UNITED STATES AIR FORCE

AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

U-28A, T/N 07-0736
HURLBURT FIELD, FLORIDA

LOCATION: NEAR CAMP LEMONNIER, DJIBOUTI

DATE OF ACCIDENT: 18 FEBRUARY 2012

BOARD PRESIDENT: BRIG GEN TIMOHTY LEAHY

Conducted IAW AFI 51-503, *Aerospace Accident Investigations*

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EXECUTIVE SUMMARY
AIRCRAFT ACCIDENT INVESTIGATION

U-28A, T/N 07-0736
5 NM SOUTHWEST OF AMBOULI INTERNATIONAL AIRPORT, DJIBOUTI
18 FEBRUARY 2012

On 18 February 2012, at approximately 1918 local time (L), a United States Air Force U-28A aircraft, tail number 07-0736, crashed five nautical miles (NM) southwest of Ambouli International Airport, Djibouti. This aircraft was assigned to the 34th Special Operations Squadron, 1st Special Operations Wing, Hurlburt Field, FL, and deployed to the 34th Expeditionary Special Operations Squadron, Camp Lemonnier, Djibouti. The aircraft was destroyed and all four aircrew members died instantly upon impact.

The mishap aircraft (MA) departed Ambouli International Airport, Djibouti at 1357L, to accomplish a combat mission in support of a Combined Joint Task Force. The MA proceeded to the area of responsibility (AOR), completed its mission in the AOR and returned back to Djiboutian airspace at 1852L arriving overhead the airfield at 1910L to begin a systems check. The MA proceeded south of the airfield at 10,000 feet (ft) Mean Sea Level (MSL) for 10 NM then turned to the North towards the airfield, accomplished a systems check and requested entry into the pattern at Ambouli International Airport. This request was denied due to other traffic, and the MA was directed to proceed to the west and descend by Air Traffic Control (ATC). The MA began a left descending turn to the west and was directed by ATC to report final. The mishap crew (MC) reported they were passing through 4,000 ft MSL and would report when established on final approach. The MA, continuing to descend, initiated a right turn then reversed the turn entering a left turn while continually and smoothly increasing bank angle until reaching 55 degrees prior to impact. Additionally, the MA continued to steadily increase the descent rate until reaching 11,752 ft per minute prior to impact. The MC received aural “Sink Rate” and “Pull Up” alerts with no apparent corrective action taken. The MA impacted the ground at approximately 1918L, 5 NM southwest of Ambouli International Airport, Djibouti.

The MC never lost control of the aircraft; there are no indications of mechanical malfunction; and there are no indications the crew took any actions to control or arrest the descent rate and nose down attitude. The evidence demonstrates that the MC did not recognize the position of the aircraft and, as a result, failed to take appropriate corrective actions. The only plausible reason for the MC not recognizing the situation or reacting to aural alerts is the cognitive disconnect associated with spatial disorientation. The Board President found that the clear and convincing evidence indicated the cause of the mishap was unrecognized spatial disorientation. Additionally, the Board President found by a preponderance of the evidence that failing to cross-check and ignoring the “Sink Rate” caution substantially contributed to the mishap.

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.

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SUMMARY OF FACTS AND STATEMENT OF OPINION
U-28A, T/N 07-0736
18 FEBRUARY 2012

Table of Contents

COMMONLY USED ACRONYMS & ABBREVIATIONS

A&P	Airframe and Powerplant
AC	Aircraft Commander
AD	Airworthiness Directives
ADI	Attitude Display Indicator
ADO	Assistant Director of Operations
AFB	Air Force Base
AFE	Aircrew Flight Equipment
AFI	Air Force Instruction
AFSOC	Air Force Special Operations Command
AGL	Above Ground Level
AIB	Accident Investigation Board
AIMWTS	Aeromedical Information Management Waiver Tracking System
AIS	Advanced Instrument School
ALZ	Assault Landing Zone
AOA	Angle of Attack
AOR	Area of Responsibility
ATC	Air Traffic Control
ATO	Air Tasking Order
BFT	Blue Force Tracker
BP	Board President
BR	Board Recorder
CAMS	Core Automated Maintenance System
CAWS	Central Advisory and Warning Ssytem
CC	Commander
CDI	Course Direction Indicator
CLU	Containerized Living Unit
CP	Command Post
CSO	Combat Systems Officer
DC	District of Columbia
DE	Delaware
Det	Detachment
DME	Distance Measuring Equipment
DO	Director of Operations
DoD	Department of Defense
EGPWS	Enhanced Ground Proximity Warning System
ELT	Emergency Locater Transmitter
EP	Emergency Procedure
ESOS	Expeditionary Special Operations Squadron
FAA	Federal Aviation Administration
FCIF	Flight Crew Information File
FL	Florida
FLIR	Forward Looking Infrared
FMS	Flight Management System
fpm	Feet Per Minute
ft	Feet
Gen	Generator
GPS	Global Positioning System
HFACS	Human Factors Analysis and Classification System
HSI	Horizontal Situation Indicator
IA	Inspection Authorized
IF	Initial Approach Fix
ILS	Instrument Landing System
IS	Intelligence Squadron
ISB	Interim Safety Board
ISNS	Inertial Satellite Navigation System
ISR	Intelligence, Surveillance, and Reconnaissance
JOC	Joint Operations Center
JSOAD	Joint Special Operations Air Detachment
KIA	Killed in Action
KIAS	Knots Indicated Airspeed
L	Local Time
LA	Legal Advisor
M3	Modular Maintenance Management
MA	Mishap Aircraft
MC	Mishap Crew
MCP	Mishap Co-Pilot
MFD	Multifunction Display
MI	Michigan
MM	Medical Member
MOP1	Mishap Operator #1
MOP2	Mishap Operator #2
MP	Mishap Pilot
MQF	Master Question File
MS	Mishap Sortie
MSL	Mean Sea Level
MXM	Maintenance Member
NATO	North Atlantic Treaty Organization
NCIS	Navy Criminal Investigative Service
NM	Nautical Miles
NOTAM	Notices to Airmen
NSAv	Non-standard Aviation
NTSB	National Transportation Safety Board
NVG	Night Vision Goggles
OBS	Omni Bearing Selector
OH	Ohio
OI	Operating Instruction
OP	Operator
ORM	Operational Risk Management
OSI	Office of Special Investigations
PAE	Pacific Architects and Engineers
PCL	Power Control Lever
PERSTEMPO	Personnel Tempo
PHA	Preventative Health Assessment
PJ	Pararescue Jumper
PM	Pilot Member
PME	Professional Military Education
PMEL	Precision Measurement Equipment Laboratory
rad-alt	Radar Altimeter
SA	Situational Awareness
SAF	Secretary of the Air Force
SAV	Staff Assistance Visit
SITREP	Situational Report

SNC	Sierra Nevada Corporation	TO	Technical Order
SOCOM	Special Operations Command	TOC	Tactical Operations Center
SOF	Special Operations Forces	TSO	Tactical Systems Officer
SOP	Standard Operating Procedures	TV	Television
SOG	Special Operations Group	UAV	Unmanned Aerial Vehicle
SOS	Special Operations Squadron	USAF	United States Air Force
SOSS	Special Operations Support Squadron	V	Volume
SOW	Special Operations Wing	VFR	Visual Flight Rules
T/N	Tail Number	VOR	Visual Operating Restriction
TCAS	Traffic Collision Avoidance System	VVI	Vertical Velocity Indicator
TCN	Third Country National	WA	Washington
TF	Task Force	WV	West Virginia
TMO	Traffic Management Office	Z	Zulu Time

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 22 February 2012, Major General O.G. Mannon, Vice Commander, Air Force Special Operations Command (AFSOC), convened an Accident Investigation Board (AIB) in accordance with Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, to investigate the 18 February 2012 mishap involving U-28A aircraft, tail number (T/N) 07-0736, which crashed five miles southwest of Djibouti International Airport, Djibouti (Tabs J-88; N-11; Y-3). Brigadier General Timothy J. Leahy, United States Special Operations Command J7/9, MacDill Air Force Base (AFB), FL, was appointed AIB President (BP). A Pilot Member (PM), Maintenance Member (MXM), Medical Member (MM), Legal Advisor (LA), and Recorder (BR) were appointed to the AIB (Tab Y-3, -5). This investigation was conducted at Hurlburt Field, FL from 1 May 2012 through 18 May 2012 and 5 June 2012 through 15 June 2012.

b. Purpose

This is a legal investigation convened to inquire into the facts surrounding the aircraft or aerospace 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.

2. ACCIDENT SUMMARY

At 1357 local time (L), Camp Lemonnier, Djibouti, the mishap crew (MC) departed aboard the mishap aircraft (MA), a U-28A, T/N 07-0736, on a mission in support of a Combined Joint Task Force. (Tabs M-19; V-9.6) The MA was designated as Ratchet 33 for the mishap sortie (MS). (Tab K-3, -5) The MA departed uneventfully. (Tab EE-7) The MC completed their mission in their Area of Responsibility (AOR) and returned to Djiboutian airspace at 1852L. (Tab M-19) The MA approached the airfield from the South at 10,000 feet (ft) mean sea level (MSL) for systems checks. (Tabs N-6; JJ-5) The MC requested a descent for the right base, a right turn to final for runway 09, but the Ambouli control tower instead cleared the MC to descend west of the airfield due to traffic. (Tab N-6 to -7) The MC acknowledged and said that they would report for a left base, a left turn to final. (Tab N-7) At 1917L, the control tower told the MC to report final for runway 09, and the MC responded with “Ratchet 33 passing 4,000 feet in the descent west of the field, we’ll report final.” (Tab N-7) At 1918L, the MA entered into a steadily increasing left bank, eventually reaching 55 degrees of left bank. (Tab JJ-9) The descent rate increased from 2,985 feet per minute (fpm) to 11,752 fpm. (Tab JJ-9) Approximately seven seconds prior to impact, the Enhanced Ground Proximity Warning System (EGPWS) emitted an aural warning to the MC of “Sink Rate, Sink Rate.” (Tab JJ-9) Three seconds later, the EGPWS instructed the MC to “Pull up, Pull up.” (Tab JJ-9) The MA impacted the ground approximately four seconds later at North 11° 31.61’ East 043° 04.41’, an uninhabited area approximately 5 miles southwest of Ambouli International Airport. (Tabs JJ-9; N-11) All four crewmembers were killed on impact. (Tab X-3)

3. BACKGROUND

a. 1st Special Operations Wing

The 1st Special Operations Wing (1 SOW) at Hurlburt Field, FL, is one of two Air Force active duty Special Operations wings and falls under AFSOC. The 1 SOW mission focus is unconventional warfare, counter-terrorism, combat search and rescue, personnel recovery, psychological operations, aviation assistance to developing nations, "deep battlefield" resupply, interdiction and close air support. The wing has units located at Hurlburt Field, FL and Eglin Air Force Base, FL. (Tab FF-15)

The wing's core missions include aerospace surface interface, agile combat support, combat aviation advisory operations, information operations, personnel recovery/recovery operations, precision aerospace fires, psychological operations dissemination, specialized aerospace mobility and specialized aerial refueling. (Tab FF-15)

