UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-15C, S/N 79-0025

44TH FIGHTER SQUADRON
18TH WING
KADENA AIR BASE, JAPAN

LOCATION: KADENA AIR BASE, JAPAN

DATE OF ACCIDENT: 28 MAY 2013

BOARD PRESIDENT: COLONEL TERRY SCOTT

Conducted IAW Air Force Instruction 51-503

EXECUTIVE SUMMARY
AIRCRAFT ACCIDENT INVESTIGATION

F-15C, S/N 79-0025
NEAR KADENA AIR BASE, JAPAN.
28 May 2013

On 28 May 13 at approximately 0840L, the mishap aircraft (MA), an F-15C, S/N 79-0025, assigned to the 44th Fighter Squadron (FS), 18th Wing (WG), Kadena Air Base (AB), Japan, crashed into the Pacific Ocean approximately 60 miles east of Kadena AB, Japan. The mishap pilot (MP) ejected from the MA and sustained minor injuries. Japan Air Self Defense Force rescue forces recovered the MP. There was no damage to civilian property. The MA broke apart upon impact with a loss valued at $31,964,644.01. There was media interest as reported by local, national, and international outlets.

The MP was on a training mission as part of a two-ship formation. The two-ship executed take off, airspace entry and two training engagements without incident. Upon termination of the second training engagement, the MP attempted to rejoin with the lead pilot (LP), at which time the MA no longer responded to MP flight control inputs. At approximately the same time, the MP noticed the hydraulic, yaw, roll, and pitch control augmentation system warning lights were illuminated. The MP was unable to recover the MA from a left descending spiral for over 20 seconds, and ejected at 4,500 feet mean sea level.

The Accident Investigation Board (AIB) President found, by clear and convincing evidence, the cause of this accident was the MA failing to respond to MP flight control inputs due to a failure in the hydro-mechanical flight control system. Additionally, the Pitch Roll Channel Assembly provided inputs to the flight control surfaces not commanded by the MP. Furthermore, the AIB President found, by a preponderance of evidence, the following factors substantially contributed to the mishap:

(1) a malfunction in the hydro-mechanical flight control system
(2) limited time for malfunction analysis by the MP
(3) lack of simulator emergency procedure training for the cause of this mishap
(4) expectancy of the MP based on previous mishaps of a similar nature

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-15C, S/N 79-0025
28 May 2013

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

AB Air Base
AB After Burner
ABA Adaptive Battle Space Awareness
AC Aircraft
ACES II Advanced Concept Ejection Sheet
A1C Airman First Class
ACMI Air Combat Maneuvering Instrumentation
ADCC Assistant Dedicated Crew Chief
AF Air Force
AFB Air Force Base
AFCS Automatic Flight Control System
AFE Aircrew Flight Equipment
AFI Air Force Instruction
AFMAN Air Force Manual
AFRL Air Force Research Laboratory
AFSEC Air Force Secretary
AFTO Air Force Technical Order
AGE Aerospace Ground Equipment
AGL Above Ground Level
AIB Aircraft Investigation Board
AIC Air Inlet Controller
AMAD Airframe Mounted Accessory Drive
AMU Aircraft Maintenance Unit
AMXS Aircraft Maintenance Squadron
AOA Angle of Attack
APG Airframe Powerplant General
AR Aircraft Recovery
ARI Aileron Rudder Interconnect
ASCT Advanced Concepts and Technology
ASO Aviation Supply Office
AT Avionics Technician
ATC Air Traffic Control
ATR Aviation Training Relocation
AWACS Airborne Warning and Control System
BDA Battle Damage Assessment
BFM Basic Fighter Maneuver
BMC Basic Mission Capable
BP Board President
BPO Basic Postflight
CA Convening Authority
CANN Cannibalization
CAP Combat Air Patrol
CAS Control Augmentation System
CAT Category
CATM Combat Arms Training and Maintenance
CC Crew Chief
CC2 Crew Chief 2
CFETP Career Field Education Training Plan
C-MAJCOM Component Major Command
CMR Combat Mission Ready
CMSGT Chief Master Sergeant
COMAFFOR Commander, Air Force Forces
COMPACAF PACAF Commander
CP Command Post
CPU Cockpit Units
CV Vice-Commander
DCC Dedicated Crew Chief
DOC Document
DoD Department of Defense
DTM Data Transfer Module
DV Distinguished Visitor
ELT Emergency Locator Transmitter
EOR End of Runway
EM Engine Mechanic
EMI Electromagnetic Interference
EP Emergency Procedure
EXP Expeditor
FAE Functional Area Expert
FAST Fuel And Sensor Tactical
FERMS Flight Equipment Records Management System
FLITS Flight Line Test
FMC Fully Mission Capable
FOM Facilitate Other Maintenance
FPIG Forms, Preflight, Intake, Gas
FS Fighter Squadron
G Gravitational Force
GC Gyro Compass
GMT Greenwich Mean Time
HFACS Human Factors and Classification System
HQ Headquarters
HUD Heads up Display
IAW In Accordance With
IAC International Annealed Copper Standard
ICS Internal Countermeasure Set
ID Identification
IDG Integrated Drive Generator
IMDS Integrated Maintenance Data System
INU Internal Navigation Unit
IP Instructor Pilot
ISB Interim Safety Board
ITL Individual Task List
JASDF Japan Air Self Defense Force
JCN Job Control Number
JFACC Joint Force Air Component Commander
JFS Jet Fuel Starter
JHMCS Joint Helmet Mounted Cueing System
K Thousand
KIAS Knots Indicated Air Speed
KITS Kadena Instrument Training System
L Local
LOFES Load Force Error Sensor
LP Lead Pilot
LPU Life Preserver Unit
LRS/FMF Logistics Readiness Squadron Fuels Flight
LVDT Linear Variable Differential Transformer
LVS Left Vertical Stabilator

MA	Mishap Aircraft
MAJCOM	Major Command
MDG	Medical Group
MDS	Mission Design Series
MICAP	Mission Capable
MOC	Maintenance Operations Control
MP	Mishap Pilot
MPCD	Multipurpose Color Display
MXG	Maintenance Group
MSL	Mean Sea Level
NDI	Non-Developmental Item
NLG	Nose Landing Gear
NO	Number
NOTAM	Notice to Airman
OCF	Operational Check Flight
OG	Operations Group
OIC	Officer in Charge
OPLAN	Operations Plan
OPS	Operations
OPS Sup	Operations Support
ORM	Operational Risk Management
PDM	Programmed Depot Maintenance
PC	Power Control
PC1	Power Control 1
PC2	Power Control 2
PCA	Permanent Change of Assignment
PM	Program Manager
PMEL	Precision Measurement Equipment Lab
POC	Point of Contact
PRCA	Pitch Roll Channel Assembly
PRCC	Personal Rescue Coordination Center
PRO SUPER	Production Superintendent
PSI	Pounds per Square Inch
PTC	Pitch Trim Controller
PTM	Practice Training Missile
QVI	Quality Verification Inspection
RAP	Ready Aircrew Program
RTB	Return To Base
RWR	Radar Warning Receiver

