UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-15C, T/N 84-0008

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

LOCATION: NEAR KADENA AIR BASE, JAPAN

DATE OF ACCIDENT: 11 JUNE 2018

BOARD PRESIDENT: COLONEL HARMON S. LEWIS, JR.

Conducted IAW Air Force Instruction 51-503

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

F-15C, T/N 84-0008
NEAR KADENA AIR BASE, JAPAN
11 JUNE 2018

On 11 June 2018, at approximately 0617 hours local time (L), the Mishap Aircraft (MA), an F-15C, T/N 84-0008, assigned to the 44th Fighter Squadron (44 FS), 18th Wing (18 WG), Kadena AB, Japan, crashed into the Pacific Ocean approximately 70 miles south of Kadena Air Base. The MA broke apart upon impact with a loss valued at $42,360,014.00. The Mishap Pilot (MP) ejected from the MA and sustained serious injuries. Japan Air Self Defense Force (JASDF) rescue forces flying a UH-60J helicopter, from Naha International Airport, rescued and transported the MP to a military hospital at Camp Foster, Japan. There were no fatalities or damage to civilian property. There was media interest as reported by local, national, and international agencies.

The MP was flying as lead of a two-ship formation during a dissimilar basic fighter maneuver (BFM) sortie with an F-22A, assigned to the 525th Fighter Squadron. While maneuvering defensively in relationship to the Mishap Wingman (MW), at approximately 5,400 feet mean sea level (MSL) and 180 knots indicated airspeed (KIAS), the MP initiated a vertical climb to 65 degrees nose high, 20 degrees of right bank, 39 degrees Angle-of-Attack (AOA), and 1.2 Gs, which apexed near 6,300 feet MSL and 105 KIAS, before a significant nose drop occurred. The MP perceived the MA was not tracking as desired and initiated an unload of approximately one fist-width's forward stick with full right rudder. The nose pitched down and to the right to 65 degrees nose low, 110 degrees of right bank, -26 degrees AOA and G forces decreasing from 1.2 to -0.3 Gs. With right rudder still commanded, the MA experienced a negative G departure from controlled flight with a snap roll entry to the left that transitioned to an inverted, negative G spin. The MP received no indications of hydraulic, electrical, fuel, engine, structural, or flight control system malfunctions. The MP was unable to recover the MA and ejected at approximately 1,100 feet MSL.

The Accident Investigation Board (AIB) President found, by a preponderance of the evidence, the cause of the mishap was the MP's improper application of forward stick with full right rudder, which resulted in a negative G departure from controlled flight due to the coupling of aerodynamic forces of yaw and roll.

Additionally, the AIB President found by a preponderance of the evidence that spatial disorientation, lack of emergency procedure training for negative G departures from controlled flight, and limited time to analyze the situation and recover substantially contributed to the mishap.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-15C, T/N 84-0008
11 June 2018

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ACRONYMS AND ABBREVIATIONS

5 AF	5th Air Force
18 WG	18th Wing
18 OG	18th Operations Group
18 AMXS	18th Aircraft Maintenance Squadron
3 WG	3rd Wing
525 FS	525th Fighter Squadron
33 RQS	33d Rescue Squadron
A1C	Airman First Class
AB	After Burner
AB	Air Base
ACM	Aircraft Combat Maneuvering
ACMI	Air Combat Maneuvering Instrumentation
ACT	Air Combat Training
ADC	Air Data Computer
AF	Air Force
AFB	Air Force Base
AFE	Air Flight Equipment
AFI	Air Force Instruction
AFPAM	Air Force Pamphlet
AFPET	Air Force Petroleum
AFTO	Air Force Technical Order
AFTTP	Air Force Tactics, Techniques and Procedures
AGL	Above Ground Level
AIB	Accident Investigation Board
AIC	Air Inlet Controller
AIM	Air Intercept Missile
AMXS	Aircraft Maintenance Squadron
AOA	Angle-of-Attack
ASA	Accelerometer Sensor Assembly
BFM	Basic Fighter Maneuver
BP	Board President
BPO	Basic Postflight
CAD	Cartridge Actuated Devices
CANN	Cannibalization
Capt	Captain
CAS	Control Augmentation System
CATM	Captive Air Training Missile
CAUT	Caution
CIP	Core Integrated Processor
CMR	Combat Mission Ready
Col	Colonel
CRM	Crew Resource Management
CSMU	Crash Survivable Memory Unit
CT	Continuation Training
DO	Director of Operations
DoD	Department of Defense
DRS	Digital Recovery Sequencer
ECS	Environmental Control System
EP	Emergency Procedure
FCF	Functional Check Flight
FCIF	Flight Crew Information File
FL	Flight Lead
FL	Flight Level
FLUG	Flight Lead Upgrade
FMF	Fuels Management Flight
FOM	Facilitate Other Maintenance
FPCD	Flat Panel Color Display
FPM	Feet Per Minute
FPS	Fire Protection System
FRC	Fault Reporting Codes
FS	Fighter Squadron
ft	Feet
FTU	Formal Training Unit
G	Gravitational Force
HABFM	High Aspect Basic Fighter Maneuver
HF	Human Factors
HFACS	Human Factors Analysis And Classifications System
HPO	Hourly Postflight
HUD	Heads-Up Display
IAW	In Accordance With
INS	Inertial Navigation System
INU	Inertial Navigation Unit
IO	Investigation Officer
IP	Instructor Pilot
IQT	Initial Qualification Training
ISB	Interim Safety Board
JASDF	Japan Air Self-Defense Force
JBER	Joint Base Elmendorf-Richardson
JHMCS	Joint Helmet Mounted Cueing System
K	Thousand
KCAS	Knots Calibrated Airspeed
KIAS	Knots Indicated Airspeed
KIO	Knock It Off
KITS	Kadena Instrument Training System
L	Local Time
lbs.	Pounds
LA	Legal Advisor
LASDT	Low Altitude Step Down Training
LOX	Liquid Oxygen
LRS	Logistic Readiness Squadron
Lt Col	Lieutenant Colonel
MA	Mishap Aircraft
MB	Mass Briefer
Maj	Major
MAJCOM	Major Command
MDS	Mission Design Series
MFL	Mishap Flight Lead
MOA	Military Operating Area
MM	Medical Member
MP	Mishap Pilot
MPCD	Multipurpose Color Display
MQT	Mission Qualification Training

MS	Mishap Sortie
MSgt	Master Sergeant
MSL	Mean Sea Level
MXM	Maintenance Member
MXW1	Maintenance Witness 1
MXW2	Maintenance Witness 2
MXW3	Maintenance Witness 3
MXW4	Maintenance Witness 4
MXW5	Maintenance Witness 5
MXW6	Maintenance Witness 6
MW	Mishap Wingman
MSIP	Multistage Improvement Program
ND	Nose Down
NDI	Non-Destructive Inspection
NM	Nautical Miles
NOTAMs	Notices to Airmen
OCF	Operational Check Flight
OG	Operations Group
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
OSC	On Scene Commander
OSS	Operation Support Squadron
P&W	Pratt and Whitney
PA	Public Affairs
PACAF	Pacific Air Forces
PAD	Propellant Actuated Devices
PEP	Production Eagle Package
PDM	Program Depot Maintenance
PHA	Preventive Health Assessment
PLB	Personal Locator Beacon
PLI	Pre-Launch Inspection
PM	Pilot Member
PMP	Packaged Maintenance Plan
PR	Pre Flight
PRCA	Pitch Roll Channel Assembly
PSI	Pounds Per Square Inch
PW1	Pilot Witness 1
PW2	Pilot Witness 2
PW3	Pilot Witness 3
PW4	Pilot Witness 4
PW5	Pilot Witness 5
PW6	Pilot Witness 6
PW7	Pilot Witness 7
PW8	Pilot Witness 8
PW9	Pilot Witness 9
PW10	Pilot Witness 10