The 1 SOW also serves as a pivotal component of AFSOC's ability to provide and conduct special operations missions ranging from precision application of firepower to infiltration, exfiltration, resupply, and refueling of special operations force operational elements. In addition, the 1 SOW brings distinctive intelligence capabilities to the fight, including intelligence, surveillance and reconnaissance contributions, predictive analysis, and targeting expertise to joint special operations forces and combat search and rescue operations. (Tab FF-15)

b. 1st Special Operations Group

The 1st Special Operations Group (1 SOG), located at Hurlburt Field, FL, is one of four groups assigned to the 1 SOW. The group plans, prepares, and executes special operations, foreign internal defense, and security assistance worldwide in support of theater commanders. The 1 SOG also provides aircraft and instructors for the Air Force Special Operations Training Center school for the AC-130H/U Gunship, MC-130E/H Combat Talon I/II, and U-28 Pilatus qualification. (Tab FF-13)

In order to accomplish its special operations mission, the group employs more than 70 aircraft to provide day or night, all-weather access to hostile and/or denied airspace. More than 1,400 people are assigned to the group. There are ten squadrons within the group with one at a geographically separated location. (Tab FF-13)

c. 34th Special Operations Squadron

The 34th Special Operations Squadron was activated at Hurlburt Field, FL on 9 April 2010 to conduct special operations mission. They operate the U-28A aircraft, a variation of the Pilatus PC-12. (Tab FF-5)

d. 319th Special Operations Squadron

The 319th Special Operations Squadron (319 SOS) mission is to provide intra-theater support for special operations forces. To accomplish the mission, they use the U-28A, a variation of the Pilatus PC-12. (Tab FF-7)

e. 25th Intelligence Squadron

The 25th Intelligence Squadron (25 IS) is a selectively-manned and uniquely tasked unit, chartered to provide specialized intelligence across the spectrum of conflict. Squadron personnel are qualified to operate as aircrew on board every combat aircraft within the AFSOC inventory. By integrating all-source intelligence and electronic combat capability for special operations forces (SOF), the 25 IS has made Air Force Intelligence, Surveillance, Reconnaissance (ISR) Agency resources integral to SOF mission planning, rehearsal, and execution--truly highlighting AFSOC's motto: "One Team, One Fight." (Tab FF-9)

f. U-28A

The U-28A is part of AFSOC's Non-Standard Aviation (NSAv) fleet, and is operated by the 319 SOS and 34 SOS. Training is conducted by the 5 SOS and 19 SOS; all squadrons are located at Hurlburt Field, FL. The rapidly changing and diverse United States Special Operations Command (SOCOM) mission requirements generated a need for small numbers of mission specific aircraft which were procured rapidly to address specific mission needs. The NSAv fleet is a general program term and encompasses several light and medium aircraft performing utility missions for SOCOM. Overall, the NSAv mobility fleet untethers SOF from robust infrastructures, extended timelines and allows freedom of movement. (Tab FF-3)

The U-28A provides a manned fixed wing, on-call/surge capability for Improved Tactical Airborne ISR in support of SOF. (Tab FF-3)

The U-28A is a modified single engine Pilatus PC-12 that operates worldwide. The initial block of U-28 aircraft were procured and modified for use in Operations ENDURING FREEDOM and IRAQI FREEDOM. The U-28A fleet evolved from commercially available aircraft that were purchased and then modified with communications gear, aircraft survivability equipment, electro-optical sensors, and advanced navigation systems. The advanced radio-communications suite is capable of establishing Department of Defense (DoD)/North Atlantic Treaty Organization (NATO) data-links, full motion video, data, and voice communications. The U-28A has outstanding reliability and performance, and is certified to operate from short and semi-prepared airfields. (Tab FF-3)

All U-28A aircraft are maintained through contractor logistics support. (Tab FF-3)

4. SEQUENCE OF EVENTS

a. Mission

The MS was a combat sortie tasked in support of a Combined Joint Task Force. (Tab V-9.6) The MC consisted of a mishap aircraft commander (MP), copilot (MCP), operator 1 (MOP1), and operator 2 (MOP2).

b. Planning

The MS was planned the day prior by the Duty Desk Officer. (Tab V-9.5) The takeoff and landing data and the international flight plan (DD Form 1801) were all complete and accurate. (Tab K-3, -9) The Form 1801 was filed with Base Operations on 17 February 2012 for the MS. (Tab V-2.3) The Flight authorization orders, weather, and Notices to Airmen (NOTAM) were all completed by the Duty Desk Officer prior to the MC showing up for their flight. (Tab V-2.3) The MC was handed an aircraft weight and balance that was incorrect and showed the aircraft to be aft of the allowable center of gravity. (Tab K-7) This weight and balance was corrected after the mishap. (Tab V-9.5) The weight and balance given to the crew did not account for the life raft being moved forward which, in turn, moved the center of gravity into a flyable range. (Tab K-7) This corrected weight and balance was done after the mishap by the Duty Desk. (Tab V-9.5) The operational risk management (ORM) was filled out but did not reflect the required extra level of ORM due to the low moon illumination. (Tabs K-11 to -12, BB-3 to -4) It is unknown if the low moon illumination was briefed during the crew brief.

c. Preflight

The MC arrived at 1200L to the Tactical Operations Center (TOC) to look over the flight plan and receive the intelligence brief. (Tab EE-5) The MC briefed with the crew of Ratchet 26 on the emergency procedure of the day, the troubleshooting procedure of the day, and both crews received the intelligence brief together. (Tab EE-5) After those briefs, the crews separated and the MC executed the crew brief for the MS in a separate room. (Tab EE-6) The MC stepped to the MA at approximately 1300L, started the engine, taxied, and took off at 1357L. (Tab M-19)

d. Summary of Accident

The MA departed the airfield, climbed to altitude, and proceeded into the AOR uneventfully (Tab EE-7). The MC completed the assigned mission uneventfully and returned to Djiboutian airspace at 1852L. (Tab M-19) The MA arrived over the airfield at 10,000 ft MSL and was given permission by the Ambouli control tower to proceed to the South of the field for systems checks. (Tab N-6) The control tower told the MC to remain at 10,000 feet MSL due to traffic leaving the airfield. (Tab N-6) The MA proceeded south of the airfield at 10,000 feet MSL and turned back to a North heading to initiate the systems check. (Tab M-4) After the completion of the systems check, the MC requested a descent for the right base, a right turn to final for runway 09, but the Ambouli control tower instead cleared the MC to descend west of the airfield due to traffic. (Tab N-6 to -7) The MC acknowledged and said that they would report for a left base, a left turn to final. (Tab N-7)

According to testimony, the normal procedure for descending from 10,000 ft MSL to enter into the visual pattern at Ambouli at night and on Night Vision Goggles (NVGs) is to slow down below 177 knots indicated air speed (KIAS), lower the gear, then descend ensuring to not exceed 236 KIAS at 15 to 20 degrees nose low attitude. (Tab V-2.9 to -2.11, V-3.10 to -3.11) According to the radar tracks from the approach control radar at Ambouli, the MA was using this normal procedure to descend to the west. (Tab M-4 to -18) According to testimony; the MP would normally perform this maneuver on NVGs. (Tab V-2.9 to -2.11, V-3.10 to -3.11) The radar track shows a left descending turn with an initial descent rate of 6,000 fpm which slows to 2,400 fpm until an altitude of 6,300 ft MSL where the descent rate begins to climb to 8,400 fpm until leveling off at 4,400 ft MSL. (Tab M-5 to -13) The MA is level at 4,400 ft MSL for approximately 5 seconds until the MA begins another descent starting at 8,400 fpm. At 1917L, the MA is told by the control tower to report final for runway 09, and the MC responds with "Ratchet 33 passing 4,000 feet in the descent west of the field, we'll report final." (Tab N-7)

At 1917:52, and at 2,972 ft MSL, the onboard EGPWS shows a descent of 2,443 fpm and a 24.5 degree right turn with 195 knots ground speed. (Tab JJ-9) The EGPWS shows data every second and shows the MA in a relatively constant descent, a decreasing right turn, and decreasing ground speed for ten seconds. (Tab JJ-9) At 1918:04L, the MA enters into a steadily increasing left bank eventually reaching 55 degrees, while increasing the descent rate from 2,985 fpm to 11,752 fpm, and decreasing the ground speed from182 knots to 165 knots. (Tab JJ-9) Approximately seven seconds prior to impact, the EGPWS emitted an aural warning to the MC of "Sink Rate, Sink Rate," advising the MC that there was an excessive descent rate occurring. (Tab JJ-9) This warning occurred at 1,800 ft MSL, approximately 1,600 ft above ground level (AGL), with an approximate descent rate of 5,400 fpm. (Tab JJ-9) Another warning was issued by the EGPWS approximately four seconds prior to impact that instructed the MC to "Pull up, Pull up." (Tab JJ-9) This warning occurred at 1,302 ft MSL, approximately 1,102 ft AGL, with a 8,000 fpm descent rate and 174 knots ground speed. (Tab JJ-9) The last EGPWS data for the MA prior to impact is at 1918:18L and shows the MA was in a 55 degree left bank, 11,752 fpm descent rate, and at 165 knots ground speed. (Tab JJ-9) The times on the EGPWS are running clock time. To have accurate times, the radar track data, EGPWS data, and radio transmissions were compared to correlate the times to a synchronized time. (Tab JJ-3)

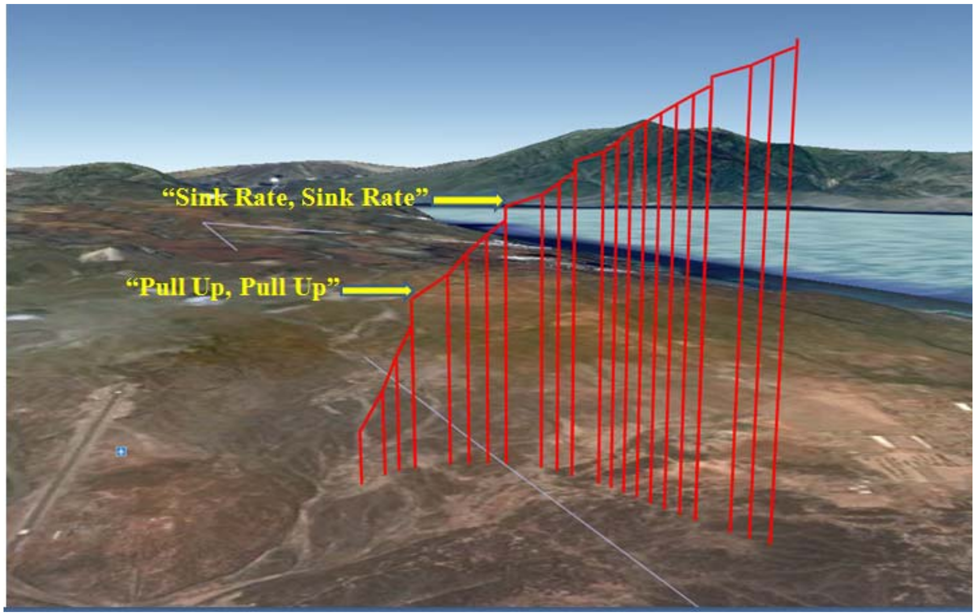

Figure 1. Descent profile provided by Enhanced Ground Proximity Warning System, looking west. (Tab J-89)

