
b. Testing 10
7. WEATHER 10
a. Forecast Weather 10
b. Observed Weather 10
c. Space Environment 10
d. Conclusion 10
8. CREW QUALIFICATIONS 10
a. Training 10
b. Experience 11
9. MEDICAL 11
a. Qualifications 11
b. Health 11
c. Toxicology 11

d. Lifestyle 12
e. Crew Rest and Crew Duty Time 12
10. OPERATIONS AND SUPERVISION 12
a. Operations 12
b. Supervision 12
11. HUMAN FACTORS 13
a. Mission 13
12. GOVERNING DIRECTIVES AND PUBLICATIONS ..... 17~~16~~
a. Primary Operations Directives and Publications ..... 17~~16~~
b. Maintenance Directives and Publications 17
c. Known or Suspected Deviations from Directives or Publications 17
13. NEWS MEDIA INVOLVEMENT ..... 18~~17~~
14. ADDITIONAL AREAS OF CONCERN ..... 18~~17~~
STATEMENT OF OPINION ..... 19~~18~~
1. OPINION SUMMARY ..... 19~~18~~
2. DISCUSSION OF OPINION ..... 19~~18~~
a. Cause ..... 19~~18~~
b. Contributing Factors ..... 21~~20~~
INDEX OF TABS ..... 23~~22~~3

COMMONLY USED ACRONYMS AND ABBREVIATIONS

°	Degree
§	Section
1 ACCS	1st Airborne Command Control Squadron
1 AMU	1st Aircraft Maintenance Unit
12 AF	12th Air Force
55 OG	55th Operations Group
55 WG	55th Wing
623	Air Force Form 623, On-the-Job-Training Record
797	Air Force Form 797, Job Qualification Standard Continuation
AB	Air Base
ACC	Air Combat Command
ADI	Attitude Director Indicator
AEF	Air Expeditionary Force
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFIP	Air Force Institute of Pathology
AFPAM	Air Force Pamphlet
AFSC	Air Force Specialty Code
AFTO	Air Force Technical Order
AFTTP	Air Force Tactics, Techniques and Procedures
AGL	Above Ground Level
AIB	Aircraft Investigation Board
AMU	Aircraft Maintenance Unit
AMXS	Aircraft Maintenance Squadron
API	Aviation Preflight Indoctrination
AR	Air Refueling
ATC	Air Traffic Controller
AUX	Auxiliary
BS	Body Station
C	Celsius
C3	Command, Control, and Communication
CAMS	Computer Automated Maintenance System
Capt	Captain
CCOC	Command Center Operations Chief
CDC	Career Development Course
CDO	Consolidated Daily Operations
CG	Center of Gravity
CMSgt	Chief Master Sergeant
Col	Colonel
COMMS	Communications
CSAR	Combat Search and Rescue
Dash-1	A.F.T.O. E-4B Flight Manual
DFDR	Digital Flight Data Recorder
DG	Distinguished Graduate
DH	Decision Height
DO	Director of Operations
DSN	Defense Switch Network
DTS	Data Transfer System
EOR	End of Runway
EP	Emergency Procedures
EPE	Emergency Procedures Evaluation
EX	Exercise
FAR	Federal Aviation Regulation
FDP	Flight Duty Period
FEF	Flight Evaluation Folders
FLUG	Flight Lead Upgrade
FMC	Fully Mission Capable
FOD	Foreign Object Damage
G	Force of Gravity
HFACS	Human Factors Analysis and Classification System
HPO	Hourly Post Check
HPT	High Pressure Turbine
HSI	Horizontal Situation Indicator
HSC	Home Station Check
HUD	Heads up Display
IAW	In Accordance With
IFE	In-Flight Emergency
IFF	Introduction to Fighter Fundamentals
ICS	Intercommunication Systems
IDG	Integrated Drive Generators
ILS	Instrument Landing System
IMDS	Integrated Maintenance Data System
IP	Instructor Pilot
ISR	Intelligence, Surveillance, and Reconnaissance
JASDF	Japanese Air Self Defense Force
JCS	Joint Chiefs of Staff
JEIM	Jet Engine Intermediate Maintenance
K	Thousand
KIAS	Knots Indicated Air Speed
L	Local
Lt Col	Lieutenant Colonel
MA	Mishap Aircraft
Maj	Major
MAJCOM	Major Command
MAT	Maintenance Training
MC	Mishap Crew
MDS	Mission Design Series
MFE	Mishap Flight Engineer
MIL or MIL POWER	Military Power
MISCAP	Mission Capability
MN	Mishap Navigator

MP	Mishap Pilot
MP1	Mishap Pilot 1
MP2	Mishap Pilot 2
MQT	Mission Qualification Training
MSgt	Master Sergeant
MSL	Mean Sea Level
NAOC	National Airborne Operations Center
NCO	Noncommissioned Officer
NCOIC	Noncommissioned Officer in Charge
NDI	Nondestructive Inspection
NM	Nautical Miles
NMC	Non Mission Capable
NOTAMS	Notices to Airmen
OAP	Oil Analysis Program
OG	Operations Group
Ops O	Operations Officer
Ops Tempo	Operations Tempo
ORE	Operational Readiness Exercise
OSC	On-Scene Commander
P and S	Plans and Scheduling
PA	Public Affairs
PAPI	Precision Approach Path Indicator
PCS	Permanent Change of Station
PHA	Physical Health Assessment
PIT	Pilot Instructor Training
PRD	Pilot Reported Discrepancy
PT	Physical Training
QA	Quality Assurance
QC	Quality Check
QUAL	Qualification
QVI	Quality Verification Inspection
RAF	Royal Air Force
RAP	Ready Aircrew Program
RPM	Revolutions Per Minute
RTB	Return to Base
RW	Runway
SA	Situational Awareness
SAR	Search and Rescue
SIB	Safety Investigation Board
SIMS	Simulations
S/N	Serial Number
SOF	Supervisor of Flying
Sortie	Flight
SSgt	Staff Sergeant
Stan Eval	Standardization and Evaluation
STAR	Standard Terminal Arrival
TACAN	Tactical Aid to Navigation
TAWS	Terrain Alert Warning Systems
TCI	Time Change Inspection
T.C.T.O.	Time Compliance Technical Order
TDY	Temporary Duty
Tech School	Technical School
T/N	Tail Number
T.O.	Technical Order
TSgt	Technical Sergeant
UHF	Ultra High Frequency
U.S.	United States
USAF	United States Air Force
VFR	Visual Flight Rules
VHF or Victor Frequency	Very High Frequency
VMC	Visual Meteorological Conditions
VSD	Vertical Situation Display
VTR	Video Tape Recorder
VVI	Vertical Velocity Indicators
Z	Zulu or Greenwich Mean Time

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

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 11 June 2010, Lieutenant General William J. Rew, Vice Commander, Air Combat Command (ACC), appointed Colonel Scott A. Forest, to conduct an aircraft accident investigation of a mishap that occurred on 12 May 2010, involving an E-4B aircraft, tail number (T/N) 73-1676, at Offutt Air Force Base (AFB), Nebraska (NE) (Tab Y-1). The investigation was conducted at Offutt AFB, NE, from 17 June 2010 through 1 July 2010. Board Members were Lieutenant Colonel Shelley L. Griffin (Legal Advisor), Major Michael E. Tellier (Pilot), Master Sergeant Ronald L. Chapman (Maintenance), and Staff Sergeant Renee J. Vega (Recorder) (Tab Y-2).

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.

c. Circumstances

The accident board was convened to investigate the Class A accident involving an E-4B aircraft, T/N 73-1676, assigned to the 1st Airborne Command and Control Squadron (1 ACCS), 55th Operations Group (55 OG), 55th Wing (55 WG), Offutt AFB, NE, which occurred during a weather evacuation mission by the alert crew on 12 May 2010 (Tab V-6.5).