QA	Quality Assurance
RAP	Ready Aircrew Program
REC	Recorder
RESCAP	Rescue Combat Air Patrol
RMM	Removable Memory Module
RSA	Rate Sensor Assembly
RTB	Return-To-Base
SA	Situational Awareness
SAR	Search and Rescue
SD	Spatial Disorientation
SEPT	Situational Emergency Procedures Training
SFS	Stick Force Sensor
SIB	Safety Investigation Board
SII	Special Interest Item
SIM	Simulator
SME	Subject Matter Expert
SOF	Supervisor of Flying
SPINS	Special Instructions
SPO	System Program Office
SrA	Senior Airman
SRD	Spin Recovery Display
SSgt	Staff Sergeant
Stab Ex	Stability Exercise
T/N	Tail Number
TCI	Time Change Item
TCTO	Time Compliance Technical Order
TDY	Temporary Duty
TO	Technical Order
TOD	Tech Order Data
UWARS	Universal Water Activated Release System
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VSD	Vertical Situation Display
VVI	Vertical Velocity Indication
WAT	Weapons and Tactics
IMDS	Integrated Maintenance Data Systems
JFS	Jet Fuel Starter
JCN	Job Control Number
FO	Foreign Objects
TAC	Tactical
REPO	Reposition
GOJ	Government of Japan
WPS	Weapons Squadron
Z	Zulu

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 26 September 2018, General Russ L. Mack, deputy commander, Pacific Air Forces (PACAF), appointed Colonel Harmon S. Lewis, Jr. to conduct an aircraft accident investigation of a mishap that occurred on 11 June 2018 involving an F-15C aircraft, T/N 84-0008, 70 miles south of Kadena Air Base (AB), Japan (Tabs J4-1, and Y-2 to Y-3). The following board members were appointed: a pilot member (Lieutenant Colonel), a medical member (Major), a legal advisor (Captain), a maintenance member (Master Sergeant), and a recorder (Technical Sergeant) (Tab Y-4 to Y-7). PACAF Staff Judge Advocate appointed the following SMEs: a human factors aerospace physiologist (Major), an F-15 systems engineer (Contractor), a hydraulics engineer (Contractor), an aero stability and control engineer (Contractor), a flying qualities engineer (Contractor), an aviation safety engineer (Contractor), and a test pilot (Contractor) (Tab Y-8 to Y-14). The Accident Investigation Board (AIB) was conducted in accordance with Air Force Instruction (AFI) 51-503, *Aerospace and Ground Accident Investigations*, dated 14 April 2015 (Tab Y-2 to Y-3).

b. Purpose

In accordance with AFI 51-503, *Aerospace and Ground Accident Investigations*, this accident investigation board conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force ground accident, prepare a publicly releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action (Tab BB-91).

2. ACCIDENT SUMMARY

On 11 June 2018, at approximately 0617 hours local time (L), the Mishap Aircraft (MA), an F-15C, T/N 84-0008, assigned to the 44th Fighter Squadron (44 FS), 18th Wing (18 WG), Kadena AB, Japan, crashed into the Pacific Ocean approximately 70 miles south of Kadena AB (Tabs J4-1 and N-2). The MA broke apart upon impact with a loss valued at $42,360,014.00 (Tab II-2). The Mishap Pilot (MP) ejected from the MA and sustained serious injuries (Tab X-2). Japan Air Self Defense Force rescue forces flying a UH-60J helicopter, from Naha International Airport, rescued and transported the MP to a military hospital at Camp Foster, Japan (Tab AA-4). There were no fatalities or damage to civilian property (Tab II-2 and II-5). There was media interest as reported by local, national, and international agencies (Tab II-5 to II-9).

3. BACKGROUND

The 44 FS falls under the 18th Operations Group (18 OG), which falls under the 18 WG (Tab CC-8 to CC-10). All fall under 5th Air Force (5 AF), which is a numbered Air Force (NAF) within Pacific Air Forces (PACAF) (Tab CC-5 to CC-7).

a. Pacific Air Forces (PACAF)

PACAF's primary mission is to deliver agile air, space, and cyberspace capabilities in support of U.S. Indo-Pacific Command objectives, uniting allies and partners to enhance regional stability and security (Tab CC-2). The command's vision is to be a lethal, innovative, and interoperable force upholding a free and open Indo-Pacific with decisive advantage from cooperation to conflict (Tab CC-2). PACAF's area of responsibility is home to 60 percent of the world's population in 36 nations spread across 53 percent of the Earth's surface and 16 time zones, with more than 1,000 languages spoken (Tab CC-4).

b. 5th Air Force (5 AF)

5 AF's mission is three-fold (Tab CC-6). First, 5 AF plans, conducts, controls, and coordinates air operations in accordance with tasks assigned by the PACAF Commander (Tab CC-6 to CC-7). 5 AF maintains a level of readiness necessary for successful completion of directed military operations (Tab CC-7). And 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 (Tab CC-7). 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-7).

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 (Tab CC-9). 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-9).

d. 18th Operations Group (18 OG)

The 18 OG manages the flight activites of Kadena AB bringing America's airpower to the furthest reaches of the globe with operations that include search and rescue, reconnaisance, special operations and airborne air control (Tab CC-12). The 18 OG is the largest combat ops group in the Air Force with eight squadrons, one flight, 842 active-duty members and approximately 80 aircraft, including the F-15 Eagle, E-3 Sentry, KC-135 Stratotanker and the HH-60 Pave Hawk (Tab CC-12).

e. 44th Fighter Squadron (44 FS)

Flying the all-weather, highly maneuverable F-15C Eagle, the 44 FS is one of only two F-15C units in the Asian-Western Pacific area of operations (Tab CC-13). The 44 FS is part of the tip of the spear with the F-15's unique role in support of Indo-Pacific Command operation plans and headquarters-directed contingency operations (Tab CC-13).

f. F-15C Eagle

The F-15C Eagle is an all-weather, extremely maneuverable, tactical fighter designed to permit the Air Force to gain and maintain air supremacy over the battlefield (Tab CC-19). The single-seat F-15C and two-seat F-15D models entered the Air Force inventory beginning in 1979 (Tab CC-20). These new models have Production Eagle Package (PEP 2000) improvements, including 2,000 pounds (900 kilograms) of additional internal fuel, provision for carrying exterior conformal fuel tanks and increased maximum takeoff weight of up to 68,000 pounds (30,600 kilograms) (Tab CC-20). The F-15 Multistage Improvement Program (MSIP) was initiated in February 1983, with the first production MSIP F-15C produced in 1985 (Tab CC-20). Improvements included an upgraded central computer; a Programmable Armament Control Set, allowing for advanced versions of the AIM-7, AIM-9, and AIM-120A missiles; and an expanded Tactical Electronic Warfare System that provides improvements to the ALR-56C radar-warning receiver and ALQ-135 countermeasure set (Tab CC-20).