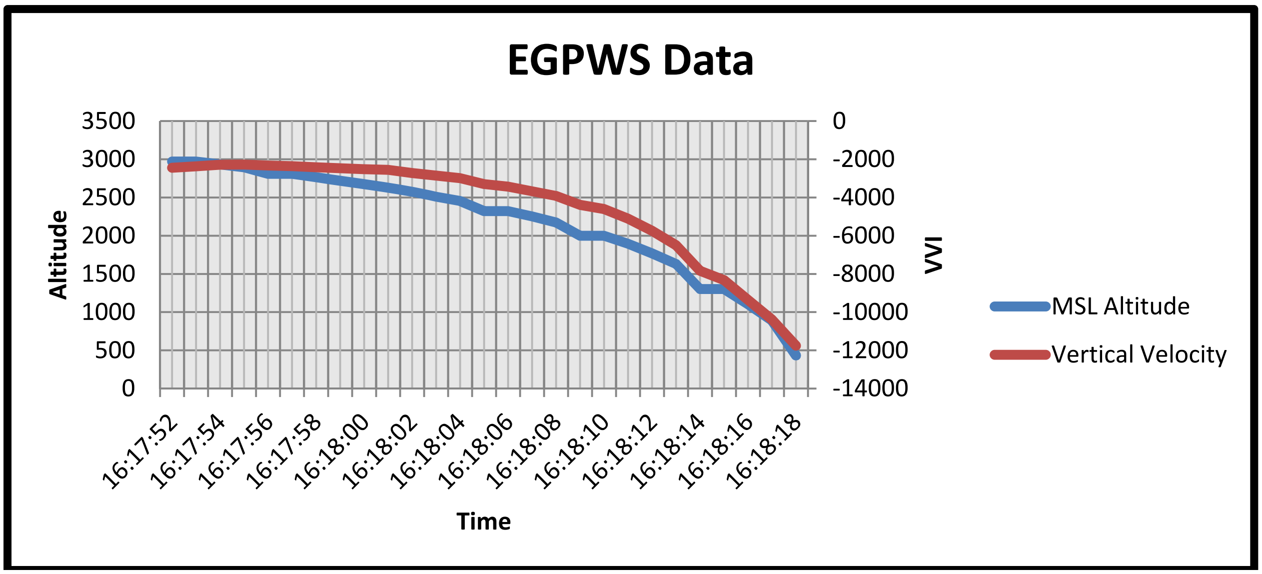

Figure 2. Enhanced Ground Proximity Warning System Data showing Altitude and Decent Rate in feet per minute**.** (Tab JJ-9)

e. Impact

The MA impacted the ground five miles southwest of Ambouli International Airport in an uninhabited and remote location strewn with boulders up to a two to three of feet in diameter, at North 11° 31.61' East 043° 04.41', 265 ft MSL. (Tab N-13) After initial impact, most of the MA cleared the ridgeline before breaking apart.

Figure 3. Aerial view of crash site from CH-53, looking west northwest.

f. Egress and Aircrew Flight Equipment

The U-28A is not equipped with ejection seats. All required life support and survival equipment inspections were up to date. (Tab K-35) There was no attempt to use the equipment after the mishap. Most of the life support equipment was found at the crash site to include weapons, radios, and handheld Global Positioning System (GPS) devices. (GG-3 to -5)

g. Search and Rescue

Approximately two minutes after the mishap, at 1919L, the control tower made five attempts to reach the MA over the radio with no success. (Tab N-7) A local national heard the crash and called the local police to report it around 1930L. (Tab N-15) Approximately 40 local police officers arrived on the scene and searched for survivors until U.S. military personnel arrived. (Tab N-16 to -17)

Approximately 16 minutes following the mishap, at 1935L, the crew of Ratchet 30 queried the control tower at Ambouli to find out if the MA had landed. (Tab N-8) The control tower began another query over the radio for the MA with no success. (Tab N-8) The control tower was notified by a host nation civilian that the MA crashed six miles southwest of the airfield. (Tab N-11) There is a 12-minute discrepancy between the tower mishap log and the Command Post (CP) log on when the notification came in about the MA. (Tab N-12 to -13) According to the CP log, the tower notified the CP at 1958L that the MA was reported down six miles southwest of the airfield. (Tab N-13) At 2009L, the Executive Camp Commander put the Fire Department unit on standby and called for all medical personnel to report to the Expeditionary Medical Facility. (Tab N-13, -16)

At 2011L, Hoss 61, two United States Air Force (USAF) F-15Es, were recalled to provide an overhead presence at the incident. (Tab EE-12) Hoss 61 arrived overhead at 2019L and descended to get a better look. At 2037L, Hoss 61 saw personnel moving around the site and reported seeing personnel to Ratchet 30. (Tab EE-12) At 2041L, Eagle 80, a USAF MQ-1, arrived overhead and reported seeing 3 hot spots, wreckage, 8 people, and two vehicles, including one with a light bar on top. (Tab EE-10) Hoss 61 returned to base by 2057L while Eagle 80 remained overhead. (Tab EE-10, -12)

Naval Criminal Investigative Service (NCIS) agents were the first U.S. military personnel on the ground at the scene and arrived at approximately 2100L with assistance from a local who knew the area. (Tab N-16) The crash site was located a few miles off a road and was difficult to reach. The NCIS agents determined that there were no survivors. (Tab N-16) At 2134L a Marine CH-53 helicopter arrived with an Army Quick Reaction Force and USAF Pararescue Jumpers (PJs). The lead PJ took over as the incident commander. (Tab N-16) At 2149L, the CP received the call that all four souls on board were killed in action. (Tab N-13)

h. Recovery of Remains

The deceased personnel (MP, MCP, MOP1, and MOP2) were recovered from the mishap site by the PJs and brought back to Camp Lemonnier. (Tab V-9.7) The remains were met at the gate by the 34th Expeditionary Special Operations Squadron (ESOS) Commander where American flags were draped over the remains before entering the camp and taken to the medical facility. (Tab V-9.7) The next day, a memorial was held at Camp Lemonnier for the MC. The remains were loaded onto a transport aircraft for the trip to Dover AFB, DE. (Tab V-9.7)

5. MAINTENANCE

a. Forms Documentation

(1) Discrepancy Records

Aircraft maintenance and inspections on the Pilatus U-28A/PC-12 aircraft are documented on Form 8-40001-1 Discrepancy Records. (Tab D-7 to -9) History of these maintenance and inspection actions is input and maintained in an electronic maintenance documentation system called M3. (Tab D-47 to -67) In addition to documenting routine and scheduled maintenance actions, these tools allow aircrews to report aircraft discrepancies and enable maintenance personnel to document the actions taken to resolve the reported issues. Documentation includes work instructions, planned action, corrective action taken, the maintenance personnel who corrected and inspected the maintenance action (if required), and the date the problem was corrected. Additionally, the discrepancy records and M3 provide maintenance personnel the information necessary to research past aircraft problems to more effectively troubleshoot and solve new maintenance discrepancies. (Tab D-7 to -9, -47 to -67)

Active discrepancy records are those that have not been corrected by maintenance personnel. These discrepancies are evaluated to determine whether they affect the aircraft’s airworthiness. Airworthiness is a term used to describe whether an aircraft has been certified as suitable for safe flight. Airworthiness is maintained by performing required maintenance actions by licensed maintenance personnel. If maintenance personnel determine discrepancies do not affect airworthiness, the aircraft can be flown without corrective action. There were three active discrepancy records at the time of the mishap flight, none of which affected airworthiness. (Tab D-7 to -9)

Record#	Discrepancy	Action Taken
B54558	Aux comm disconnected	Mission equipment, does not affect airworthiness
B42617	Line ready units removed	Doesn't affect airworthiness; verified weight/balance
B82130	Monitor soft keys not working	Bad USB cable; part on order; mission equipment, does not affect airworthiness

Table 1. Open Discrepancy Records.

Airworthiness Directives (ADs) are legally enforceable rules issued by the Federal Aviation Administration (FAA) in accordance with the Code of Federal Regulations, Title 14, Part 39, to correct an unsafe condition in an aircraft, aircraft engine, propeller, or appliance. There were seven ADs issued by the FAA for the MA since acceptance of the MA by the Air Force on 7 May 2007. (Tab II-7) Maintenance personnel complied with all seven ADs. They documented their actions on a discrepancy record and in M3. (Tab U-5 to -11)

A review of maintenance documentation was completed to determine whether historical records revealed any recurring maintenance problems on the MA. Discrepancy records and M3 documentation from 1 January 2011 to 18 February 2012 revealed no such recurring issues (Tab II-7).

(2) Aircraft Flight Hours/Engine Hours

Aircraft flight hours are tracked and documented to ensure that scheduled inspections are accomplished on time and to help determine overall wear and tear on the aircraft and its components. Prior to the MS, the MA had accumulated 8,981.8 total flight hours. Engine hours are tracked to monitor the total life of an engine, the total hours since last overhaul, the date of last install, and the hours since installation. Prior to the MS, the mishap engine, PT6A-67B, serial number PCE-PR0357, had accumulated 5,490.6 total engine hours. 2,023.4 hours had accumulated since the last overhaul on 2 June 2010. Overhauls are required every 3,500 hours on PT6A-67B engines. The mishap engine was installed on the MA on 9 August 2011. The mishap engine had accumulated 205.9 hours since installation. (Tab D-3)

b. Inspections

(1) Preflight/Postflight

Maintenance personnel complete an inspection prior to and after each flight, which are referred to as preflight and postflight inspections respectively. The purpose of these inspections is to visually inspect and operationally check various areas and systems of the aircraft in preparation for a flying period. The U-28A/PC-12 Pilot's Operating Handbook, Section 4, directs these inspections, which are documented on a daily flight log. (Tab BB-7 to -14) The daily flight log also includes other pertinent flight data: airframe and engine data, servicing log, flare status, time before next inspection, maintenance release and flight times. Documentation was completed as required for the preflight inspection, servicing, and maintenance release of the MA on the daily flight log, dated 18 February 2012. (Tab D-5)

(2) Progressive Inspection Program

The progressive inspection program is designed for high utilization aircraft. For every aircraft maintained under this program, a complete inspection cycle consists of six mini or minor inspections and six phase inspections at alternating intervals every 100 hours. This must be complied with while not exceeding 1200 hours time in service or 12 months, whichever comes first. The mini inspection consists of a visual inspection of the wing, tail, fuselage, landing gear, fluid levels, cabin, cockpit, propeller, engine oil filter, and fuel filter. The phase 1 through 6 inspections include all 100-hour and annual tasks as well as time limited and overhaul tasks that fall within 12 calendar months. Once the 1200-hour cycle and all inspections in the program are completed, the cycle starts over. (Tab U-15)

