UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

AC-130J, T/N 09-5710

413TH FLIGHT TEST SQUADRON
96TH TEST WING
EGLIN AIR FORCE BASE, FLORIDA

LOCATION: EGLIN AIR FORCE BASE, FLORIDA

DATE OF ACCIDENT: 21 APRIL 2015

BOARD PRESIDENT: LIEUTENANT COLONEL MICHAEL P. DAVIS

Conducted IAW Air Force Instruction 51-503

EXECUTIVE SUMMARY

UNITED STATES AIR FORCE

AIRCRAFT ACCIDENT INVESTIGATION

AC-130J, T/N 09-5710
Eglin AFB, FL
21 April 2015

On 21 April 2015, at approximately 12:18:40 hours local time (L), AC-130J, tail number 09-5710, assigned to the 413th Flight Test Squadron, 96th Test Wing, Eglin Air Force Base (AFB), Florida, departed controlled flight over water approximately 41 nautical miles (NM) south of Eglin AFB and then was recovered and landed safely. There were no significant injuries to the crew or anyone else. Post-flight engineering analysis revealed that the mishap aircraft (MA) exceeded the Design Limit Load (DLL), thus rendering it unsafe for further flight. The damages are estimated to be $115,600,000, which includes the total loss of the MA.

The mishap occurred on a medium risk flying qualities test sortie out to the edges of the flight envelope. The mishap pilot (MP) was attempting to execute a Steady Heading Sideslip (SHSS) to the RUDDER Special Alert of the Advisory Caution and Warning System (ACAWS). This is normally a prohibited maneuver, but the Director of Operations at Air Force Materiel Command (AFMC/A3) signed a waiver approving the test team to fly to this limit. The MA exceeded 14.5^{o} Angle of Sideslip (AoS), triggering the RUDDER Special Alert and continued increasing AoS until it departed controlled flight, eventually tumbling to an inverted position. Shortly thereafter, the MA recovered from the departure and the mishap copilot (MCP) took the controls to recover from the near vertical dive. In the process of the departure and recovery, the aircraft lost approximately 5,000 feet of altitude, experienced 3.19 times the normal force acceleration (Gs), and over sped the flaps by over 100 knots. The over G exceeded the aircraft's DLL, thereby nullifying the airworthiness of the MA, rendering it a total loss.

The Accident Investigation Board (AIB) President found, by a preponderance of the evidence, the cause of this mishap was the MP's excessive rudder input during the test point followed by inadequate rudder input to initiate a timely recovery from high AoS due to Overcontrolled/Undercontrolled Aircraft and Wrong Choice of Action During an Operation.

Additionally, the AIB President found, by a preponderance of the evidence, the following factors substantially contributed to the mishap: Instrumentation and Warning System Issues, Spatial Disorientation, Confusion, and the fact the test team was Provided Inadequate Procedural Guidance or Publications.

SUMMARY OF FACTS AND STATEMENT OF OPINION
AC-130J, T/N 09-5710

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

ACAWS	Advisory, Caution and Warning System
ACO	Access Control Officer
ADC	Area Defense Counsel
ADI	Attitude Director Indicator
ADO	Assistant Director of Operations
AF	Air Force
AFE	Aircrew Flight Equipment
AFSOC	Air Force Special Operations Command
AFB	Air Force Base
AFE	Air Flight Equipment
AFI	Air Force Instruction
AFL	Above Floor Level
AFLCMC	Air Force Life Cycle Management Center
AFMC	Air Force Materiel Command
AFOTEC	
AFPAM	Air Force Pamphlet
AFTC	Air Force Test Center
AGL	Above Ground Level
AIB	Accident Investigation Board
AOA	Angle of Attack
AoS	Angle of Sideslip
AMC	Air Mobility Command
AT&L	Acquisitions Training and Logistics
ATRSB	Airborne Technical Review & Safety Board
BDA	Battle Damage Assessment
BP	Board President
BRU	Bomb Rack Unit
CA	California
Capt	Captain
CBT	Computer Based Training
CFP	Compatibility Flight Profile
CG	Center of Gravity
CMDU	Color Multi-Functional Display Unit
CN	Coefficient of Yawing Moment
CRH	Combat Rescue Helicopter
CRM	Crew Resource Management
Col	Colonel
CSO	Combat Systems Officer
CTF	Combined Test Force
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DO	Director of Operations
DoD	Department of Defense
DR	Deficiency Report
DT	Developmental Test
DT&E	Developmental Test & Evaluation
DTIC	Defense Technical Interchange Center
EO/IR	Electro-optical/Infrared
EP	Emergency Procedures
EW	Electronic Warfare
FAA	Federal Aviation Administration
FAR	FAA Regulation
FCF	Functional Check Flight
FL	Florida
FLTS	Flight Test Squadron
FQ	Flying Qualities
ft	Feet
FTE	Flight Test Engineer
FTT	Flight Test Techniques
g	Gravitational Force
GS	General Schedule
HF	Human Factors
HUD	Heads-Up Display
IADS	Interactive Analysis and Display System
IAW	In Accordance With
ICD	Interface Control Document
ICS	Internal Communication System
IFE	In-Flight Emergency
IFR	Instrument Flight Rules
IMDS	Integrated Maintenance Data System
ITS	Individual Training Summary
IOT&E	Initial Operation Test and Evaluation
JAO	Joint Area of Operations
JON	Job Order Number
KIO	Knock It Off
KCAS	Knots Calibrated Airspeed
LA	Legal Advisor
LAIRCM	Large Aircraft Infrared Countermeasures
lbs	Pounds
LDTO	Lead Developmental Test Organization
LMAC	Lockheed Martin Aeronautical Corporation
LPU	Life Preserver Unit
Lt Col	Lieutenant Colonel
MA	Mishap Aircraft
Maj	Major
MAJCOM	Major Command
MCG	Minimum Control Ground Speed
MCP	Mishap CoPilot
MCTF	MC-130 Terrain Following
MDAP	Major Defense Acquisition Program
MFL	Mishap Flight Lead
MFP	Major Force Program
MFR	Memorandum for Record
MFTE	Mishap Flight Test Engineer
MIL	Military
ML	Mishap Loadmaster
MLM	Mishap Loadmaster
MM	Maintenance Member
MOA	Military Operating Area
MOP	Munitions Operator Pallet
MOT	Method of Test
MP	Mishap Pilot
MS	Mishap Sortie
MTC	Mishap Test Conductor
O_2	Oxygen
OEM	Original Equipment Manufacturer
OFP	Operational Flight Program
OG	Operations Group

OPR	Officer Performance Report
ORA	Operations Research Analysis
OSD	Office of the Secretary of Defense
OSS	Operations Support Squadron
OTA	Operational Test Agency
PA	Public Address
PEO	Program Executive Office
PFD	Pilot's Flight Display
PM	Pilot Member
PR	Pre Flight
PSP	Precision Strike Package
PTO	Participating Test Organization
QA	Quality Assurance
REC	Recorder
RF	Radio Frequency
RTB	Return-To-Base
RWD	Right Wing Down
SA	Situational Awareness
SAR	Search and Rescue
SAR	Synthetic Aperture Radar
SAX	Surface to Air Threat
SDB	Small Diameter Bomb
SHSS	Steady Heading Sideslips
SI	Special Instrumentation
SIB	Safety Investigation Board
SIO	Single Investigating Officer
SMA	Special Mission Aviator
SME	Subject Matter Expert
SOF	Special Operations Forces
SOS	Special Operations Squadron
SOT	Safety of Test
SPO	Systems Program Office
SRB	Safety Review Board
SWA	State Warning Airspeed
TAB	Test Approval Brief
TCTO	Time Compliance Technical Order
TE	Test Engineer
TELECON	Tele-Conference
THA	Threat Hazard Analysis
THAW	Test Hazard Analysis Worksheet
TIDAS	Test Instrumentation Data Acquisition System
T/N	Tail Number
TO	Technical Order
TOD	Tech Order Data
TP	Test Pilot
TPS	Test Pilot School
TW	Test Wing
USSOCOM	United States Special Operations Command
VMC	Visual Meteorological Conditions
VMCA	Minimum Control Airspeed
V_{SWA}	Velocity – Stall Warning Airspeed
WSMR	White Sands Missile Range
Z	Zulu

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 7 July 2015, Major General H. Brent Baker, Sr., Vice Commander, Air Force Materiel Command (AFMC), appointed Lieutenant Colonel (Lt Col) Michael P. Davis to conduct an aircraft accident investigation of a mishap that occurred on 21 April 2015 involving an AC-130J aircraft near Eglin Air Force Base (AFB), Florida (FL). The aircraft accident investigation was conducted in accordance with (IAW) Air Force Instruction (AFI) 51-503, *Aerospace and Ground Accident Investigations* (14 April 2015), at Eglin AFB, FL, from 28 July 2015 through 30 September 2015. The following Accident Investigation Board (AIB) members were also appointed: Major pilot member, Captain medical officer/human factors member, Captain maintenance member, Captain legal advisor, and Staff Sergeant recorder (Tab Y-2 to Y-6).

b. Purpose

In accordance with AFI 51-503, *Aerospace and Ground Accident Investigations*, this AIB conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force (AF) aerospace accident, prepare a publicly-releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action.

2. ACCIDENT SUMMARY

On 21 April 2015, at approximately 12:18:40 hours local time (L), the mishap aircraft (MA), AC-130J, tail number (T/N) 09-5710, assigned to the 413th Flight Test Squadron (FLTS), 96th Test Wing (TW), Eglin AFB, FL, departed controlled flight, inverted, and subsequently experienced an over G during the dive recovery on a medium risk flying qualities mission. The MA was recovered and landed safely at 13:24:36L (Tab U-145, Tab U-158). There were no significant injuries to the aircrew or to anyone on the ground (Tab CC-3). The AF rendered the aircraft a total loss due to exceedances of the Design Limit Load (DLL) (Tab P-2). The loss is valued at an estimated $115,600,000 (Tab BB-141).

3. BACKGROUND

At the time of the mishap, AFMC possessed the MA (Tab U-116). The MA was operated by the 413 FLTS, 96 TW, Air Force Test Center (AFTC), AFMC, stationed at Eglin AFB, FL (Tab D-3). The Lead Developmental Test Organization (LDTO) for integration of the MA during developmental testing was United States Special Operations Command (USSOCOM), Detachment 1 (DET 1), stationed at Eglin AFB, FL (Tab BB-46).

a. Air Force Materiel Command

Air Force Materiel Command's primary mission is to deliver war-winning expeditionary capabilities to the warfighter through development and transition of technology, professional acquisition management, exacting test evaluation, and world-class sustainment of all AF weapon systems. From cradle-to-grave, AFMC provides the work force and infrastructure necessary to ensure the United States remains the world's most respected air and space force (Tab DD-2).

b. Air Force Test Center

The Air Force Test Center conducts developmental test and evaluation of air, space and cyber systems to provide timely, objective and accurate information to decision makers. The AFTC has oversight of work carried out at three primary locations across AFMC, including 412 TW at Edwards AFB, CA; Arnold Engineering and Development Center, Arnold AFB, TN; and 96 TW, Eglin AFB, FL (Tab DD-3).

c. 96th Test Wing

The 96th Test Wing executes developmental test and evaluation enabling the warfighter to put weapons on target in all battlespace media while also providing support for all other Team Eglin missions as the installation host wing. Eglin AFB deploys combat ready forces while delivering full spectrum support to the Department of Defense's (DoD) largest, most dynamic AF installation (Tab DD-4).

d. 413th Flight Test Squadron

The 413th Flight Test Squadron (FLTS) plans, executes, and manages developmental and qualification test and evaluation of USAF Special Operations, Combat Search and Rescue (including Guardian Angel), tactical mobility and vertical lift aircraft. Coordinates assets from USSOCOM, Air Force Major Commands, and other commands and agencies to accomplish ground and flight tests on 21 different aircraft types. Provides test results and recommendations to program management offices for use in acquisition program milestone decisions (Tab DD-6).

e. USSOCOM DET 1

USSOCOM Detachment 1 provides robust reliable weapon's capabilities to Special Operations Forces through safe and thorough testing, diligent management, and integration of emerging weapon system capabilities. DET 1 works for USSOCOM Program Executive Office (PEO) – Fixed Wing and plays a vital role as part of Special Operations Forces Acquisition, Technology and Logistics (SOF AT&L) efforts developing and implementing

USSOCOM acquisition, technology, contracting, and logistics policy for all USSOCOM (Tab DD-7).

f. AC-130J Ghostrider

The AC-130J is a highly modified MC-130J aircraft that contains many advanced features to make it the most modern gunship in the Air Force inventory. It contains an advanced two-pilot flight station with fully integrated digital avionics. The aircraft is capable of extremely accurate navigation due to the fully integrated navigation systems with dual inertial navigation systems and global positioning system. Additionally, the AC-130J is modified with a precision strike package, which includes a mission management console, robust communications suite, two electro-optical/infrared sensors, advanced fire control equipment, precision guided munitions delivery capability as well as a trainable 30mm weapon (Tab DD-8).