g. 525th Fighter Squadron (525 FS)

The 525 FS is a combat-ready fighter squadron prepared for rapid worldwide deployment of F-22A Raptor aircraft to accomplish precision engagement of surface targets using a variety of conventional air-to-surface munitions (Tab CC-21). The 525 FS trains in the fighter missions of strategic attack, interdiction, offensive counter-air (air-to-surface), suppression of enemy air defenses, as well as offensive and defensive counter-air (air-to-air) (Tab CC-21).

h. F-22A Raptor

The F-22A Raptor is the Air Force's first 5th generation fighter aircraft (Tab CC-23). Its combination of stealth, supercruise, maneuverability, and integrated avionics, coupled with improved supportability, represents an exponential leap in warfighting capabilities (Tab CC-23). The Raptor performs both air-to-air and air-to-ground missions allowing full realization of operational concepts vital to the 21st century Air Force (Tab CC-23). The F-22A, a critical component of the Global Strike Task Force, is designed to project air dominance rapidly and at great distances and defeat threats attempting to deny access to our nation's Air Force, Army, Navy and Marine Corps (Tab CC-23).

i. Basic Fighter Maneuvers (BFM)

In accordance with Air Force Tactics, Techniques, and Procedures (AFTTP) 3-3.F-15, BFM is the efficient application of aircraft handling skills either to attain a position from which weapons may be employed, or to deny the adversary a position from which weapons may be launched (Tab BB-235). The F-15 community treats certain BFM training engagements as a maximum performance exercise, with the objective of maneuvering to the control zone as the attacker, while max performing in relation to another fighter that is max performing. (Tab BB-235).

j. Air Combat Maneuvering Instrumentation (ACMI)

ACMI systems are utilized for air-to-air combat training and provide the ability to accurately recreate mission events in a manner that allows a detailed discussion and evaluation during the postflight debrief (Tab CC-26 to CC-27). The ACMI system at Kadena Air Base consists of the Misawa, Osan, Kunsan, Kadena Instrumentation Training System (MOKKITS) pods, otherwise referred to as Kadena Instrumentation Training System (KITS) pods (Tab II-4).

4. SEQUENCE OF EVENTS

a. Mission

The mission on 11 June 2018 was planned with the flexibility to be flown as either a two aircraft BFM sortie or a three aircraft Air Combat Maneuvers (ACM) sortie, pairing F-15Cs from the 44 FS and F-22As from the 525 FS, as part of a two squadron surge (Tab K-3 to K-8, and K-13 to K-17). The mission was the first of three sorties the MP was scheduled to fly that day (Tab K-2). The operations supervisors in the respective squadrons properly authorized the flights (Tabs K-9 and AA-15). The MP's mishap aircraft (MA) was an F-15C, T/N 84-0008 (Tab AA-2).

b. Planning

The mission was properly planned and the mass briefing covered the required topics, to include high aspect BFM (HABFM) setups (Tabs BB-227 to BB-230 and K-13 to K-43). HABFM typically starts between 18,000 feet and 20,000 feet Mean Sea Level (MSL) and at 400 to 440 knots indicated airspeed (KIAS), tactical formation, line abreast (See Figure 4.1) (Tabs K-33, K-37, and BB-238). A fight floor of 5,000 feet above MSL was briefed for HABFM (Tab K-37). Weather and Notices to Airmen (NOTAM) were reviewed, and the briefing lasted approximately 15-20 minutes (Tab V-2.25).

An F-15C flight lead, MB, gave the mass briefing (Tab V-10.3 and V-10.8). All F-22A and F-15C pilots flying that morning were in the mass briefing with the ability to pair as two or three aircraft formations during any of the three planned sorties (Tab K-13 to K-17). The 44 FS Commander and the 525 FS Director of Operations were scheduled to fly that morning and attended the mass briefing (Tabs V-10.3, AA-2, and AA-15).

c. Preflight

The MP had an appropriate 15-20 minutes between the mass brief and step brief (Tab V-2.25). The MP reported nothing abnormal with the MP's flight gear and signed the Aircrew Flight Equipment (AFE) log for accomplishing the AFE preflight (Tabs V-2.25 and GG-2 to GG-11). The assigned Operations Supervisor, PW5, gave the step brief by recapping highlights from the mass briefing, covering airfield status, Operational Risk Management (ORM) and assigned aircraft for each pilot (Tab V-8.2). PW5 addressed the *increased stress/challenges at home* on the MP's ORM worksheet (Tabs T-93 and V-8.3). The MP woke up once during the night to care for MP's young daughter (Tab V-2.25). The MP had adequate pilot rest with six to seven hours of sleep and the overall risk on the ORM worksheet was still *Low* (Tabs T-93 and V-2.25). The MP arrived at the MA and performed a normal preflight; there were no discrepancies in the aircraft forms that would hinder a BFM mission (Tabs D2-1 to D2-25 and V-2.4). The MP accomplished a full visual inspection of the aircraft and did not find any cracks or loose bolts (Tab V-2.28). The MA was in a clean configuration with no external wing tanks, one captive carry inert AIM-9X on the left wing pylon and one Kadena Instrumentation Training System (KITS) pod on the right wing pylon (Tab U-146 to U-147).

The MP performed a normal engine start and pre-taxi procedures (Tab V-2.28 to V-2.29). The MA passed all flight control checks by utilizing mirrors and the crew chief (Tab V2-28 to V-2.30). After taxiing to the end of runway area, the PW5 paired MP with MW, a current and qualified F-22A instructor pilot (IP) flying an F-22A (Tabs R-3, R-41, and T-81 to T-92).

d. Summary of Accident

Evidence for accident reconstruction was limited to the KITS data, MP and MW testimony. (Tabs J1-1 to J1-13, R-2 to R-5, V-2.1 to V-2.39, and V-3.1 to V-3.11). The Removable Memory Module, which contains video and audio from the MA cockpit, was not recovered (Tab V-16.3). The Flight Data Recorder with the Crash Survivable Memory Unit was recovered, but contained only manufacturer test data and no data from the actual MA due to faulty wiring during installation (Tabs V-16.4 and II-3). Aircraft trajectory acquired from KITS was further analyzed by Boeing engineers to estimate rates and accelerations (Tab J1-1). The KITS data for this mishap originated from the other KITS pods airborne at the time and not the KITS pod recovered from the MA (Tab II-4). When airborne, each KITS pod transmits data on the KITS data link and records all received data from other airborne pods (Tab II-4). The master mission file had no gaps during the pertinent time of flight (Tab II-4).

The MP and MW executed an instrument trail departure from Runway 23R at 0603L and proceeded to enter Lion airspace, Surge Sector 6 (Tabs R-3 and AA-3). Both pilots accomplished a fence-in and force of gravity (G) awareness exercise in accordance with Air Force flight manuals (Tabs R-3 and BB-240). The MP achieved approximately 3-4 Gs in the first turn and 7 Gs in the second turn of the G awareness exercise (Tab V-2.3). The MP performed operational checks after the G-awareness exercise and recalled approximately 11,000 lbs. of fuel with no fuel imbalances (Tab V-2.4).

The MP and MW proceeded to set up their first HABFM engagement (See Figure 4.1) (Tab R-3). The MP made the weather call of "unlimited, clear of clouds, 5,000 feet MSL floor, altimeter

29.51” (Tab R-3). For this mission, the MP directed a cooperative first merge at 17,000 feet MSL, which allowed for only small variations in altitude between the MP and MW prior to the first merge (Tab R-3).