2. ACCIDENT SUMMARY

The mishap aircraft (MA) an E-4B, T/N 7301676, departed Offutt AFB, NE at 2038 local time (L) (0138 Greenwich Mean Time or Zulu time (Z)) on 12 May 2010 to conduct an operational National Airborne Operation Center (NAOC) mission to avoid incoming severe weather, in the form of a thunderstorm with hail, that was forecast for Offutt AFB (Tabs F and W). Approximately 2 hours and 32 minutes later, the MA experienced a tail strike on Runway 30 at Offutt AFB on second touchdown, following an initial bounced landing attempt (Tabs DD and V-1.7). Mishap Pilot 1 (MP1) completed the landing and, following an inspection by the Offutt AFB Fire Department, taxied the MA to parking. The MA sustained damage to parts of the lower fuselage resulting in repair costs estimated at approximately $3.1 million. The accident caused no damage to private property (Tab P-4). Local media and local government officials have expressed no interest to this point in the circumstances surrounding the mishap (Tab CC).

3. BACKGROUND

The 55 WG owns the MA. The 1 ACCS is a squadron within the 55 OG. The 55 OG is, in turn, part of the 55 WG which is a subordinate unit to 12th Air Force (12 AF). 12 AF is a Numbered Air Force within ACC.

a. 55th Wing (55 WG)

The 55 WG's mission is to provide dominant intelligence, surveillance, reconnaissance (ISR), electronic attack, command and control and precision awareness to national leadership and warfighters across the spectrum of conflict any time, any place. Its vision is to provide unmatched ISR, electronic attack, and command and control capabilities across the range of military operations. It operates a variety of aircraft to conduct operations from Offutt AFB, NE; Kadena Air Base, Japan; Royal Air Forces (RAF) Mildenhall, United Kingdom; Souda Bay Naval Support Activity, Crete; and other locations around the world. The 55 WG is the largest wing in Air Combat Command(ACC) and the second largest in the Air Force. (Tab GG-3)

b. 55th Operations Group

The 55 OG, ACC's largest group, has operational control over 12 squadrons and 2 detachments worldwide. The group consists of approximately 3,200 personnel. It employs 46 aircraft, including 13 models of 7 different types of airframe. The 55 OG executes worldwide ISR, command and control, Presidential support, treaty verification, and airlift missions directed by the President and Secretary of Defense, Joint Chief of Staff, theater commanders, major command commanders, and national intelligence agencies. The 55 OG flies all variants of the RC-135, OC-135, WC-135, and E-4B aircraft. The 55 OG is located at Offutt AFB, NE. (Tab GG-6)

c. 1st Airborne Command Control Squadron

The mishap unit, the 1 ACCS, flies the E-4B. The 1 ACCS's mission is to provide the President and Secretary of Defense with a survivable command center for directing U.S. forces during all conditions of peace and war. It provides direct support to the federal government during military, national, and natural emergencies. (Tab GG-8)

d. E-4B

The E-4B is a militarized version of the Boeing 747-200. It is a four-engine, swept-wing, long-range, high-altitude aircraft capable of being refueled in flight. The E-4B serves as the National Airborne Operations Center (NAOC) for the President, Secretary of Defense and the Joint Chiefs of Staff. In case of national emergency or destruction of ground command control centers, the aircraft provides a highly survivable, command, control and communications center to direct U.S. forces, execute emergency war orders and coordinate actions by civil authorities. The E-4B has been in the Air Force inventory since January 1980. All E-4Bs are assigned to the 55th Wing, Offutt AFB, NE. (Tab GG-10)

4. SEQUENCE OF EVENTS

a. Mission

The mishap mission was planned and briefed as a short-notice NAOC operational mission to move the E-4B out of the way of incoming severe weather with potential hail forecast for Offutt AFB (Tab F-4). The E-4B has a number of systems vulnerable to damage from hail, and short-notice moves of the E-4B in support of NAOC operational missions are routine. The Mishap Crew (MC), in conjunction with the NAOC on board battlestaff commander, determined the need to execute an operational mission in order to prevent weather damage to the alert E-4B (Tab F-4, V-6.5). To support that requirement, the MC selected and flew a routing north of Offutt AFB, predominantly over Minnesota, the Dakotas, and western Nebraska (Tab V-6.5). The 1 ACCS director of operations (DO) and NAOC battlestaff Team Chief properly authorized the mission (Tabs K-3 through K-6, V-6.5). Following a departure of the severe weather from the Offutt AFB area, the MA returned to Offutt AFB for a full stop landing (Tab V-6.5).

b. Planning

The MC planned and conducted a pre-alert mission briefing as a NAOC operational mission on the day prior to assuming alert, in accordance with all applicable directives (Tab V-6.3). During the mission brief, the MC briefed all known potential mission scenarios (Tab V-6.5). Additionally, the MC briefed specifics of the weather evacuation mission, to include weather and Notices to Airmen (NOTAMs) just prior to stepping to the aircraft to execute the mission. (Tab V-6.5)

c. Preflight

The MA was an alert-configured E-4B aircraft, ready to fly at a moment's notice. The aircraft was "cocked on alert," a configuration that allows maintenance Quick Start Team personnel, or the alert flight crew, to quickly start the aircraft and configure it for takeoff (Tab V-6.3). In this instance, the MC conducted all Alert Engine Start procedures. The MC executed a takeoff, cruise and en route descent to Offutt AFB. All of this activity was uneventful. The MA had no maintenance issues. (Tabs V-6.5, 6.6)

d. Summary of Accident

The MA departed Offutt AFB at 2038L (Tab V-5.4). There was no schedule for this mission, as NAOC operational missions flown for weather avoidance are executed on an as needed basis. Following an uneventful take off, the MA climbed to a cruise altitude of 31,000 feet and headed towards the Gopher VORTAC (GEP), a navigational aid near Minneapolis, MN. From there the MA proceeded to the Aberdeen VOR/DME (ABR), a navigational aid in SD, then to the Sioux Falls VORTAC (FSD), another navigational aid in SD, then towards the Fort Dodge VOR/DME (FOD), a navigational in IA (Tab K-15). At this point, the MC deviated from the flight plan, after determining a need to remain aloft longer in order to allow time for any remaining severe weather in the Offutt AFB area to clear (Tab V-6.5). The MC requested to proceed to the area of North Platte VOR/DME (LBF), in NE. From there the MC approached Offutt AFB from the west and commenced an en route descent, briefing an Instrument Landing System (ILS)

approach to Runway (RW) 30 at Offutt AFB (Tab V-6.8). The MC then flew a Standard Terminal Arrival (STAR), terminating the STAR with vectors from Omaha Approach to the RW 30 ILS.

During the en route descent and vectors to the RW 30 ILS, the MC configured the MA for the approach in accordance with the applicable checklists from T.O 1E-4B(II)-1 (Tab V-6.9). Once established on the final approach segment of the ILS to RW 30, the MC continued to configure the MA for a full stop landing in accordance with T.O 1E-4B(II)-1, selecting landing gear down and wing flaps 30 percent for the full stop landing (Tab V-6.8).

During the en route descent and final approach, the Mishap Pilot 1 (MP1) was flying the aircraft from the right, or copilot seat. Mishap Pilot 2 (MP2), the pilot not flying, was the Aircraft Commander, and sat in the left seat monitoring the approach. The Mishap Flight Engineer (MFE) was at his assigned station, as was the Mishap Navigator (MN) (Tab V-6.8).