4. SEQUENCE OF EVENTS

a. Mission

The 413 FLTS was executing a medium risk flight test under the AXZD0023 Job Order Number (23 JON) to determine if the modifications required to produce the AC-130J had adversely affected the MA's flying qualities (Tab BB-51). On 21 April 2015, the test included a series of flying qualities maneuvers to include Steady Heading Sideslips (SHSSs) at various flap and gear configurations (Tab BB-52 to BB-54). The purpose of the SHSS was to demonstrate positive lateral-directional stability throughout the entire designed envelope (Tab V-11.23). The test team determined that the designed envelope included the RUDDER Special Alert (Tab V-19.5). The RUDDER Special Alert is the second of two sideslip Advisory Caution and Warning System (ACAWS) special alerts designed to advise aircrews of an unsafe condition and prompt an immediate corrective action to alleviate the condition (Tab BB-122 to BB-123). The Special Alert includes both visual and auditory warnings. The authority to execute the mission was the 96th Operations Group Commander (Tab BB-50).

b. Planning

Planning for the test effort as a whole was quite extensive, spanning several months via a well-documented test and safety process (Tab BB-48). Both technical adequacy and safety risks were captured in the Test Directive for the 23 JON (Tab BB-78). This flying qualities test effort was not originally envisioned in the acquisition strategy (Tab V-21.1-21.2). The initial set of developmental tests were covered under the Test Directive for the AXZD0017 JON (17 JON) with a different set of technical objectives and safety limitations. The 17 JON effort never planned on testing out to the sideslip angles that were reached in the 23 JON (Tab V-9.3-V9.4). However, while executing the fourth flight of the 17 JON on 25 February 2014, the MA experienced a departure from controlled flight during stall testing, but was recovered after approximately 4,000 feet of altitude loss (Tab V-21. 2).

An analysis independent of the safety investigation for the 2014 departure event included the following synopsis:

> "Up to the point of stick pusher activation, rates of pitch, roll and yaw were all relatively steady, consistent with relatively steady turning flight at gradually decreasing airspeed. Coincident with stick pusher activation a large left rudder input was made and sustained for about 5 seconds, resulting in an approximately steady left yaw acceleration to about -15 deg/sec of left yaw rate. As TEL [Trailing Edge Left] rudder was input, roll control was increased from 60% to 90% in the RWD [Right Wing Down] direction, resulting in nearly full cross-control inputs. The combination of left yaw rate and right roll produced a change of sideslip to the right that exceeded sideslip for fin stall and rudder lock… It appears that, following stick pusher activation, if no rudder was input, or, if the TEL rudder was removed shortly after input, a yaw departure would not likely have developed" (Tab V-18.27).

This event caused some of the test team to question how the flying and handling qualities of the AC-130J may differ from the C-130J (Tab V-11.3). The outer mold line (OML) of the AC-130J was changed during the modification process to include the addition of weapons and stores, which could account for different flight characteristics (Tab V17.4). Thus, the 23 JON effort began as a direct result of the 25 February 2014 departure to investigate whether, and to what extent, the modifications had degraded the flying qualities of AC-130J aircraft (Tab BB-88, V9.4).

However, the need for the 23 JON effort was not unanimous among the USSOCOM Det 1, the 413 FLTS, and the C-130 program office (Tab V-16.4, V-18.3). The USSOCOM Det 1 Commander as LDTO (i.e., the lead for the entire test) said:

> "It was one of those kinds of deals where, you may have disagreed with it and you may have not completely understood exactly why, or if it made sense at all but it became more of those ones, as a function of being able to—to execute and get further testing done, we needed to play nice with—with the folks who were making the recommendations, even if we didn't necessarily believe 100% in them, if that makes sense" (Tab V-18.7).

Regardless of this disagreement in the requirement for the 23 JON, the test team pressed forward with an extensive flying qualities test program that took the aircraft to the edges of the aircraft envelope in sideslip 183 times before the mishap event (Tab BB-109 to BB-111).

In order to proceed to and perhaps beyond the RUDDER Special Alert, the test team initially inquired into getting some predictive flight data from previous C-130J testing (Tab V-9.4, V-9.28). However, the team did not think it received the data due to issues with data rights (Tab V-18.7, V-18.8). Lockheed Martin Aerospace Corporation (LMAC) developed the C-130J independently of a DoD acquisition program, so it claimed ownership of the data rights and would not release certain details without a contract (Tab V-5.20, V-19.3). According to several testimonies, members of the test team thought access to the data had been requested but was denied by LM (Tab V-9.4, V-9.28). With a lack of predictive data, members of the team admitted they did not understand how much stability margin existed at the second special alert, but admitted it could potentially be very little (Tab V-1.7, V-5.7).

The 31 July 2013 Air Vehicle Substantiation report, "OF THE UNITED STATES AIR FORCE AC-130J PRECISION STRIKE PACKAGE," contained predictive data that the test team could have used (Tab BB-147 to BB-149). Specifically, the report includes data plots from previous flight test for SHSS that the test team could have used to predict how much rudder force would be required to achieve specific AoS (Tab BB-149).

The lack of data rights was an issue that also extended to the test team's use of 1553 data bus access in flight (Tab V-5.20). The 1553 data bus contains electronic signals that convey specific flight parameters of the aircraft (Tab V-5.20). The test team desired to have access to 1553 bus message traffic for real-time flight test execution (Tab V-5.20). The 1553 bus was instrumented, but the test team could only record the "ones and zeroes" so they could not use the 1553 bus data real-time. It had to be post-processed by LMAC, since LMAC denied its use during contract negotiations with USSOCOM from 2012 through 2013 (Tab BB-143). Since the test team was proceeding towards potential "cliffs" of the flight envelope without substantial predictive data or real-time 1553 bus message traffic, the testing was exposed to certain risk factors (Tab V-5.20). To mitigate risk factors, the aircraft special instrumentation (SI) was changed (Tab V-14.3, Tab V-18.5, V-18.12). The original SI package for the 17 JON was insufficient for the testing of the 23 JON (Tab V-14.3, Tab V-18.5, V-18.12). For more information regarding SI for the 23 JON, see the aircraft systems section. The test team chose a path forward to test with caution and "nibble" out carefully to find the edges of the aircraft envelope with the new SI package, but without predictive data (Tab V-19.13). The MP, reflecting on the events in hindsight, thought perhaps they should not have proceeded beyond the second alert without predictions (Tab V-1.24).

The one piece of predictive data the team had was a chart and table provided by LMAC describing when the Special Alerts would sound based on the AoS (Tab BB-57). The chart was provided to the team in February 2014, prior to the completion of safety planning and was included in the test cards (Tab BB-150). This table and chart implied the second alert would trigger at 16^{o} AoS instead of the of 14.5^{o} AoS (Tab V-6.16). A corrected chart was provided after the mishap (Tab BB-38). Although the incorrect chart was included in the test cards, it was not referenced by pilots prior to execution of each test point, but it was used to set depictions for the safety of test monitors (Tab V-1.11, BB-145).

During the first departure, the test team accomplished the stall test point near 10,000 feet and the aircraft was recovered near 5,000 feet (Tab V-19.9). The test team decided to pad the altitude thereafter by an additional 5,000 feet, so all SHSS test points were executed around 15,000 feet above mean sea level (MSL) (Tab V-20.6). The test team had confidence that since the first departure was recoverable, subsequent departures would be recoverable as well (Tab V-20.6).

Other than the increase in altitude, the test directive included a four-fold build-up approach to safety (Tab BB-79). First, there was a build-up in gross weight and center of gravity (C.G.) combinations starting with forward C.G. and progressing towards aft C.G. (Tab BB-79). Second, there was a build-up in configurations; starting with clean configurations; then progressing to symmetric stores; then to asymmetric stores on the right and finally asymmetric stores on the left (Tab BB-79). Third, there was a build-up in sideslip for each speed/configuration/C.G. combination until the objective was reached or a set of safety parameters dictated termination of the test (Tab BB-79). Additionally, for each test condition, the test point was executed in a nose-right sideslip before executing in a nose-left sideslip (Tab

BB-79). Fourth, there was a build-up towards the stall speed by starting with a given speed and then carefully decrementing the speed (Tab BB-79).

The previous mitigations were part of the general minimizing procedures that applied to all flying qualities tests, but more specific criteria for SHSS and other elevated risk test points were documented in the Threat Hazard Analysis Worksheet (THAW) (Tab BB-83). The 30 September 2014 THAW for departure from controlled flight states, "1. Real time monitoring of safety of flight parameters during all flying qualities and approach to stall test points -- safety of flight parameters include: airspeed; load factor; AoS; angle of attack (AoA); pitch; roll; yaw rate; heading; control column position; control wheel position; rudder pedal position; and rudder pedal forces" and lists the termination criteria as "Sideslip excursions will be terminated no later than 21 degrees, at the first indication of buffet in the vertical stabilizer, if difficulty stabilizing at a test condition is experienced, or if rudder force lightening is observed" (Tab BB-76).

In order to get to the second alert and comply with the THAW, the team relied on the Heads Up Display (HUD) to give the pilot indications of sideslip and the SI package for monitoring safety parameters such as rudder pedal force (Tab BB-76, BB-130). The PTO 1C-130(A)J-1 (preliminary technical order for the aircraft) does not make it clear that the SIDE SLIP INDICATOR freezes once it bisects the fence, and according to TP1, this fact was not understood by the test team (Tab BB-37 and Tab V-19.18).

Figure 1

Referring to Figure 1, the symbols show the SIDE SLIP INDICATOR or "Doghouse" as it appears in the pilot's HUD at 0^o AoS as well as what indication the pilot has the AoS is reaching the proscribed limits (Tab BB-130).

Rudder pedal force was displayed in various forms to the crew via the Interactive Analysis and Display System (IADS) (Tab BB-145). The rudder force instrumentation was calibrated to 200 lbs of force, which provides a margin above the Federal Aviation Administration limit of 180 lbs (Tab BB-131, Tab BB-140). However, neither the THAW nor the MOT limit the test crew to 180 lbs, and during multiple SHSS test points, the test crew exceeded the 200 lbs calibration limit (Tab BB-83, Tab BB-109).

Part of the overall test planning included two waivers; one of those waivers, signed by the AFMC/A3, was "approval to intentionally maneuver the AC-130J into a sideslip resulting in a LEFT/RIGHT RUDDER alert during regression testing" (Tab AA-10). This maneuver violates PTO 1C-130(A)J-1, 8 January 14. Specifically, the "Prohibited Maneuvers" paragraph states: "Intentionally maneuvering into a sideslip resulting in a LEFT/RIGHT RUDDER alert" (Tab AA-10). Per AFMC Supplement to AFI 11-215, *USAF Flight Manuals Program,* paragraph 1.4.2, the waiver approval for a Medium Risk or higher test is AFMC/A3 (Tab AA-10). In the COMMENT / RESTRICTION portion of the waiver, aircrews were directed to review the High Sideslip Recovery Procedures (C-130J-1) and Fin Stall Recovery (C-130H-1) prior to flight when intentional rudder alert test points were to be flown (Tab AA-10). Of note, the Fin Stall warning section describes the risk of fin stalls at angles of sideslip from 15-20 degrees of sideslip and at speeds from stall to 170 knots (Tab BB-123). The High Sideslip Recovery Procedures states, "If either RUDDER Special Alert occurs, immediately apply the indicated rudder to center the sideslip display on the HUD" (Tab BB-123).

The waiver was signed in February 2014 as part of the 17 JON test effort, before the first departure and safety planning for the 23 JON, so its guidance could have been incorporated into the THAW during the Safety Review Board (SRB) on 18 July 2014 (Tab BB-73). However, while the THAW does stipulate, "Recovery procedures for high angles of sideslip will be briefed before executing steady heading sideslips or approach to stalls," it fails to mention reviewing the Fin Stall warning as directed by the waiver (Tab AA-10). All of these technical and safety considerations were reviewed and approved by the 96 Operations Group Commander (96 OG/CC) during the Test Approval Brief (TAB) on 6 August 2014 (Tab BB-142). The TAB to the 96 OG/CC was on 6 August 2014, and the first flight under the 23 JON took place on 15 August 2014. The Safety Annex was updated with Amendment 1 on 18 September 2014, but did not make any changes regarding the High Sideslip Recovery or the Fin Stall warning even though the first departure was a departure in sideslip (Tab V- 20.6, Tab V-18.27).