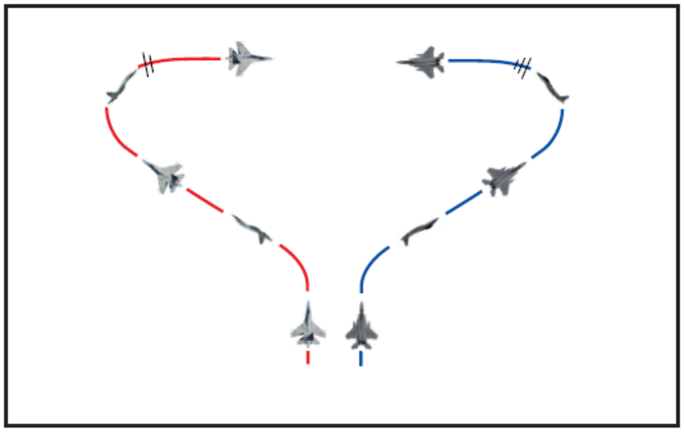

Figure 4.1 High Aspect BFM Setup (Tab BB-238)

At 0614L the MP and MW achieved a slant range of approximately five nautical miles (NM) and began the engagement with the MP making the radio call “MW, turn in, fights on” (Tab N-2). The first merge was a left-to-left pass between 17,000 feet and 18,000 feet MSL (Tab V-2.5). The MP and MW both executed a two circle left turning, descending fight with multiple merges, during which the MP took several simulated missile shots at the MW’s aircraft (Tab V-2.5 and V-2.6).

At approximately 7,000 feet MSL, the MP and MW again merged left-to-left (Tab R-3). The MW began to gain an offensive advantage by tightening the turn and bringing the nose of MW’s aircraft towards the MA as the MA continued in a left hand turn (Tab R-3). As the MW attempted to establish lead pursuit for simulated air-to-air weapons employment, the MW observed the MA execute a level reversal from left to right in a defensive maneuver (Tab R-3 and Tab V-2.7 and Tab BB-237).

The MP recalled an airspeed of approximately 220 to 230 KIAS and 5,900 feet MSL during this maneuver (Tab V-2.3). The MP used right rudder and pro right yaw differential throttles; left engine in maximum afterburner and right engine in minimum afterburner to reverse the turn direction to the right (Tab V-2.3 and V-2.9). The MP assessed the MW would remain offensive and not significantly overshoot and attempted to continue the defensive turn to the right by slicing out of the MW’s plane of motion with approximately 200 KIAS and 60 to 90 degrees right angle of bank (Tabs V-2.3, V-2.7, V-2.8 and BB-237). In response, the MW executed a reposition by pulling the nose of MW’s aircraft away from the MA into a climb above and slightly aft of the MA (See Figure 4.2) (Tab R-3). KITS data confirmed this portion of the MP and MW’s accounts, showing the MP initially turned with 60 to 80 degrees of right bank (See Figure 4.2), then to 110 degrees right bank, pulling for five seconds across (parallel to) the horizon, with 5 to 10 degrees of nose low pitch and 180 KIAS (Tab J1-8).

Figure 4.2, 06:16:29L (Tab Z-4)

Note: In Figures 4.2 through 4.8, the MA is the red aircraft and the MW is the blue aircraft. Images are derived from KITS data (Tabs Z-4 to Z-5).

The MP recalled continuing a right, descending turn with 900 feet of altitude remaining above the fight floor of 5,000 feet MSL, with right rudder, differential throttles and the stick three quarters aft and centered (Tab V-2.7 to Tab V-2.9). However, KITS data, supported by MW testimony, revealed that the MA's lift vector had shifted from tracking across the horizon (60-90 degrees of bank) to nearly straight up in the vertical, eventually settling at 20 degrees of right bank angle (See Figure 4.3) (Tabs J1-8 and R-3). KITS data showed the MA pitched up initially to 40 degrees nose high, and after a pause, to 65 degrees nose high (Tab J1-8).

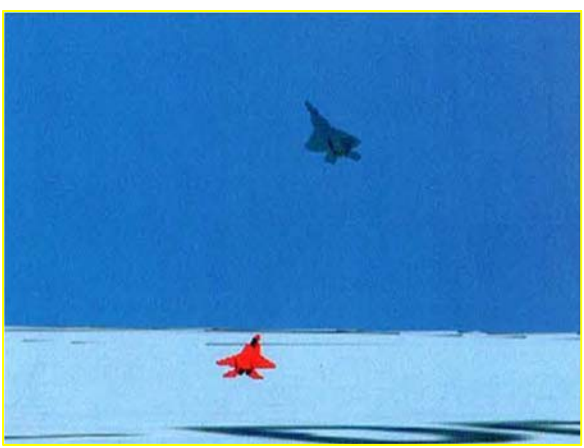

Figure 4.3, 06:16:32L (Tab Z-4)

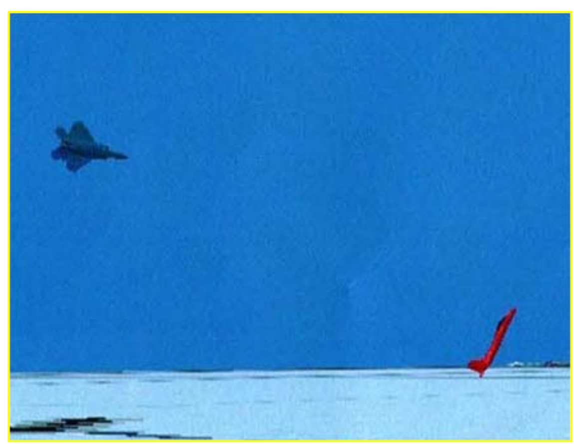

Figure 4.4, 06:16:45L (Tab Z-4)

The MA's airspeed decreased to 145 KIAS, then to 105 KIAS while altitude increased from approximately 5400 feet MSL to 6300 feet MSL and G forces decreased from +1.2 to +0.5 Gs with a maximum angle-of-attack (AOA) of 39 degrees (See Figure 4.4) (Tab J1-8 to J1-9 and J1-11). AOA is the angle between an aircraft wing's mean aerodynamic chord and the relative wind (Tab BB-232). As the MW rotated the nose down toward the MA, the MA's lift vector was on MW's aircraft with planform increasing (Tab R-3 and R-20) (See Figure 4.4).

The MW assessed increasing closure and decreasing range to the MA and executed a second nose high, climbing reposition (Tab R-21). The MP did not recall the change in flight path to the vertical, placing the MA lift vector onto the MW, nor pulling the nose of the MA to a high pitch attitude above the horizon and slowing to 105 KIAS (Tabs J1-9, V-2.8 to V-2.9, and V2.21 to V2.22). Rather, the MP perceived that the MA's turn rate had decreased (because the nose was not tracking across the horizon at the high AOA) and executed a fist width unload (forward stick) to break the AOA and get the nose tracking faster during the perceived right turn (Tabs V-2.3, V-2.10 and V-2.24). This action is consistent with executing a turn with rudder at high AOA, however, KITS data and MW testimony showed the MA in a nose high condition and no longer in a right hand turn (Tabs J1-8, R-3, and BB-236). From this steep pitch attitude, KITS data showed the MA began a right yawing nose drop from 65 degrees nose high and 20 degrees right bank to 65 degrees nose low and 110 degrees right bank (See Figure 4.5) (Tabs J1-8 and R-3). As the MA dropped below the MW's canopy line of sight during this reposition, the MW witnessed the MA's nose had begun to rotate down and to the right (See Figure 4.5) (Tab R-21).