100-hour phase inspections may be completed and signed off between 10 hours prior to or after the due time without altering the due time of the next 100-hour inspection. (Tab U-15) A 400-hour Progressive Phase 2 inspection was conducted on the MA on 15 February 2012 (Tab D-66), 2.7 hours prior to the accumulated 100 hours (Tab U-3). The maintenance conducted in conjunction with the Phase 2 inspection is contained in the discrepancy records listed in M3. (Tab D-63 item 3 to D-67 item 2)

The MA flew five sorties totaling 26.6 hours between the 400-hour inspection and the MS. (Tab D-43, -44, -46) A documentation error was noted in the daily flight logs for those five sorties. Although the 400-hour inspection was complied with as previously mentioned, the 400-hour Phase 2 inspection was still listed as the next inspection due. (Tab D-43, -44, -46) This minor discrepancy had no bearing on the mishap.

c. Maintenance Procedures

Prior to launching an aircraft, many maintenance actions and procedures must be completed and documented to include servicing, preflight, maintenance release, and time before next scheduled inspection. Documentation of these actions is required on a daily flight log. The most common servicing operations include fuel, engine oil, and tire pressure. Preflight inspections are completed and documented prior to each sortie. Once the servicing log and preflight inspection is complied with, a review of discrepancy records and M3 is conducted to ensure there is no maintenance action ongoing that would affect airworthiness of the aircraft. Once complete, a FAA certified Airframe and Powerplant (A&P) mechanic signs the maintenance release section. (Tab D-5)

At the end of the day's flying period, additional actions are required. A postflight inspection is completed to verify the continued airworthiness of the aircraft. The day's sorties are tallied to keep track of aircraft and engine operating time. This is recorded in M3 to ensure time tracked components are changed per the items' life expectancy, while also ensuring scheduled inspections are completed when required. The type of the next upcoming inspection and hours until due are included on the daily flight log. (Tab D-15 to -46)

d. Maintenance Personnel and Supervision

The Sierra Nevada Corporation (SNC) is a contractor logistics support organization that provides maintenance for the U-28A/PC-12 at Hurlburt Field, FL and any forward deployed locations. SNC employs FAA certified A&P mechanics, FAA certified Inspection Authorized (IA) mechanics and avionics specialists to maintain the U-28A/PC-12. The SNC A&P mechanics complete a theoretical and practical familiarization program on servicing and maintenance within the context of the Pilatus PC-12 maintenance manual on airframe, powerplant, controls and associated systems, including engine ground runs and taxi operations. Avionics mechanics complete a theoretical and practical familiarization program on servicing and maintenance within the context of the Pilatus PC-12 maintenance manual on electrical systems, airframe, power plant controls, reduced vertical separation minimum requirements, along with all avionics systems, including engine ground runs and taxi operations. (Tab II-7)

SNC maintains a training record for each SNC maintenance member that includes, if applicable: job description, A&P certification, Inspection Authorization, certificates of training, familiarization training documentation, prior aircraft training, on-the-job training and Air Force deployment-related computer based training. Maintenance training records were reviewed for the SNC personnel deployed to Djibouti with the U-28A aircraft. The training records for personnel who worked on the MA met or exceeded FAA requirements. (Tab II-7)

e. Fuel and Oil Inspection Analyses

(1) Fuel

SGS Oil, Gas and Chemical Services of Djibouti conducted analysis of the JP-5 fuel used in the MA to ensure it was not a factor in the mishap. Analysis included tests for appearance, density, flashpoint, particle matter, and filtration time. Results cited in the completed certificate of analysis were unremarkable. (Tab D-71)

(2) Oil

An engine oil-servicing cart, serial number 7944101201, was used on 15 February 2012 to service the MA. A review conducted on the cart’s serviceable equipment tag showed documentation of the required monthly inspection on 2 February 2012 and six-month filter replacement on 18 December 2011. (Tab D-73) Aviation Laboratories analyzed an oil sample collected from the servicing cart to ensure it was not a factor in the mishap. Results cited in the completed analysis were unremarkable. (Tab D-75)

Given the extensive physical damage to the engine from the mishap, normal collection of the oil sample was not possible. However, an oil sample was collected post mishap from the remains of the mishap engine’s oil cooler and forwarded to Aviation Laboratories for analysis. The sample consisted of debris sent in a jar that included a major amount of dirt and grit. Metal that was found in the debris consisted of 1 piece of stainless steel, 100 fine wear pieces of carbon steel, and 60 fine wear pieces of alloy steel. The two most recent analysis reports for the mishap engine oil cooler prepared prior to the MS stated that the samples appeared normal. (Tab D-77)

(3) Unscheduled Maintenance

As mentioned above in paragraph 5.b.2., the last scheduled inspection was completed on 15 February 2012. Between the 400-hour Progressive Phase 2 inspection and the MS, aircrew reported three discrepancies, resulting in unscheduled maintenance. Each discrepancy was reported on a discrepancy record and documented in M3. (Tab D-67) SNC personnel conducted maintenance on each system and cleared all three discrepancies after operation checks were normal. Each unscheduled maintenance action involved mission equipment that would not impact airworthiness.

6. AIRFRAME SYSTEMS

a. Structures and Systems

The condition of the MA rendered many components destroyed beyond recognition and/or damaged to a state that would not allow for analysis or evaluation. The only sections of the aircraft that were mostly intact were the right wing and tail (vertical and horizontal stabilizer). This type of aircraft is not equipped with a cockpit voice recorder or a flight data recorder. However, several structures and systems were recovered in a condition that could be evaluated and considered potentially relevant to the mishap investigation. None of the parts recovered indicated a problem with the MA prior to the impact.

(1) Mishap Engine

a. Powerplant

Pratt & Whitney Investigation Facilities in Bridgeport, WV evaluated the recovered mishap engine. The evaluation concluded that damage to the lower gas generator case suggested that the engine and aircraft were upright when they impacted the ground. Further investigation revealed that the 1st stage compressor blades were bent opposite the direction of rotation, which indicated that the blades were rotating upon impact. Rubbing between several components and the sheared turbine shaft was linked to impact loads and internal/external housing deformation. The Pratt & Whitney investigation concluded that: “The engine displayed contact signatures to its internal components characteristic of an engine producing power at the time of impact. The engine did not display any evidence of any pre-impact distress or anomalies that would have prevented normal engine operation prior to impact.” (Tab J-39)

b. Propeller

Some propeller components from the mishap engine were able to be recovered and sent to Hartzell Propeller Inc. in Piqua, OH for evaluation. Due to damage to the parts, and some parts never being recovered, a significant assessment of the propeller was not possible. Nevertheless, an impact mark between the piston and cylinder was noted. This mark could indicate a blade angle lower than the flight idle position; however, the evaluation notes that impact often drives the pitch change mechanism toward a lower blade angle. Several reasons were given for why it is unlikely that this mark reflects a pre-impact blade angle. (Tab J-72) The Hartzell Propeller investigation concluded that: "An evaluation of power output could not be determined. Damage was indicative of frontal impact at high speed. There were no discrepancies noted that would preclude normal operation. All damage was consistent with impact damage." (Tab J-72)

(2) Enhanced Ground Proximity Warning System

The EGPWS was recovered and forwarded to Honeywell in Redmond, WA for analysis. The report noted that the most up-to-date version of the terrain database was not in use. Honeywell confirmed that the outdated database did not affect EGPWS operation due to airport/terrain information near Djibouti remaining unchanged between the version in use and the most updated version. (Tab J-87) The EGPWS unit was heavily damaged, but the flash chip on the circuit board that contains flight history non-volatile memory was not damaged. Honeywell was able to make a full download of the flight history by removing the chip from the board and installing it in a chip reader. All indications suggest the EGPWS was fully functional at the time of the mishap. (Tab J-88) The data from the flash chip was processed and used by investigators to recreate the last 27 seconds of the MA's flight track. (Tab JJ-3 to -8)

(3) Attitude Indicator

One of the MA's standby attitude indicators was recovered and forwarded to L3 Communications Avionics Systems in Grand Rapids, MI for evaluation. Based on external evaluation of the component it was determined that during the mishap, both the mechanical and electrical components of the attitude indicator were damaged extensively. L3 noted the gimbal alignment and damage to the rotor suggested that the aircraft may have been in a steep dive of up to 70 degrees nose down. L3 evaluation concluded that "the unit showed no evidence of abnormal operation prior to the mishap." (Tab HH-3) The 70 degrees nose down is inconsistent with the flight data recovered from the EGPWS and may reflect a position after initial impact. (Tab JJ-9)

(4) Flight Control Trim Tabs

The horizontal stabilizer trim, aileron trim, and rudder trim actuators were removed from the wreckage and forwarded to Pilatus for evaluation. The purpose of the evaluation was to determine the position of each flight control trim at the time of the mishap.

a. Horizontal stabilizer trim

The horizontal stabilizer trim actuator was still intact and connected to the horizontal stabilizer post mishap. The actuator was removed from its mount position within the vertical stabilizer. Horizontal stabilizer trim position was determined by measuring the extension rod of the actuator. The measurement was consistent with a trim setting of nearly neutral. (Tab HH-21) The Pilatus report states that the post-mishap position of the trim actuator would be identical to the pre-mishap position assuming that there was no internal damage to the actuator. The forward portion of the horizontal stabilizer was severely impacted and damaged during the mishap. The trim actuator, which mounts to the forward portion of the stabilizer, also showed evidence of impact at the lower mount, which was cracked and bent roughly 30 degrees from normal. (Tab HH-25 to -26) Due to the damage, internal evaluation of the actuator was conducted by the Air Force Research Laboratory at Wright-Patterson AFB, OH. A thorough examination showed no damage to the internal components of the actuator that would suggest the post-mishap position was different from the pre-mishap position. (Tab HH-37 to -38)

b. Aileron trim

The aileron trim actuator is attached only to the left wing aileron trim tab. Even though the left wing and actuator were severely damaged during the mishap, it was still possible to determine the aileron trim position by measuring the extension rod of the actuator, which was still intact. (Tab HH-16) The measurement was consistent with a slight left aileron trim, which is within normal takeoff range, which is appropriate for this phase of flight. (Tab HH-17)

c. Rudder trim

The rudder trim actuator was still intact and undamaged post mishap. The actuator was removed from its normal mount position inside the vertical stabilizer. The rudder trim position was determined by measuring the extension rod of the actuator. The measurement was consistent with full left rudder trim. (Tab HH-18) When the yaw damper is engaged and active, the auto trim function is also active. The yaw damper provides turn coordination for the aircraft's yaw axis through an auto trim function that automatically operates the aircraft's rudder trim system. (Tab U-17 to -18) It is normal practice to engage the yaw damper shortly after takeoff and only disengage it prior to landing. The yaw damper is required to be in the off position prior to takeoff and landing. (Tab BB-15) Otherwise, it is normal to have the yaw damper engaged during flight to auto trim the rudder trim system. Full left rudder trim position is possible when the yaw damper is commanding the trim position in a left hand turn, as was the case during the last 13 seconds of the MS, which is consistent with the yaw damper being engaged and active. (Tab JJ-7)