In December 2014, some test team "turbulence" resulted in an email from the 413 FLTS technical director (SQ/CZ) to the squadron commander (413 FLTS/CC) and Director of Operations (SQ/DO) (Tab BB-95 to BB-96). As the situation progressed, the SQ/CZ removed himself from reviewing test cards on 12 February 2015 (Tab BB-93 to BB-94). The SQ/CZ was not required to review or sign test cards per the Operations Group instruction, but it had been an additional layer of review implemented per squadron policy (Tab BB-93 to BB-94, Tab V-11.13 to Tab V-11.15, Tab BB-40). On 5 March 2015, SQ/CZ rescinded his signature authority on all test planning and execution documentation associated with the AC-130J Developmental Test via a memorandum to the 413 FLTS/CC (Tab BB-47). Despite the fact the he rescinded his signature, he made no indication he wanted the test to stop (Tab BB-47). He remained confident in the soundness of the MOT as he stated, "The 23 JON test plan is the best product that the Air Force Test Center could put out under the circumstances" (Tab V-11.14).

The 5 March 2015 memorandum cited a "…breakdown in test planning and execution discipline…" that the SQ/CZ had observed over the course of the program (Tab BB-47). The SQ/CZ stated, "No changes need to be made to the existing documentation," but did not give an explanation as to why removal of his signature did not invalidate the MOT (Tab BB-47). The SQ/CZ's signature is the final signature on the MOT, which is the first annex in the test directive (Tab BB-89). In an interview, the 96 OG/CC stated that the SQ/CZ's signature on the MOT meant "that it is sufficient…. and meets the test and safety requirements and being able to meet the objectives" (Tab V-12.3). The test approval authority (OG/CC) was never informed that the final signature on the MOT had been rescinded (Tab V-12.3).

Planning for the specific test mission utilized test cards that were reviewed and signed by the deputy group commander the day prior to the mishap flight (Tab BB-51). The test cards were created IAW existing instructions that require all applicable Warnings be included (Tab BB-41). The test cards include warnings for stalls, but do not include warnings for High Angle of Sideslip or Rudder Overbalance (Tab BB-62). The last page of the test cards abbreviate the THAW, repeating that recovery from departure from controlled flight is IAW the PTO (extreme AoA recovery) (Tab BB-63). The test cards also contain various pertinent Notes, Cautions, and Warnings as required by 96 TW guidance for test cards (Tab BB-51 to BB-63). For example, the test cards page 36 of 41 includes a Warning for reinforcing the concern and recovery for a stall (Tab BB-62). The test cards do not include the warning for Fin Stall or any guidance for recovering from an overbalance rudder condition (Tab BB-51 to BB-63).

The final portion of planning for the mishap flight occurred when the aircrew was briefed . The mishap crew conducted a "T-1" brief the day prior to the flight covering all test safety considerations to include Flight Test Techniques (FTTs) and Threat Hazard Analysis Worksheets (THAWs) (Tab V-2.8). During the morning of the mishap, the aircrew conducted a mission brief, which covered the specific sequence of events, FTTs and THAWs (Tab V-2.8). According to the MP, the crew briefed the Fin Stall Warning as directed by the AFMC/A3 Waiver during the T-1 or mission brief (Tab V-1.10).

c. Preflight

Notices to Airmen (NOTAMs), weather, flight plans, all ground operations up to and including engine start, etc. were all unremarkable (Tab F-2 to F-8, Tab K-2). Preflight appears to have been normal with one discrepancy in the aircraft configuration related to the fuel weight (Tab K-5). More information on this discrepancy is noted in the Areas of Additional Concern.

d. Summary of Accident

The MA took off at 10:46:34L and conducted a series of flying qualities test points at approximately 15,000 feet MSL in W-151 in the Gulf of Mexico just South of Eglin AFB, FL (Tab U-145). During earlier SHSS test points in the flight, the crew had discussions about the recovery technique. In one instance, the MP mentored the mishap copilot (MCP) with the advice "don't dance on the rudders during recovery" (Tab EE-4).

At 12:10L, the crew began performing SHSS with flaps at 100%, gear down and a speed of 140 Knots Calibrated Airspeed (KCAS) (Tab EE-6). Per the test safety build-up, SHSSs to the right were conducted first. The MP was able to reach but not stabilize at the rudder alert, even though he was applying as much as 278 lbs of rudder pedal force (Tab EE-7). He made the statement that his feet were all the way on the floor (Tab EE-7). The test point to the right was terminated and then the test proceeded to the left at 12:16:34L (Tab EE-7).

The MP stabilized at the SIDESLIP Special Alert (the first alert) for nearly 10 seconds, applying approximately 125 lbs of rudder pedal force (Tab S-12). At 12:18:35L, as the mishap test conductor (MTC) began to clear the MP to proceed to the second Special Alert, the MP was already increasing rudder pedal force; within two seconds of increasing force, he reached 180 lbs (Tab S-12). Less than one second later, the RUDDER Special Alert annunciated immediately after the MTC finished the words "continue nose left, second alert" at approximately 14.5^{o} AoS, with a force of 204 lbs (Tab BB-38; S-12). The rudder pedal force peaked at 229 lbs one and a half seconds later, already greater than 17^{o} AoS (Tab S-12). At approximately four seconds after the RUDDER Special Alert annunciated, the MP modulated rudder pedal force back down to 160 lbs, but the AoS was already greater than 21^{o} (test termination criteria) and getting worse (Tab S-12). At this point, the MP began to completely release all rudder pedal force immediately prior to the MTC calling, “Recover” (Tab S-12). The rudder was in an overbalance state or “locked” since there was no pilot rudder force applied, yet the rudder was still deflected (Tab S-12).

The MCP made several directive call outs to assist including “Nose down,” “Power out,” and “Let go, Let go” (Tab EE-8). The MA eventually inverted and recorded over 56^{o} of sideslip although the instrumentation may be considered unreliable at those extreme conditions (Tab S-12). The MA violently dropped its nose, rolled and inverted (Tab S-12). The MP never applied corrective rudder (Tab S-12). Since only the left seat rudder pedals were instrumented, it is impossible to tell when or if the MCP began applying any corrective forces, but the rudder pedal position did not approach neutral or an “unlocked” state until 12:18:55L (Tab S-12). Just one second prior, the rudders were deflected to 55% of rudder pedal position (Tab S-12). The MP became distracted during the sequence of events when his checklist or some object from the cockpit hit him in the head and momentarily distracted him from recognizing the aircraft was recoverable Tab V-1.17).

Figure 2

The picture above is from animation produced by LM, created from flight data that shows the attitude of the MA and cockpit presentation after the MA went inverted during the departure (Tab S-12).

At some undetermined point, the MCP began flying the aircraft to recover it from the dive (Tab V-2.19). He pulled the aircraft out of the dive, retracted the flaps, and recovered with under

10,000 ft of altitude (Tab S-12). The MA was over G'd, reaching 3.194 Gs during the recovery, and the flaps were over sped by more than 100 knots (Tab U-158).

Immediately following the recovery, the crew responded to an alarm for smoke in the cargo compartment and the crew began donning oxygen masks. The mishap loadmaster (ML) realized it was not smoke, but rather powder from a fire extinguisher which had been thrown around during the violent aircraft movement (Tab V-3.8).

The crew requested the safety chase aircraft to perform a damage assessment, a visual inspection in flight (Tab V-1.4). The MP then performed a controllability check (Tab V-2.7). The crew elected not to change the flaps or gear any further since those structures had been over-sped (Tab V-1.4). The crew declared an in-flight emergency (IFE) (Tab V-4.7). The MP performed a flaps-up landing uneventfully (Tab V-1.18). The crew was met by emergency response and the IFE was terminated (V-4.6).

e. Recovery and Post-accident Activity

The mishap was initially classified as a "Class E" mishap per AFI 91-204, *Safety Investigations and Reports* (12 February 2014), prior to any damage being noted and was subsequently upgraded to a "Class C" mishap (Tab A-2). On 10 June 2015, LM analysis concluded that many structural areas of the MA exceeded DLL, and the mishap category was immediately upgraded to "Class A" (Tab P-2 to P-6). The MA was not correctly impounded post-mishap IAW AFI 21-101, *Aircraft and Equipment Maintenance Management* (26 July 2010), Chapter 9 (Tab U-161). The Single Investigating Officer (SIO) controlled access to the aircraft during the "Class C" investigation, but that access control did not meet impoundment requirements of AFI 21-101 (TAB U-162). The SI and other articles were removed from the aircraft and repair work was done before the AIB had a chance to inspect the MA (Tab U-162).

f. Simulation and Analysis

LMAC created a simulation of the mishap to assist the investigation (Tab S-12). Screen shots of the simulation are shown in Figure 2.

g. Egress and Aircrew Flight Equipment (AFE)

There are no provisions on the aircraft to securely hang parachutes and life preserver units (LPUs) once sized and fitted (Tab V-4.5). This allowed the parachutes and LPU's to become tangled in the flight control cables during the accident sequence (Tab V-3.14). The Purple K fire extinguisher did not have a permanent hard mounting location (Tab V-3.12). During the accident sequence, the Purple K fire extinguisher slid out from under the cargo strap securing it to the top of several A-bags and impacted the interior structure of the aircraft (Tab S-4 to S-5). This caused the seal under the handle to rupture and the agent to discharge into the cargo area of the aircraft with the safety pin and plastic retaining lock still in place (Tab S-4 to S-5). This resulted in the activation of the cargo compartment smoke detection system (Tab U-152).

h. Search and Rescue (SAR)

Not applicable.

i. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The Air Force Technical Order (AFTO) 781 series forms, Integrated Maintenance Data System (IMDS), and Time Compliance Technical Orders (TCTO) document aircraft maintenance, inspections, servicing, and airworthiness of the aircraft IAW T.O. 00-20-1 (Tab D-9 to D-12, Tab U-3 to U-36, U-98 to U-110).

A detailed review of the AFTO Form 781A, 781H, 781K, and 781J (from here on referred to as the 781 set) for the mishap flying period and all sets for the 90 days prior to the mishap revealed that maintenance documentation was completed IAW applicable maintenance directives, with minor documentation errors noted (Tab D-9 to D-12, Tab U-3 to U-36, U-98 to U-110). There were no overdue TCTOs, time change items, or special inspections (Tab D-9 to D-12, Tab U-98 to U-110). No recurring maintenance issues were revealed. (Tab U-6 to U-36). There is no evidence to suggest that forms documentation was a factor in this mishap.

b. Inspections

The AC-130J does not yet have maintenance Preliminary Technical Orders specific to the AC variant; the AC-130J maintainers use the MC-130J TOs to perform all standard C-130J maintenance, and use drawings to complete maintenance on AC-130J-specific components (Tab U-111). The AC-130J uses a progressive isochronal inspection cycle called a Letter Check (Tab U-113). A Letter Check inspection is completed every 270 days, with increasing inspection requirements at each 270-day interval (Tab U-113). These inspections ensure the aircraft systems and structural integrity are within prescribed limits (Tab U-113).

Airframe total time was 299.4 hours after the mishap flight (Tab U-3). Total operating time for the engines after the mishap flight were 299.4 hours for engine #1, 310.9 hours for engine #2, 306.8 hours for engine #3, and 308.9 hours for engine #4 (Tab U-3, U5). The MA was gained to the Air Force inventory on 7 December 2012, and transferred from Lockheed Martin to the government for Developmental Testing after AC-130J modifications on 22 January 2014 (Tab U-116, U-119).

The most recent Letter Check was an “A” check, completed on 12 September 2014 (Tab U-37 to U-97). A review of the AFTO Form 781A set for this inspection revealed that all required maintenance was completed IAW prescribed directives (Tab U-37 to U-97). Since the most recent Letter Check, the MA had gained a total of 222 days and 180.7 flying hours (Tab U-118). The MA and engines were within prescribed intervals for scheduled maintenance (Tab D-9).

The AFTO Form 781K for the mishap flying period along with IMDS records were reviewed to ensure currency of hourly/calendar inspections, TCTOs, time change items, and completion history of hourly/calendar special inspections. There were no overdue special inspections, TCTOs, or time change items that would have prevented flight on the date of the mishap (Tab D-9 to D-12, Tab U-98 to U-105). All special inspections required per 1C-130(H/M)J-6 were annotated on the AFTO Form 781K (Tab D-9). There was no evidence to suggest that non-compliance with AFTOs, inspections, or relevant maintenance practices was a factor in this mishap.

c. Maintenance Procedures

Maintenance responsibility for the MA was USSOCOM DET 1 via contract for standard organizational maintenance functions performed by Lockheed Martin (Tab V-18.17, Tab U-117).