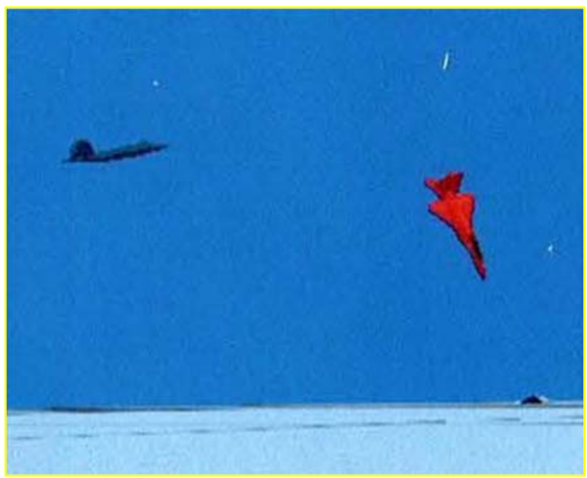

Figure 4.5, 06:16:52L (Tab Z-5)

While actual timing of the forward stick unload executed by the MP could not be determined, KITS data showed the MA entered a region of low to neutral pitch stability for the F-15C (0 to -10 AOA) as the MA's nose fell through the horizon (Tab J1-3 and J1-8). When the F-15C obtains an excessively nose-high pitch attitude, there is a possibility of a sudden nose-down pitch leading to a negative G excursion (Tab BB-234). Once the MA's nose was falling, the F-15C's lower pitch stability, assisted by gravity, explains the rapid nose down pitch rate that forced the MA into a negative AOA, negative G condition (Tab J1-10).

Rudder inputs at negative AOA (between 0 and -0.5 G) result in extreme sideslip angles causing the aircraft to fly sideways, resulting in high cockpit lateral G loads (Tab BB-252). The KITS data showed the MA at -0.3 Gs during the nose drop (Tab J1-10). The MP recalled having a full application of right rudder and pro right yaw differential throttles throughout the perceived right turn and during the forward stick unload (Tab V-2.13 to V-2.15). When reducing Gs, rudder inputs produce more and more yaw induced sideslip (Tab BB-252). Due to the stable dihedral effect of the F-15C design, the aerodynamic response to the left sideslip angles (developed as the MA pitched down with right yaw inducing flight control inputs) was a snap roll to the left (Tab J1-4).

KITS data confirmed a six-second nose drop followed by a negative AOA snap roll to the left (See Figure 4.6) (Tab J1-8). Parameters according to KITS data at the start of the snap roll were 145 KIAS, 65 degrees nose low, 110 degrees of right bank, 26 degrees AOA and -0.3 Gs (Tab J1-8 to J1-11).

Figure 4.6, 06:16:54L (Tab Z-5)

The MP described it as an abrupt, uncommanded nose low maneuver in the opposite (to the left) direction of MP's flight control inputs (to the right) accompanied by departure warning tones (Tabs V-2.10 to V-2.11 and BB-248). An uncommanded, abrupt flight path change is the definition of a departure from controlled flight (Tab BB-247). According to the MP and analysis of the KITS data, the MA experienced a departure at this time (Tabs J1-4 and V-2.11).

Engineering analysis of the MA's flight trajectory concluded this departure was a negative G departure from controlled flight, with a snap roll to the left that transitioned to an inverted, negative G spin (Tabs J1-8 to J1-11, V-2.15 to V-2.16, BB-232, BB-254 to BB-255, DD-6 to DD-17, and HH-12). From the initial departure until MP's ejection (approximately 15 seconds), the MA exhibited 30 to 50 degrees per second range of right yaw, 100 degrees per second of left roll, decreasing but oscillating nose down pitch, -20 to -30 degrees AOA and -0.5 to -1.5 Gs (See Figures 4.6 to 4.8) (Tab J1-5, J1-8, and J1-10).

Figure 4.7, 06:17:01L (Tab Z-5)

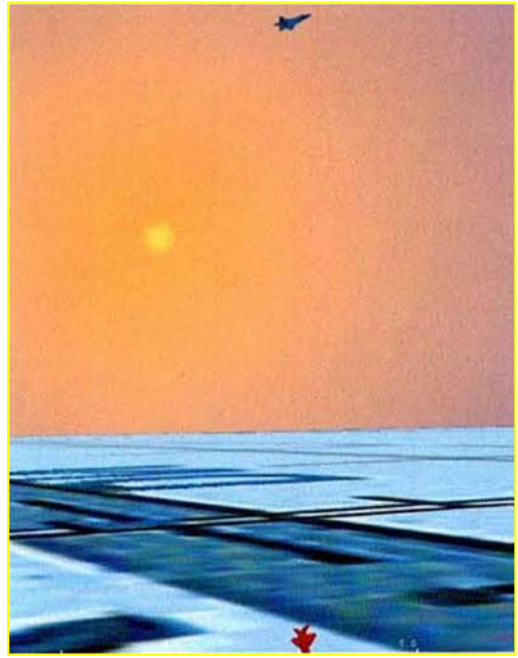

Figure 4.8, 06:17:09L (Tab Z-5)

Multiple simulations were performed to determine possible flight control inputs and/or aircraft malfunctions that could have resulted in a similar nose drop and subsequent departure of the MA (Tab EE-2 to EE-3). Two scenarios resulted in a similar nose drop, pitch decrease and right yaw as experienced by the MA: (1) a rapid aft stick application that spiked the AOA followed by a forward stick unload with full right rudder, or (2) a significant and sustained forward stick unload with full right rudder (Tabs DD-2 to DD-3, DD-8 to DD-9 and EE-2 to EE-3,). Neither scenario required an induced aircraft malfunction (Tabs DD-2 to DD-3, DD-8 to DD-9 and EE-2 to EE-3). Engineering analysis confirmed that only two inches of longitudinal stick travel forward of center was required to generate the large spike in negative AOA (Tab DD-2 to DD-3 and DD-8 to DD-9). Simulator replication with two inches of forward stick and full right rudder exhibited a similar condition of 40 degrees per second right yaw, 10 to 120 degrees per second left roll, decreasing but oscillating nose-down pitch, -20 to -40 degrees AOA, and -0.5 to -2.0 Gs (Tab DD-8 to DD-9).

The MP recognized the MA's departure from controlled flight and attempted the initial steps of the Out of Control/Departure Recovery Procedure (Tabs V-2.12 and BB-217 to BB-224). The rapid MA motion to the left pinned the MP to the right side of the cockpit and forced MP to remove MP's hands from the throttles and flight controls (Tab V-2.11). The MP utilized MP's right hand to push off the right side of the canopy and placed MP's left hand on top of the stick (Tab V-2.11). The MP initially applied right rudder to counter perceived left roll and yaw (Tab V-2.3). The MP did not recall seeing the Spin Recovery Display (SRD), which was consistent with simulator replications and system requirements of higher yaw rates to initiate the display (Tabs V-2.3, BB-243, and EE-2 to EE-3).