MP1, as the pilot flying, was utilizing one of the three autopilots installed on the E-4B to fly the en route descent and most of the final approach portion of the RW 30 ILS. MP1 kept the autopilot engaged on the ILS through approximately 800 feet above ground level (AGL), when he disconnected it shortly after passing through a thin cloud deck on final approach to the runway. MP1 manually flew the aircraft from that point through the rest of the approach (Tab V-4.34). Weather was good below the cloud deck, with a visibility of at least 7 nautical miles (NM) as observed by the MC and reported by Offutt AFB Weather (Tab V-6.8). MP1 testified to seeing the Precision Approach Path Indicator (PAPI) as three red lights and one white light initially, then two white and two red after correcting. Two red and two white lights indicates an aircraft is on the proper glide slope for landing (Tab V-4.16). MP1 was not able to precisely recall the last time he saw two red and two white PAPI lights. At approximately the Decision Height (DH) of 1,172 feet above Mean Sea Level (MSL), or 200 feet AGL on the ILS RW 30, MP2 testified he saw three red, and one white light on the PAPI during short final, indicating the aircraft was slightly below glide slope (Tab V-6.12).

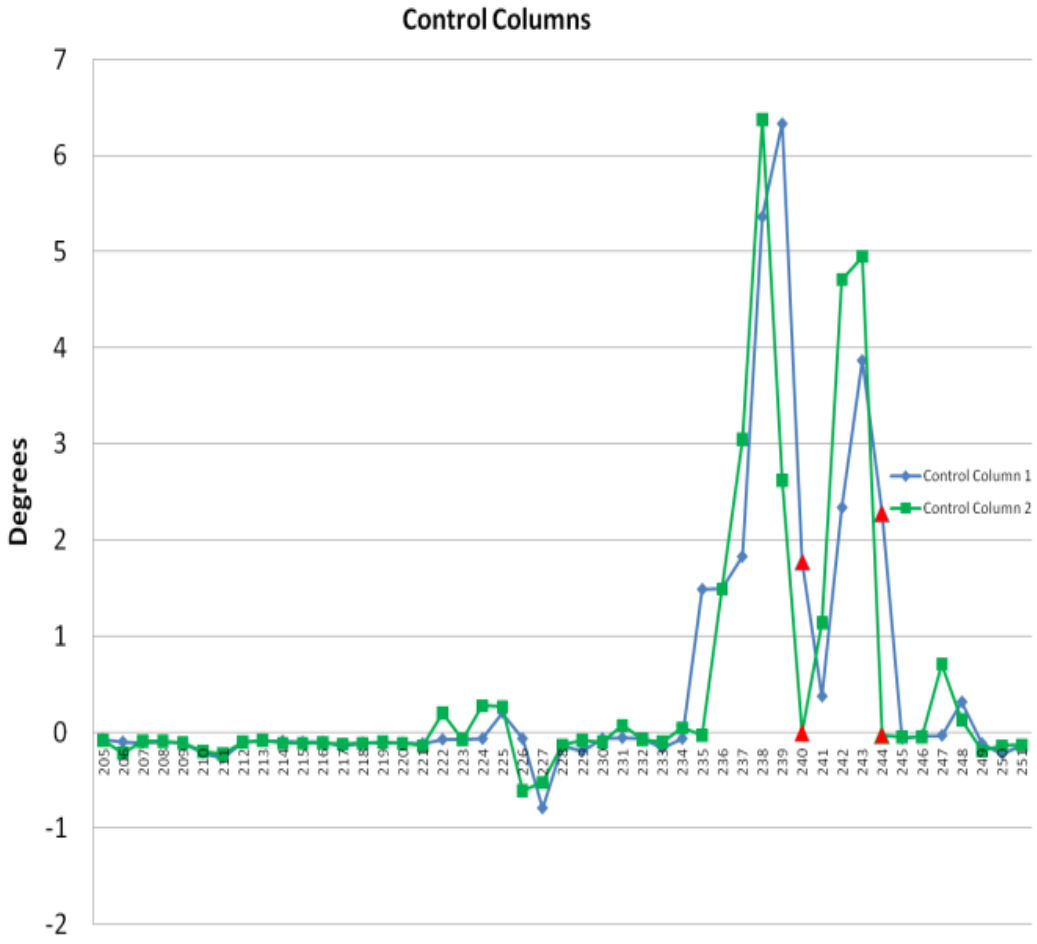
While on short approach, MP1 and MFE both heard a faster than normal "50, 40, 30, 20, 10" feet remaining until touchdown countdown from the automated system as the MA was crossing the runway threshold, indicating the descent rate was slightly faster than normal (Tab V-4.11). When MP1 realized that he was actually slightly low and descending slightly faster than normal, MP1 made a faster and larger than normal pitch up input to the steering column, or yoke (pulled back on the yoke). The result was that the aircraft touched down in a firm landing, with a 9-degree pitch attitude (Tab DD-6, DD-8). The touchdown point was short—500 feet past the threshold (approximately 500 feet short of the PAPI point of intercept and the thousand foot "Captain's Bars" runway marking in the recommended touchdown zone). Upon landing, the aircraft bounced. (Tabs V-4.28)

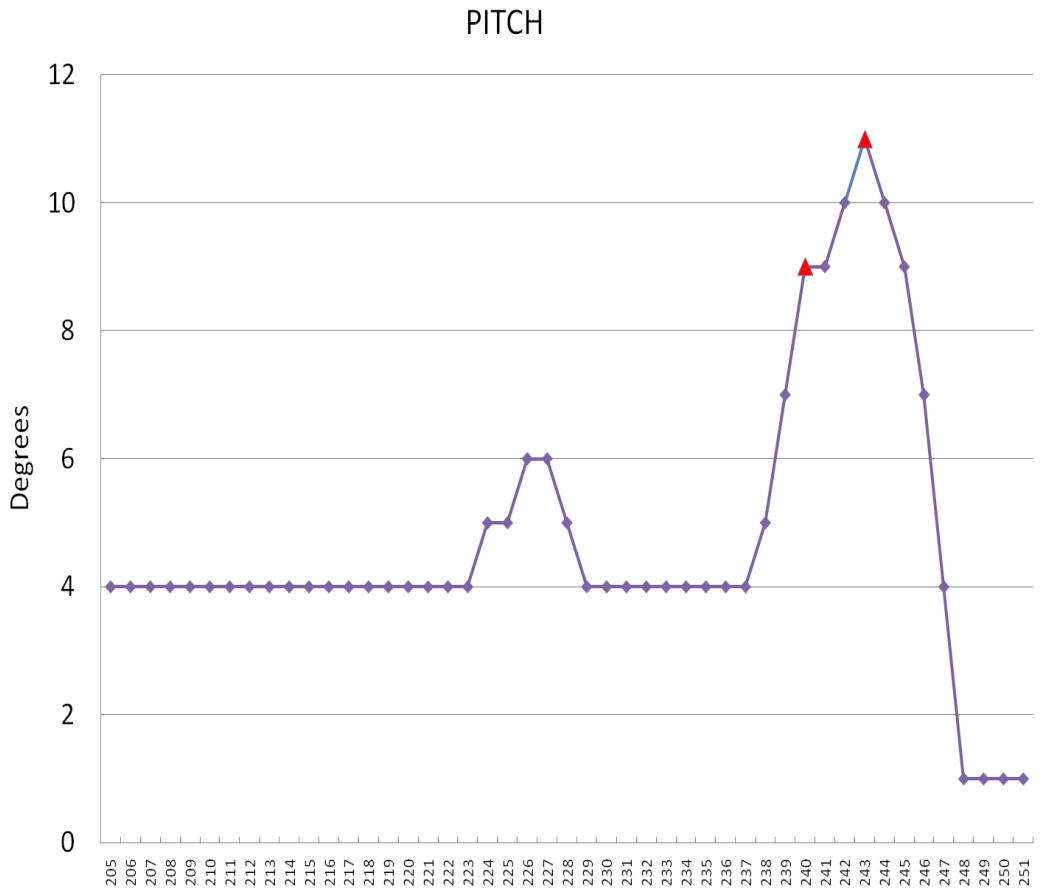
As the MA's wheels initially touched down on the runway, the aircraft's spoilers automatically deployed as they were designed to do when the speed brake lever is placed in the armed position (Tab DD-9). The armed position was in accordance with the Before-Landing Checklist in T.O 1E-4B(II)-1. The ground function of the spoilers raises all six panels on the upper surface of each wing to help the aircraft slow down by reducing lift, thus causing the aircraft wheel brakes

to be more effective. In flight, the spoilers add drag to slow the aircraft, and also tend to raise the pitch of the aircraft slightly (Tab V-4.28).