A review of the MA's AFTO 781 series forms (all AFTO Forms 781 for 90 days prior to mishap, 25 February 2014 mishap flying period 781A set, and Letter Check AFTO Form 781A set) revealed that all maintenance procedures were in compliance with all applicable instructions. The only exception was the aircraft impoundment, which was not completed IAW AFI 21-101, Chapter 9, following the mishap (Tab U- 36, Tab U-120 to U-141). Since the MA was not impounded properly, evidence preservation could not be guaranteed.

A review of the AFTO 781 series forms revealed that all other maintenance was accomplished in compliance with applicable maintenance directives (Tabs U-3 to U-36). The forms and records annotated various delayed discrepancies, none of which would have prevented flight on the mishap date or likely affected the mishap (Tabs U-6 to U-36). There is no evidence to suggest that maintenance procedures were a factor in this mishap.

d. Maintenance Personnel and Supervision

All maintenance activities reviewed were normal and consistent with prescribed maintenance directives (Tab U-159). All personnel involved in the preflight, servicing, inspecting, and launch of the MA were qualified in their duties (Tab U-115). The Special Certification Roster was reviewed to ensure maintenance personnel were qualified for their duties as applicable (Tab U-115). All personnel were qualified.

The AFTO Form 781H was reviewed to ensure flight preparedness of the mishap flight (Tab U-3, U-4). A pre-flight inspection was accomplished on 20 April 2015 at 2115L by qualified Lockheed Martin personnel, and a qualified supervisor reviewed the MA forms prior to flight (Tab U-3, U-4). There were multiple open discrepancies annotated in the mishap forms set, but none related to the mishap, and none that would have prevented flight (Tab U-6 to U-36). There is no evidence to suggest that maintenance personnel, training, or supervision were a factor in this mishap.

e. Fuel, Hydraulic, and Oil Inspection Analyses

No fuel, hydraulic, or oil samples were taken from MA following the mishap, due to the extended time between the mishap and the mishap Class A determination. By the time the AIB was convened, significant maintenance had been performed on the MA that would have rendered fluid samples impossible or inconclusive as to the MA fluid state at the time of mishap (Tab U-

142 to U-144). There is no evidence to suggest that the fuel, hydraulic, or oil were factors in this mishap.

f. Unscheduled Maintenance

There were two unscheduled maintenance actions since the last scheduled inspection on the MA (Tab U-33, U-36). On the flight prior to the mishap flight, the aircrew noted, "Excessive noise coming from rudder pressure boot area" (Tab U-33). This sound was identified as a leaking rudder push-pull rod seal and placed on order by the LM maintenance team (Tab U-33). The leak was not determined to be severe enough to warrant discontinuing the flight test (Tab R-54). The second unscheduled maintenance event following scheduled maintenance was a ground crew identified discrepancy, "LH EXT [left hand external] tank FWD [forward] pump ECB#230 [electronic circuit breaker] tripped. Reset ECB#230, cycled LH EXT tank FWD & AFT pumps, ECB#230 trips. ECB#230 (LH EXT FWD PUMP) pulled & strapped" (U-36). P.T.O. 1C-130(A)J-1 explains that the two pumps provide dual reliability for the system (Tab U-114). The Debrief Summary Report does not indicate a fail in the LH EXT AFT PUMP during the mishap flight (Tab U-145 to U-157), and shows both tanks indicating empty within 44 seconds of each other (Tab U-154), which indicates the pumps were working properly. There is no evidence to suggest that either of these unscheduled maintenance actions were a factor in this mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

There are no indications that the pre-crash condition of the aircraft systems or structures was a factor in the mishap. Indeed, initial aircraft inspections following the mishap revealed only minor damage (Tab P-2 to P-3, Tab U-142 to U-144). Further analysis of the mishap identified 200% DLL (Tab P-6).

(1) Test Instrumentation

The MA was modified with a suite of SI to facilitate specific test data requirements (Tab BB-3 to BB-33). The test team used the SI suite in-flight for test execution as well as to collect data for post-flight analysis (Tab BB-3 to B-33). SI helps crews execute test because the basic aircraft instruments do not provide all the information required to perform certain maneuvers (e.g., AoS, rudder pedal position, force applied to rudder pedals, etc.). Specific parameters are targeted and monitored via specially designed displays as part of the IADS (Tab BB-145 to BB-146). IADS helps ensure safety during test maneuvers as the pilots, test conductor, and flight test engineers monitor key Safety of Test (SOT) parameters (Tab BB-73).

The SI suite did not include real-time readouts of the 1553 bus data in-flight (Tab BB-9, BB-14, BB-16). That data was captured during the test but not useful until post-flight since the aircraft Original Equipment Manufacturer (OEM) is the only one with data rights to translate 1553 bus data into information useful to the test team (Tab V-5.20). Therefore, all 1553 data had to be provided to LMAC for analysis after the flight (Tab V-11.5)

The SI suite consisted of sensors and data recording equipment to collect 1553 bus data, video data, flight control data, GPS data, Air Data Boom data, acoustic data, and analog data (Tab BB-5 to BB-6). 1553 Data Bus collection was accomplished by direct feed from eight channels of 1553 data bus to the Test Instrumentation Data Acquisition System (TIDAS) Rack mounted in the cargo compartment at Flight Station 577, (Tab BB-7 to BB-9).

Video data was collected through mini video cameras mounted throughout the aircraft that fed collected video data from the pilot's Head's Up Display (HUD), pilot's and combat system operator's (CSO) Communication/Navigation/Identification Management Unit (CNI-MU) displays, cargo compartment, and aircraft exterior to the TIDAS rack (Tab BB-17 to BB-24). Three Color Multi-Functional Display Units (CMDUs) and eight channels of Munitions Operator Pallet (MOP) video data was recorded through direct connection from the CMDU and MOP to the flight recorder on the TIDAS rack (Tab BB-17 to BB-24).

Flight control data acquisition was provided through sensors that acquired rudder pedal load, yoke forces, yoke position, rudder pedal position, Air Data Boom data (AoA, AoS, static pressure, total pressure, and air temperature) (Tab BB-25 to BB-31). An air data boom was mounted on the tip of the right wing to provide real-time data monitoring of the parameters mentioned above, and was recorded via the flight recorder on the TIDAS rack (Tab BB-30 to BB-31).

High precision GPS was provided through a ruggedized receiver to the flight recorder on the TIDAS rack (Tab BB-10). Acoustic data recording included Internal Communication System (ICS) feeds, 23 external microphones, and a handheld acoustic device that all fed data to the TIDAS rack (Tab BB-11, BB-32 to BB-33). Analog data was recorded through accelerometers and 30MM gun strain gauges (Tab BB-31 to BB-32).

(2) Rudder Operation

The rudder is a primary flight control attached to the trailing edge of the vertical stabilizer. The purpose of the rudder is to allow the crew to control the aircraft in yaw axis. The rudder booster assembly provides hydraulic boost to control forces from the rudder (Tab BB-36). 3,000 psi of hydraulic pressure boost is provided anytime the flaps are at 15% or greater of travel (Tab BB-36). Anytime flap position is less than 15%, 1,300 psi of hydraulic boost is used (Tab BB-36).

(3) Side Slip Warning System

The sideslip warning system provides aural and visual cues on aircraft sideslip position (Tab BB-37). These cues warn pilots of increasing side slip angles relative to the aircraft limits (Tab BB-37, Tab BB-38). The visual cues are displayed on the pilot's and co-pilot's HUDs (Tab BB-37).

(4) Parametric Data

The Digital Flight Data Recorder (DFDR) was downloaded post-mishap and sent to WR-ALC/AIRCRAT for Military Flight Operations Quality Assurance (MFOQA) analysis (Tab BB-

34). LMAC produced an animation that included all standard DFDR inputs as well as test instrumentation inputs to include 1553 bus data (Tab S-12).

The Cockpit Voice Recorder (CVR) was not downloaded post-mishap due to the delay in properly classifying the mishap as "Class A" (Tab BB-34). Similar to the DFDR data, the inputs from the CVR were downloaded to the test instrumentation data recorder and used to produce the LMAC animation (Tab S-12). The AIB investigated the possibility of retrieving the CVR data at the time the board convened, and determined that the aircraft overwrites CVR data whenever power is applied, with a two-hour maximum storage (Tab BB-35). Due to the extended length of time between the mishap and AIB convening, significant maintenance actions following the mishap, and lack of evidence preservation, it was determined that the CVR no longer contained any data relevant to the mishap (Tab U-142 to U-144, Tab U- 36, Tab U-120 to U-141).

b. Evaluation and Analysis

There were no evaluations or analyses deemed necessary for the aircraft vehicle systems.

7. WEATHER

a. Forecasted Weather

Weather conditions at the time of departure were forecast to be less than 25^{o} Celsius (77^{o} Fahrenheit) for the duration of the flight with winds from 020^{o} - 050^{o} at 9 knots (Tab F-2). The minimum altimeter setting for the flight was 29.95 inches of mercury (in Hg) (Tab F-2). Skies were forecast to be clear below 150 (cloud heights reported in hundreds of feet altitude above the surface) with scattered cloud layers at 150 and 200 and visibility was forecast to be greater than 6 miles for the duration of the scheduled flight (Tab F-2). Sunrise was 0613L and sunset was 1918L (Tab F-2). The conditions in the planned working area at the planned altitudes were forecast to be a maximum temperature of 6 degrees Celsius with winds 272 degrees at 28 knots (090) and a minimum temperature of -6 degrees Celsius with winds 286 degrees at 30 knots (150) (Tab F-2).

b. Observed Weather

Weather conditions at takeoff time were observed to be: 21^{o} Celsius (70^{o} Fahrenheit) with surface winds from 050^{o} at 12 knots; the altimeter setting was 30.05 in Hg; skies were reported with few clouds at 190 and scattered clouds at 250; visibility was 10 miles (Tab W-2). Weather conditions at the time of the accident at the field of departure (Eglin AFB) were observed to be: 24^{o} Celsius (75^{o} Fahrenheit), with surface winds from 070^{o} at 7 knots; the altimeter setting was 30.02in Hg; skies were reported with few clouds at 190 and few clouds at 230; visibility was 10 miles. Weather conditions at landing time were observed to be: 26 degrees Celsius; with surface winds from 020 at 8 knots; the altimeter setting was 29.99 in Hg; skies were reported with few clouds at 180 and few clouds at 230; visibility was 10 miles (Tab W-2).

c. Space Environment

Not Applicable.

d. Operations

The test mission was filed as an IFR flight flown in visual meteorological conditions and was flown IAW AFI 11-202v3, *General Flight Rules,* 7 November 2014, weather requirements. Both the forecast and observed weather conditions were typical for the region and time of year (Tab-F, Tab-W). There is no evidence to suggest that weather was a factor in the mishap.

8. CREW QUALIFICATIONS

Crew qualifications were not a factor in the mishap.

a. Mishap Pilot (MP)

MP was current and qualified in the MA and was familiar with multiple C-130 aircraft (Tab G-4 to G-8, G-74). MP was a graduate of the Air Force Test Pilot School (TPS) and had flown multiple aircraft (Tab G-4 to G-10). MP was part of the Initial Cadre for the AC130J (Tab T-2). He had 3807.4 total hours: 2,797.2 in C-17s, 429.2 in C-130 aircraft, 289.6 in C-130J variants, and 88.2 in the AC-130J (Tab G-4 to G-10).

Recent C-130J flight time is as follows (Tab G-11):

	Hours	Sorties
Last 30 Days	10.3	5
Last 60 Days	34.6	10
Last 90 Days	48.8	15

b. Mishap Copilot (MCP)

MCP was current and qualified in the MA and was familiar with multiple C-130 aircraft (Tab G-24 to G-27, G-88). MCP was a graduate of the Air Force TPS and had flown multiple aircraft (Tab G-24- to G-27). He had 3,039.6 total hours: 1,628.4 in C-130 aircraft, 95.1 in C-130J variants, and 19.4 in the AC-130J (Tab G-24 to G-28).

Recent C-130 flight time is as follows (Tab G-29 to G-31, G-36):

	Hours	Sorties
Last 30 Days	33.3	11
Last 60 Days	49.9	16
Last 90 Days	65.7	22

c. Mishap Loadmaster 1 (MLM1)

MLM1 was current and qualified in C-130J aircraft (Tab G-101). MLM1 was a previously qualified evaluator gunner in the AC-130H (Tab G-42 to G-44). MLM1 had 2,156.6 total hours: 1,985.9 in the AC-130H as a gunner, 170.7 in C-130J variants as a loadmaster, and 143.2 in the AC-130J as a Special Mission Aviator (Tab G-42 to G-43).