(5) Flaps

The flaps were evaluated to determine the position at the time of the mishap. Each wing has two jackscrew type flap actuators. Three of the four actuators were recovered from the wreckage and evaluated by Pilatus to determine flap positioning. The fourth actuator could not be located. Each of the three flap actuator jackscrews were sheared off during the mishap. However, Pilatus was able to conclude that each actuator was at the "in" position, which correlates to flaps up. (Tab HH-13 to -14) The flaps should have been in the up position due to the airspeed prior to the mishap. The airspeed limitation for flap operation to 15 degrees is 163 KIAS and greater than 15 degrees is 130 KIAS. (Tab BB-6) The lowest airspeed recorded during the mishap sequence is 165 knots ground speed, one second prior to impact. (Tab JJ-9)

(6) Airspeed Indicator

The face of the MA's airspeed indicator was recovered and forwarded to the National Transportation Safety Board (NTSB) in Washington, DC for evaluation. There was a clear indicator mark identified at the 350-knot position. The NTSB determined that the mark identified was made by the max allowable indicator needle, not the airspeed needle. There were no other marks found on the face consistent with indicator needle marks; therefore, the airspeed needle position at the time of the mishap could not be determined. (Tab HH-27 to -31)

(7) Emergency Locator Transmitter

The Emergency Locator Transmitter (ELT) was recovered and forwarded to ACR Electronics for evaluation to determine if the beacon activated post mishap. The on/off switch was damaged and not functional. The battery assembly and ELT encasement was torn open, but the battery was still in place. Nevertheless, battery usage data could not be retrieved. During the ELT investigation, a test connector was installed and the component was activated manually, but "no signals on any frequency were emitted from the ELT." (Tab HH-24)

(8) Other Evaluated Components

There were several other components examined in an attempt to capture all possible mishap data. Both LCR-100s from the Altitude Heading Reference System (Tab HH-12), both of the Air Data Modules (Tab HH-9), the stick pusher computer (Tab HH-12), and the Air Data Computer (Tab HH-13) were all evaluated to determine whether any significant information could be retrieved. No relevant information could be recovered from any of the components.

7. WEATHER

a. Forecast Weather

At brief time, weather for takeoff was forecast to have a scattered layer of clouds at 4000 ft AGL with the winds from the east, 080 degrees at 12 knots gusting to 18 knots and unlimited visibility. (Tab F-7) The forecast weather at the time of landing was clear skies with winds from the Southeast, 120 degrees at 6 knots and unlimited visibility. (Tab F-7) There were no forecasted thunderstorms for the area and route of flight. Sunset was at 1815 local time and moonrise was at 0414 local time on 19 February 2012 with a moon illumination of 9%. (Tab F-7) End of Evening Nautical Twilight was 1901L, the time when the sun's light is below the horizon. (Tab F-7) At the time of the incident, the moon was not up and the sun was down. (Tab F-7)

b. Observed Weather

At the time of the mishap, Camp Lemonnier was reporting skies clear with winds from the east, 110 degrees at 6 knots and unlimited visibility. (Tab F-3) Weather given to the MC by Djibouti approach control when the MA entered Djiboutian airspace was: winds from the east at 120 degrees and 9 knots, visibility 15 kilometers (over 9 miles), few clouds at 600 meters (about 2000 ft), temperature 27 degrees Celsius (80 degrees Fahrenheit), and the altimeter setting of 1012 millibars (29.88 inches of mercury), which is barometric pressure adjusted to sea level. (Tab N-3) Post-mishap weather, recorded at 1955L was a few clouds at 2000 feet AGL, winds from the east, 110 degrees at 5 knots and unlimited visibility. (Tab F-3) Weather was not a factor in the mishap.

c. Space Environment

Not applicable.

d. Operations

Based on the forecast, the weather was within limits for the mission. Operations were conducted in accordance with applicable directives.

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was a current and qualified Evaluator Pilot with 2316.8 total flight hours including 2213.1 hours in the PC-12/U-28A, 1403.3 hours of combat, 903.2 hours with NVGs, 547 total sorties, and 273 combat sorties. (Tab G-7 to -19, -73) The MP arrived at Camp Lemonnier, Djibouti on 16 January 2012 and was on his ninth combat deployment. (Tab DD-3) The MP was on the 20th combat sortie for his current deployment. (Tab G-17 to -19)

The MP had been previously deployed to Djibouti from September to October 2010. (Tab DD-3) The MP was last deployed from 11 June 2011 to 3 September 2011 and returned to Hurlburt Field for four months prior to this deployment. (Tab DD-3) During this time, the MP upgraded to Evaluator Pilot. (Tab T-8)

The MP was an Advanced Instrument School (AIS) graduate and was considered to be a conservative pilot. (Tab V-6.4, -6.25 to -6.26) The MP was known to be a pilot that flew both looking outside the cockpit for visual reference and inside the cockpit backing up with instruments, and would always have backup instrument approaches loaded even in visual flight rules (VFR) conditions. (Tab V-2.7, -2.8, V-6.4) According to other members of the squadron, the MP was a good instructor that tried to impart knowledge on the crew force. (V-6.4, -6.25 to -6.26)

At the time of the mishap, the MP's recent flight time was as follows (Tab G-9):

	Hours	Sorties
30 Days	94.8	19
60 Days	110.5	24
90 Days	132.4	32

Table 2. Mishap Pilot's 30/60/90 Day Flying Report.

b. Mishap Copilot

The MCP was a current and qualified Mission Pilot with 1245.9 total flight hours including 1245.1 hours in the PC-12/U-28A, 817.4 hours of combat, 439.7 hours with NVGs, 270 total sorties, and 151 combat sorties. (Tab G-25 to -27, -83) The MP arrived at Camp Lemonnier, Djibouti on 16 February 2012 and was on his fourth combat deployment. (Tab DD-4) The MCP was on his first sortie for the current deployment (Tab G-35). The MCP had been previously deployed to Djibouti from 13 May to 19 July 2011 and returned to Hurlburt Field for six months prior to this deployment. (Tab DD-4)

The MCP was known to be a very detail oriented pilot that would use a crew mentality on every flight. (Tab R-4 to -5) The MCP was a highly regarded officer and a real stand up individual. (Tab R-88) The MCP was known to be very engaged in the flight, even when not at the controls. (Tab R-4 to -5)

At the time of the mishap, the MCP's recent flight time was as follows (Tab G-27):

	Hours	Sorties
30 Days	10.8	3
60 Days	20.9	6
90 Days	56.6	17

Table 3. Mishap Copilot's 30/60/90 Day Flying Report.

c. Mishap Operator 1

The MOP1 was a current and qualified Combat Systems Officer with 554.8 total flight hours all in the PC-12/U-28A, 430 hours of combat, 114 total sorties, and 79 combat sorties. (Tab G-39 to -41, -91) The MOP1 arrived at Camp Lemonnier, Djibouti on 16 February 2012 and was on his third combat deployment. (Tab DD-4) The MOP1 was on his first combat sortie for the current deployment. (Tab G-51) The MOP1 had been previously deployed to Djibouti from 29 October to 18 December 2011 and returned to Hurlburt Field for two months prior to this deployment. (Tab DD-4)

The MOP1 was a very highly regarded officer in the squadron. (Tab R-88)

At the time of the mishap, the MOP1's recent flight time was as follows (Tab G-41):

	Hours	Sorties
30 Days	11.1	3
60 Days	16.3	5
90 Days	121.9	24

Table 4. Mishap Operator 1's 30/60/90 Day Flying Report.

d. Mishap Operator 2

The MOP2 was a current and qualified Tactical Systems Operator with 924.1 total flight hours, 153.7 hours in the PC-12/U-28A, 845.6 hours of combat, 226 total sorties, and 205 combat sorties. (Tab G-56 to -59, -97) The MOP2 arrived at Camp Lemonnier, Djibouti on 20 January

2012 and was on his third combat deployment. (Tab DD-5) The MOP2 was on his 16th combat sortie for the current deployment. (Tab G-71 to -72)

This was the MOP2's first deployment to Djibouti and was last deployed from 24 June 2011 to 15 September 2011. (Tab DD-5) He returned to Hurlburt Field for four months prior to this deployment.

The MOP2 was a detail oriented person that was always seen studying the job at hand and gathering as much knowledge as possible on the mission tasks. (Tab R-106)

At the time of the mishap, the MOP2's recent flight time was as follows (Tab G-57):

	Hours	Sorties
30 Days	74.5	15
60 Days	74.5	15
90 Days	77.9	16

Table 5. Mishap Operator 2's 30/60/90 Day Flying Report.

9. MEDICAL

a. Qualifications

The MP was medically qualified to perform flying duties at the time of the incident. His most recent Preventative Health Assessment (PHA) was performed on 21 December 2011, and he was issued a Medical Recommendation for Flying or Special Operational Duty (Air Force Form 1042) indicating that he was cleared for duty following his periodic medical examination. It was noted that the MP required vision correction devices such as glasses or contacts while performing flight duties. (Tab DD-10) MP was enrolled in the Aircrew Soft Contact Lens Program and was current in this program with his most recent optometry appointment occurring on 15 April 2011. A review of Aeromedical Information Management Waiver Tracking System (AIMWTS) indicated that the MP never required a medical waiver. (Tab X-3)

The MCP was medically qualified to perform flying duties at the time of the incident. His most recent PHA was performed on 20 January 2012, and he was issued a Form 1042 indicating that he was cleared for duty following his periodic medical examination. (Tab DD-9) A review of AIMWTS indicated that the MCP had a valid medical waiver to allow him to fly. The waiver was granted by AFSOC and was valid until 31 January 2013. (Tab X-3)

The MOP1 was medically qualified to perform flying duties at the time of the incident. His most recent PHA was performed on 3 February 2012, and he was issued a Form 1042 indicating that he was cleared for duty following his periodic medical examination. (Tab DD-7) A review of AIMWTS indicated that the MOP1 never required a medical waiver. (Tab X-3)

The MOP2 was medically qualified to perform flying duties at the time of the incident. His most recent PHA was performed on 26 May 2011, and he was issued a Form 1042 indicating that he was cleared for duty following his periodic medical examination. (Tab DD-8) A review of AIMWTS indicated that the MOP2 never required a medical waiver. (Tab X-3)

b. Health

The outpatient medical and dental records as well as the military electronic medical record for each member of the MC were reviewed. No significant health issues were identified for any member of the MC. (Tab X-3)

c. Pathology

The remains of the MC were transported to Dover Port Mortuary at Dover AFB, DE. Autopsies were performed and the cause of death was determined to be multiple injuries for each of the MC. Toxicology tests were performed on each of the MC with no evidence of unapproved medication use. There was no evidence of alcohol or any illegal substance playing a role in the accident. The MP was noted to have a carboxyhemoglobin level of 8%. Levels below 10% are considered normal in a post-mortem sample. (Chaturvedi, Arvind K., "Aviation Combustion Toxicology: An Overview," *Journal of Analytical Toxicology*, Vol. 34, 2010)

d. Lifestyle

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

e. Crew Rest and Crew Duty Time

AFI 11-202, Volume 3, indicates that the crew rest period is normally at least a 12-hour non-duty period before the aircrew enters the flight duty period. The purpose of crew rest is to ensure the aircrew member is adequately rested before performing flight or flight related duties. Crew rest is free time, and includes time for meals, transportation and rest. Aircrew members require at least 10 continuous hours of restful activities (including an opportunity for at least 8 hours of uninterrupted sleep) during the 12 hours immediately prior to the flight duty period.