RSA	Rate Sensor Assembly
SEM	Scanning Electron Microscope
SGT	Sergeant
SIB	Safety Investigation Board
S/N	Serial Number
SOF	Special Operation Forces
SOF	Supervisor of Flying
SPO	Systems Program Office
SrA	Senior Airman
SSgt	Staff Sergeant
Stab Ex	Stability Exercise
SYM	Symbol
TBA	Training Business Area
TCTO	Time Compliance Technical Order
TO	Technical Order
TSGT	Technical Sergeant
TTP	Tactics, Techniques and Procedures
UCMJ	Uniform Code of Military Justice
USPACOM	United States Pacific Command
USAF	United States Air Force
USN	United States Navy
UTL	Utility
UWARS	Universal Water Activated Release System
Vert	Vertical Stabilizer
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VS	Vertical Stabilator
VSD	Vertical Situation Display
W	Whisky
WEZ	Weapons Engagement Zone
WG	Wing
WIC	Weapons Instructor Course
XRF	X-Ray Fluorescence Analyzer
Z	Zulu time
PACAF	Pacific Air Forces
5 AF	5th Air Force
18 WG	18th Wing
18 OG	18th Operations Group
44 FS	44th Fighter Squadron

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 2 July 2013, General Herbert J. Carlisle, Commander, Pacific Air Forces (PACAF), appointed Colonel Terry Scott to conduct an aircraft accident investigation of a mishap that occurred on 28 May 2013 involving an F-15C aircraft, S/N 79-0025, 60 miles east of Kadena Air Base (AB), Japan (Tab Y-3 thru 4). The investigation was conducted in accordance with Air Force Instruction (AFI) 51-503, Aerospace Accident Investigations, at Kadena AB, Japan, from 24 Oct 13 through 8 Nov 13. Additionally, the pilot advisor scheduled a Boeing Flight Simulator in the St Louis area from 25-26 Nov 13, and his finding were added to this report (Tab FF-39). Board members included a pilot advisor, medical advisor, legal advisor, maintenance advisor, and a recorder (Tab Y-3 thru Y-4). PACAF Staff Judge Advocate appointed multiple flight control technicians as functional area experts (Tab Y-5).

b. Purpose

This was a legal investigation convened to inquire into the facts surrounding the aircraft accident, to prepare a publicly releasable report, and to gather and preserve all available evidence for use in litigation, claims, disciplinary actions, administrative proceedings, and for other purposes.

2. ACCIDENT SUMMARY

On 28 May 13 at approximately 0840 hours local time (L), the mishap aircraft (MA), an F-15C, S/N 79-0025, assigned to the 44th Fighter Squadron (44 FS), 18th Wing (18 WG), Kadena AB, Japan, crashed into the Pacific Ocean approximately 60 miles east of Kadena AB, Japan (Tab V-2.6). The mishap pilot (MP) ejected from the MA and sustained minor injuries (Tab X-3). Japan Air Self-Defense Force (JASDF) rescue forces recovered the MP (Tab V-1.6). There was no damage to civilian property. The MA broke apart upon impact with a loss valued at $31,964,644.01 (Tab P-6). There was media interest as reported by local, national, and international outlets (Tab EE-3 thru EE-5).

3. BACKGROUND

The MA was assigned to the 44 FS stationed at Kadena AB, Japan. The 44 FS is a squadron within 18 WG, which falls under 5th Air Force (5 AF). 5 AF is a Numbered Air Force within PACAF (Tab CC-3 thru CC-11).

a. Pacific Air Forces (PACAF)

PACAF's primary mission is to provide Pacific Command integrated expeditionary Air Force (AF) capabilities to defend the Homeland, promote stability, dissuade/deter aggression, and swiftly defeat enemies. The command's vision is to bring the full power of America's AF and the skill of its Airmen to promote peace and stability in the Asia-Pacific region. PACAF's area of responsibility extends from the west coast of the United States to the east coast of Africa and from the Arctic to the Antarctic, covering more than 100 million square miles. The area is home to 50 percent of the world's population in 36 nations and over one-third of the global economic output. The unique location of the Strategic Triangle (Hawaii-Guam-Alaska) gives our nation persistent presence and options to project United States airpower from sovereign territory. (Tab CC-3)

Headquarters (HQ) PACAF, as a Component Major Command (C-MAJCOM), is the United States Air Force's (USAF) first War fighting headquarters on a MAJCOM scale. The Commander, Pacific Air Forces (COMPACAF) assumes multiple leadership roles: Commander of a USAF MAJCOM, U.S. Pacific Command (USPACOM) Commander of Air Force Forces (COMAFFOR), and the USPACOM Joint Force Air Component Commander (JFACC). HQ PACAF provides AF component support to USPACOM in all operational phases and across the range of military operations. Additionally, HQ PACAF serves as the senior administrative Service headquarters for COMPACAF, performing Service organize, train, and equip functions not appropriate for reach-back. (Tab CC-3)

b. 5th Air Force (5 AF)

5 AF's mission is three-fold. First, 5 AF plans, conducts, controls, and coordinates air operations in accordance with tasks assigned by the PACAF Commander. 5 AF maintains a level of readiness necessary for successful completion of directed military operations. And last, but certainly not least, 5 AF assists in the mutual defense of Japan and enhances regional stability by planning, exercising, and executing joint air operations in partnership with Japan. To achieve this mission, 5 AF maintains its deterrent force posture to protect both U.S. and Japanese interests, and conducts appropriate air operations should deterrence fail. (Tab CC-6)

c. 18th Wing (18 WG)

As the host unit at Kadena AB, Okinawa, Japan, the mission of the 18 WG is to deliver unmatched combat airpower and a forward-staging base to provide sovereign options that promote peace and stability in the Asia-Pacific region, ensure the common defense of our allies, and enhance the United States' unparalleled global engagement capability. As the largest combat wing in the Air Force, operating out of the largest Air Force installation in the Pacific, the 18 WG is ideally suited to accomplish these critical objectives. (Tab CC-8)

d. 18th Operations Group (18 OG)

The 18 OG manages the flight activities of Kadena AB bringing America's airpower to the farthest reaches of the globe with operations that include search and rescue, reconnaissance, special operations and airborne air control. (Tab CC-10)

e. 44th Fighter Squadron (44 FS)

The mission of the 44 FS is to provide unmatched air superiority on demand who can deploy, with little to no notice, in support of combatant commander operational plans (OPLANS) that will decisively defeat a numerically superior, well-trained enemy while preserving combat assets to fight a protraced, high-intensity air-to-air conflict. (Tab CC-12)

f. F-15C Eagle

The F-15C Eagle was an updated version of the F-15A. Major improvements include 2,000 pounds of additional internal fuel capacity, provisions for Fuel And Sensor Tactical -- FAST Pack conformal external fuel tanks with weapons mount points for AIM-7 Sparrow missiles, and greatly improved avionics and radar. The addition of a programmable signal processor for the radar allows for easier updates of the system to meet changing combat conditions. The first flight of the C model was Feb. 27, 1979, with initial deliveries starting later in the year. The F-15D, a combat-capable two-seat trainer version, first flew on 19 Jun 79. In addition to the USAF, the F-15 is flown by Israel, Japan, Saudi Arabia, South Korea and Singapore. (Tab CC-13)