Recent AC-130J flight time is as follows (Tab G-42):

	Hours	Sorties
Last 30 Days	6.5	3
Last 60 Days	20.0	6
Last 90 Days	39.6	12

d. Mishap Loadmaster 2 (MLM2)

MLM2 was current and qualified in C-130J aircraft and was a previously qualified evaluator loadmaster in the AC-130U (Tab G-47, G-111). MLM2 had 3,626.3 total hours: 3,430.7 in the AC-130U as a loadmaster, 36.1 in C-130J variants as a loadmaster, and 36.1 in the AC-130J as a Special Mission Aviator (Tab G-46).

Recent C-130J flight time is as follows (Tab G-48 to G-49):

	Hours	Sorties
Last 30 Days	17.9	5
Last 60 Days	23.6	7
Last 90 Days	31.6	11

e. Mishap Test Conductor (MTC)

MTC was current and qualified in C-130J aircraft and had 141.5 total hours: 126.4 in C-130 aircraft, of which 94.2 were in the AC-130J (Tab G-53 to G-54, G-139). This was MTC's first flight after a lengthy absence to attend Army Logistics University (Tab G-54, V-5.4). MTC was non-current for water survival training (Tab T-4). The mishap flight was conducted in a warning area over open water, at a distance outside of the gliding distance from land (Tab S-11 and S-12).

Recent C-130J flight time is as follows (Tab G-55):

	Hours	Sorties
Last 30 Days	0	0
Last 60 Days	0	0
Last 90 Days	0	0

f. Mishap Flight Test Engineer 1 (MFTE1)

MFTE1 was current and qualified in C-130J aircraft (Tab G-171).

g. Mishap Flight Test Engineer 2 (MFTE2)

MFTE2 was current and qualified in C-130J aircraft (Tab G-156).

h. Mishap Flight Test Engineer 3 (MFTE3)

Although MFTE3 was not current and qualified in C-130J aircraft, he was under the supervision of an instructor loadmaster (Tab G-169). MFTE3 was non-current for water survival training (Tab T-4). The mishap flight was conducted in a warning area over open water, at a distance outside of the gliding distance from land (Tab S-11 and S-12). Per DCMA INST 8210.1C "Water Survival Training/Under Water Egress Training currency is required prior to operating any Government aircraft over open water beyond the gliding distance to land" (Tab BB-112 and BB-113).

9. MEDICAL

a. Qualifications

Based on all applicable medical information, all eight mishap crewmembers appeared medically qualified for flying duties at the time of the mishap (Tab CC-2 to CC-3). Each crewmember was current on his Periodic Health Assessment (Tab CC-2 to CC-3). All four active duty crew members had current AF Form 1042s, *Medical Recommendation for Flying or Special Operational Duty*, and the non-active duty members had the appropriate medical clearances to fly (Tab CC-2 to CC-3). Everyone had current physiological training (Tab CC-2 to CC-3). There is no evidence to suggest any crewmember had a medical condition, illness, or performance-limiting condition that would have caused or contributed to the mishap (Tab CC-2 and CC-3).

b. Health

Nobody was treated for injuries sustained during or after the mishap (Tab CC-2 and CC-3). However, MLM1 and MLM2 were both seen at Flight Medicine the day after the mishap for possible respiratory irritation due to inhalation of fire extinguisher material after the fire extinguisher broke apart during the departure, releasing a white powder (Tab CC-2 to CC-3). Both were monitored appropriately and neither sustained lasting symptoms or injuries (Tab CC-2 and CC-3).

c. Pathology

Toxicology tests were performed on the MP, MCP, and MTC (Tab CC-2 to CC-3). Blood and urine samples were sent to the Armed Forces Medical Examiner's Forensic Toxicology Laboratory at Dover Air Force Base, Delaware (Tab CC-2 to CC-3). Blood and urine were tested and all results were negative (Tab CC-2 and CC-3).

d. Lifestyle

There is no evidence to suggest lifestyle factors were a factor in the mishap (Tab CC-2 to CC-3, R-6 to R-13, R-18 to R-25, R-35 to R-42).

e. Crew Rest and Crew Duty Time

AFI 11-202v3, *General Flight Rules* (7 November 2014), paragraph 2.1 states, "Crew rest is free time and includes time for meals, transportation, and rest. This time must include an opportunity for at least 8 hours of uninterrupted sleep. Crew rest period cannot begin until after the completion of official duties," (Tab BB-66). The 72-hour and 14-day histories for the MP, MCP and MTC show that each crewmember had the opportunity for at least eight hours of rest (Tab R-6 to R-13, R-18 to R-25, R-35 to R-42). No 72-hour or 14-day histories were collected for the MLM1, MLM2, MFTE1, MFTE2, or MFTE3 (Tab R-29, R-32, R-48, R-52, R-59).

For the 72-hour and 14-day histories that were collected, there is no evidence to suggest inadequate crew rest was a factor in the mishap (Tab CC-2 to CC-3).

10. OPERATIONS AND SUPERVISION

a. Operations

The 413 FLTS did not have an elevated operations tempo in the months leading up to the mishap. A few individuals interviewed stated that the workload ebbed and flowed but they did not remember it being elevated nor did the volume of work negatively affect the mission (Tab V-2.24, V-4.3, V5.24). All crewmembers flew 11 times or less in the proceeding 30 days and nobody flew more than 22 times for a total of 65.7 hours in the proceeding 90 days (Tab G-11, G29, G-42, G-48, G-55). There is no evidence that operations tempo was a factor in this mishap.

b. Supervision

The appropriate individuals assigned to the 413 FLTS prepared, reviewed, and approved the test plan and test planning criteria along with the TAB, SRB, THAW, and all applicable waivers (Tab BB-58, Tab BB-63, Tab BB-75). All crewmembers received the appropriate training to conduct the flight (Tab BB-99 to Tab BB-108).

Due to the nature of the acquisition process and the parties involved, there appeared to be poorly defined and/or confusing lines of communication and organizational priorities (Tab V-9.2 to V-9.4, V-18.3 to V-18.5). The result of this was competing priorities and influences on 17 JON and 23 JON, which directly led to the SQ/CZ withdrawing his signature authority (and therefore his authorization) from the MOT (Tab BB-93 to BB-96, Tab V-11.13). A dispute as to the overall thoroughness of the tests and direction from LDTO to fly cards out of order as well as concern about some corruption of the data gathered as a result of poorly defined test criteria was the SQ/CZ's reasoning (Tab V-11.13 to V-11.15). There is no evidence the group leadership or the test team were aware of the withdrawal of his signature (Tab V-9.26, Tab V-11.26, Tab V-11.27 to V-11.32, V-12.3). This is further discussed in the Human Factors section below.

11. HUMAN FACTORS

Air Force Guidance Memorandum 2015-01, 14 April 2015, to AFI 91-204, *Safety Investigations and Reports,* with corrective actions applied on 10 April 2014, contains the Department of

Defense Human Factors Analysis and Classification System (DoD HFACS) 7.0 (Tab CC-8 to CC-17). DoD HFACS 7.0 lists potential human factors (including organizational influences, supervision, preconditions, and specific acts) that may play a role in aircraft mishaps. The following human factors were relevant to this mishap:

a. AE104 Overcontrolled/Undercontrolled Aircraft/Vehicle/System

Overcontrolled/Undercontrolled Aircraft/Vehicle/System is a factor when an individual responds inappropriately to conditions by either over- or undercontrolling the aircraft/vehicle/system. The error may be a result of preconditions or a temporary failure of coordination (Tab CC-11).

Evidence supports that the MP overcontrolled the rudder during test point 59 while transitioning from the SIDESLIP Special Alert to the RUDDER Special Alert to the left (Tab S-12 and Tab BB-54). The MP stabilized at the SIDESLIP Special Alert for nearly 10 seconds, applying approximately 125 lbs of rudder pedal force (Tab S-12). As the MTC began to clear the MP to proceed to the second Special Alert, the MP was already increasing rudder pedal force; within two seconds of increasing force, he reached 180 lbs (Tab S-12). Less than one second later, the RUDDER Special Alert annunciated immediately after the MTC finished the words "continue nose left, second alert" at approximately 14.5^{o} AoS (per design for the test point conditions), with a force of 204 lbs (Tab BB-38; S-12). The rudder pedal force peaked at 229 lbs one and a half seconds later, and already greater than 17^{o} AoS (Tab S-12). At approximately four seconds after the RUDDER Special Alert annunciated, the MP modulated rudder pedal force back down to 160 lbs but the AoS was already greater than 21^{o} and getting worse (Tab S-12). The MP eventually reduced all pressure against the left rudder, but the aircraft had already departed from controlled flight (Tab S-12).

According to previous flight test data provided by the OEM to the Air Force in July 2013, the rudder force required to achieve 14.5^{o} AoS for 100 percent flaps is approximately 150 lbs (Tab BB-149). The 150 lbs required was less than 180 lbs of force reached within two seconds of being cleared to continue to the second alert and much less than the 229 peak force used (Tab S-12). Therefore, the aircraft was overcontrolled for the test point conditions.

Overcontrolling can happen for a variety of reasons. One of the possible reasons is the difficulty of the task (Tab V-19.12). Several test pilots commented on how difficult the task is due to the variation in sensitivity on the rudder pedals required for each test point condition compounded by the waffling flight characteristics of the Dutch Roll (Tab V-19.12, V-20.10). Test Pilot 1 (TP1) stated the following:

> "So, you are doing a fine motor skill task with your quadriceps, right? And so, it's about like trying to drive a finish nail with a sledgehammer, okay? Um, it's not an easy task to do that and you have to move in very small discrete increments. And the task is different at higher speeds than it is at slower speeds. At higher speeds you've got a lot of force your pressing on the rudder, at the slower speeds, -- you know, and so you are kind of metering force. At the slower speeds you are metering position because your -- because your forces get a lot lighter and so you don't want to -- you don't want to just honk on like you were doing up at those faster speeds. So, as you build down in speed, you're, I don't want to say you're changing your technique, but you are probably changing how you, at least when I do it, how I -- how I

am monitoring what I am doing, and I'm using the flight test display is feedback on the position when we're doing it…So, um, I mean, there is probably 100 different ways of how to officially work through these tests point, you know, whether you do it all left leg, all right leg, whatever. The reason why we were swapping between the two is, honestly, is fatigue. Because, although left seat instrumented so the left seat guys are the ones doing all the test points when it comes to this. Um, and so as you, um, as you work through it, just by the nature of the way we are doing it, you know -- luckily when you get to the slowest speeds it's the lightest forces, because you're tired by then, but you also got to watch what you're doing because you're tired by then. Um, make sure that you're not over controlling the rudder, so a lot depended upon the pilot to monitor his fatigue level and there were a couple of flights where I would turn around look at the flight testing units and say were done today. You know, three hours of me doing this and my legs are shot. And so, but its, um, but yeah, there's just no other way to do it, I mean, we were slowly and incrementally stepping out trying to nibble at the edge of this thing without, without, you know, running over the top -- running over a cliff somewhere. And so, there was no other good way to do it, um, other than build down speed and build up in rudder force. I mean, it was the only way that made sense as far as from a safety standpoint, but obviously there is a, there is a lot of pilot technique and an pilot ability stuff that comes in there, because, you know, the difference between, you know, the first point the next point may be, you know, three quarters of an inch of rudder travel, you know. You know, when you're going from first alert to the second alert, that is two degrees of side slip and so it may literally be an inch or less of rudder travel to get you to that point…So, you get out and trying to nail a test point and trying to nail a position there in the nose is kind of wanting to hunt on you a little bit, and so it just -- some days it was easier than others to get that thing to stop where you wanted it to (Tab V-19.12 thru V-19.13)."

Evidence also supports that the MP undercontrolled the rudder during the recovery (Tab S-12). In accordance with 1C-130(A)J-1, page 2E-8, HIGH SIDESLIP RECOVERY PROCEDURES:

> "If either RUDDER Special Alert occurs, immediately apply the indicated rudder to center the sideslip display on the HUD. . . If rudder overbalance is encountered (one pedal pushes against the pilot's foot as the rudder floats towards the stop), the rudder pedal must be pushed back immediately towards center. Rudder pedal force to accomplish this can vary from 50 lbs at slow speeds to over 200 lbs at 180 knots" (Tab BB-123).

Similarly the test team recognized this possibility when applying for the waiver. The test team wrote:

> "If the pilot continues to push the pedals, the rudder pedal force continues to decrease until the rudder floats toward full deflection by itself. This is called rudder overbalance. If this condition occurs, the other pedal must be pushed to bring the rudder back toward center (opposite rudder pedal, 50 – 200+ lbf required). If this is not accomplished quickly, the airplane reaches extreme sideslip and may roll to a high angle of bank. Up to 5,000 feet of altitude loss could occur during the recovery" (Tab AA-13).