Immediately after the initial touchdown, the MA became airborne again, with no members of the MC immediately aware they were airborne (Tab V-6.18). Upon the first touchdown, MP1 had initially relaxed aft control column pressure (released backpressure on the yoke) (Tab DD-3). However, when he realized the MA was again airborne, MP1 pulled back on the yoke again in an attempt to smooth the subsequent landing (Tabs DD-3 and V-4.13). While airborne from the bounce, pitch on the MA came up to approximately 11 degrees, due in part to MP1's aft control column input (Tabs DD-3 and DD-6). As the MA then settled back towards the runway, portions of the lower aft fuselage made contact with the runway surface, causing a "tail strike" (Tab V-4.14).

The Aircraft Commander for the sortie, MP2, gave no verbal or physical input to MP1 or the MA during the landing, bounce, and second touchdown (Tab V-4.17).





As the MA landed, the tower watch supervisor noted a bright flash and sparks from the MA and notified the aircrew (Tab V-1.2). Following the full stop landing, the MA taxied clear of RW 30, and was instructed by the Offutt control tower to hold position (Tab II-5). The tower controller initiated the Offutt Crash Net, effectively declaring an emergency (Tab V-1.2). Offutt fire/crash rescue personnel performed a visual inspection of the aircraft and discovered damage on the aft fuselage, enabling them to conclude that the bright flash and sparks seen by the tower controller and Supervisor of Flying (SOF) were from tail contact with the runway and not from any other malfunction. Following this inspection, the MC taxied the MA to parking under its own power (Tabs II-7).

e. Impact

At approximately 2310 local time, at approximately 1,300 feet past the approach end threshold of RW 30, the tail section of the MA struck the ground approximately 2-3 feet to the right of the centerline nearly simultaneously to the landing gear touching down (Tab II-6). The MA sustained damage under the fuselage tail area that contacted the runway, as described in section 6 below.

f. Life Support Equipment, Egress and Survival

Not applicable.

g. Search and Rescue (SAR)

Not applicable.

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

At the time of the mishap, the MA total aircraft time was 15,052.6 hours. The #1 engine (left outboard engine), serial number (S/N) GE0E517109, had 8,837.5 hours total engine operating time with 9,418 operating cycles. The #2 engine (left inboard engine), S/N GE0E455481, had 10,471.8 hours total engine operating time with 10,634 operating cycles. The #3 engine (right inboard engine), S/N GE0E455471, had 10,227.0 hours total engine operating time with 8,647 operating cycles. The #4 engine (right outboard engine), S/N GE0E455472, had 6,948.9 hours total engine operating time with 6,704 operating cycles. (Tab D-3) All four engines were General Electrics CF6-50 F103 (Tabs D-3, U-3).

A detailed review of active and historical Air Force Technical Order (AFTO) Form 781 series aircraft maintenance forms revealed no discrepancies indicating engine, mechanical or flight control anomalies existed on the MA (Tabs D-8 and D-9). A thorough review of the active AFTO 781 forms and AFTO 781 historical records for the time period 90 days preceding the mishap revealed no evidence of mechanical, structural or electrical failure. The Integrated Maintenance Data System (IMDS) historical records for 90 days prior to the mishap were used to validate and confirm all form entries (Tab U-4). No open Time Compliance Technical Orders (TCTOs) in the active forms restricted the MA from flying. A review of the historical records showed all TCTOs had been accomplished in accordance with applicable guidance (Tab D-7). There were no TCTO compliance issues relevant to the mishap.

The MA flew a total of 49 flights in the 90 days prior to the mishap. MA was the primary alert aircraft for 62 of the 90 days prior to the mishap (Tabs U-5 and U-6). The MA experienced only one Code III discrepancy during this time, which was for a bird strike on the # 4 Canoe 7 May 2010 (Tab U-7). The area was inspected and no defects were noted.

There were no major maintenance discrepancies that would have prevented the MA from accomplishing its tasked mission on 12 May 2010. Historical records also did not reveal any recurring maintenance problems with the MA.

b. Inspections

(1) Mishap Aircraft

Isochronal inspections are regularly-scheduled maintenance performed on Air Force aircraft at periodic periods. The E-4B has a 6-month isochronal inspection period, with a Home Station

Check (HSC) three months after an isochronal inspection. The last major inspection accomplished on the MA was a minor "A" isochronal inspection, which was started on 2 December 2010. The next scheduled isochronal inspection would have been a minor "B" isochronal inspection, scheduled for 17 June 2010. The MA had approximately 36 days remaining before this next isochronal inspection due date (Tab D-7). The MA had an HSC on 8 March 2010 where all four engines were inspected. No defects were noted (Tab U-4).

On 4 May 2010, prior to taking alert, the MA's crew chief conducted a pre-flight and post-flight inspection on the MA, commonly termed a combined inspection (Tab D-5). Additionally, the MA's crew chief completed an alert walk-around inspection at 0800 on 12 May 2010. This type of inspection is valid for 24 hours and was still valid when the MA took off for the mishap mission. The maintenance documentation confirmed all inspections were satisfactorily accomplished in accordance with applicable maintenance directives (Tab D-5).

(2) Mishap Engines

The MA's engines were inspected during the scheduled HSC on 8 March 2010. Inspections included the inspection and cleaning of the master magnetic chip detector, the inspection and servicing of the engine starter, and a borescope inspection. (Tab U-4). There were no overdue inspections for either engine at the time of the mishap.

The 781K inspection lists 150 hour Oil Analysis Program (OAP) samples for all four engines are overdue for the airframe. However, these requirements have been abandoned by the inspection program for the E-4B, and the unit is currently awaiting the new change to the 1E-4B-6 identifying this change. The 1st Aircraft Maintenance Unit (1 AMU) has letters validating this change in inspection. Due to this abandonment letter, no OAP samples were actually due at the time of the mishap. (Tab U-8).

c. Maintenance Procedures

A detailed review of active and historical AFTO Form 781 series aircraft maintenance forms revealed no discrepancies indicating a deviation from established maintenance procedures on the MA (Tab U-4). A thorough review of the active AFTO 781 forms and AFTO 781 historical records for the time period 90 days preceding the mishap revealed only minor inconsequential documentation errors; no actual maintenance deviation was identified. The IMDS historical records for 90 days prior to the mishap were used to validate and confirm all form entries (Tab U-4).

d. Maintenance Personnel and Supervision

Informal interviews conducted with maintenance personnel indicated all preflight activities were normal and all personnel involved in the preflight and launch of the MA were experienced and qualified (Tab U-9). Maintenance supervisors appeared engaged in daily maintenance activities and actively involved in the repair and launch of aircraft (Tab U-9). All maintenance personnel interviewed expressed in the strongest terms possible that they would never deliver a jet to a pilot unless they were personally convinced it was safe to fly (Tab U-9). A thorough review of individual military training records on all personnel who performed maintenance on the MA

indicated maintenance personnel were well trained on all tasks they executed on the MA (Tabs U-4 and U-9).