At load factors more negative than -0.5 G, rudder input causes a roll in the opposite direction and is accompanied by high pitch rate and pitch angle changes (Tab BB-252). This condition is extremely disorienting due to the combined effect of negative and lateral Gs and severe pitch and roll oscillations (Tab BB-252). The MP did not recognize the negative G condition and did not execute the Flight Manual's associated warning to "counter any negative G with aft stick" to break the negative G condition (Tabs V-2.21 to V-2.22, BB-247, and BB-254 to BB-255).

The MP reapplied full or nearly full right rudder to counter MP's perceived roll and yaw to the left (Tab V-2.14 and V-2.37). Still under negative G, the commanded right rudder sustained the aerodynamic coupling that generated roll in the opposite direction (to the left) (Tab BB-252). Additionally, MP did not retard the throttles out of AB (Tab V-2.14). The MP did not observe any caution or warning lights or other system malfunction indications (Tab V-2.8).

Without aft stick to counter the negative G condition and split throttles still in AB, the initial steps of the checklist were not fully executed (Tabs V-2.14, and BB-247 to BB-248). The application of right rudder was in accordance with the checklist step to "apply rudder smoothly opposite roll/yaw" (Tab BB-219 to BB-220). However, this step in the Flight Manual was written for a positive G auto roll (Tab BB-219 to BB-220). The checklist does not account for a negative G situation where rudder input causes roll in the opposite direction (Tab BB-252).

According to MP testimony and KITS data, the MA was below the Flight Manual's Minimum Uncontrolled Ejection Altitude (6,000 feet AGL) in less than two seconds from the moment of departure (Tabs J1-1, V-2.15, and BB-250). Approximately eight seconds later, at 3,500 feet MSL with the ground rush of the low cloud layer, the MP focused on ejecting from the MA (Tabs J1-11, V-2.15, and W-2). Although unable to complete the Flight Manual recovery procedures, given the initial low altitude at the beginning of the event, F-15 System Program Office engineers assessed it was unlikely the MA could have recovered before hitting the water (Tab J1-6).

The MP proceeded to checklist step nine and the associated warning: If spin recovery is not indicated by minimum recommended ejection altitude (6,000 feet AGL), eject (Tabs V-2.15 and BB-224).

Due to the forces pinning the MP to the right side of the cockpit, MP's first attempt at ejection was unsuccessful because MP gripped and pulled the emergency manual chute handle (Tabs V-2.15 and Z-3). The emergency manual chute handle is for use after ejection to manually force pilot separation from the seat (Tab BB-251). With the seat in the rails, the emergency manual chute handle is locked and cannot be pulled from its stowed position (Tab BB-245). This error resulted in further loss of altitude prior to the MP's ejection (Tabs V-2.15).

On the second attempt, the MP successfully pulled the ejection handles and initiated ejection at an altitude no lower than 1,100 feet AGL according to acceleration data and timing extrapolated from the ejection seat Digital Recovery Sequencer (DRS) (Tab J4-2). The MP stated having full right rudder application and throttles in a split condition at the time of ejection (Tab V-2.14 and V-2.17). The MP was unable to achieve the proper body position for ejection due to lateral and negative G forces generated by the out of control MA (Tab V-2.17).

According to KITS data, the MA started to recover after the MP's ejection exhibiting smaller pitch oscillations, decreasing yaw rate, increasing airspeed and AOA, and G forces increasing to positive

(Tab J1-8 to J1-12). The last KITS data showed the MA in a left rolling motion, -90 degrees nose low pitch, 260 KIAS, and 15 degrees positive AOA (Tab J1-8 to J1-12).

e. Impact

The MA impacted the Pacific Ocean at 0617L on 11 June 2018, 70 miles south of Kadena AB (Tabs N-2 and J4-1). The MA broke apart on impact and sank to the ocean floor at a depth of approximately 15,000 feet to 16,000 feet below sea level (Tab J4-1). The US Navy led an eight-day salvage recovery mission from a US commercial vessel (Tab V-16.2). An underwater remotely operated vehicle submersed to a depth of 15,000 feet to 16,000 feet and recovered, inventoried and photographed minimal MA wreckage (Tab V-16.2 to V-16.4).

f. Egress and Aircrew Flight Equipment (AFE)

According to acceleration data and timing extrapolated from the ejection seat DRS, the MP ejected from the MA at 1,100 feet AGL, within the F-15's ejection envelope (Tabs J4-1 and BB-246). This value was estimated based on the ejection seat being airborne for approximately 3.8 seconds prior to impact with the water (Tab J4-1). The ejection seat deployed the drogue which selected Mode II based on the MA airspeed and altitude (Tab J4-2). Given the scope of the MP's injuries following MP's rescue from the water, the data analysis demonstrates the MA ejection was complicated when compared to other Mode II ejection scenarios (Tab J4-2).

The MP's seat was decelerating backwards rather than the optimal orientation of forward (Tab J4-2). Further, correction performed by the seat to re-orient to a forward facing position at 306 milliseconds was unsuccessful as X-accelerations produced 17 Gs, allowing the seat to maintain a backwards position (Tab J4-2). Simultaneously, Y-axis accelerations (i.e.- lateral aerodynamic forces), were acting to produce instability of the seat (Tab J4-2 and J4-3). As a result, the previously mentioned X and Y accelerations resulted in a scenario that is referred to as a slow or fouled drogue (Tab J4-2 and J4-3). In this case, the drogue became slow or fouled secondary to its backwards orientation and the instability of the seat due to the out of control aircraft motion (Tab J4-2 and J4-3). The lack of seat deceleration reduced the altitude for a safe recovery, with insufficient time for full recovery parachute inflation allowing the MP to impact the water at an unsafe speed (Tab J4-4).

The MP's post-mishap injuries are consistent with a low altitude ejection and injuries resulting from rapid deceleration when MP impacted the water (Tab X-2). These injuries indicate the MP impacted the water feet first at an angle causing damage along the right side of the MP's body, with the decelerating forces being transferred from the feet upwards at the time of impact (Tab X-2).

The MP stated the survival equipment performed as designed with the exception of the life raft, which did not inflate when it contacted the water (Tab V-2.19). The MP attempted to manually inflate the life raft and was able to mostly inflate the outer ring (Tab V-2.20). However, due to MP's injuries, the MP was unable to climb out of the water up into the life raft (Tab V-2.19). The MP waited in the water with life preserver units (LPUs) inflated and hung on the side of the partially inflated life raft until the rescue team arrived (Tab V-2.19).

The AN/URT-44 Personnel Locator Beacon (PLB) failed to transmit in this mishap, however, the MW visually found the MP approximately four minutes after ejection (Tabs R-4 and GG-15). A voltage measurement conducted on the mishap PLB battery indicated depletion of all battery charge (Tab GG-15). Additional testing showed an excessive leakage current from the battery with the mishap PLB in the OFF position (Tab GG-15).