The MC was afforded adequate crew rest in the time leading up to the accident. However, on the day prior to the incident, there was an exercise scenario at the deployed location. Announcements regarding this exercise were broadcast to the base utilizing a loudspeaker system. One of the speakers for the system was located near the sleeping quarters of the aircrew. (Tab V-4.18) A lost sleep list was initiated by the MP to document any crew members in the squadron that had their sleep interrupted by the exercise announcements. (Tab V-4.23) Only one member of the MC, the MOP1, was included on the lost sleep list (Tab K-23), although his roommate reported that he appeared to have slept well (Tab EE-3). Even though the MP did not put his name on the list, he mentioned that the exercise announcements did affect his sleep. (Tab V-4.23) The ORM worksheet, a risk management tool that was filled out by the MC prior to the flight, showed that the MC determined that the risk stemming from preflight fatigue was low. (Tab K-11)

The deployed unit utilized a block schedule system to minimize the effects of changing duty times on the Airmen's circadian rhythm. Aircrew were placed into a certain block of time for scheduling purposes and they stayed in this block allowing the aircrew to maintain a regular schedule. The MP had recently been given additional duties as a mission commander. Along with this came a shift to a later block. (Tab R-24) This allowed the MP to attend meetings that came along with his additional duties. The MP was left off of the flying schedule for two days prior to the mishap to allow him time to adjust to the new block time. (Tab G-18)

10. OPERATIONS AND SUPERVISION

a. Operations

At the time of the mishap, the 34 ESOS was running operations 24 hours a day, seven days a week. The operations tempo was robust with 16 sorties spread out over every 24 hour period. The sorties were divided up through block scheduling so that the crews' circadian rhythm would not be affected. The leadership tried to keep crews in the same blocks and if crews had to change blocks, they would get two days off in between to adjust the circadian rhythm. (Tab V-9.3) The crewmembers continuously rotate through the deployed location as the squadron has been continuously deployed there. The MP deployed to Djibouti on 16 January 2012 and was on his third Djibouti deployment with 2,316 total hours of flight time. (Tabs DD-3, G-8) The MCP deployed to Djibouti on 14 February 2012 and was on a third deployment to Djibouti with 1,245 total hours of flight time. (Tabs DD-4, G-25) The MOP1 deployed to Djibouti on 14 February 2012 and was on his third deployment to Djibouti with 554 total hours of flight time. (Tabs DD-4, G-39) The MOP2 deployed to Djibouti on 20 January 2012 for his first deployment to Djibouti with 924 total hours of flight time. (Tabs DD-5, G-56) The MS was the first sortie on this deployment for the MCP and the MOP1 and thus the MC had not flown together on this deployment before the MS. (Tab G-27, -41)

There is no evidence to suggest that squadron operations tempo was a factor.

The mission was properly authorized and approved by the 34 ESOS Commander. (Tab K-5) A records review showed that all MC were current and qualified to participate in the scheduled sortie. (Tab G-3 to -71) The flight planning was done by the duty desk prior to the MS to include flight plan, weather, NOTAM, and weight and balance. (Tabs V-9.5, K-3 to -16) The weight and balance incorrectly showed the life raft placement in the rear of the aircraft and was corrected post incident at the request of the 34 ESOS Commander. (Tabs K-7, V-9.5) The ORM worksheet, which was filled out by the MC, made no mention of the low illumination that was planned for the night of the incident nor, as required by AFI 11-2U28, Volume 3, paragraph 6.18.1, which requires an extra level of ORM when moon illumination is less than 10%. (Tab K-11 to -12, BB-3 to -4) The forecasted moon illumination for the night of the mishap was 9%, which should have required an extra level of ORM, but was not accounted for on the ORM worksheet. (Tab F-7) The MC briefed on their own, so it is unknown if the crew brief included a discussion about the low moon illumination and the visual illusions that can accompany it. (Tab EE-6)

There is no evidence to suggest deployed procedures, planning, preparation and briefing were a factor.

b. Supervision

The leadership of the 34 ESOS provided adequate supervision. The leadership identified fatigue as a potential issue due to the 24/7 operations tempo of the deployed unit and implemented measures such as block scheduling and down days if the aircrew's schedule needed to shift. (Tab V-9.4) The leadership also implemented a policy in which on the first sortie of the deployment, the new pilot will observe the take-off and landing and not perform them. (Tab V-9.3) The MC was a mixed crew from different squadrons. The MP was a member of the 319 SOS, the MC and MOP1 were members of the 34 SOS, and the MOP2 was a member of the 25 IS. All MC were well trained for the mission and the deployment. (Tab K-5)

There is no evidence to suggest that deployed supervision was a factor.

11. HUMAN FACTORS ANALYSIS

a. Overview

The DoD Human Factors Analysis and Classification System (HFACS) is a system that allows for categorization of human factors when it comes to investigating mishaps. (AFI 91-204, *Safety Investigations and Reports*, 24 September 2008, Attachment 5) Human factors are not just about the humans. They are about how features of people's tools, tasks and working environment systematically influence human performance. The HFACS model is designed to present a systematic, multidimensional approach to error analysis. The HFACS system describes four main levels of human factors that may have contributed to the mishap. These four levels are Acts, Preconditions, Supervision and Organizational Influence and are described in more detail below:

> Acts are those factors that are most closely tied to the mishap, and can be described as active failures or actions committed by the operator that result in human error or an unsafe situation. Acts may be either errors or violations. Errors are factors in mishaps when mental or physical activities of the operator fail to achieve their intended outcome as the result of skill-based, perceptual, or judgment and decision making errors leading to an unsafe situation. Errors are unintended. Violations are factors in a mishap when the actions of the operator represent willful disregard for rules and instructions and lead to an unsafe situation. Violations are deliberate.
>
> Preconditions are factors in a mishap if active and/or latent preconditions such as conditions of the operators, environment or personal factors affect practices, conditions or actions of individuals and result in human error or an unsafe situation.
>
> Supervision is a factor if the methods, decisions or policies of the supervisory chain of command directly affect practices, conditions, or actions of individuals and result in human error or an unsafe situation.

Organizational influences are factors in a mishap if the communications, actions, omissions or policies of upper-level management directly or indirectly affect supervisory practices, conditions or actions of the operator(s) and result in system failure, human error or an unsafe situation.

Multiple interviews were conducted and volumes of documents were reviewed to support human factors analysis. The unavailability of eyewitness accounts and cockpit voice recordings were significant limiting factors. However, based on the evidence recovered from the mishap, the board considered the following human factors and found them to be relevant:

b. PC508 Spatial Disorientation (Type 1) Unrecognized

Spatial Disorientation is a failure to correctly sense a position, motion or attitude of the aircraft or of oneself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical. Spatial Disorientation (Type 1) Unrecognized is a factor when a person's cognitive awareness of one or more of the following varies from reality: attitude; position; velocity; direction of movement or acceleration. Proper control inputs are not made because the need is unknown. (AFI 91-204)

There is no evidence that there was a mechanical failure with the MA. There is no evidence for a sudden medical incapacitation prior to impact with any of the MC. The flight profile flown by the MC is consistent with spatial disorientation. There is no indication that the MC applied any flight control inputs showing that they were aware of the correct position of the MA, which is indicative of unrecognized spatial disorientation. (Tab JJ-9) Unrecognized Spatial Disorientation would explain the failure of the MC to take corrective action in response to the position of the MA.

c. PC503 Illusion – Visual

Illusion – Visual is a factor when visual stimuli result in an erroneous perception of orientation, motion or acceleration, leading to degraded performance. (AFI 91-204)

The MA was sent to the west of the airfield because of traffic in the pattern. (Tab N-7) This area has minimal cultural lighting (Tab V-4.11 to -4.12) and a "black hole" was described out to the west and south of the airfield. (Tab V-6.11, -6.19) At the time of the mishap there was no lunar illumination. (Tab F-7) With the use of NVGs the field of view is limited and depth perception is reduced. This reduction in visual clues could have caused the MC to have a false perception of their altitude, attitude and descent rate. This could have caused the MC to become spatially disoriented.

d. PC502 Illusion – Vestibular

Illusion – Vestibular is a factor when stimuli acting on the semicircular ducts or otolith organs of the vestibular apparatus cause the individual to have an erroneous perception of orientation, motion or acceleration leading to degraded performance. (AFI 91-204)

The G-excess illusion occurs when a pilot enters a greater than 1 G (1 times the force of gravity) turn with the aircraft, looks back into the turn and experiences the sensation that the aircraft is leveling out from the roll and having a pitch up attitude. Given this input the pilot will often apply more bank and nose-down pitch in order to maintain the desired bank angle and pitch. (Newman, David G, *An overview of spatial disorientation as a factor in aviation accidents and incidents*, Flight Medicine Systems Pty Ltd, Dec 2007) The unintended consequence is that the aircraft experiences significant overbank and descent. (Tab Z-5) In a situation where the aircraft is already at a low altitude, this could cause a controlled flight into terrain. The G-excess illusion causes pilots to increase bank angle and pitch forward as they perceive the aircraft to be leveling out and pitching up, which matches the mishap flight profile. (Tab JJ-9) This could have caused the MC to become spatially disoriented.

e. AE205 Caution/Warning – Ignored

Caution/Warning – Ignored is a factor when a caution or warning is perceived and understood by the individual but is ignored by the individual leading to an unsafe situation. (AFI 91-204)

When replicating the flight parameters in the simulator, the MA could be controlled and pulled out of the descent if the MC had applied the correct flight control inputs when auditory alerts were given by the EGPWS. There is no evidence to indicate that the MC applied any corrective inputs to the flight controls when the EGPWS issued the auditory alerts of “Sink Rate” and “Pull Up.” (Tab JJ-9) This factor was felt to contribute to the mishap.

f. PC102 Channelized Attention

Channelized Attention is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of other of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. It is a tight focus of attention that leads to the exclusion of comprehensive situational awareness. (AFI 91-204)

When looking at the data retrieved from the EGPWS, the MC showed no signs of pulling up in response to the “Sink Rate” and “Pull Up” auditory alerts. (Tab JJ-9) This could happen if they were focusing all of their attention on some other factor and these alerts were not consciously addressed. The evidence raises the possibility of this being involved.

g. PC307 Fatigue – Physiological/Mental

Fatigue – Physiologic/Mental is a factor when the individual’s diminished physical or mental capability is due to an inadequate recovery, as the result of restricted or shortened sleep or physical or mental activity during prolonged wakefulness. Fatigue may additionally be described as acute, cumulative or chronic. (AFI 91-204)

The MP had recently had a change in his duty schedule where he advanced his duty day almost 12 hours. He was given 2 days off from the flying schedule to adjust to this new schedule. (Tab G-18) The day prior to the mishap, the MP was issued four zolpidem (Ambien) tablets. (Tab DD-11) Ambien is a medication that is approved for use in aviators as an adjunct to the aircrew fatigue management program. (Tab BB-27 to -28) The MCP and MOP1 had just arrived at the deployed location 2 days prior to the mishap and had shifted 9 hours ahead during that timeframe. These changes in the circadian rhythm of these three members of the MC could have led to them suffering from acute fatigue. While this was not likely incapacitating, it is possible that fatigue could have delayed a necessary response in a situation where a time-critical decision had to be made.