According to the data, the MP released left rudder pedal force but never applied right rudder pedal force as required by the procedure (Tab S-12). Immediately after the MA was recovered, the MP told the MCP, “Well I was trying to not overcontrol” (Tab EE-9). Therefore, the aircraft was undercontrolled for the recovery from departure from controlled flight.

Several test pilots cited their reluctance to be aggressive with the rudders and felt reducing rudder pedal force was preferred to being too aggressive with applying rudder inputs (Tabs V-10.8, V-19.11, V-20.14). During a previous test point on the mishap flight, the MP stated, “For the most part we don’t dance on the rudders at all during the recoveries” (Tab EE-4). He later commented, “I think in the back of -- any pilot of an aircraft of a rudder or fin, it's always in the back of our minds that large abrupt motions on the rudder can cause an overstress condition and, you know, could have structural damage” (Tab V-1.16). However this reluctance to use the rudder seems more tied to spatial disorientation than anything else since the MP answered, “I think if I had known what I know now, and I knew that what we were in was a sideslip departure or a spin motion, I wouldn't have hesitated to apply the correct procedure” (Tab V-1.17).

b. AE206 Wrong Choice of Action During an Operation

Wrong Choice of Action During an Operation is a factor when the individual, through faulty logic or erroneous expectations, selects the wrong course of action (Tab CC-12).

The test cards, THAW, and waiver directed, “Recover IAW PTO (extreme AoA procedures)” for a departure from controlled flight (Tab BB-63, Tab BB-73, Tab AA-7). The first steps of the extreme AoA procedures include “1. Lower the nose, apply appropriate rudder (step on the ball or ‘dog house,’ as indicated by the special alert and reduce asymmetric power. (Set all power levers to FLT IDLE if the nose is very low.) 2. Once the turn rate stops, neutralize the rudder and recover from the dive...” (Tab AA-7). The MP never stepped on the right rudder as previously discussed. Also, the MP never reduced the throttles completely even though he was instructed by the MCP (Tab EE-8). Furthermore, during the event, the MCP directed the MP, “Nose down, nose down” to lower the nose and the MP responded “pushing, pushing, pushing” (Tab EE-8). The MP pushed the nose down and rolled right, but the aircraft continued to yaw even more to the left (Tab S-12).

According to the MP, he was disoriented during the departure from controlled flight and all that made sense was airspeed; he thought it was the one thing he could control so he pushed forward on the control column (Tab S-12). This action, along with his right roll inputs exacerbated the left yaw condition due to a flight dynamics phenomenon known as “coupling” (Tab BB-143).

The MP admitted had he known that the rudder was locked, he would have applied correct rudder, “if I knew exactly we were in an overbalanced condition and the fin was stalled or was beginning to stall, I don't think I would have hesitated to put the correct action in” (Tab V-1.26).

There are various reasons why the wrong choice of action was applied. One reason may be confusion (Tab CC-15). Confusion will be further discussed in an upcoming section. Another possibility includes an inaccurate expectation or disposition by the test team to think departures from controlled flight would occur during a stall (Tab CC-15, V-20.6). When Test Pilot 2 (TP2) was asked if it would have made sense to use the high AoS recovery procedure for SHSS test points instead of the extreme AoA procedure, the witness responded, “We had one data point that basically said it worked” referring to the fact that he thought during the February 2014 departure the aircraft was recovered by breaking the stall (Tab V- 20.6). However, according to the non-safety privileged analysis of the first departure, the aircraft self-recovered due to coupling dynamics that reduced sideslip (Tab V-18.27). If the pilots expected the aircraft to depart during a stall rather than a sideslip excursion, this could have predisposed them to take actions to recover from a stall rather than an overbalance (Tab AA-13). The waiver that allowed the test team to proceed to the RUDDER Special Alert contained the fact that opposite rudder pedal force must be used to overcome a rudder overbalance and could require between 50 and 200 lbs or force (Tab AA-13). The guidance goes on to say, "If this is not accomplished quickly, the airplane reaches extreme sideslip and may roll to a high angle of bank. Up to 5,000 feet of altitude loss could occur during the recovery," which is basically what happened (Tab AA-13).

c. PE202 Instrumentation and Warning System Issues

Instrumentation and Warning System Issues is a factor when instrument factors such as design, reliability, lighting, location, symbology, size, display systems, auditory or tactile situational awareness or warning systems create an unsafe situation (Tab CC-13).

The current design of the aircraft's sideslip warning system visual cues provides only limited real-time positional information beyond the SIDESLIP Special Alert (2^{o}) and freezes at the RUDDER Special Alert (Tab BB-37). The sideslip warning system visual cues consist of a sideslip indicator and sideslip limit fence symbols in the HUD (Tab BB-130). The space between these symbols represents the difference between the airplane sideslip angle and the sideslip limit (Tab BB-37). When the sideslip indicator touches the "fence," the SIDESLIP Special Alert is activated; if sideslip continues to increase until the sideslip indicator extends halfway through the "fence," the RUDDER Special Alert is activated (Tab BB-37). After RUDDER Special Alert is activated, the sideslip indicator does not move beyond half way through the fence, regardless of a continual increase in sideslip (Tab BB-37 and Tab V-19.18). The PTO 1C-130(A)J-1 does not make it clear that the sideslip indicator freezes once it bisects the fence and according to TP1, this fact was not understood by the test team (Tab BB-37 and Tab V-19.18).

TP1 stated:

> "Um, a little hard to define where that second alert is other than just eyeballing it. What I didn't realize, until after we started a lot more in-depth discussion on this, and I guess I should have, as many as these test points as I've done, is once it gets to the second alert it does not move any further. So it stops, so, you have no indication past -- if you've gone past that point and if so how far. With the OEM's assumption being is that once you've hit that point you don't need to be going any further than that so I'm not going to tell you how much further you can go. So, so if I were to change that, I would change that mechanization somehow to, to show if I've gone past that how far past that I have gone" (Tab V-19.18).

Similarly, the MTC observed, "…there is an audio alert that you get, but there is hysteresis in the audio alert. So, if you were to touch the fence and come away from the fence, the audio alert will continue to sound…So, if the audio is sounding, that means we're -- could be getting close to the test point…or at the test point or past the test point" (Tab V-5.8).

Therefore, the test crews had no indication if they were stabilized beyond the RUDDER Special Alert. The MP stated, “I think the biggest and obvious one [human factor] was I didn't have a good way to tell what the motion of the aircraft was, that the sideslip had continued to increase. I had no cultural references. And the one piece, the doghouse, stopped moving, and I wasn’t able to use it to help me determine what the aircraft was doing” (Tab V-1.18).

d. PC508 Spatial Disorientation

Spatial Disorientation is a factor when an individual fails to correctly sense a position, motion, or attitude of the aircraft/vehicle/vessel or of oneself (Tab CC-14). Spatial Disorientation may be unrecognized and/or result in partial or total incapacitation (Tab CC-14). The MP describes his challenge correctly to sense motion, confusion about what was happening and how he tried to respond below:

> “As I moved from initial alert to the second alert, I recognized the rate that I was not intending to occur, and I decreased the pressure I was putting on the pedal. Near the same time the flight test engineer recognized my force being removed from the pedal and called "recover." I further reduced my pressure on the pedal as far as I could, and the resulting motion of the aircraft as I did that instantaneously and debilitating disoriented me. I couldn't quite recognize why the aircraft was continuing to do what it was doing. Out of all the things that I could see, in my field of view, the only thing that I could recognize as status of the aircraft was the airspeed. I saw the airspeed bleeding down at a rate that was not inconsistent with I saw since that's the only thing I could verify at the time. I attempted to decrease the pitch of the aircraft by pushing forward on the yoke to arrest the decrease in airspeed. The elevator did not move with the authority that I was hoping it would have, and the airspeed continued to decrease… I recall not fully having my SA about me. When the FT called recover, I was -- I don't know the appropriate word, but I was disoriented in a way that I don't remember ever feeling before in an aircraft. It was almost like the aircraft was doing something that I couldn't figure out why it was doing it. And while hindsight may appear like it was something that I caused when I removed the force on the rudder, I couldn't ascertain what the aircraft was actually doing. And so the only thing I could actually latch onto was the airspeed decreasing, and I believe a left rolling tendency. That's the only thing that I could definitely say the aircraft was doing, and so I tried to correct those two conditions by putting in right roll and pushing forward on the yoke to eliminate the decrease in airspeed…We were far south in the water ranges; so I had no cultural references to ascertain motion of the aircraft; so I was fully dependent on the HUD and the instrumentation inside the aircraft” (Tab V-1.3, Tab V-1.15 thru V-1.17).

During his interview, the MCP stated, “At one point, I remember looking at the water and I just remember the water—it was very difficult to make a reference of which way was what because of the water. We still had the HUD, but the water was—there was no ground reference” (Tab V-2.19). This is consistent with the first AC-130J departure event in 2014 according to a witness who stated that the crew thought they were spinning to the right when in fact they were spinning to the left (Tab V-19.10). The MP and MCP described conditions that are most conducive to spatial disorientation including lack of visual references, loss of situational awareness, and distraction (Tab CC-20).

e. PC104 Confusion

Confusion is a factor when the individual is unable to maintain a cohesive and orderly awareness of events and required actions, and instead experiences a state characterized by bewilderment, lack of clear thinking or (sometimes) perceptual disorientation (Tab CC-15).

The MP described some of his confusion during the MA's departure from controlled flight, saying to the MCP after recovery, "I was unsure, bringing the power back if the reverse gyroscopic effects would undo something" (Tab EE-12). He later stated, "I was trying to analyze everything . . . I was just, I was trying to contemplate everything. There were just too many things" (Tab EE-12). During the MP's interview, he stated, "I couldn't quite recognize why the aircraft was continuing to do what it was doing. Out of all the things that I could see, in my field of view, the only thing that I could recognize as status of the aircraft was the airspeed. I saw the airspeed bleeding down at a rate that was not inconsistent with I saw since that's the only thing I could verify at the time" (Tab V-1.3).

f. OP003 Provided Inadequate Procedural Guidance or Publications

Provided Inadequate Procedural Guidance or Publications is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading, or inappropriate (Tab CC-17).

Test card 14 contained a table and chart that identified expected activation of the SIDESLIP Special Alert and the RUDDER Special Alert (Tab BB-57). These predictions would have the test crew not expect the RUDDER Special Alert for high power settings (greater than 10,000lb total horsepower) to activate prior to 16^{o} AoS. In fact, the RUDDER Special Alert activates at 14^{o} AoS for high power settings. The Board retrieved a document believed to be the source for test card 14 which identified a Lockheed Martin employee as the author (Tab BB-150). The data contained within the table and chart conflict with a subsequent version of expected alert activation Lockheed Martin provided after the mishap (Tab BB-38). The expected alert activations identified in the chart provided by Lockheed Martin after the mishap are 1.5^{o} lower than the alert activations identified in test card 14 for both sideslip and rudder activation (Tab BB-38, BB-57).

Despite these errors, they likely did not contribute substantially to how the MP flew the aircraft. He stated, "It was more up to me to use the cues and the HUD to determine what rudder position would be required for me to get those alerts" (Tab V-1.11). What they did affect was the boundaries placed on the IADS display and therefore what a safety monitor may be looking at (Tab BB-145).

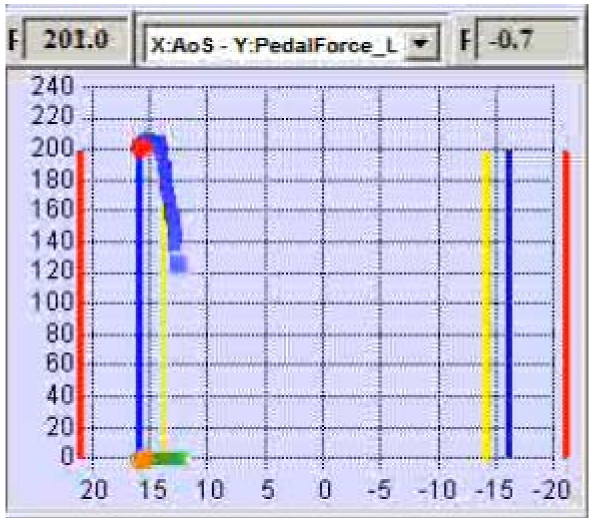

Figure 3

Figure 3 is representative of a segment of the IADS display viewed by the Test Conductor and Safety of Test monitors (Tab S-11). The red line is the global test limit of 21^{o} AoS (Tab BB-70). The yellow and blue lines are for awareness when the 1st and 2nd special alerts should activate (Tab BB-57). The Blue line should have been at 14.5^{o} instead of 16^{o} (Tab BB-38).

g. PC106 Distraction

Distraction is a factor when the individual has an interruption of attention and/or inappropriate redirection of attention by an environmental cue or mental process (Tab CC-15).