All inspections were current for the Aircrew Flight Equipment (AFE) (Tab GG-2 to GG-14). After recovery, the MP's AFE exhibited damage indicative of high loading (cracks/chips on helmet exterior, bent oxygen mask right hand bayonet fitting, bent PLB rocker switch bracket) (Tab GG-15). The chipped and scratched damage regions are consistent with impact from other hard bodies, but there was no material transfer so the impacting bodies could not be determined conclusively (Tab GG-15). The areas of global damage are consistent with high velocity water impact (Tab GG-15). The parachute, parachute container, risers and drogue parachute were not recovered (Tab GG-15). The ejection seat showed damage from asymmetric motion of the aircraft including three of the six rollers missing and two of the remaining rollers with flat spots from sliding or binding instead of rolling (Tab J4-3).

g. Search and Rescue (SAR)

The MW lost sight of the MA during reposition and continued to climb to avoid any potential mid-air collision (Tab R-4). After initially suspecting a loss of radio communications with the MP, the MW called PW10, an airborne F-22A, on the radio and relayed that MW could not find the flight lead (Tab N-2). The MW turned back toward the last known location of the MA and used aircraft sensors and visual scan to search for the MA (Tab R-4). After descending below the scattered cloud deck, the MW visually acquired the crash site and the MP in the water (Tab R-4). The MW called "knock it off" on the airspace common frequency and established a RESCAP over the MP as the initial on-scene commander (Tabs N-2 and R-4).

At 0621L, the MW established radio contact with PW2, flying an F-15C, who was at a higher altitude to execute radio relay to the Kadena Supervisor of Flying (SOF) in the Kadena Tower (Tab N-2). PW2 passed MP's coordinates to the SOF (Tab N-2 and N-5). The SOF initiated the Downed Aircraft checklist and coordinated by telephone with PW5, 18 WG Command Post, Japanese Air Self Defense Force (JASDF) rescue coordinator at Naha, and the 33rd Rescue Squadron (33 RQS) at Kadena AB (Tabs R-28 and BB-88 to BB-89). The JASDF rescue coordinator is primary for daytime SAR operations with a UH-60J and U-125 on alert (Tabs V-8.9 and BB-88 to BB 89). The 33 RQS is primary for Kadena AB night operations (Tabs V-12.4 and BB-88). For this mishap, the JASDF rescue assets scrambled and the 33 RQS, while not on alert, still launched an HH-60 (Tab AA-4).

Multiple pilots performed on-scene commander and radio relay duties throughout the rescue effort (Tab AA-10 to AA-12). Airborne on-scene commanders established intermittent radio contact with the MP on Guard who reported having a broken leg and hand (Tab R-4).

At 0702L, a JASDF UH-60J rescue helicopter took off from Naha airport (Tab AA-4). A 33 RQS HH-60 took off from Kadena AB at 0713L (Tab AA-4).

A U-125 (Hawker 750) JASDF SAR aircraft was the first SAR aircraft on scene at 0722L and reported a visual on the MP (Tab AA-11 and AA-13). At 0731L, U-125 reported UH-60J was approaching for pickup (Tab AA-14). At 0746L, U-125 reported the MP rescue complete and departed for U.S. Naval Hospital Okinawa Camp Foster (Tab AA-14). The UH-60J landed at 0819L and the MP was transported to the hospital (Tab AA-4).

h. Recovery of Remains

Not Applicable.

5. MAINTENANCE

a. Forms Documentation

The Air Force Technical Order (AFTO) 781 series forms documents maintenance actions, inspections, servicing, configuration, status, and flight activities (Tab BB-96). Additionally, the Integrated Maintenance Data System (IMDS) is a central database to track maintenance tasks, engines, line replaceable units, scheduled maintenance, time-change requirements, and Time Compliance Technical Order (TCTO) (Tabs BB-97 to BB-99).

The 18th Aircraft Maintenance Squadron (18 AMXS) personnel prepared the MA for its 11 June 2018 flight (Tabs D2-3 to D2-15). According to the active AFTO 781 forms, maintenance personnel completed the preflight (PR) inspection, power-on checks, servicing, weapons post-load inspection, installed chaff and flare, loaded communication codes, and completed the aircraft exceptional release for the MA on 10 and 11 June 2018 (Tabs D2-3 to D2-15).

A review of the active AFTO 781 forms and IMDS revealed the MA had four open discrepancies (Tab D2-6 to D2-9). Specifically, the discrepancies documented related to cockpit interior lighting, secure voice system, communication system, and a scheduled inspection for the Identification, Friend or Foe system (Tab D2-6 to D2-9). Additionally, the MA had 14 open TCTOs, two overdue time-change items (TCI), and no overdue inspections (Tabs D2-17 to D2-20, U-3 to U-5, U-152 to U-155, and U-159 to U-161). The two overdue TCIs were part of the F-15C's escape system and were on a temporary shelf/service life extension, which was approved by the Air Force Life Cycle Management Center's Cartridge Actuated Devices/Propellant Actuated Devices (CAD/PAD) Manager (Tabs U-152 to U-155). The post-mishap evaluation of the F-15C escape system did not reveal abnormalities with the CAD/PAD sub-system (Tab J4-1 to J4-8). None of the overdue TCIs, TCTOs, or other open discrepancies affected the aircraft's serviceability (Tabs D2-3 to D2-20, U-2 to U-4, and U-152 to U-155).

The active AFTO 781K revealed an erroneous TCI for the Universal Water Activated Release System (UWARS) (Tab D2-22). This UWARS is a sub-assembly for the recovery parachute, which Egress replaced on 12 January 2018 (Tab U-162 to U-163). This TCI did not apply to the UWARS installed on the MA, which was serviceable at the time of the mishap (Tab U-162 to U-163).

In the miscellaneous tab of the active AFTO 781 forms, there was a propulsion waiver for the number one engine and a waiver for a displacement block in the wing (Tab D3-1 to D3-3). The number one engine was allowed to fly with a recurring nuisance fault code, and the MA was allowed to fly without the block (Tab D3-1 to D3-3). The performance history of the MA's number one engine did not indicate any type of negative trends, and there is no indication either engine malfunctioned at the time of the incident (Tabs U-164 to U-166, and V-2.8).

Additionally, in the miscellaneous tab of the active AFTO 781 forms, there was an erroneous discrepancy sheet for the radome (Tab D3-10). On 17 November 14, a defect was identified on the top left six inches aft of the nose cap (Tab D3-10). According to historical records, the radome was repaired on 2 December 2014 (Tab U-156). Furthermore, the repaired radome from 2 December 2014 had been replaced several times since then, with the most recent replacement occurring on 19 October 2017 during cannibalization (CANN) rebuild (Tab U-135 and U-156). Historical records did not reveal any discrepancies with the radome installed on the MA (Tab U-156). Additionally, pilot simulations ruled out radome malfunctions (Tab DD-8 to DD-9).

Historical records showed the MA had a history of automatic flight control discrepancies from 14 November 2017 to 28 February 2018, which caused the MA to be impounded five separate times (Tab U-6 to U-49). Specifically, the control augmentation system (CAS) falling offline inflight caused the MA to be impounded four times (Tab U-11 to U-15, U-21 to U-30, and U-39 to U-49). Additionally, a missing bearing in the mixing assembly impounded the MA (Tab U-31 to U-38). Maintenance personnel conducted a thorough search of the MA, to include a non-destructive inspection (NDI) of the air inlet ramps, and determined the bearing was not in the MA (Tab U31 to U-38).

The MA failed two operational check flights (OCF) on 6 December 2017 and 18 December 2017, and failed two functional check flights (FCF) on 14 January 2018 and 14 February 2018 (Tab U-148 to U-151). Maintenance personnel worked with engineers to troubleshoot the MA, and on 26 February 2018, identified and corrected an improperly installed rate sensor assembly (RSA), which corrected the CAS discrepancy (Tab U-11 to U-15, U-22, U-50 to U-61, and U-136 to U-140).