4. SEQUENCE OF EVENTS

a. Mission

The lead pilot (LP) planned and briefed the mishap mission as a two-aircraft Basic Fighter Maneuvers (BFM) mission using the call signs Knife 01 and Knife 02 to Warning Area 173D (W-173D) (Tab K-2). The 44 FS Operations Officer authorized the flight (Tab K-27). The pilot of Knife 01 was the LP. The pilot of Knife 02 was the MP and the wingman. (Tab K-2)

IAW aircraft flight manuals, BFM training consists of one fighter aircraft attacking another fighter aircraft within visual range of each other at pre-determined parameters of airspeed, altitude and distance between the aircraft. The pilot in the attacking, or offensive, role attempts to maneuver his aircraft into a position to employ weapons against the defending aircraft. The defending pilot attempts to maneuver his aircraft to prevent the offensive aircraft from achieving a position where it can employ weapons. For this mission, the LP and MP planned to swap the offensive and defensive roles starting at a distance of 6,000 feet between aircraft with the attacking aircraft behind and 40 degrees off the defending aircraft's tail. (Tab V-1.2)

b. Planning

The LP planned the mishap mission as a preparation sortie for the F-15C Weapons Instructor Course (WIC), which the LP anticipated attending in the coming months (Tab K-2). Knife flight (KNIFE), another two aircraft flight of F-15s, Bat flight (BAT), and an additional four aircraft flight of F-15s, Blade flight (BLADE), planned similar takeoff times, but were not planning to train together (Tab K-2). The LP, Bat 01 and Blade 01 coordinated during planning to divide the available training airspace (Tab K-2).

The LP conducted the majority of preflight planning the evening prior (Tab V-2.1). The following morning, the LP gave a thorough briefing, emphasizing engaged maneuvering from the defending aircraft position (Tab K-3 thru K-26). The briefing also included basic administration required to maneuver the two aircraft to and from the airspace (Tab K-3 thru K-26). According to the LP and MP, the briefing lasted approximately 60-65 minutes (Tab V-1.2 and V-2.2).

c. Preflight

According to the LP, KNIFE had 20 minutes from the conclusion of the brief until they departed the building for the sortie, or "stepped" to the aircraft (Tab V-2.2). The MP noted that he had more time than usual to accomplish the visual inspection of the MA prior to starting engines (Tab V-1.7 and V-1.8). Engine start and the remainder of the preflight inspection were normal and the MP did not note any anomalies (Tab V-1.8).

d. Summary of Accident

KNIFE took off at approximately 0820L from Kadena AB and proceeded to W-173D on a W-173 Departure Procedure (Tab K-2).

According to the MP, upon entering W-173D airspace, KNIFE conducted a routine force of gravity (G) awareness exercise IAW Air Force flight manuals (Tab V-1.2). A G-awareness exercise consists of two 180-degree turns, which allows the pilot to ensure the aircraft anti-G system is functioning properly and prepare for later applications of high G-forces during the tactical portion of the sortie. During the first turn, the pilot applies a moderate amount of G and during the second turn, applies a higher level of G, up to the maximum allowable. KNIFE accomplished the G-exercise uneventfully. (Tab V-1.2).

After the G-awareness exercise, KNIFE conducted a routine aircraft stability exercise IAW Air Force flight manuals (Tab V-1.2). A stability exercise consists of one 90-degree turn, which allows the pilot to ensure there are no anomalies with the aircraft flight controls or handling characteristics while in a controlled environment. During the turn, the pilot reduces aircraft thrust while increasing the turn rate to evaluate aircraft performance at decaying airspeed and increasing AOA. The MP did not observe any flight control anomalies during the stability exercise (Tab V-1.2).

Upon conclusion of the stability exercise, KNIFE leveled off at 18,000 feet to set up for the first engagement. The first briefed training event was a 6,000-foot BFM engagement with the LP defending against a simulated attack executed by the MP. KNIFE began the setup with the MP in trail of the LP by approximately 9,000 feet in a gentle, left hand turn and the MP began closing the distance between the two aircraft. As range closed, the MP counted down the distance every 1,000 feet. At approximately 0830L, the MP radioed "six thousand," which signified the beginning of the simulated attack. The training event lasted approximately two minutes during which the MP aggressively maneuvered his aircraft to gain a favorable attack position and employ weapons against the LP. The MP did not observe any unusual flight characteristics while maneuvering the MA during the training event. (Tab V-1.3)

KNIFE climbed in preparation for the second training event, leveling off at 18,000 feet. The second briefed training event was a 6,000-foot BFM engagement in which the MP defended against a simulated attack executed by the LP. KNIFE began the setup with the LP in trail of the MP by approximately 9,000 feet in a gentle, left-hand turn and the LP began closing the distance between the two aircraft. As range closed, the LP counted down the distance every 1,000 feet. At 0838L, the LP radioed "six thousand" which signified the beginning of the simulated attack. The MP selected maximum afterburner (AB) on his engines and initiated a maximum G, defensive break turn to the left. This maneuver was intended to prevent the LP from entering a favorable attack position to employ weapons against the MP. (Tab V-1.3, V-1.10 and V-1.11)

The LP briefly continued straight ahead and then began his own high G, left turn in attempt to gain a favorable attack position. The MP responded by executing a downward corkscrewing, left-hand turn by applying full left rudder and placing the left throttle in minimum AB while leaving the right throttle in maximum AB. (Tab V-1.3, V-1.10 and V-1.11). The MP continued this turn until his aircraft was in a position that created the most angular advantage. At this time, the MP returned the left throttle to maximum AB and began reducing the slant range between the MA and the attacking aircraft. (Tab V-2.3). The MP estimated his altitude to be approximately 14,000 feet and his airspeed to be approximately 200 knots indicated airspeed (KIAS). At this time, the MP began increasing the MA's AOA to slow his rate of descent and forward flight path while monitoring the attacking aircraft. The MP stated that he noticed the attacking aircraft over his right shoulder with a high line-of-sight rate toward his 6 o'clock position and believed the LP would not be able to maintain an offensive position. The MP stated he waited approximately three seconds and initiated a maneuver to obtain a neutral to slightly offensive position followed shortly thereafter by a "knock-it-off" radio call, initiated by the LP due to desired learning objectives being met. The MP acknowledged the "knock-it-off" call and began maneuvering the MA to regain a tactical formation position, line abreast with the LP aircraft (Tab V-1.3 thru V-1.4).

Shortly after establishing a nose-low, left bank turn, the MP attempted to maneuver the MA to level flight when the MP noticed the MA did not respond to flight control inputs. The MP immediately looked inside the cockpit and noticed several warning lights illuminated on the caution panel to include all three CAS lights and a hydraulic light. IAW the aircraft flight manual, the CAS will sometimes disengage during aggressive aircraft maneuvering. However, the MP was not aggressively maneuvering the MA in this phase of flight (Tab V-1.4). According to the aircraft flight manual, the CAS should not disengage during non-aggressive maneuvering unless an aircraft malfunction occurred. Additionally, the CAS did not disengage at any other time during the mishap sortie. The MP did not notice which associated hydraulic lights illuminated on the bit panel on the left side of the cockpit. (Tab V-1.4 thru V-1.5)

The MP stated that the MA was approximately 30-45 degrees of left angle of bank, approximately 40 degrees nose low and approximately 200 KIAS (Tab V-1.4). The Kadena Instrumented Training System (KITS) playback, which was inoperative until approximately 10 seconds prior to the termination of the engagement, confirmed the MA parameters (Tab S-5).