e. Fuel, Hydraulic and Oil Inspection Analysis

No fuel or oil samples were taken from the MA after the mishap. Since engine performance was not at issue in the mishap, no samples were taken. While hydraulic fluid samples were taken post-accident, the AIB determined the hydraulic systems performance was not at issue in the mishap and did not request that samples be tested.

f. Unscheduled Maintenance

The AIB thoroughly reviewed all aircraft maintenance activities on the MA since completion of the minor "A" isochronal inspection in December 2009. Nothing relevant to the mishap was found. A review of the MA's performance for the 1-year period prior to the mishap revealed 78 of 81 sorties flown landed either Code I or Code II, meaning mission capable (Tabs U-10 and U-11). A review of IMDS and AFTO 781 maintenance records (90 days prior to the mishap) revealed the only repeat Pilot Reported Discrepancy (PRD) was a #3 thrust reverser that would not deploy. This was corrected on 6 April 2010 and was not relevant to the mishap (Tab U-4).

The 1 AMU completed all corrective actions in accordance with applicable technical data.

6. AIRCRAFT AND AIRFRAME

a. Condition of Systems

After landing, the MA taxied under its own power after the mishap and was inspected by Quality Assurance and 55 WG Safety personnel. Damage to the aircraft was photographed immediately following the mishap after the aircraft taxied to parking. (Tabs S-7 through S-14). The aircraft sustained substantial damage from Body Station (BS) 1800 to BS 2320 on the belly of the aircraft. External damage to the very high frequency data link antenna, a command, control, and communications (C3) "receive" antenna, drain mast next to the long trailing wire antenna doors, aircraft left outflow valve, and the drain mast for the aft lavatories was visible upon landing, along with scrapes along the skin (Tab P-3). No relevant pre-existing defects were noted.





b. Testing

Not applicable.

7. WEATHER

a. Forecast Weather

At takeoff time for the MA, forecast weather at Offutt AFB was for winds from 300 degrees at 08 knots, with a ceiling of broken clouds at 1,000 feet above the ground and an overcast deck at 2,000 feet above the ground. The term "broken" refers to cloud layers that cover more 5/8 to 7/8 of the sky. The term "overcast" refers to cloud layers that completely cover the sky. Temperature was forecast to be +08 degrees Celsius and the visibility 7 miles (Tab F-1).

b. Observed Weather

Reported weather at the time of the mishap was winds from 320 degrees (out of the northwest) at 08 knots with broken clouds at 2,400 feet above the ground, a temperature of +09 degrees Celsius and a visibility of 10 miles (Tab F-2). The control tower at Offutt AFB passed current runway winds to the MC as from 350 degrees (out of the north) at 06 knots. The MC reported a thin layer of clouds, no lower than 800-1,000 feet above the ground (Tab V-6.7).

c. Space Environment

Not applicable.

d. Operations

Weather was well within operational limits.

8. CREW QUALIFICATIONS

a. Training

The MC was current, qualified and proficient for this mission with both pilots performing night landings within the past three weeks (Tabs G and T). MP1 completed E-4B qualification training in August 2007, Alert Aircraft Commander training in May 2008, and Instructor Pilot

Training in November 2008 (Tab G-5). MP2 completed E-4B qualification training in August 2007 and Alert Aircraft Commander training in November 2009 (Tab G-11). The MN completed E-4B qualification training in May 2007, and Instructor Navigator training in May 2008 (Tab G-19). The MFE completed E-4B qualification training in February 2001, and Instructor Flight Engineer training in August 2002 (Tab G-27). All E-4B training was based out of Offutt AFB. The AIB reviewed the 30/60/90 day look-back, flight evaluation folders (FEF), and training records for all members of the MC. All appeared unremarkable.

b. Experience

Prior to the mishap, MP1 flew a total of 3206.2 hours, with 646.4 hours in the E-4B and 121.7 of those E-4B hours flown as an Instructor Pilot (Tabs G-3). MP2 flew a total of 3977.3 hours, with 644.3 hours in the E-4B (Tab G-9). The MN flew a total of 2385.4 hours, with 986.6 hours in the E-4B, and 205.4 of those E-4B hours flown as an Instructor Navigator (Tab 17). The MFE had 6970.5 hours, with 2564.0 hours in the E-4B, and 534.8 of those hours being flown as Instructor/Evaluator (Tab G-25). Overall, the MC was an experienced crew, with two evaluators, an instructor pilot and a 3900-hour aircraft commander.

9. MEDICAL

a. Qualifications

At the time of the mishap, the MC was fully medically qualified for flight duty without medical restrictions or waivers. All MC members had current physicals and were medically qualified for flight duties and worldwide military duty (Tabs G-4, G-12, G-18, G-26). The MC displayed no physical or medical limitations prior to the mishap (Tab HH-3).

b. Health

The AIB Board President and pilot advisor reviewed medical records for the Mishap Crew, as well as their 72-hour histories (Tabs HH-4 through HH-20). Medical records revealed all individuals were in good health and had no recent performance-limiting illnesses prior to the mishap. All had current physical health assessments (Tab HH-3). After interviewing the Mishap Crew, and thoroughly reviewing their medical records, no relevant medical information was noted. Since there were no injuries in this mishap, there were no post-accident medical examinations.

c. Toxicology

Immediately following the mishap, commanders directed toxicology testing for the MC. Blood and urine samples were submitted to the Armed Forces Institute of Pathology (AFIP) for toxicological analysis. This testing included carbon monoxide and ethanol levels in the blood and drug testing of the urine. Tests revealed carbon levels were normal, and neither drugs nor alcohol were found in the blood or urine of the MC (Tab HH-33).

d. Lifestyle

There is no evidence of any unusual habits, behavior, or stress on the part of any members of the MC. Witness testimonies, as well as review of 72-hour histories of the MC revealed no lifestyle factors, including unusual habits, behavior, or stress relevant to the mishap (Tabs HH-5 through HH-21).

e. Crew Rest and Crew Duty Time

Air Force Instructions require flight crew have proper "crew rest," as defined in AFI 11-202, Volume 3, *General Flight Rules*, 05 April 2006, prior to performing in-flight duties. AFI 11-202 defines normal crew rest as a minimum 12-hour non-duty period before the designated flight duty period (FDP) begins. During this time, an aircrew member may participate in meals, transportation or rest as long as he or she has the opportunity for at least eight hours of uninterrupted sleep. (Tabs HH-4 through HH-20).

A review of the duty cycles of the MC leading up to the mishap indicated they all had adequate crew rest (Tabs HH-4 to HH-20). The MC all stated they were well-rested and had no complaints or illnesses (Tabs HH-4 to HH-20). The MC complied with the crew rest and duty day requirements on the day of the mishap. The MC was near the very end of their 16-hour duty day when this incident occurred (Tab V-4.5). At the time of the mishap, MP1 had been awake over 18 hours, and would typically be sleeping at that time of night on a non duty day (Tab HH-6). MP2 and the MN had also been awake for over 18 hours at the time of the mishap. The MFE reported a mid-morning nap of approximately two hours on the day of the mishap (Tab V-3.2). No members of the MC suffered from non-duty related stress or pressure prior to or during the mishap sortie (Tabs V-3.3, V-4.6, V-5.4, V-6.5). All members of the MC stated that they were not suffering from any non-duty distracters at the time of the mishap (Tabs V-3.3, V-4.6, V-5.4, V-6.5).