The MP stated he was distracted after the MA's departure from controlled flight just prior to the dive recovery by an unsecured item, possibly a checklist, hitting him in the head as the MA inverted (Tab V-1.4 and Tab V-1.17).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 51-503, *Aerospace and Ground Accident Investigations* (14 April 2015)
(2) AFI 91-204, *Safety Investigations and Reports* (12 February 2014 with corrective actions applied on 10 April 2014)
(3) AFI 11-202V3, *General Flight Rules* (7 November 2014)
(4) AFI11-2FTV3, 96 TW Supplement to *Flight Test Operations Procedures* (28 February 2013)
(5) AFI 11-401, *Aviation Management* (9 January 2013)
(6) AFI 99-103, *Capabilities Based test and Evaluation* (16 October 2013)

(7) AFI 21-101, *Aircraft and Equipment Maintenance Management* (22 April 2014)
(8) AFTCI91-203, 96 TW Supplement to *AFTC Test Safety Review Policy* (18 September 2014)
(9) DODI 6055.07, *Mishap Notification, Investigation, Reporting and Record Keeping* (6 June 2011)

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

b. Other Directives and Publications Relevant to the Mishap

(1) AC-130J Modification Airworthiness Certification Criteria (MACC), Military Flight Release Compliance Report (26 February 2015)
(2) AC-130J Military Flight Release No. AC-130J-R0006A1 (26 February 2015)
(3) AC-130J Military Flight Release No. AC-130J-R0006A1 (27 February 2015)
(4) PTO 1C-130(A)J-1, Flight Manual USAF Series AC-130J Aircraft (8 January 2014)
(5) PTO 1C-130(A)J-1-1, Flight Manual USAF Series AC-130J Aircraft (8 January 2014)
(6) PTO 1C-130(A)J-6CF-1, Acceptance or Functional Check Flight Procedures USAF Series AC-130J Aircraft (8 January 2014)
(7) PTO 1C-130(A)J-9,Cargo Loading Manual, USAF Series, AV-130J Aircraft (8 January 2014)
(8) TO 1C-130(A)U-1, *Flight Manual USAF Series AC-130U* Aircraft (1 December 2007)
(9) TO 1C-130H-1-1, *Flight Manual USAF Series C-130 Airplanes Equipped with T56-A-15 Engines* (1 June 2014)
(10) TO 1C130(M)J-1, *Flight Manual USAF Series MC-130J Aircraft* (1 November 2014)
(11) 96 OG OI 99-1, Method of Test Technical Review (29 June 2012)
(12) 46 OG OI 11-3, Aircrew Flight Test Cards (3 March 2006)
(13) AC-130J Flying & Handling Qualities Flight Test Cards, JON: AXZD0023 (20 April 2015)
(14) Test Instrumentation Plan, AC-130J, 5710 (15 November 2014)
(15) Memorandum for AFLCMC/EN, AC-130J SERIOUS Risk Acceptance (2 May 2014)
(16) Memorandum for AFLCMC/EN, AC-130J Medium and Low Risk Acceptance (15 January 2014)
(17) Method Of Test, Test Directive JON AXZD0023 AC-130J Flying Qualities Evaluation (31 July 2014)
(18) Ops Order MSN# 1566, Operations Order for Mission 1566, AC-130J Flying Qualities Evaluation (10 July 2015)
(19) RMB Summary, Test Directive No. AXZD0017, AC-130J Developmental Flight, Test (10 February 2014)

(20) Safety Annex, Test Directive No. AXZD0023, AC-130J Flying Qualities Evaluation (4 August 2014)

(21) Safety Annex, Safety Annex, Amendment No. 1, Test Directive No. AXZD0023, AC-130J Flying Qualities Evaluation (3 October 2014)

(22) Safety Appendix. Safety Appendix, Amendment No. 2, Test Directive No. AXZD0017, Test Directive Amendment No. 1 (23 April 14)

(23) Safety Appendix, Amendment No. 1, Test Directive No. AXZD0017, AC-130J Developmental Flight Test (22 January 2014)

(24) Safety Appendix, Test Directive No. AXZD0017, AC-130J Developmental Flight Test (10 January 2014)

(25) Air Vehicle Substantiation of the United States Air Force AC-130J Precision Strike Package (31 July 2013)

c. Known or Suspected Deviations from Directives or Publications

The aircraft was never impounded IAW AFI 21-101, Chapter 9 (Tab U-161).

Additionally, the test team intentionally maneuvered the AC-130J into a sideslip resulting in a LEFT/RIGHT RUDDER alert which would normally be a deviation from directive or publications (Tab AA-10). Since the test crew was doing so in accordance with a test plan and waiver signed by AFMC/A3, this action does not be constitute a deviation (Tab AA-10).

Finally, the test cards did not contain all pertinent Warnings (i.e. High Sideslip Recovery Procedures) as required by 96 TW guidance for test cards (Tab BB-41).

13. ADDITIONAL AREAS OF CONCERN

The MA exceeded the maximum allowable equivalent fuel weight. In TO 1C130(A)U-1 there is a statement in NOTE 2 that limits the maximum allowable fuel weight for Tank No. 1 and Tank No. 4 by the weight of any “external stores" (Tab BB-144). In PTO 1C130(A)J-1 the only reference to external stores and reduction in fuel weights is in reference to landing sink rates (Tab BB-144).

The additional weight levied on the outer wing sections is approximately 1,500 pounds when SDB's the MAU-40 and BRU-61 are loaded and installed and 950 pounds when the AN/ASQ-236 and pylon adaptor are installed (Tab K-5). For the accident involving aircraft 09-5710, the MA departed Eglin with SDB's, MAU-41 and BRU-61A on the right wing and AN/ASQ-236 plus pylon adapter on the left wing (Tab K-5). The takeoff fuel was 47,130 pounds with 8,180 pounds in both the No. 1 and No. 4 tanks (16,360 pounds total in the outboard tanks) (Tab K-5). If NOTE 2 applies to the C130J variants the aircraft was overloaded in the outboard sections by 1370 pound on the right wing and 820 pounds on the left outboard wing section (Tab BB-144).

The aircraft was not in primary fuel management (Tab U-158). The outboard wing sections were experiencing the equivalent of 9,680 pounds of fuel in the No. 4 tank and 9,130 pounds of fuel in the No. 1 tank. The No. 2 and 3 tanks (inboard tanks) had 7,430 pounds each (Tab K-5). Therefore, the MA loading exceeded the maximum equivalent fuel weight.

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30 September 2015

MICHAEL P. DAVIS, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

AC-130J, T/N 09-5710
Eglin AFB, FL
21 April 2015

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 21 April 2015, at approximately 12:18:40 hours local time (L), AC-130J, tail number (T/N) 09-5710, assigned to the 413th Flight Test Squadron, 96th Test Wing, Eglin AFB, Florida, departed controlled flight approximately 41 nautical miles (NM) south of Eglin AFB and then recovered to a safe landing. The mishap aircraft (MA) exceeded its Design Limit Load (DLL) to an extent that rendered it unsafe for flight and is considered a total loss to the Air Force inventory.

The mishap occurred on a medium risk flying qualities test sortie out to the edges of the flight envelope. The mishap pilot (MP) was attempting to execute a Steady Heading Sideslip (SHSS) to the RUDDER Special Alert of the Advisory Caution and Warning System (ACAWS), normally a prohibited maneuver. At approximately 12:18:35L, the MA exceeded 14.5^{o} Angle of Sideslip (AoS), triggering the RUDDER Special Alert and continued increasing AoS until it departed controlled flight shortly thereafter. At an undetermined time, the mishap copilot (MCP) took the controls and recovered the aircraft. In the process of the departure and recovery, the aircraft lost approximately 5,000 feet and experienced 3.19 times the normal force acceleration (Gs) and over sped the flaps by more than 100 knots. The over G exceeded the aircraft's Design Limit Load (DLL), thereby nullifying the airworthiness of the MA rendering it a total loss.

By a preponderance of the evidence, I find the cause of the mishap was the MP's excessive rudder input during the test point followed by inadequate rudder input to initiate a timely recovery from high angle of sideslip due to Overcontrolled/Undercontrolled Aircraft and Wrong Choice of Action During an Operation.

By a preponderance of the evidence, I also find Instrumentation and Warning System Issues, Spatial Disorientation, Confusion and the fact the test team was Provided Inadequate Procedural Guidance or Publications were factors that substantially contributed to the mishap.

I developed this opinion by analyzing factual data from historical records, Air Force directives and guidance, engineering analysis, witness testimony, and information provided by technical experts. The AIB obtained an animation provided by Lockheed Martin engineering analysis, which was used in conjunction with flight test data to determine the mishap sequence.

2. CAUSE

During the mishap sortie, a chain of events was triggered at some point when the MP applied too much rudder pedal force. According to the 31 July 2013 Air Vehicle Substantiation Report page 185, approximately 150 lbs should correlate to 14.5^{o} angle of sideslip (AoS), so that should have been sufficient to trigger the second alert. After the MP applied 229 lbs of force, the rudder was in an overbalance state or “rudder locked,” because even though he reduced left rudder force, the MA continued to yaw to the left. In my opinion, some critical AoS occurred between 150 and 229 lbs of rudder pedal force that resulted in a rudder overbalance due to overcontrolling.

The board sought to discover why so much rudder force was used, but found no single ultimate cause other than the MP overcontrolled the aircraft. Preceding the nose left SHSS, the MP used very large rudder forces in an unsuccessful attempt to stabilize at the right RUDDER Special Alert. The board explored the possibility of negative transfer applying heavy forces to needing lighter forces. This was not supported by testimony or data. The MP appeared to be “recalibrated” even before stabilizing at the SIDESLIP Special Alert using 125 lbs. The board also explored mental or physical fatigue, but the MP’s testimony did not support that as a likely cause. The board also sought to understand the difficulty of the required task. The challenge associated with task should not be understated. The “dutch roll” of the aircraft and the ability to meter small forces with the quadriceps are challenging. The MP had performed this maneuver many times before and the test team had, in aggregate, performed 183 successful SHSS test points before this final event. However, there is one possible substantial contributing factor related to the Heads Up Display (HUD) symbology when compounded by the difficulty of the task that will be discussed in the next section. In the end, the preponderance of the evidence supports that the MP overcontrolled the aircraft with respect to placing it into the departure from controlled flight.

With the rudder “locked,” the appropriate response IAW the checklist would have been to apply opposite (right) rudder sufficient to center the “doghouse,” but the MP did not--he only released left rudder according to the data. The waiver that allowed the test team to proceed to the RUDDER Special Alert contained the fact that opposite rudder pedal force must be used to overcome a rudder overbalance and could require between 50 and 200 lbs or force. The guidance goes on to say, “If this is not accomplished quickly, the airplane reaches extreme sideslip and may roll to a high angle of bank. Up to 5,000 feet of altitude loss could occur during the recovery,” which is basically what happened since sufficient opposite (right) rudder pedal was never applied. Therefore, the MP undercontrolled the aircraft with respect to recovering from the departure.

The MP also pushed the nose down when he still had flying airspeed and applied right roll input to counteract the left roll that was occurring. The right roll input actually worsened the left yaw. Therefore, he also made a wrong choice of action by pushing the nose down and rolling right when he still had flying airspeed.

The board sought to discover why the MP did not apply right rudder to stop the yawing motion but instead pushed nose down when he still had flying airspeed. He, like many test pilots according to their testimonies, would have been reluctant to apply opposite rudder for multiple reasons. Being aggressive with rudders in cargo/transport airplanes is not a good practice in general as it can overstress the vertical fin. It can also cause or exacerbate a departure in sideslip especially if the wrong rudder is used. The analysis of the first departure confirms this when it stated, "It appears that, following stick pusher activation, if no rudder was input, or, if the TEL [Trailing Edge Left] rudder was removed shortly after input, a yaw departure would not likely have developed." This cautionary philosophy may have preconditioned the MP not to reverse the rudder. However, this principle is referring to inputs to prevent the departure. Once a rudder is "locked," a significant amount of rudder force must be applied to "unlock" it and recover the aircraft. The MP could have neutralized the rudder first and then applied opposite rudder had he understood the situation clearly. I suspect Spatial Disorientation and Confusion are substantial contributing factors as to why he undercontrolled the recovery, so those will be discussed in the next section.

Not only did the MP undercontrol the recovery, he also made a wrong choice of action. By pushing the nose before it was stalled and rolling right, he exacerbated the left yaw. He also did not reduce the thrust IAW the recovery from extreme angles of attack procedure.