The MP momentarily neutralized all flight controls in accordance with the aircraft flight manual. The MP then applied full right lateral stick in an attempt to roll the MA right. However, the MA did not respond to flight control inputs. At this time the MP applied full right rudder while maintaining full right lateral stick. The MP stated that he made a very conscious effort to avoid applying longitudinal stick inputs, primarily to ensure full aileron deflection with full right lateral stick application. During recovery attempts, the MP reset the CAS multiple times, but the CAS did not come back online. The MA did not respond to lateral stick or rudder commands, and remained in a left bank, nose low attitude. (Tab V-1.4 thru V-1.5)

While maintaining both lateral stick and rudder commands, the MP attempted to split the throttles to increase thrust on the left side of the MA, in an attempt to roll using differential thrust. However, the MA did not respond to split throttle application. (Tab V-1.4 and V-1.5). About 20 seconds after the MP recognized the MA was not responding to flight control commands, the MP radioed the LP that the MA would not recover (Tab N-2). The LP informed the MP that his altitude was approximately 6,000 feet, which was the pre-briefed altitude to eject if the aircraft was out-of-control (Tab N-2). The MP matched both throttles in military power, radioed the LP that he was ejecting, and initiated the ejection sequence at approximately 4,500 feet (Tabs V-1.5 and DD-3).

After ejection, the MA began to increase bank angle and steepen dive angle toward the water, which triggered a very tight, left-hand, corkscrew flight path. This continued until the MA accelerated to approximately 300 KIAS, at which time the MA stopped turning, descended approximately 500 feet, and impacted the water. (Tab S-5)

e. Impact

The MA crashed into the Pacific Ocean at 0840L on 28 May 13 at latitude 26-29.8 North and longitude 128-55.7 East (Tab S-5). The MA broke apart on impact and sank to the ocean floor. Based on KITS, the MA's impact parameters were heading 307, airspeed 347 KIAS, AOA zero, 45 degrees of left bank and approximately 70 degrees nose low (Tab S-5). The United States Navy (USN) recovered, inventoried, and photographed minimal MA wreckage (Tab S-3 thru S-4).

f. Egress and Aircrew Flight Equipment (AFE)

The MP ejected from the MA shortly after the LP called out "you look like you're around 6,000 feet." The MP estimated, and KITS verified an ejection altitude of approximately 4,500 feet MSL and airspeed between 230 and 250 KIAS. (Tabs H-3 and V-1.5). Upon ejection, the MA bank angle was approximately 80 degrees left bank and about 40 degrees nose low (Tab S-5).

The MP's Advanced Concept Ejection Seat II (ACES II) functioned normally and the parachute deployed immediately after ejection. According to the MP, the egress and survival equipment performed as designed. (Tab V-1.5 thru V-1.6). The life support equipment inspections were current at the time of the mishap (Tab H-4 thru H-11). During parachute descent, the MP noted his life raft inflated and hanging by a lanyard below him. Once in the water, the MP climbed into his life raft and utilized the PRC-90 survival radio to contact the LP. The ACES II is equipped with an emergency beacon, the URT-33, which emits a tone to help locate the pilot. The MP's beacon functioned normally and he deactivated the device once in the life raft. (Tab V-1.6)

g. Search and Rescue (SAR)

The LP established a combat air patrol (CAP) over the ejection site, radioed the Kadena Supervisor of Flying (SOF), and stated the MP ejected and the MA crashed into the ocean. The LP reported seeing a good parachute and passed coordinates to begin the rescue process. The LP also talked to the controlling agency for W-173D airspace for additional assistance. Finally, the LP contacted Blade 01 to request assistance in the CAP. The LP made contact with the MP on his survival radio, confirmed his ambulatory status, and confirmed he was in the life raft. At this time, the MP recapped the mishap over the radio, providing details about what he saw in the cockpit and how the flight controls malfunctioned. (Tab V-2.4 thru V-2.5)

After 15 minutes, BLADE arrived on station to replace LP (Tab V-2.5). Blade 01 divided his three ship formation into an altitude stack to assist with relaying radio calls and to conserve fuel to remain on station as long as possible (Tab AA-4).

The Kadena SOF coordinated with the JASDF rescue cell to begin recovery of the MP, and alerted the 33rd Rescue Squadron that a pilot ejected from an F-15. Additionally, a USN EP-3 offered assistance to the Kadena SOF and proceeded to the MP's location. Blade 03 coordinated with the JASDF rescue helicopter to pass the MP's location and ambulatory status and obtained their time enroute, which he passed to the MP. As the JASDF helicopter arrived on station at approximately 0855L, there was already a Japanese Coast Guard helicopter, in the area attempting to rescue the MP. The JASDF helicopter relieved the Japanese Coast Guard helicopter and inserted two rescue swimmers into the ocean to assist with recovery efforts. At approximately 0905L, the JASDF recovered the MP, treated for minor injuries, and flew to Camp Foster, Japan for further medical evaluation and treatment. Additionally, two USAF HH-60 rescue helicopters arrived on scene to assist with recovery efforts. (Tab AA-4)

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The 18th Aircraft Maintenance Squadron (18 AMXS) prepared the MA for flight on 27 May 13. Maintenance personnel completed the preflight, performed basic servicing actions, and released the MA for flight on 28 May 13. (Tab D-5 thru D-11). Sixteen Time Compliance Technical Orders (TCTO) remained open on the MA; however, none were relevant to the mishap (Tab U-8 thru U-9).

Historical records indicate a recurring landing gear discrepancy, which caused aircraft impoundment. Specifically, the landing gear handle light illuminated when the aircraft performed maneuvers. Maintenance personnel corrected the discrepancy and released the MA from impoundment. (Tab U-25 thru U-29)

b. Inspections

The last programmed depot maintenance (PDM) inspection occurred at Gimhae, South Korea, on 3 May 10, with 7648.2 airframe hours. PDM replaced the MA left rudder actuator, right aileron actuator, rudder trim actuator, right aileron surface and left rudder surface. (Tab U-15 thru U-20)

18th Equipment Maintenance Squadron personnel completed the 400-hour Hourly Postflight Inspection on 26 Nov 11 (Tab U-3). Maintenance personnel inspected the left and right stabilator cable area, which reset the inspection cycle. Maintenance personnel replaced the nose landing gear (NLG) shock strut. The aircraft inspection did not require flight control actuator or surface replacement as indicated by aircraft database records. The MA had 146.9 hours remaining until the next Hourly Postflight Inspection. (Tab U-3 thru U-4)

Maintenance personnel completed the last preflight inspection on 27 May 13 at 1159 hours (Tab D-5). SrA CC2 completed the combined basic postflight/preflight inspection on 22 May 13 at 1900 hours (Tab D-5). SrA CC2 testified there were no anomalies discovered during the maintenance inspection (Tab V-8.2).