10. OPERATIONS AND SUPERVISION

a. Operations

The squadron did not have an elevated operations tempo in the six months prior to the mishap (Tab GG-12). All witnesses described the operations tempo as average and asserted it did not negatively affect their ability to perform the mission (Tabs V-3.3, V-4.6, V-5.4, V-6.5). The MC assumed alert status the morning of the mishap, reporting for duty at 0730 local. The MC all asserted that the level of work that day was elevated because it was the first day of an alert week, but was not different than a typical first day of a week of alert duty. All MC flight deck members stated that the operations tempo and work performed during the day prior to the flight did not negatively affect their ability to perform the mission.

b. Supervision

The MA and MC were properly generated to alert status. The mishap sortie was not preplanned to take off at the time it did, but was generated from alert status to prevent forecast weather from impacting the NAOC alert posture readiness. The sortie was alerted as a 2.0 hour weather

thunderstorm avoidance sortie in accordance with alert procedures, and was extended by approximately 30-40 minutes to allow the weather to clear from Offutt AFB, NE. (Tab V-6.6). The MC was prepared to launch the sortie. No operators cited any concerns about the support they received from their squadron leadership (Tabs V-3.3, V-4.6, V-5.4, V-6.5).

11. HUMAN FACTORS

a. Mission

The board and two additional human factors experts (a trained Air Force (AF) physiologist, and an AF doctor trained in aerospace psychology) considered all of the environmental and individual human factors elements contained in AFI 91-204 attachment 5, Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS), and paragraph 8.7.8.11 of AFI 51-503.

The AIB evaluated every action the MC took during the mishap sequence using all available evidence, such as witness testimony, radio transmissions, and Digital Flight Data Recorder (DFDR) information. The following information was reviewed:

MP1, MP2, MFE, and MN witness interview transcripts (Tabs V-3 through V-6)
DFDR Information (Tab DD)
Nighttime viewing of runway, its associated horizon, and touchdown points
Re-creation of flight simulation (animation)
Electronic Medical Records of MP1 and MP2
14-day and 72-hour histories of all MP1, MP2, MFE, and MN (Tab HH)

The following factors were deemed to NOT relevant to in the mishap:

Personnel Factors
Environmental Factors
Violations (Procedural or Supervisory)
Physical/Mental Limitations
Psycho-Behavioral
Organizational Climate
Adverse Physiological State
Physical/Technological Environment
Failures to Correct Known Problems
Planned Inappropriate Operations
Resource/Acquisition Management

The AIB also found no evidence of AFI 51-503 factors in paragraph 8.7.8.11: maintenance crew complacency, overconfidence, low motivation, distraction, disruption, supervisory pressure, channelized attention, or other degradation may have led to the accident. The following factors were not relevant: MC complacency, overconfidence, under motivation or over-motivation to succeed, distraction, disruption, pressure, panic, channelized attention, overt mental confusion, or other degradation as causes of the accident. Consideration of an uncharacteristic mistake on the part of MP1 was relevant (Tab V-4.11).

Nine human factors from the DoD HFACS model (AFI 91-204, attachment 5) are relevant to this mishap (Tab II-3 to II-5): (1) PC504, Misperception of Operational Conditions; (2) AE105, Breakdown in Visual Scan; (3) AE104, Overcontrol/Undercontrol; (4) AE103, Procedural Error; (5) PC101, Inattention; (6) OP003, Procedural Guidance/Publications; (7) SI003, Local Training Issues/Programs; (8) SI004, Supervision – Policy; (9) PP102, Cross-Monitoring Performance. The RW 30 profile and its varying up gradient and its possible effect on the pilots is also discussed in this section.

(1) Misperception of Operational Conditions. Misperception of Operational Conditions is a factor when an individual misperceives or misjudges altitude, separation, speed, closure rate, road/sea conditions, aircraft/vehicle location within the performance envelope or other operational conditions and this leads to an unsafe situation. It is relevant in this mishap because evidence suggests MP1 misjudged his altitude, glide path, and descent rate within the performance envelope of the MA on short final. (Tab V-4.39).

(2) Breakdown in Visual Scan. Breakdown in Visual Scan is a factor when the individual fails to effectively execute learned /practiced internal or external visual scan patterns leading to unsafe situation. It is relevant in this mishap because evidence suggests MP1 did not notice, or noticed late, he was slightly low during a night landing performed using visual references (Tab V-4.39).

(3) Overcontrol/Undercontrol. Overcontrol/Undercontrol is a factor when an individual responds inappropriately to conditions by either overcontroling or undercontroling the aircraft/vehicle/system. The error may be a result of preconditions or a temporary failure of coordination. Overcontrol/Undercontrol is relevant because of MP1's reaction once he recognized the increased descent rate on short final. His reaction was basically correct but was an "over control" input to the yoke, resulting in an aircraft designed to touch down at 5 degrees of pitch touching down at 9 degrees of pitch (Tab V-4.11, V-4.13, DD-3 and DD-6). The "over control" of the control column prior to the initial touchdown was assessed can be described as an "uncharacteristic mistake" (per paragraph 8.7.8.11 of AFI 51-503) by MP1 because he is not characterized by mistakes in his training or evaluation records (Tab G-5 to G-8) and the E-4B has not sustained a tail strike in its employment history in the AF since 1980.

(4) Procedural Error. Procedural Error is a factor when a procedure is accomplished in the wrong sequence or using the wrong technique or when the wrong control or switch is used. This also captures errors in navigation, calculation or operation of automated systems.. Procedural Error is relevant because MP1 moved the control column aft during the bounce, increasing the pitch angle even further above the 5 degrees specified in the flight manual to 11 degrees (Tab II-4 and DD-6). MP1's recovery technique from the initial bounce resulted in too much pitch.

(5) Inattention. Inattention is a factor when the individual has a state of reduced conscious attention due to a sense of security, self-confidence, boredom or a perceived absence of threat from the environment which degrades crew performance. (This may often be a result of highly repetitive tasks. Lack of a state of alertness or readiness to process immediately available

information.). Inattention is relevant because inattention during an approach can lead to similar circumstances of being below glide slope while having an elevated descent rate.

(6) Procedural Guidance/Publications. Procedural Guidance/Publications is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading or inappropriate and this creates an unsafe situation. In this case, Procedural Guidance/Publications is relevant because the flight manual neither quantifies the degrees of pitch that will result in a tail strike nor contains a note, caution, or warning about the risk of tail strike during landing In addition, there are no AF, ACC, WG, or unit level tail strike prevention programs or tail strike threat awareness programs.

(7) Local Training Issues/Programs. Local Training Issues/Programs are a factor when one-time or recurrent training programs, upgrade programs, transition programs or any other local training is inadequate or unavailable (etc) and this creates an unsafe situation. In this case, Local Training Issues/Programs is relevant because there is no training in place to help prevent or avoid tail strikes or how to properly handle the E-4B in a bounce recovery, despite the fact that the manufacturer and commercial operators know this to be a risk to safe 747 "classic" operations (Tab FF-3 through FF-10 and V-7.8).

(8) Supervision – Policy. Supervision – Policy is a factor when policy or guidance or lack of a policy or guidance leads to an unsafe situation. In this case, Supervision – Policy is relevant because there was no policy or guidance related to tail strikes in an aircraft susceptible to tail strikes. In this instance, however, as far as the AIB was able to tell, the information related to tail strikes was not passed from the manufacturer to the Air Force, and supervision was unaware of the elevated potential for such occurrences. Accordingly, though relevant for discussion, the AIB did not find error or fault in Air Force supervision or policy.