12. FLIGHT SIMULATION

a. Flight Simulator

To simulate the MA flight conditions, the U-28A non-motion flight simulator at Hurlburt Field, FL was used. The U-28A simulator allows for multiple emergency procedures (EPs) in multiple environments to be displayed for both day and night. The terrain around Djibouti and Hurlburt Field, FL were used to include Ambouli International Airport.

b. MA Profile

The profile began at 10,000 ft MSL, 10 miles south of the airfield, and at 130 KIAS. The profile simulated a systems check and then went into a modified Max Rate Descent to the west. The aircraft was on a 360 degree heading, approaching the airfield from the south when the Power Control Lever (PCL) was pushed up to increase airspeed reaching 180 KIAS. Three miles from the airfield, the PCL was moved back to the IDLE position, decreasing the power to an idle state, and at 177 KIAS, the landing gear were lowered. As the landing gear were coming down, the attitude was lowered slightly to approximately 10 degrees nose low to maintain 170 KIAS while the gear were in transit. Once there were three green lights on the landing gear indicators, the pitch was lowered initially to 20 degrees nose low to build up airspeed and then raised to 15 degrees nose low to maintain 220 KIAS in the descent. The descent was started two miles south of the airfield with a 6,000 fpm descent and a 30 degree left bank turn. The descent rate was shallowed out to 4,800 fpm, 2,400 fpm, and 3,200 fpm to match the descent profile of the MA to an altitude of 4,400 ft MSL. The profile included a 5-second level off at 4,400 ft MSL then a descent down to 3,000 ft MSL where the simulator was frozen so that the current parameters could be recorded and a starting point could be established at 3,000 ft MSL and 190 KIAS for further simulations. There was nothing significant to note in the descent from 10,000 ft MSL to 3,000 ft MSL.

Numerous descents from 3,000 ft MSL were attempted to try and best match the final profile of the MA. Descents with emergencies, without emergencies, and numerous bank angles and pitch angles were attempted. Through extensive interviews, the experience and expertise of the AIB members and subject matter experts, the analysis done by Pilatus, and the simulator modeling, the following scenarios can be ruled out: (Tab HH-15 to -21, JJ-9)

Engine flameout: According to the report produced by the engine manufacturer, Pratt & Whitney, the engine was operating at the time of impact. (Tab J-39) Taking into consideration the glide ratio of the U-28A, the high final descent profile of the MA, and the standard flameout procedures used by U-28A crews, engine flameout can be ruled out as the cause of the mishap.

Mid-air collision: According to the radar returns, there were no other aircraft in the vicinity of the MA when the mishap occurred. (Tab M-4 to -18)

Electrical failure: Several electrical failures were duplicated in the simulator to determine if any type of electrical failure could either cause or factor into the final descent profile of the MA. The design of the electrical system, the backup systems, and the instruments of the U-28A prevents anything short of a complete electrical failure from causing a loss of all flight instruments. A complete electrical failure can be ruled out due to the data that was able to be retrieved from the EGPWS, which indicates that electrical power was being supplied to the EGPWS and the other aircraft avionics. (Tab BB-17 to -23)

Aircraft structural integrity failure: No aircraft pieces were found outside of the immediate impact site.

Pitch Trim: After running a nose down pitch trim runaway scenario, an unrecognized pitch trim runaway matches the profile flown by the MA but analysis of the pitch trim actuator by Pilatus showed the pitch trim in a neutral position at impact. (Tab HH-21)

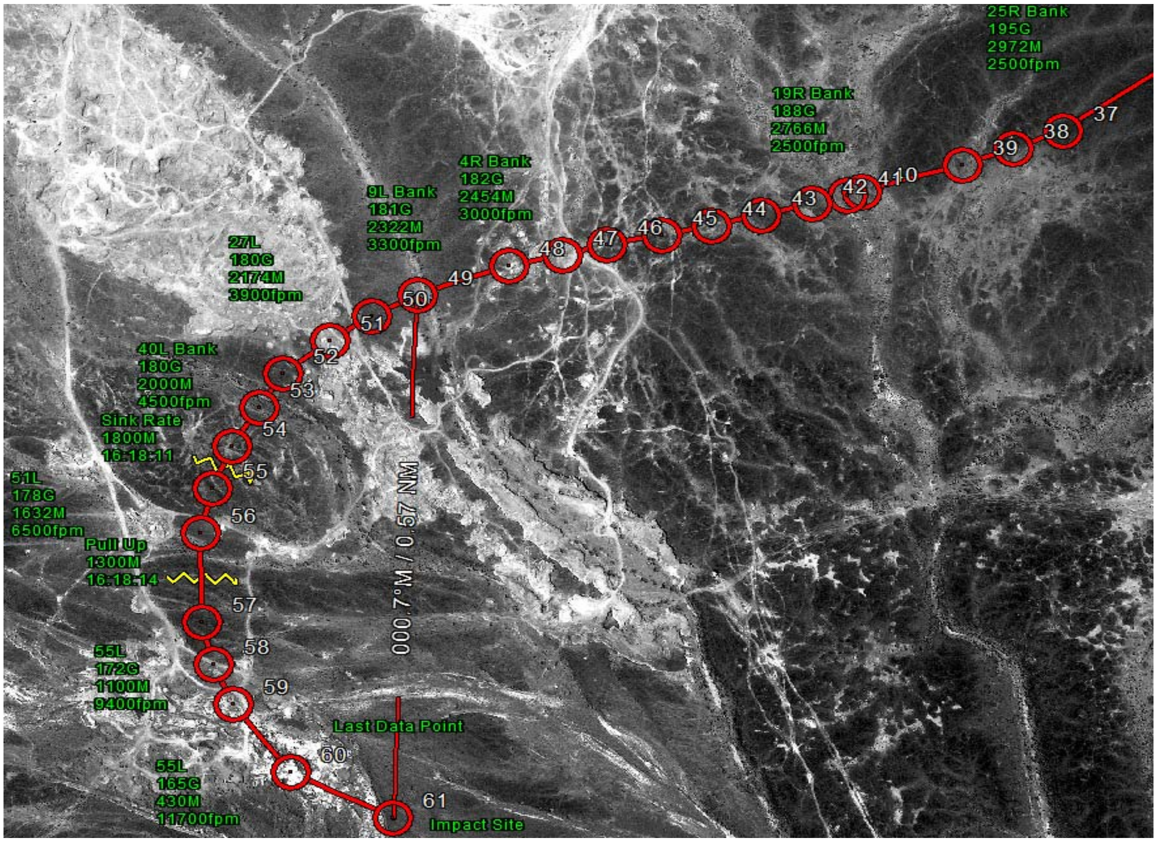

Figure 4. MA Descent profile from 2972 ft MSL to impact. (Tab JJ-9)

After ruling out the above malfunctions as improbable, the board looked into what could cause the MC to put the MA into the aggressive final turn and descent assuming that the MC was wearing NVGs and that the MP was flying the MA. (Tab V-9.3)

c. Spatial Disorientation

Multiple scenarios were run in the simulator to determine how the MC could have placed the MA into the final profile. At the beginning of the EGPWS data, the MA is south of extended runway centerline, heading west, away from the airfield in an extended downwind. The MA was in a 25 degree right bank which indicates a possible turn back to final which would be consistent with the last reported instructions. The MA then began a turn to the left while at the same time, increasing the descent rate from around 2,500 fpm to 5,100 fpm in 10 seconds. (Tab JJ-9) In the simulator, the board considered what could lead to the decision to turn left and examined potential threats such as hostile fire, another aircraft, or a bird. The turn does not seem to be aggressive at the beginning, which could indicate that the turn was not in response to a threat. There were no reports of surface-to-air fire, the radar does not show any other aircraft around the MA, and a continued turn would not be needed to avoid a bird; therefore, it is unknown what precipitated the decision to turn left. (Tab M-15 to -18)

A spatial disorientation simulator profile was flown, in which the pilot flying in the left seat would look out the left pilot's window, simulating an attempt to acquire the runway environment. While looking out the window, the aircraft would increase in bank angle and increase the descent rate by pitching down similar to the MA profile. The bank angle was matched easily on every attempt, but the computed pitch of 36 degrees nose low at impact was not naturally occurring. (Tab JJ-9) To achieve the 36 degrees nose low, the aircraft yoke had to be pushed in slightly during the turn, which could be a response to a vestibular illusion by the MP. Numerous attempts at achieving the flight profile were successful in getting close to the MA's profile.

Time	MSL Altitude	Vertical Velocity	Bank Angle	Ground Speed
16:17:52	2972	-2443	R25	195
16:17:53	2972	-2370	R25	195
16:17:54	2934	-2282	R25	194
16:17:55	2896	-2272	R25	193
16:17:56	2810	-2329	R22	190
16:17:57	2810	-2358	R22	190
16:17:58	2766	-2414	R19	188
16:17:59	2720	-2469	R17	187
16:18:00	2674	-2520	R15	186
16:18:01	2630	-2551	R12	185
16:18:02	2574	-2723	R9	184
16:18:03	2510	-2856	R6	183
16:18:04	2454	-2985	R4	182
16:18:05	2322	-3299	L9	181
16:18:06	2322	-3430	L9	181
16:18:07	2252	-3676	L18	180
16:18:08	2174	-3914	L27	180
16:18:09	2000	-4388	L40	180
16:18:10	2000	-4602	L40	180
16:18:11	**1894**	**-5107**	**L45**	**179**
16:18:12	**1770**	**-5741**	**L48**	**179**
16:18:13	1632	-6493	L51	178
16:18:14	**1302**	**-7835**	**L54**	**174**
16:18:15	**1302**	**-8323**	**L54**	**174**
16:18:16	1104	-9358	L55	172
16:18:17	890	-10389	L55	170
16:18:18	434	-11752	L55	165

Table 6. MA Descent profile from 2972 ft MSL to impact from EGPWS. The red/bold numbers show when EGPWS gave aural warnings. 1618:11-12 indicates a SINK RATE caution and 1618:14-15 indicates a PULL UP warning. (Tab JJ-9)

The EGPWS indicates two alerts that were displayed in the cockpit to warn the MC of the descent rate and approaching terrain. (Tab JJ-9) The first alert, a “Sink Rate, Sink Rate” aural caution, occurred approximately 7 seconds prior to impact. (Tab JJ-9) The second alert occurred approximately 4 seconds prior to impact and was a “Pull Up, Pull Up” aural warning. (Tab JJ-9) In the simulator, a 2-second delay was added by the pilot to signify the average time it takes the pilot flying to look in the cockpit from outside, determine if the sink rate is excessive and react. The question was, after each of the alerts, if the MC attempted to recover the MA, could it have been saved? While matching the MA’s profile, a “Sink Rate, Sink Rate” caution was given in the simulator at 1,800 ft MSL and on all occasions, the aircraft leveled off by 1,000 ft MSL after applying the 2-second delay. If corrective action was taken after the Sink Rate caution, the aircraft could have been recovered. While matching the MA’s profile and ignoring the Sink Rate caution, a “Pull Up, Pull Up” warning was given at 1,300 ft MSL, a 2-second delay was added and the aircraft leveled off by 300 ft MSL which would have been 100 ft above the terrain. Had corrective action been taken after hearing the Pull Up warning, the MA could have been saved. Any delay, and the aircraft could not have been recovered. The backpressure on the yoke to pull the airplane out of the dive in the simulator was within tolerances and power was applied after the pull up to climb away from the ground.

13. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications

(1) AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010
(2) AFI 11-2U28, Volume 3, *Flying Operations: U-28 Operations Procedures*, 27 January 2009
(3) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010

b. Maintenance Directives and Publications

(1) Code of Federal Regulations, Title 14: Aeronautics and Space, Part 39: Airworthiness Directives

c. Medical Directives and Publications

(1) AFI 48-123, *Medical Examinations and Standards*, 24 September 2009
(2) AFI 44-170, *Preventive Health Assessment*, 10 December 2009
(3) AFI 91-204, *Safety Investigations and Reports* 24 September 2008 (listing of Department of Defense Human Factors Analysis and Classification System)

d. Known or Suspected Deviations from Directives or Publications.

According to the AFI 11-2U28, Volume 3, paragraph 6.18.1, “Any training or operational missions planned when the lunar illumination is forecast to be less than 10% during the mission will require an additional level of ORM.” (Tab BB-3 to -4) The ORM worksheet does not reflect that the crew applied an additional level of ORM to the sortie. (Tab K-11 to -12) On the back of the ORM worksheet, there is a place for the MC to request approval for flying in a low illumination condition. On the MC's ORM worksheet, this approval was not requested nor was it approved. (Tab K-12)

14. ADDITIONAL AREAS OF CONCERN

Not applicable.

15. SIGNATURE AND DATE

[redacted]
TIMOTHY J. LEAHY
Brigadier General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

U-28A, T/N 07-0736 ACCIDENT
18 FEBRUARY 2012

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

On 18 February 2012, at approximately 1918 local time (L), a United States Air Force U-28A aircraft, tail number 07-0736, crashed five nautical miles (NM) southwest of Ambouli International Airport, Djibouti. This aircraft was assigned to the 34th Special Operations Squadron, 1st Special Operations Wing, Hurlburt Field, FL, and deployed to the 34th Expeditionary Special Operations Squadron, Camp Lemonnier, Djibouti. The aircraft was destroyed and all four aircrew members died instantly upon impact.

The mishap aircraft (MA) departed Ambouli International Airport, Djibouti at 1357L, to accomplish a combat mission in support of a Combined Joint Task Force. The MA proceeded to the area of responsibility (AOR), completed its mission in the AOR and returned back to Djiboutian airspace at 1852L arriving overhead the airfield at 1910L to begin a systems check. The MA proceeded south of the airfield at 10,000 feet (ft) Mean Sea Level (MSL) for 10 NM then turned to the North towards the airfield, accomplished a systems check and requested entry into the pattern at Ambouli International Airport. This request was denied due to other traffic, and the MA was directed to proceed to the west and descend by Air Traffic Control (ATC). The MA began a left descending turn to the west and was directed by ATC to report final. The mishap crew (MC) reported they were passing through 4,000 ft MSL and would report when established on final approach. The MA, continuing to descend, initiated a right turn then reversed the turn entering a left turn while continually and smoothly increasing bank angle until reaching 55 degrees prior to impact. Additionally, the MA continued to steadily increase the descent rate until reaching 11,752 ft per minute prior to impact. The MA impacted the ground at approximately 1918L, 5 NM southwest of Ambouli International Airport, Djibouti.

2. DISCUSSION OF OPINION

I find by clear and convincing evidence that the cause of the mishap was unrecognized spatial disorientation. Additionally, I find by a preponderance of the evidence that failing to cross-check and ignoring the “Sink Rate” caution substantially contributed to the mishap. With no eyewitness accounts, surviving aircrew members, emergency radio calls or “black box” recordings, the specific reason for the spatial disorientation cannot be determined. The board looked at three potential scenarios that could have caused the mishap:

Scenario 1: Loss of controlled flight due to over aggressive aircraft handling. The final left hand turn approached the maximum allowed bank angle of the aircraft. However, extensive simulator recreation of the flight, based on recovered Enhanced Ground Proximity Warning System (EGPWS) and Blue Force Tracker (BFT) data, indicated that at no time did the MA depart controlled flight. Furthermore, through interviews with numerous crewmembers, who had previously flown with the MP and MCP, it was evident that aggressive turns at low altitude and overly aggressive aircraft handling were not standard for the MA pilots. Specifically, the MP was known to be a conservative pilot who was always teaching less experienced pilots to remain aware of aircraft performance, practice energy management and know how to use aircraft systems and instruments to maintain situational awareness. It is my opinion that the MC did not intentionally execute an aggressive, descending turn at low altitude.

Scenario 2: Loss of aircraft control and/or situational awareness due to aircraft malfunction. The board analyzed the effects of malfunctioning flight control surfaces and compared that to the flight profile. Based on simulator recreation, it was determined a runaway pitch trim would provide a flight profile similar to the profile the MA flew based on EGPWS and BFT data. If this malfunction was not recognized in a timely manner it would have made aircraft recovery difficult. However, engineering analysis of pitch trim actuators and all other flight control surfaces indicated no mechanical discrepancy. Additionally, the board analyzed the failure of multiple electrical inputs to flight instruments in an attempt to remove all critical flight information from the flight crew. Due to multiple redundancies, in order to deny the crew of all aircraft attitude reference, this would require the loss of all electrical power. However, since data was recorded on the EGPWS until impact, which required electrical power, the MA could not have lost all electrical power. It is my opinion that the MA did not have any mechanical problems that caused the mishap.

Scenario 3: The MA was descending to the west of Ambouli International Airport, Djibouti on a zero illumination night with the only significant cultural lighting off the tail of the aircraft. Other crews described this area as a "black hole". The MC began a turn from this area of minimal cultural lighting toward an area of significantly greater cultural lighting and from an area with an elevation of 265 ft MSL to Ambouli International Airport, with an elevation of 49 ft MSL. The MC had Night Vision Goggles (NVGs) and it was standard practice to wear the NVGs during night operations. With the use of NVGs, the field of view is limited and depth perception is reduced. The EGPWS and BFT data indicates the aircraft entered a left hand turn and consistently and smoothly increased bank angle and descent rate. The MC was provided both visual and aural "Sink Rate" and "Pull Up" alerts due to MA descent rate and proximity to terrain. While it is not uncommon for U-28A crews to disregard a "Sink Rate" alert if visual with the terrain and the aircraft is in a safe position, it is uncommon to get or disregard a "Pull Up" alert, which was received 4 seconds prior to impact. This same EGPWS data depicts no corrective action was initiated prior to impact. A crew that was cognizant of its altitude, attitude and sink rate would have immediately leveled the wings and increased pitch and power as described in the U-28A Pilot's Operating Handbook. (Tab BB-16 to -17) Failure to immediately react to the "Pull Up" warning indicates a crew that does not take action because it believes the aircraft is in a position that does not warrant a "Pull Up" warning. There was a cognitive disconnect with the MC's perception of the flight envelope they were operating in and the alerts provided by the aircraft.

Spatial Disorientation, as defined in Air Force Instruction 91-204, is a failure to correctly sense a position, motion or attitude of the aircraft or of oneself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical. Spatial Disorientation (Type 1) Unrecognized is a factor when a person's cognitive awareness of one or more of the following varies from reality: attitude; position; velocity; direction of movement or acceleration. Proper control inputs are not made because the need is unknown. The MA was in a high bank turn with an excessive nose down attitude that resulted in a high descent rate in close proximity to the ground that was incongruent with normal aircraft operation. Extensive flight recreations of this profile in the simulator allowed the board to successfully recover the aircraft when corrective action was taken. This includes delaying corrective action until after the "Sink Rate" and "Pull Up" alerts were received. There was sufficient time to react to these alerts if the MC was aware of the situation the MA was in; therefore, failure to accurately react to these alerts is indicative of a lack of cognitive awareness of the attitude, altitude and sink rate of the aircraft as experienced by a pilot that was spatially disoriented.

Unrecognized spatial disorientation can be difficult to react to, even with aural alerts, because the aural alerts are counter to the pilot's perception of reality. The pilot must interpret the alerts, which are inconsistent with his perceptions, and attempt to reconcile them with instrument or visual reference. Action to save the MA after receiving the aural "Pull Up" warning was required within two seconds; any action taken after that would not have saved the MA and might not be reflected in the EGPWS data. As previously mentioned, a crew that was aware of its altitude, attitude and sink rate would have immediately leveled the wings and increased pitch and power. While there would be some delay between flight control input and displacement of the aircraft coupled with EGPWS recording latency, there is no indication that corrective action was taken. The evidence demonstrates that the MC did not recognize the position of the aircraft and, as a result, failed to take appropriate corrective actions. The only plausible reason for the MC not recognizing the situation or reacting to aural alerts is the cognitive disconnect associated with spatial disorientation. Therefore, I find by clear and convincing evidence that the mishap was caused by unrecognized spatial disorientation.

I find two additional human factors that substantially contributed to the mishap. The first of these is "Caution/Warning Ignored." It is apparent that the MC disregarded or ignored the "Sink Rate" caution. It would not have been unusual to receive this caution during a tactical arrival, particularly if they believed they were visual with the terrain. The MC had sufficient time to react to the "Sink Rate" caution, and there is no evidence showing that they attempted to do so. Therefore, I have concluded by a preponderance of the evidence that the MC disregarded the "Sink Rate" caution, which substantially contributed to the mishap.

The second substantially contributing human factor is a failure in "Cross-Monitoring Performance." As previously mentioned, it is not uncommon for U-28A crews to disregard a "Sink Rate" caution if visual with the terrain and the aircraft is in a safe position. However, the recommended altitude to the west of Ambouli International Airport is 1300 ft MSL and the "Sink Rate" caution was received at 1800 ft MSL. (AFI 11-202V3, paragraph 5.14.3) If the MC was aware of the attitude, altitude and sink rate of the aircraft, they should have made a control input at that time in order to level off at 1300 ft MSL. The MC could have cross checked their instruments to verify they were in a safe position in order to purposely disregard the "Sink Rate" caution. If they had, they would have realized the attitude and sink rate at that altitude put the MA into an unsafe position requiring corrective action. Therefore, I find by a preponderance of the evidence that failure to cross check was substantially contributing to this mishap.

3. CONCLUSION

The MC never lost control of the aircraft; there are no indications of mechanical malfunction; and there are no indications the crew took any actions to control or arrest the descent rate and nose down attitude. I find that the clear and convincing evidence indicates the cause of the mishap was unrecognized spatial disorientation. Additionally, I find by a preponderance of the evidence that failing to cross-check and ignoring the "Sink Rate" caution substantially contributed to the mishap.

[redacted]

TIMOTHY J. LEAHY
Brigadier General, USAF
President, Accident Investigation Board

INDEX OF TABS