A1C APG Launch testified the MA did not reveal any evidence of faulty systems during the morning walk around and launch preparation (Tab V-8.2). After MA engine start, A1C APG Launch verified servicing of the hydraulic systems per technical manuals (Tab V-8.4).

c. Maintenance Procedures

Maintenance personnel performed a flight control operational check during phase inspection from 16 Nov 11 through 26 Nov 11 (Tab U-4).

The MA was in cannibalization (CANN) status from 18 Feb 13 through 18 Apr 13. During this time, maintenance personnel removed the MA's left horizontal stabilator actuator and rudder actuator. (Tabs V-6.3 and R-21 thru R-58). After reinstallation of the left horizontal stabilator actuator and rudder actuator, maintenance personnel performed the following checks:

(1) longitudinal control system bleed

(2) directional control system bleed
(3) horizontal actuator and rudder actuator rig checks
(4) stabilator pitch limits operational check
(5) rudder control operational check
(6) Automatic Flight Control System (AFCS) functional test/AFSC system test
(Tab V-6 and Tab V-11).

d. Maintenance Personnel and Supervision

A1C APG Launch verified completion of aircraft servicing and the production superintendent released the MA for flight (Tabs CC-41 and V-8.3).

A1C APG Launch was qualified in aircraft launch and hydraulic servicing (Tab T-8 and T-12). SrA CC2 was qualified to perform the combined basic postflight/preflight inspection on the MA (Tab T-25).

e. Fuel, Oxygen, Hydraulic and Oil Inspection Analysis

On 29 May 13, the 18th Logistics Readiness Squadron Fuels Management Flight (LRS/FMF) obtained samples from the R-11 refueling truck, Seido fill stand number 4 and Seido tank number 5 for testing at Aerospace Fuels Laboratory, Kadena AB, Japan. Additionally, LRS/FMF collected liquid oxygen samples from the equipment used to service the MA. Finally, the 18th Maintenance Group obtained oil samples from the MA oil-servicing cart. All samples tested within normal limits and contained no contaminants, and there is no evidence that the servicing equipment contributed to the mishap. (Tab D-37 thru D-48, and U-14)

According to the MA historical 781 file, Non-Destructive Inspection (NDI) records and associated maintenance forms, there is no evidence that either engine had excessive engine contaminants, oil consumption or any other negative trends (Tab D-46 thru D-48).

Limited MA recovery prevented post-mishap collection and analysis of MA fluids.

f. Unscheduled Maintenance

The last three flights flown by the MA prior to the mishap sortie occurred on 22 May 13. The pilot from the first and third sorties did not report any discrepancies. However, after the second sortie, the pilot reported an unreadable Heads Up Display (HUD), which required maintenance within the cockpit. Additionally, the pilot reported the captive air-training missile unusable and maintenance personnel replaced it. During the post flight inspection, the maintenance technician, SrA CC2, discovered the right vertical stabilator anti-collision light inoperative, and coordinated the repair with other maintenance technicians. (Tab D-4 thru D-22)

According to aircraft database records, maintenance personnel performed the following unscheduled maintenance between 26 Nov 11 and 28 May 13:

(1) 19 Feb 12 - Installed left air inlet controller (AIC)
(2) 22 Feb 12 - Removed and replaced the pitch roll channel assembly (PRCA)

(3) 2 Oct 12 - Replaced left vertical stabilator (LVS), forward upper 8 inch skin, LVS aft upper box assembly, oversized all spar holes, and installed a new LVS tip assembly
(4) 2 Nov 12 - Removed and replaced the pitch computer
(5) 3 Jan13 - Removed and replaced the pitch computer
(6) 27 Mar 13 - Installed a rudder actuator
(7) 26 Apr 13 - Removed and replaced the left AIC
(Tab U-4 thru U-5)

6. AIRCRAFT AND AIRFRAME

a. Structures and Systems

The physical condition of the MA wreckage was not fully accessible. The MA crashed into the Pacific Ocean and the majority of the wreckage remains on the ocean floor. Recovery of the base of the left and right vertical stabilator, part of the left and right wing, and a partial structure of a wing mount enabled further analysis of multiple components of the hydraulic system and flight control system. (Tab S-3 thru S-4 and Tab J-2 thru J-6)

Lower portions of the left and right vertical stabilator contained the right rudder actuator and both left and right stabilator actuators. The Aircraft Investigation Board (AIB) utilized Air Force Research Laboratory's (AFRL) analysis of the rudder and horizontal stabilator actuators as part of their investigation (Tab J-1 thru J-56).

Functional Area Experts (FAE) assigned to Kadena AB explained in detail how the lateral, longitudinal, and directional control mechanical system functions normally and how these components react to a particular fail or jam, to include a failure in the avionics system in the F-15. FAEs used a flight control trainer to demonstrate and explain control stick/rudder pedal inputs through the Pitch Roll Channel Assembly, Aileron Rudder Interconnect, safety spring cartridges, mechanical mixer, control rods, cable assemblies and multiple bellcranks, which showed deflections in flight control surfaces according to MP input. (Tab U-31)

The USN recovered portions of the left and right wings, which included the left and right aileron actuators. AFRL analyzed both actuators and provided their findings, which the AIB utilized as part of this investigation. (Tab J-1 thru J-56)

b. Engineering Evaluation and Analysis

AFRL's analysis of recovered flight control components revealed the following:
(1) gouges and other damage to the left horizontal stabilator actuator. A witness mark on the cylinder wall indicates the rod end and the cylinder contacted each other upon impact. When the witness mark is aligned with the cylinder wall and the rod end, the measured extension of the piston is 7 ¾ inches. (Tab J-2). The left horizontal stabilator surface was slightly above the neutral position upon impact (Tabs J-2 and Z-1 thru 3). Technicians were unable to determine the cause of additional damage (Tab J-2).
(2) gouges and other damage to the right horizontal stabilator actuator. AFRL did not discover a witness mark on the cylinder wall. (Tab J-2)

(3) damage occurred at the same location to the left and right horizontal stabilator actuator summing levers (Tab J-2).
(4) no witness marks on the left and right aileron actuators (Tab J-3).
(5) the rudder actuator coupling was at a neutral position. Technicians found cracks and fractures on the actuator body in numerous areas, which appear to have failed in a brittle overload (a clean break). The splines on the input and feedback shaft appear normal and there were no witness marks. The recovery team did not locate the servo valve, Linear Variable Differential Transformer (LVDT), switching valve and solenoid valve from the rudder actuator. (Tab J-4)
(6) a dented and crushed aileron rudder interconnect (ARI) with the roll input in the full right position, yaw input/output in the neutral position, and pitch input in a nose down condition. No pre-impact anomalies in the switch-off, flow limiter, thermal bypass, ratio changer and lock actuators (Tabs J-4 and DD-1).
(7) missing electromagnetic interference (EMI) filter cover, damaged EMI filters, a broken load force error sensor cover, a bent solenoid valve armature, and no evidence of witness marks from the pitch trim controller (PTC) (Tab J-4 thru J-5).
(8) gouges and other damage on the utility reservoir head assembly. The tank separated from the head assembly with no extension of the hydraulic circuit "A" and circuit "B" indicators (Tabs J-5 and Z-4).