(9) Cross-Monitoring Performance. Cross-monitoring performance is a factor when crew or team members failed to monitor, assist or back-up each other's actions and decisions. Cross-Monitoring Performance is relevant because MP2 did not provide input to the pilot flying to help him recognize the low glide path, slow the descent rate, or prevent the over control and the increase of the pitch attitude during the bounce to 220% of the 5 degrees specified for landing in the flight manual (Tab V-4.23).

Careful analysis of DFDR information, witness testimony, and expert witness evaluation reveals MP1 made what can be classified as an uncharacteristic mistake by MP1 (Tab DD-3 through DD-9). DFDR data indicates that at approximately 18 seconds prior to the first touchdown, MP1 corrected what was a minor glide path deviation on the low side (Tab DD-5). MP1 made this correction by adding a slight bit of power, and reducing the rate of descent using aft control column movement (DD-3). MP1 testified that after this correction, he was on glide slope, observing two red and two white on the PAPI. Based on MP1 testimony, this is the last time in the mishap sequence where he referenced the PAPIs. At some undetermined time, MP1 had a momentary loss of Situational Awareness (SA) and this momentary loss ceased when he heard the radar altimeter calling off the 50, 40, 30, 20, and 10 foot calls more rapidly than normal (Tab V-4.11).

The AIB consulted a trained physiologist and a doctor trained in aerospace psychology factors in an effort to determine what factors might have been influencing the MC (Tab II-3 to II-5). Writing a joint report, they determined that MP1 displayed evidence of being tired, but did not characterize the MC as fatigued (Tab HH-3). In other words, there was the potential for minor performance deviations based on the fact that MP1 had been awake for almost 18 hours, and was past the point at which he would be sleeping on a non-duty night (Tab V-4.5). Their report notes that a momentary loss of SA, such as that theorized to have occurred with MP1, is likely to have arisen because of MP1 being tired (Tab HH-3). In addition, the expert testimony suggests that a common human reaction to a momentary loss of SA and the realization that an action is needed, is to make the correct action to a larger degree than normal or required (Tab HH-3), resulting in "over control" of the control column with a greater than normal pitch up movement (Tab DD-6).

Analysis of the physiologist and psychologists report at Tab HH, in conjunction with the DFDR information and witness testimony suggests that MP1 suffered a momentary loss of SA at some point after making a pitch/glide slope correction at approximately 18 seconds prior to the first touchdown (Tab HH-3). After making a pitch correction back to the proper glide slope, the MA then assumed a pitch/descent rate that was slightly greater than nominal, resulting in a three red and one white on the PAPI, as noted by MP2 (Tab V-6.12). The increased descent rate resulted in an aim point and touchdown short of the 1,000-2,000 feet down the runway target used by E-4B aircrews. MP1 did not notice the deviations. However, MP2, seeing three red and one white on the PAPI, noticed the deviations but did not believe they were enough of a concern to verbalize them to MP1. MP1 testified that he was slightly surprised when radar altimeter call outs, starting with the 50 foot call, came in at a rate perceived to be faster than normal (Tab V-4.11).

The AIB also explored human factors affecting both MP1 and MP2 for reasons why neither MP1 nor MP2 were able to discern, via visual reference from looking out the pilot windows, the excessive pitch attitude of the MA prior to the tail strike and second touchdown. One relevant factor is the runway profile at Offutt AFB. The Offutt AFB runway is not level, with a published .7% up gradient for the entire length of RW30. From USAF Flight Information Publications, and as used to calculate aircraft performance, the gradient is considered constant over the length of the runway. However, the actual gradient for RW30 is not constant. The first approximately 2,200 feet of RW30 is relatively flat, followed by an upslope approximately 4,000 feet long, where approximately 50 feet of vertical change is seen, and then the rate of gradient change decreases, but still moves up to gain another approximately 25 feet of vertical change over the remaining 3,700 of the runway length. Over the final 7,700 feet of runway, the 75 foot rise equates to about a 1.0 gradient upslope (equivalent to a .6 degree upslope). The net effect is that the horizon the pilots used at the end of RW 30 to establish a reference for landing was higher than the level part of the runway they landed on in the landing zone (first 3,000 feet) (Tab O-3).

The AIB carefully considered how this upslope condition would affect a crew landing an E-4B at night, at the end of a 16-hour duty day, experiencing an unexpected bounce, and without training or guidance to prevent over-rotation. Pilots are taught to evaluate aircraft height above the ground, and pitch, via visible references during the landing phase. In the case of RW 30 at Offutt, the true horizon (or the end of a level runway used by pilots to determine height above a runway while landing) lies behind the hill presented by the increasing gradient of RW 30. This

can affect a crew's ability to visually perceive height above runway and pitch. The memo at Tab HH-3 and consultation with a prominent Air Force runway visual illusions expert suggests that this gradient can affect a pilot's ability to determine aircraft pitch solely by visual means, but the exact amount of this effect, in mathematical terms, cannot be determined (Tab HH-3 to HH-5).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications

1. T.O. 1E-4B(II)-1, *Flight Manual, E-4B,*01 July 2000, with Change 11 Posted 15 September 2009
2. T.O. 1E-4B-1-1, *Performance Data Manual*, 01 December 2007, with Change 15 September 2009
3. Air Force Instruction (AFI) 11-202, Volume 3, *General Flight Rules*, 05 April 2006
4. AFI 11-202 ACCSUP, Volume 3, *Air Operations Rules and Procedures*, 27 February 2007
5. AFI 11-215, *USAF Flight Manuals Program (FMP)*, 22 December 2008
6. AFI 11-2E-4, Volume 1, *Aircrew Training*, 18 August 2005
7. AFI 11-2E-4, Volume 3, *E-4 Operations Procedures*, 05 March 2008
8. AFI 11-2E-4B, Volume 2, *E-4B Aircrew Evaluation Procedures*, 04 June 2009
9. AFI 11-401, *Aviation Management*, 07 March 2007
10. AFI 11-418, *Operations Supervision*, 21 October 2005, Incorporating Change 1, 20 March 2007
11. AFI 11-421, *Aviation Resource Management*, 1 November 2004
12. AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010
13. AFI 51-503 ACCSUP, *Aerospace Accident Investigations*, 27 June 2007
14. AFI 91-204, *Safety Investigations and Reports*, 24 September 2008

b. Maintenance Directives and Publications

1. AFI 21-101, *Aerospace Equipment Maintenance Management*, 12 April 2010
2. T.O. 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures*, 30 April 2003 with Change 3 dated 31 May 2005

NOTICE: The AFIs listed above are available digitally on the AF Departmental Publishing Office internet site at: **http://www.e-publishing.af.mil.**

c. Known or Suspected Deviations from Directives or Publications

By landing the aircraft with 9 degrees of nose up pitch for the initial touchdown and increasing nose up pitch to 11 degrees during the bounce, the MC deviated from the flight manual guidance that states the landing attitude for the aircraft should be 5 degrees. The nature of this deviation is further discussed in the human factors in section 11 and the statement of opinion. There were no other known or suspected deviations.

13. NEWS MEDIA INVOLVEMENT

The AIB contacted Offutt AFB Public Affairs office and other public sources. No media attention anticipated.

14. ADDITIONAL AREAS OF CONCERN

No additional areas of concern contributed to this aircraft accident.

1 Jul 2010

SCOTT A. FOREST, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

E-4B, T/N 73-1676
12 MAY 2010

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

The AIB developed plausible theories based on the evidence and tested them by comparing results predicted by the theories to aircraft flight data recorder evidence and statements of the mishap aircrew. As a result of this investigative process, I reached the following conclusions concerning this mishap.