I suspected the MP was predisposed to react to a stall in the event of a departure from controlled flight. Even though the first AC-130J departure event was in yaw with a "rudder lock," the team seemed focused on the fact that it was a stall test point. The main recovery title is "recovery from extreme angles of attack." Whenever witnesses were asked how safety planning was changed following the first departure, the focus was on the extra altitude for recovery and the fact that they would use the altitude to regain airspeed instead of applying power, referring to recovering from a stall condition. Not one witness mentioned how the safety planning for the SHSS was affected by the first departure to prevent or emphasize recovery from a high angle of sideslip departure or from rudder overbalance. I expected there to be more focus on the recovery procedures as highlighted by the waiver comments. This is not to say the test team was not prepared for these contingencies. There was probably quite a bit of "behind the scenes" discussion regarding SHSS, departures in yaw, and appropriate recovery. The issue was certainly addressed in the test safety documentation as there was clear termination criteria. It just was not as apparent to the board during the interviews conducted that the team was as prepared for a departure so high above stall speed (i.e. a departure in yaw).

The waiver was one of the few test planning documents that mentions rudder overbalance. The Threat Hazard Analysis Worksheet (THAW) and the test cards emphasis for recovery from departures was weighted toward stalls as opposed to sideslip, based on the cautions, warnings, and recovery procedures mentioned. Although I agree the test team recovery procedure would have worked if followed, the MP may have been predisposed to recover from a stall. The MP admitted had he known that the rudder was locked, he would have applied right rudder.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

There were several contributing factors to this accident. The following discussion covers four substantially contributing factors: Instrumentation and Warning System, Spatial Disorientation, Confusion, and Provided Inadequate Procedural Guidance or Publications.

a. Instrumentation and Warning System

The HUD symbology for sideslip provides an indication when the aircraft reaches, but not when it exceeds, the RUDDER Special Alert. After the second special is activated, the sideslip indicator does not move beyond half way through the fence, regardless of a continual increase in sideslip. The MP likely didn't understand this fact. Due to the long period of time before the AIB was convened, the MP could not be sure whether or not he knew this before the accident. Other testimony implied that fact was not known until after the mishap. It is not clear from the PTO 1C-130(A)J-1 that the sideslip indicator freezes once it bisects the fence. He also had the MCP's verbal indications of increasing rudder position, but according to the MP's testimony, the MP's visual focus was on the "doghouse" and fence. Since the test crews had no indication if they were beyond the RUDDER Special Alert, it is plausible the MP thought he was executing the final portion of the test point perfectly based on the visual cues alone.

The mishap test conductor mentioned that the audio for the Special Alert is similar for the visual cue. He said, "[If the alert is sounding, it] means we're -- could be getting close to the test point…or at the test point or past the test point." In other words, the audio and visual cues do not give useful indications for the purposes of executing the test point. The board recognizes the system was not designed to aid in test--rather it was built for operational use. In my opinion though, any pilot would find the test point challenging to execute. At best, the Warning System did little to help the MP avoid overcontrolling the aircraft. At worst, the Warning System could be misunderstood to make the MP perceive he was exactly on conditions while actually making the situation worse. In either case, the instrumentation and warning system was not helpful to the MP determining when he was beyond a critical AoS.

Based on other testimony and the lack of definitive system description in the technical order, it is my opinion that the instrumentation and warning system was a substantially contributing factor as to why the MP overcontrolled the aircraft.

b. Spatial Disorientation

The MP stated the lack of "cultural references" and external cues of aircraft relative motion while flying over water left him feeling "debilitating/disoriented" as the sideslip continued to increase. The MCP's testimony describes a similar phenomenon consistent with the fact that the crew of the February 2014 departure event thought they were spinning to the right when they were actually spinning to the left. It is my opinion that the MP experienced spatial disorientation, which may have contributed to the MP confusion about what was happening or what action he should take. As such, I find spatial disorientation was a substantially contributing factor as to why the MP undercontrolled the aircraft when attempting to recover from the departure.

c. Confusion

The MP described his confusion in multiple statements. For example, "I was trying to analyze everything . . . I was just, I was trying to contemplate everything. There were just too many things…I couldn't quite recognize why the aircraft was continuing to do what it was doing." Based on these statements, it is my opinion that the MP was confused about what was happening or what he should do and his confusion was a substantially contributing factor as to why he undercontrolled the aircraft when attempting to recover from the departure.

d. Provided Inadequate Procedural Guidance or Publications

Test card 14 contained a table and chart that identified expected activation of the SIDESLIP Special Alert and the RUDDER Special Alert, which the crew was treating as the envelope of the aircraft. The error amounted to a reasonable expectation that the edge of the envelope was 16^{o} AoS when in fact it was only 14.5^{o}AoS. This mis-information altered guidelines placed on the safety of test displays. Therefore, had the correct limits been used, a safety monitor may have called "terminate" earlier, possibly preventing the rudder lock and, by extension, the departure. Admittedly, this is speculation. The actual impact is undetermined, but in my opinion, this false information was more likely than not a substantially contributing factor.

4. OTHER ITEMS FOR DISCUSSION

The board considered several factors as possibly contributing to the mishap. What follows is a brief explanation of other items the board considered and why these factors were not classified as substantially contributing factors to this mishap.

a. Method of Test

The board discussed at length the requirement for doing the SHSS to the limits prescribed by the MOT. The Lead Development Test Organization (LDTO) squadron commander did not seem to understand or agree with the requirement for the test. Also, the test team admitted they did not know how much margin of stability existed at the limits without the predictive data. Additionally, the 413 FLTS commander (SQ/CC) admitted the predictive data would be a requirement to allow his team to execute this test if tasked to do so again, but he did not explain why the team proceeded to the edges of the envelope without predictive data in the first place. We did not find in the safety review process an a priori knowledge that the team could safely execute to as much as 21^{o} AoS—the final termination criteria. In fact, I thought 21^{o} AoS was well beyond what the test ever required and was not an appropriate test termination criteria. The board believed the test could have been executed without stabilizing at or beyond the RUDDER Special Alert. If the test team had recovered as soon as the RUDDER Special Alert activated the mishap probably could have been avoided. Thus, I considered categorizing the Method of Test (MOT) as a possible cause or substantially contributing factor.

However, the board decided this was more of a matter of opinion regarding the MOT rather than a contributing factor for two reasons. First, engineers will have differing opinions on how the data can be collected in an appropriate manner. This decision resides in the realm of technical adequacy. The technical adequacy of recovering at the alert without stabilizing at the limit is questionable. The MOT chosen by the test team was clear cut with regards to technical adequacy—stabilizing at the limit could prove the aircraft was safe for the entire envelope. The second reason for not ascribing the MOT as a contributing factor is I was convinced the test team could have executed the entire test as planned without a mishap. The test team executed 183 SHSS test points before the mishap without incident and had been past the RUDDER Special Alert on several occasions. That doesn't mean it was the safest or "best" approach, but ultimately I found it did not meet the level of a significantly contributing factor where it appeared the test could have been safely executed as detailed in the MOT. One caveat to note is that I only came to this conclusion by reviewing the data of the test program after it was already executed.

Furthermore, the board found the predictive data found in the Air Vehicle substantiation Report should have been known to the test team and could have been used to alter the MOT. Developmental flight tests generally follow the mantra "Predict, Test, Validate." In the board's opinion the MOT skipped a great deal of the predict portion of test plan. For instance, the test crews could have used predicted rudder pedal force to help them reach target conditions in what was an already very demanding task.

Although the board may have, in hindsight, disagreed about how the test may been alternatively constructed, the cause of the mishap ultimately was overcontrolling the test point and then undercontrolling the recovery, not the MOT.

b. Technical Director Rescission of Signature from MOT

The squadron's technical director (SQ/CZ) first removed himself from reviewing any test cards in the unit and then rescinded his signature from the MOT. This situation appeared very significant, but our question was, "Did it contribute to the mishap?". We wondered if the technical director's actions were symptomatic of safety concerns that were not being respected by other unit leadership. Why would anyone remove their signature from the MOT if he/she felt the procedures were sound. We found no substantial evidence to suggest he was concerned for the safety of the flying qualities test activities. He stated "No changes need to be made to the existing documentation."

Someone of great authority in the unit who had been reviewing test cards was no longer involved reviewing the test cards. Could he have helped break the chain of events if he had remained engaged in the 23 JON test activities? Perhaps, but it was not likely based on his confidence in the MOT. He stated "The 23 JON test plan is the best product that the Air Force Test Center could put out under the circumstances," so it was unlikely he would have had an epiphany had he remained involved with the 23 JON's day-today activities.

We further questioned whether it was possibly a distraction that prevented the rest of the team from focusing on safe execution. Our search was inconclusive. The MP did not even know the SQ/CZ had rescinded his signature from the MOT he was executing, nor did the Test Approval Authority. The board debated the significance of the situation, and was left with the impression it was a personality issue for the unit and possibly related to tension between the LDTO regarding test execution. In our final analysis, I could not ascribe this as a substantially contributing factor but felt it was significant enough to warrant discussion.

c. Distraction not listed as Substantially Contributing Factor

The board discussed distraction as human factor in the Statement of Facts because the MP used that description in his testimony and because it explains why the MCP was flying the aircraft during the dive recovery, so it was a noteworthy human factor in the sequence of events. However, the board did not find distraction to be substantially contributing. After analyzing the data of the event, the board was confident the flying article of debris in the cockpit that distracted the MP occurred as the aircraft inverted. The aircraft was out of the rudder overbalance condition at this point and it was well beyond the point the departure recovery had been undercontrolled. The distraction may have prevented the MP from recognizing it was time to transition from a departure situation to a dive recovery situation. This delay is in the board's opinion approximately when the MCP began flying the aircraft. Therefore, the board believes distraction is noteworthy, but did not substantially contribute to the mishap.

5. CONCLUSION

I find, by a preponderance of the evidence, the cause of this mishap was the MP's excessive rudder input during the test point followed by inadequate rudder input to initiate a timely recovery from high angle of sideslip due to Overcontrolled/Undercontrolled Aircraft and Wrong Choice of Action During an Operation.

Additionally, I find, by a preponderance of the evidence, Instrumentation and Warning System Issues, Spatial Disorientation, Confusion and the fact the test team was Provided Inadequate Procedural Guidance or Publications were factors that substantially contributed to the mishap.

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30 September 2015

MICHAEL P. DAVIS, Lt Col, USAF
President, Accident Investigation Board

INDEX OF TABS

TAB A	**DISTRIBUTION AND SAFETY INVESTIGATOR INFORMATION**
TAB B	**NOT USED**
TAB C	**NOT USED**
TAB D	**MAINTENANCE REPORT, RECORDS, AND DATA**
TAB E	**NOT USED**
TAB F	**WEATHER AND ENVIRONMENTAL RECORDS AND DATA**
TAB G	**PERSONNEL RECORDS**
TAB H	**EGRESS, IMPACT, AND CRASHWORTHY ANALYSIS**
TAB I	**DEFICIENCY REPORTS**
TAB J	**TECHNICAL REPORTS AND ENGINEERING EVALUATIONS**
TAB K	**MISSION RECORDS AND DATA**
TAB L	**DATA FROM ON-BOARD RECORDERS**
TAB M	**DATA FROM GROUND RADAR AND OTHER SOURCES**
TAB N	**TRANSCRIPTS OF VOICE COMMUNICATIONS**
TAB O	**ANY ADDITIONAL SUBSTANTIATING DATA AND REPORTS**
TAB P	**DAMAGE AND INJURY SUMMARIES**
TAB Q	**AIB TRANSFER DOCUMENTSQ**
TAB R	**RELEASABLE WITNESS TESTIMONY**
TAB S	**RELEASABLE PHOTOGRAPHS, VIDEOS, AND DIAGRAMS**
TAB T	**FLIGHT RECORDS AND ORDERS, NOT INCLUDED IN TAB G**
TAB U	**AIRCRAFT MAINTENANCE RECORDS, NOT INCLUDED IN TAB D**
TAB V	**WITNESS TESTIMONY AND STATEMENTS**
TAB W	**WEATHER OBSERVATIONS, NOT INCLUDED IN TAB F**
TAB Y	**DOCUMENTS APPOINTING THE AIB MEMBERSY**
TAB Z	**PHOTOGRAPHS, NOT INCLUDED IN TAB S**
TAB AA	**FLIGHT DOCUMENTS**
TAB BB	**GOVERNMENT DOCUMENTS AND REGULATIONS**
TAB CC	**MEDICAL AND HUMAN FACTORS**
TAB DD	**FACT SHEETS**
TAB EE	**TRANSCRIPT OF MISHAP SORTIE**
TAB FF	**CD OF EVIDENCE REFERENCED IN TABS A THROUGH S**