7. WEATHER

a. Forecast Weather

The weather forecast in the airspace called for multiple scattered and/or broken layers of clouds from 2,000 feet to 15,000 feet and 7 miles visibility. There were no weather advisories or warnings for the operating airspace. Forecast winds aloft were from the south/southwest at 15 knots from 5,000 feet to 15,000 feet. Forecasters predicted seas states in W-173D between 4 and 6 feet with a northwest drift. (Tab F-3)

b. Observed Weather

On 28 May 13, the LP observed a cloud layer at approximately 3,000 to 4,500 feet and visual meteorological conditions above him (Tab V-2.5). The MP observed calm seas, around 1 to 3 feet (Tab V-1.13).

c. Space Environment

Not applicable.

d. Operations

The LP conducted the mission within the prescribed operational weather limitations set forth in AFI 11-214, *Air Operations Rules and Procedures* (Tab V-2.5).

8. CREW QUALIFICATIONS

IAW AFI 11-202, Volume 1, *Aircrew Training*, the MP was a qualified instructor pilot (IP) and evaluator pilot (EP) with 2785 total hours in the F-15C/D (Tab G-2 thru G-3, and G-6). At the time of the mishap, all necessary flight currencies were up to date and all required training for the planned mission was current IAW F-15 aircrew training manuals (Tab G-56 thru G-109). The MP performed his last mission evaluation on 18 Sep 12, and his last instrument/qualification evaluation on 27 Apr 12 (Tab G-56 and G-58). Evaluators rated the MP qualified with no discrepancies on both evaluations (Tab G-56 thru G-59).

The MP's flight time during the 90 days before the mishap was as follows:

	Hours	Sorties
Last 30 Days	7.6	5
Last 60 Days	13.9	10
Last 90 Days	19.6	14

(Tab G-7)

9. MEDICAL

a. Qualifications

The MDG medically qualified the MP on 21 May 12 for flying duties from 21 May 12 through 21 Aug 13. The examination did not reveal any potentially disqualifying medical conditions and the MP continued to meet vision and hearing standards IAW AFI 48-123, *Medical Examination Standards*. The MP did not convey any medical concerns or complaints at the time of his examination. (Tab X-3)

The MDG medically qualified all personnel relevant to the mishap for their respective duties IAW AFI 48-123, *Medical Examination Standards* (Tab X-3).

b. Health

A post-mishap medical examination, conducted at a local emergency department, revealed a large contusion on the MP's left biceps and the MP reported some minor neck stiffness. The MP underwent a full work-up in the emergency department to include cervical, thoracic, lumbar, chest, and pelvic radiographs. The radiographs did not reveal any acute fractures or dislocations. After conservative treatment of the MP's left biceps contusion, and negative x-ray results, the emergency room discharged the MP with follow-up instructions. The MP's primary care physician returned him to flying status three-days after the mishap. (Tab X-3)

c. Pathology

Immediately following the mishap, all personnel involved in the MA sortie reported to Flight Medicine for toxicology testing IAW AFI 91-204, *Safety Investigations and Reports*. Flight Medicine collected blood and urine samples used to identify any elevated levels of carbon monoxide, or the presence of ethanol or drugs. A detailed Armed Forces Institute of Pathology analysis showed negative toxicology reports for all associated aircrew and maintainers. (Tab GG)

d. Lifestyle

The MDG conducted a 72-hour and 14-day history review and did not find any significant factors relevant to the mishap (Tab R-76 thru R-83).

e. Crew Rest and Crew Duty Time

The MP obtained eight hours of uninterrupted sleep the night prior to the mishap and received adequate crew rest IAW AFI 11-202, Volume 3, *General Flight Rules* (Tab R-80).

10. OPERATIONS AND SUPERVISION

a. Operations

Operations tempo for the 44 FS was normal for Kadena AB on the day of the mishap. The MP and LP were both experienced pilots in the F-15C. The MP normally flies at a Basic Mission Capable (BMC) rate which equates to five sorties per month with his experience level. The LP normally flies at a Combat Mission Ready (CMR) rate, which equates to nine sorties per month with his experience level. (Tab K-36)

b. Supervision

44 FS personnel ensured all flight members were current and qualified for the mission (K-27). The LP ensured the MP received a thorough briefing (Tab K-3 thru K-26). The operations supervisor (Ops Sup) on the day of the mishap, a current and qualified instructor pilot and the squadron operations officer, provided a standard briefing to the entire flight. IAW AFI 11-418, *Operations Supervision*, the Operations Group Commander qualified the Ops Sup and the SOF of the day. (Tab K-36)

11. HUMAN FACTORS ANALYSIS

Human error continues to plague both military and civilian aircraft mishaps. Analysis indicates human error is a causal factor in 80 to 90 percent of mishaps. (Tab FF-1). The Department of Defense Human Factors Analysis and Classification System (DoD HFACS) lists potential human factors that could contribute to a mishap (Tab FF-2).

The following human factors are relevant to this mishap:

<u>Temporal Distortion</u> (DoD HFACS PC511): Temporal distortion becomes a factor when the individual experiences a compression or expansion of time relative to reality leading to an unsafe situation. This condition is commonly associated with the "fight or flight" response. The temporal distortion factor is relevant because the MP distinctly recalls minute details of each event as he attempted to maintain aircraft control and troubleshoot the perceived problem. The

MP testified to experiencing time expansion as he felt he was troubleshooting for up to a minute and a half. After the mishap, the MP recalled the entire event lasted only 20 to 25 seconds. (Tab V-1.4)

Expectancy (DoD HFACS PC505): Expectancy is a factor when the individual expects to perceive a certain reality and those expectations are strong enough to create a false perception of the expectation. In his testimony, the MP references two of his pilot friends who experienced very similar mishaps. Upon recognition of the MA malfunction, the MP radioed the LP and stated, "I think we've seen this before." After repeated recovery attempts, the MP stated, "I don't think this one's recovering." In addition, the MP testified, "I sensed I either had a significant hydraulic failure that led to a flight control malfunction, or a significant flight control malfunction that led to a hydraulic malfunction. I was not really sure which…I knew there was nothing I could do about it." (Tab V-1.4)

Local Training Issues/Programs (DoD HFACS SI003): Local training issues/programs are a factor when one time or recurrent training programs, upgrade programs, transition programs or any other local training is inadequate or unavailable (etc.) and this creates an unsafe situation. The F-15 simulator does not have emergency procedure flight profiles that properly replicate the MA flight control failure and the flight profile that the MP experienced during this mishap. During the AIB, the pilot advisor was unsuccessful in replicating the MA emergency scenario in the fielded F-15 simulator. (Tab AA-5). However, after multiple simulator runs at the Boeing simulator facility in St. Louis, MO, the pilot advisor replicated a scenario that closely resembled the emergency procedure experienced by the MP. In this scenario, and nearly every other emergency procedure dealing with the hydromechanical flight control system, the pilot corrected the malfunction by placing the roll ratio switch or pitch ratio switch to emergency. Of note, when the pilot advisor placed the pitch ratio switch to emergency, the aircraft experienced a nose up transient that, in some cases, placed the aircraft in a position unfavorable for pilot ejection, especially when altitude is limited. (Tab FF-39)