I find by clear and convincing evidence that the root cause of this mishap was pilot error by Mishap Pilot 1 (MP1) and Mishap Pilot 2 (MP2). MP1 increased the pitch angle of the Mishap Aircraft (MA) to more than twice the pitch angle specified by the flight manual for landing, resulting in the tail striking the runway. As the Aircraft Commander for the sortie, MP2 did not ensure the safe and effective conduct of the flight, giving no input to MP1 during the landing, bounce, and second touchdown. Additionally, I find as substantially contributing factors that (1) the E-4B flight manual and training programs do not state, discuss, or address risk of tail strikes during landings or bounce recovery and (2) that the manufacturer did not provide the Air Force information concerning risks of tail strikes for 747 aircraft during landing or bounce recovery.

2. DISCUSSION OF OPINION

a. Cause

Two hours and 32 minutes after takeoff, MP1 flew an uneventful, stable, on speed precision approach to short final. On short final, MP1 flew a slightly low glide path with a higher than normal sink rate. Digital Flight Data Recorder (DFDR) information reveals that at 3-4 seconds before the initial touchdown, MP1 applied approximately 6 degrees of pitch up movement to the yoke, culminating in a firm touchdown with a 9-degree nose up attitude, and a subsequent bounce. During the bounce, MP1 applied 5 degrees of pitch up control movement to the yoke, increasing the aircraft pitch angle to 11 degrees as the aircraft settled back to the runway about 800 feet past the first touchdown point. The tail of the aircraft impacted the runway 2-3 feet right of the centerline, approximately 1,300 feet past the threshold. The Mishap Crew (MC) was not aware of the tail strike until the tower watch supervisor informed them he saw a bright flash when the aircraft touched down the second time. MP1 and the MC brought the MA to a stop on the runway, coordinated with the tower, fire crew responders, and maintenance personnel to ensure it was safe to taxi clear, and exited the runway uneventfully.

MP1 and MP2 were experienced, qualified, current and proficient in night landings. Winds were from 350 (out of the north) at 6 knots and the ceiling was at approximately 800-1,000 feet Above Ground Level (AGL) with unrestricted visibility underneath the ceiling. The landing was performed at night on runway 30, at the end of a 16-hour crew duty day. After carefully considering whether the intensity, workload, length and timing of the duty day made fatigue a factor in the mishap, I concluded it was not. Additionally, there were no personal, professional, mission, or flight distracters to MP1 or MP2 in performing the landing. The navigational aids and lighting systems were on and functioning within operating standards. All maintenance personnel who worked on the MA were well-trained, experienced and qualified. The MA was thoroughly researched, confirming it operated within tech order parameters, and there were no maintenance write-ups that could affect approach or landing phases of flight. A thorough review of maintenance procedures revealed no problems or adverse trends which could have contributed to the accident.

During the approach, MP1 thought he was on the correct glide path and descending at a normal descent rate on short final crossing the threshold. Conversely, MP2 saw three red and 1 white indicator lights from the Precision Approach Path Indicator (PAPIs), indicating the approach was slightly low on short final. MP1 and the Mishap Fight Engineer (MFE) both heard a faster than normal 50, 40, 30, 20, 10 "feet remaining" countdown from the automated system crossing the threshold, indicating the descent rate was slightly faster than normal. When MP1 realized that he was actually slightly low and descending slightly faster than normal, MP1 made a faster than normal and a larger than normal pitch up input to the steering column (pulled back on the yoke).

The result was that the aircraft initially touched down in a firm landing, with a 9-degree pitch attitude. The first touchdown point was 500 feet past the threshold (approximately 500 feet prior to the PAPI point of intercept and the thousand foot "Captain's Bars" runway marking). The firm landing and the pitch attitude caused the MA to rise off the runway in a bounce. After the initial touchdown and during the bounce, the spoilers automatically deployed and MP1 pulled back on the yoke again. The combination of both of these actions increased the pitch attitude to 11 degrees prior to the MA touching down again. Since the MA was at 11 degrees of pitch, the tail section of the aircraft struck the runway.

The flight manual states that the pitch angle for a normal landing should be 5 degrees. MP1 increased the pitch angle of the MA to more than twice the pitch angle specified by the flight manual for landing, resulting in the tail striking the runway nearly simultaneously to the landing gear. As the Aircraft Commander for the sortie, MP2 did not ensure the safe and effective conduct of the flight, giving no input to MP1 during the landing, bounce, and second touchdown.

One key human factor for pilot error by MP1 on short final was "misperception of operational conditions." MP1 misjudged his altitude, glide path, and descent rate within the performance envelope of the MA. A second relevant human factor is MP1 suffered a "break down in visual scan" when he did not notice he was slightly low and descending faster than normal during a night landing performed using visual references. A third relevant human factor for MP1 was an "over control" input to the yoke, which occurred once MP1 recognized an increased descent rate on short final, resulting in touching down at 9 degrees of pitch. Last, MP1 committed a

"procedural error" when he increased the pitch of the aircraft in the bounce. Per paragraph 8.7.8.11 of AFI 51-503, I would characterize the "over control" and "procedural error" as "uncharacteristic mistakes."

For MP2, the key relevant human factor was cross-monitoring performance. Despite his responsibility to do so as the Aircraft Commander and the pilot not flying, MP2 failed to provide input to the pilot flying to recognize the low glide path, slow the descent rate, or prevent the over control and the increase of the pitch attitude to 220% of the 5 degrees specified for landing in the flight manual. The human factors for MP1 and MP2 were exacerbated by the contributing factors below in paragraph b.

I also explored the following human factors and found them as not contributory: Inattention and Supervision—Policy. The weight of evidence suggests MP1 and MP2 were focused on accomplishing the approach and landing successfully. Thus I do not find the pilot error was caused by inattention. Additionally, I do not find Supervision—Policy as contributing either since supervision did not have the relevant data by which to form policies or guidance that might have prevented the mishap.

b. Contributing Factors

I find by a preponderance of evidence that two factors substantially contributed to this mishap: (1) the E-4B flight manual and training programs do not state, discuss, or address risk of tail strikes during landings or bounce recovery and (2) that the manufacturer did not provide the Air Force information concerning risks of tail strikes for 747 aircraft during landing or bounce recovery.

The E-4B-1 flight manual contains no notes, warnings or cautions regarding tail strikes. In addition, the E-4B-1 flight manual and ACC and unit training programs do not state, discuss, or address risk of tail strike during landings. Further, the E-4B-1 flight manual and ACC and unit training programs did not state, discuss, or address the proper reactions or proper and improper procedures for bounce recovery. In addition, there are no AF, ACC, or unit tail strike prevention programs or tail strike threat awareness training, in contrast to common commercial and industry recommendation and practice and guidance in multiple, non-Air Force Boeing 747 commercial flight manuals.

The commercial 747 manual that the manufacturer has provided the AF to compare to the E-4B flight manual does not discuss the risk of tail strikes during landing, bounce recovery considerations or procedures, or provide data, notes, cautions or warnings about when tail strikes could occur during landing. The manufacturer did not provide the AF with airworthiness directives, service bulletins, or information concerning risks of tail strikes for "747 classic" aircraft (-100, -200, -300). Minutes from the last 10 years of E-4B Flight Manual Review Conferences do not show any discussion of tail strikes or bounce recovery. The E-4B flight manual warns about tail strikes on takeoffs. The E-4B flight manual is silent with regard to deviations from the 5 degree pitch angle for landing and the number of degrees above which a tail strike will occur on landing. As a result, operators of the airframe will not fully understand the risks they incur if they deviate from the 5 degree pitch to land the E-4B, or the degree of pitch that will result in a tail strike on landing.

The lack of operational guidance in the flight manual and the lack of aircrew training on avoiding tail strikes and responding to bounces substantially contributed to pilots' operating errors, which resulted in the mishap.

19 Jul 2010

SCOTT A. FOREST, Colonel, USAF
President, Accident Investigation Board