Physical Task Oversaturation (DoD HFACS PC316): Physical task oversaturation is common in stressful situations when the number or complexity of manual tasks in a compressed time period exceeds an individual's capacity to perform. In this case, according to the MP's testimony, he had a difficult time maintaining aircraft control, which adversely affected his ability to analyze the situation. Additionally, the MP testified that time did not allow for verification of the exact hydraulic malfunction or visual verification of flight control position. (Tab V-1.4)

12. GOVERNING DIRECTIVES AND PUBLICATIONS

Publically Available Directives and Publications Relevant to the Mishap

AFI 11-2F-15, Volume 1, *F-15 Aircrew Training*
AFI 11-2F-15, Volume 3, *F-15 Operations Procedures, as supplemented*
AFI 11-202, Volume 1, *Aircrew Training*
AFI 11-202, Volume 2, *Aircrew Standardization/Evaluation Program, as supplemented*
AFI 11-202, Volume 3, *General Flight Rules*
AFI 11-214, *Air Operations Rules and Procedures*
AFI 11-418, *Operations Supervision, as supplemented*

AFI 48-123, *Medical Examinations and Standards*
AFI 51-503, *Aerospace Accident Investigations*
AFI 91-204, *Safety Investigations and Reports*

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

13. ADDITIONAL AREAS OF CONCERN

None

9 December 2013

TERRY SCOTT, COLONEL, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-15C, S/N 79-0025
NEAR KADENA AIR BASE, JAPAN.
28 May 2013

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

1. OPINION SUMMARY

I find, by clear and convincing evidence, the cause of this mishap is the mishap aircraft (MA) failed to respond to mishap pilot (MP) flight control inputs due to a failure in the hydro-mechanical flight control system. Additionally, the Pitch/Roll Channel Assembly (PRCA) provided inputs to the flight control surfaces not commanded by the pilot. Furthermore, I find, by a preponderance of evidence, the following factors substantially contributed to the mishap:

(1) a malfunction in the hydro-mechanical flight control system
(2) limited time for malfunction analysis by the MP
(3) lack of simulator emergency procedure training for the cause of this mishap
(4) expectancy of the MP based on previous mishaps of a similar nature

2. DISCUSSION OF OPINION

On 28 May 13 at approximately 0840L, the MA, an F-15C, S/N 79-0025, assigned to the 44th Fighter Squadron, 18th Wing, Kadena AB, Japan, crashed into the Pacific Ocean approximately 60 miles east of Kadena AB, Japan. The MP ejected from the MA and sustained minor injuries. Japan Air Self Defense Force (JASDF) rescue forces recovered the MP. There was no damage to civilian property. The MA broke apart upon impact with a loss valued at $31,964,644.01. There was media interest as reported by local, national, and international outlets.

The MP was on a training mission as part of a two-ship formation. The two-ship executed take off, airspace entry and two training engagements without incident. Upon termination of the second training engagement, the MP attempted to rejoin with the LP, at which time the MA no longer responded to MP flight control inputs. At approximately the same time, the MP noticed the hydraulic, yaw, roll, and pitch control augmentation system (CAS) warning lights were illuminated. The MP was unable to recover the MA from a left descending spiral for over 20 seconds, and ejected at 4,500 feet mean sea level (MSL).

a. Cause

The MA failed to respond to MP flight control inputs due to a failure in the hydro-mechanical flight control system. I arrived at this conclusion based on MP testimony of flight control inputs and lack of response, LP testimony, and a comparison of their testimonies to the recovered Kadena Instrument Training System (KITS) data. While attempting to rejoin with the LP, the MA entered a left turning descending spiral from which the MP could not recover. The MP stated he attempted to level the MA using lateral stick input to the right. The MA did not respond and continued in the left spiral, 30-45 degrees nose low, 200 knots indicated airspeed (KIAS), 26-32 cockpit units (CPU) of angle of attack (AOA), and 2.5 Gs. The MP centered the stick and, once again, applied lateral stick input to the right to level the MA, but the MA did not respond. While holding right lateral stick input, the MP applied full right rudder pedal input, but the MA still did not respond. The MP pilot reached minimum uncontrolled ejection altitude and initiated ejection.

The MA did not respond to MP flight control inputs due to the PRCA providing output commands for a left turning, descending spiral. I determined this by utilizing KITS data, derived from the LP's aircraft KITS recording, which received transmitted data from the MA KITS pod. I validated the transmitted KITS recording of the flight parameters for the MA by comparing the KITS data and heads up display (HUD) video recordings of other missions flown at Kadena AB. Based on the actual AOA flown by the MA compared to longitude stick position the MP commanded, there was a clear mismatch. According to the MP, he centered the stick, which should have caused the MA to reduce AOA and reduce G loading. However, the MA did not respond and continued in a 26-32 CPU of AOA, 2.5 G turn. This indicates the horizontal stabilators did not respond to MP input. When the MP commanded full right lateral stick, the MA did not respond, as there was no change in aircraft attitude. Based on the actual AOA flown and the KIAS, the MA should have rolled to the right. This indicates the ailerons did not respond to the MP's flight control application. When the MP applied full right rudder pedal input, the MA produced no change in flight path. Based on actual AOA and KIAS, the MA should have rolled to the right. If the rudders deflected because of MP input, the MA would have yawed to the right, which would have produced a rolling effect to the right. This indicates the rudders did not respond to MP input. I determined, through knowledge of flight control effectiveness derived from the aircraft flight manual, all MA flight control surfaces did not respond to MP flight control inputs.

I determined the flight control surfaces were functioning as commanded by the PRCA scheduled output by comparing the MA pre-ejection flight profile to the post-ejection flight profile. After the MP ejected, the MA accelerated and entered a steep vertical descending left turn. As MA airspeed increased, the roll rate decreased, AOA decreased and G loading decreased. The last KITS data depicted the MA at 347 KIAS, 0 AOA, and 0 G loading. This indicates the pitot/static inputs for airspeed to the PRCA were valid and the PRCA reduced flight control output commands as a function of airspeed. I also utilized Air Force Research Laboratory (AFRL) analysis of the left stabilitor actuator, which was in a slightly "nose down" position at impact. This position would not produce the AOA and G loading evident on the KITS playback prior to MP ejection, and verifies the PRCA commanded flight control movement as airspeed increased post ejection. This indicates that once the MP ejected from the MA, the malfunction in the MA was still present.

The PRCA provides flight control output commands to the flight control surfaces based on stick position, pitot/static information and CAS inputs. The PRCA also provides input to the aileron rudder interconnect (ARI), via the PRCA/ARI interconnect cable, which commands rudder deflection. According to the MP, when the malfunction occurred, he observed all CAS were offline and the MA displayed a hydraulic light on the caution light panel. The MP tried twice to reset the CAS, but it did not reset or even attempt to reset. Based on flight control functional area expert research, the CAS will not reset if there is a mismatch between the commanded stick position and the actual deflection of the flight controls. This indicates the flight control surfaces were deflected by the PRCA output commands and not as commanded by the MP.

Based on time available and rapid descent rate, the MP was unable to determine which hydraulic system was associated with the caution light. The utility hydraulic system provides a backup to the flight controls in the event of a power control (PC) hydraulic system failure. Additionally, the utility system provides hydraulic pressure, through the PRCA to the ARI, for flight control output commands. AFRL technical analysis of the utility hydraulic reservoirs, recovered from the aircraft wreckage, showed the utility hydraulic system was not leaking hydraulic fluid due to utility hydraulic system circuit integrity. This indicates that hydraulic pressure to the ARI was functional. In the event of a PC hydraulic system failure, the utility hydraulic system would maintain pressure to the flight control system. I could not determine the exact source of the hydraulic caution light because the United States Navy was unable to recover the PC hydraulic reservoirs. Because the utility hydraulic system was functional, I determined the flight control system had sufficient hydraulic pressure.

The MP testified binding and/or resistance did not exist in the flight controls. According to functional area expert research, if binding of the lateral and longitudinal mechanical flight control system occurred prior to the PRCA, the MP would have felt resistance on the stick. Therefore, lateral and longitudinal stick inputs to the PRCA were normal. Based on functional area expert research, the CAS fell offline due to a mismatch of stick and rudder position and actual flight control surface deflection. Additionally, the PRCA commands actual flight control deflection and can override pilot input through ratio changers. As a result, I found the faulty flight control output commands could have only come from the PRCA and were not generated by the MP.

b. Substantial Contributing Factors

(1) Malfunction in the hydro-mechanical flight control system

I examined numerous failures that could cause the flight controls to be unresponsive to pilot inputs or generate the required aerodynamic effective force to maneuver the aircraft. During my investigation, I looked for a malfunction that could affect all three flight controls (ailerons, rudders and stabilators) simultaneously. The only hydro-mechanical component that affects all three flight controls and commands flight control output is the PRCA. Unfortunately, the USN did not recover the PRCA from the aircraft wreckage, so AFRL was unable to conduct full analysis of the PRCA. However, the USN recovered, and AFRL analyzed, the Pitch Trim Controller (PTC), which directly affects PRCA flight control output. Upon analysis, the PTC had a bent armature and a broken CAS spring; however, I could not determine if this was from a failure or from the MA impact with the water.

Comparing actual aircraft performance from the KITS data to the testimony of the MP and functional area expert assessment, I determined the Mode Select Assembly, Emergency Pressure Assembly, Roll Ratio Controller, and Pitch Ratio Controller were functioning normally and could not have caused a failure in all three flight controls. I narrowed the malfunctions down to two components, the PTC or the PRCA Ratio Changer and Boosters. A failure in either of these components could produce what the MP and MA experienced. A failure in the PTC could provide incorrect inputs of lateral and longitudinal stick position to the Pitch Trim Compensator within the PRCA. This would cause the Pitch Boost Servo Valve to move the Pitch Boost Actuator, which would affect stabilator command output and position. This would also cause the Roll Ratio Controller to deflect the ailerons, and the ARI to deflect the rudders due to inputs from the PRCA/ARI Interconnect Cable. Additionally, a failure in the PRCA Ratio Changer and Boosters could provide the same effect by causing the Pitch Boost Servo Valve to schedule stabilator command output, the Roll Ratio Controller to deflect the ailerons, and the ARI to deflect the rudders due to PRCA/ARI Interconnect Cable inputs. If the PTC or the PRCA Ratio Changer and Boosters failed and commanded a flight control output that conflicted with pilot input, the PRCA would ratio out the MP's flight control inputs. This could explain why the MA did not respond to MP inputs. I found the PRCA was providing command inputs to the flight controls and eliminating/reducing the MP's inputs.

(2) Limited time for malfunction analysis

The F-15 does not provide a direct indication of a flight control malfunction or failure to the pilot in the cockpit. The only indication is when the aircraft does not respond to pilot inputs or departs controlled flight. As a result, the pilot must prioritize maintaining aircraft control, which makes analyzing the situation and taking the proper action challenging. In this mishap, from the time the MP recognized the MA would not respond to flight control inputs, to reaching his minimum ejection altitude, was 20 seconds. If the MP had more time to analyze the situation, the MP may have been able to diagnose the failure in the hydro-mechanical flight control system and apply a recommended procedure from the flight manual, which may have restored MP inputs to the flight controls.

(3) Simulator emergency procedure training

The F-15 operationally fielded simulator does not have emergency procedure scenarios that properly replicate the MA flight control malfunction. The MP was unable to experience the complexity of this situation during emergency procedure training prior to the mishap sortie. The F-15 flight manual contains a section under Roll System Malfunction entitled "lateral control lost and/or uncommanded rolls", which states to place the roll ratio switch to the emergency position. This action de-energizes the PRCA and ARI, which may have returned aileron, rudder and stabilator authority to the MP. After experimenting with multiple emergency procedures in the Boeing simulator, the pilot advisor and Boeing engineering team induced a failure in the PRCA that closely resembled the flight profile flown by the MA, both pre and post ejection. In this scenario, and in nearly every other hydromechanical flight control system emergency procedure induced by the Boeing engineering team, when the pilot advisor placed the roll ratio switch to emergency, the aircraft regained flight control effectiveness and was easily recoverable. Additionally, the F-15 flight manual states to place the pitch ratio switch to emergency if the pilot is unable to reach the roll ratio switch. This would also de-energize the ARI and may have returned full rudder authority to the MP. However, after thorough interaction with the flight control functional area experts, Boeing simulator testing, and research in applicable maintenance manuals, I found that placing the pitch ratio switch to emergency provides less flight control effectiveness (~50%) than placing the roll ratio switch to emergency (~66%). In addition, placing the pitch ratio switch to emergency may produce a significant nose up transient, increasing AOA and making the rudders that were displaced to the left more effective. In the case of the MA, had the MP placed the pitch ratio to emergency in lieu of placing the roll ratio to emergency, the MA may have increased bank angle to the left which would place the MP in a worse position for ejection. Had the MP experienced this complex situation in the simulator prior to the mishap, he may have been able to recover flight control effectiveness by placing the roll ratio switch to emergency allowing him to recover the MA.

(4) Expectancy

Expectancy is a factor when the individual expects to perceive a certain reality and those expectations are strong enough to create a false perception of the expectation. In his testimony, the MP references two of his pilot friends who experienced very similar mishaps. Upon recognition of the MA malfunction, the MP radioed the LP and stated, "I think we've seen this before." After repeated recovery attempts, the MP stated, "I don't think this one's recovering." In addition, during testimony the MP recalled, "I sensed I either had a significant hydraulic failure that led to a flight control malfunction, or a significant flight control malfunction that led to a hydraulic malfunction. I was not really sure which…I knew there was nothing I could do about it." Due to multiple conversations with the two pilots who experienced similar mishaps, the MP may have determined that that the MA was unrecoverable. I found with proper simulator emergency procedure training, the MP might have been able to overcome his expectancy and restore flight control effectiveness to the MA.

3. CONCLUSION

I find, by clear and convincing evidence, the cause of this accident is the MA failed to respond to MP flight control inputs due to a failure in the hydro-mechanical flight control system. Additionally, the Pitch/Roll Channel Assembly (PRCA) provided inputs to the flight control surfaces not commanded by the pilot.

Furthermore, I find, by a preponderance of evidence, the following factors substantially contributed to the mishap:

(1) a malfunction in the hydro-mechanical flight control system
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9 December 2013

TERRY SCOTT, COLONEL, USAF
President, Accident Investigation Board

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