Maintenance personnel cleared the CAS discrepancy, releasing the MA from its fifth impound on 27 February 2018 (Tab U-21 to U-25). On 28 February 2018, the MA passed a FCF returning the MA to service (Tab U-62 to U-65).

The MA flew from 28 February 2018 to 6 June 2018 with no further CAS discrepancies, and MP did not recall any CAS malfunctions during the mishap sequence (Tabs U-15 to U-20, V-2.11, and V-2.13).

b. Inspections

A Preflight (PR) inspection is a physical inspection of the aircraft, and operationally checking certain systems and components to ensure no defects of malfunctions exist (Tab BB-93). A Basic Postflight (BPO) inspection is a more thorough inspection than the PR inspection (Tab BB-94). A combined Preflight/Basic Postflight (PR/BPO) inspection is a combination of both the PR and BPO into one inspection (Tab BB-94). The Pre-launch Inspection (PLI) is an abbreviated PR inspection (Tab BB-93). The Hourly Postflight (HPO) inspection checks on certain components, areas and systems (Tab BB-83 and BB-94). Program Depot Maintenance (PDM), is an inspection requiring certain skills, equipment, and facilities (Tab BB-95). PDM is a thorough inspection of individual areas, systems, and components (Tab BB-95).

The last PDM inspection occurred at Gimhae, South Korea from 30 December 2016 to 24 May 2017 with 8,267.2 airframe hours (Tab U-74 to U-79). Additionally, the 1,200 HPO inspection was completed in conjunction with the PDM (Tab U-75). PDM personnel completed majority of the 1,200 HPO inspections, but due to the configuration of the MA at depot, PDM personnel were not able to complete some of the 1,200 HPO inspections (Tab U-75). PDM personnel were not able to accomplish the following inspections: integrated guidance and flight control (system 57000); fire control system; electronic countermeasure system; radio navigation systems; and power plant work cards (Tab U-75). 18 AMXS personnel completed these remaining 1,200 HPO inspections and work cards when the MA returned to Kadena AB (Tab U-141 to U-145).

PDM personnel replaced the following items: left and right (L/R) rudder servo cylinder, right aileron servo cylinder, AOA indicator, standby airspeed indicator, standby altimeter, airspeed Mach indicator, L/R AOA transmitter, left stab actuator, L/R 1st air intake ramp assembly, L/R 3rd air intake ramp assembly, L/R diffuser ramp assembly, and L/R vertical stabilizer assemblies (Tab U-75, U-76, and U-79).

PDM personnel removed and reinstalled the following items: L/R ailerons, L/R rudders, L/R horizontal stabilizers, L/R flaps, and L/R wings (Tab U-76 to U-78).

Airman First Class (A1C) MXW5 completed the PR/BPO inspection after the MA's previous flight on 6 June 2018 at 1730L (Tabs D2-3 and V-21.1 to V-21.2). Additionally, Staff Sergeant (SSgt) MXW2 and Senior Airman (SrA) MXW4, completed the PR for the MA on 10 June 2018 at 1730L (Tabs D2-3, V-18.1 to V-18.4, and V-20.1 to V-20.4). All three maintenance personnel testified that there were no discrepancies during any portions of their inspections (Tab V-18.1 to V-18.4, and V-20.1 to V-21.2).

MSgt MXW1 performed an external inspection of the MA, reviewed the aircraft forms, reviewed IMDS to ensure there were no discrepancies preventing the MA from flying, and signed the exceptional release before the MA's sortie (Tabs D2-3 and V-17.1 to V-17.5).

SrA MXW3 launched out the MA on 11 June 2018, and testified that the launch was normal (Tab V-19.1 to V-19.4). SrA MXW3 did not notice any discrepancies during the launch procedure, and verified that the MA passed all flight control checks (Tab V-19.1 to V-19.4).

The total airframe hours of the MA for the mishap sortie was 8420.8 hours (Tab D2-3). The MA had flown 153.6 hours since the last HPO, and PDM (Tab D-2). The MA number one engine had 85.5 hours remaining, and the number two engine had 78.2 hours remaining on their 200 engine flight hour inspection (Tab D2-17 and D4-1 to D4-2).

c. Maintenance Procedures

The MA was in CANN status from 11 September 2017 to 22 October 2017. During this time, the following items were removed (Tab U-135). The CAS control panel and Air Inlet Controller (AIC) were removed to facilitate other maintenance (FOM) (Tab U-135). The RSA and miscellaneous relay panel numbers 1, 4, and 8 were removed to assist in troubleshooting other aircraft (Tab U-135). The Pitch Roll Channel Assembly (PRCA) and radome were CANN to other aircraft. Additionally, during the CANN rebuild phase, the PRCA's mode select assembly was replaced for leaking out of limits (Tab U-135).

After maintenance personnel installed all removed parts, the following operational checks were performed satisfactorily (Tab U-135):

(1) Flap system operational check
(2) Speed brake system operational check
(3) Automatic flight control system operational check
(4) Roll ratio controller and emergency mode procedure of lateral control system operational check
(5) Pitch trim compensator, pitch ratio controller, and emergency mode procedures of longitudinal control system operational check
(6) Aileron rudder interconnect operational check
(7) Maintenance flight control operational check

d. Maintenance Personnel and Supervision

SSgt MXW2, SrA MXW4, and A1C MXW5 were all qualified to perform the PR and PR/BPO inspections on the MA (Tab T-2 to T-41, and T-61 to T-78). SrA MXW3 was qualified to perform the aircraft launch procedure (Tab T-42 to T-60). MSgt MXW1 was certified to sign the aircraft exceptional release (Tab T-80). Additionally, all maintenance members who signed off any major discrepancies in the active AFTO 781A forms were certified to sign off their respective major discrepancies (Tab T-79 to T-80).

e. Fuel, Hydraulic, Oil, and Oxygen Inspection Analyses

On 11 June 2018, the 18th Logistics Readiness Squadron's Fuels Management Flight (LRS/FMF) personnel obtained fuel samples from refueling trucks 05L-21 and 06L-645, Seido fill stand number three, and Seido tank number four for testing at Air Force Petroleum Office (AFPET) Laboratory, Kadena AB, Japan (Tabs U-80 to U-91 and V-22.1 to V-22.2). All fuel samples met the specification requirements (Tab U-80 to U-91).

Liquid oxygen (LOX) cart LC58 was used to service the MA on 10 June 2018 (Tabs D2-9 and U-92 to U-95). The LRS/FMF personnel were not able to obtain a sample from LOX cart LC58, because the LOX cart was depleted (Tabs V-22.1, V-22.2 and Z-2). This is not unusual since the LOX cart was used to service multiple aircraft that day, but prevented the board from verifying any discrepancy unique to LOX cart LC58 (U-95). The LRS/FMF personnel were able to obtain a LOX sample from LOX storage tank number 7, which was the last tank to service LOX cart LC58 (Tab U-94 to U-95). The sample met TO requirements, and there was no evidence that the servicing equipment was contaminated (Tab U-92 to U-96).

On 12 and 13 June 2018, oil and hydraulic fluid samples were obtained from five hydraulic servicing carts, one hydraulic test stand, and three oil servicing carts. The nine samples were submitted for analysis at the AFPET Laboratory, Warner-Robins Air Force Base (AFB) (Tab U-97 to U-113). All oil and hydraulic samples came back consistent with the appropriate type of fluids (Tab U-97 to U-113).

According to the MA active/historical AFTO 781 files and NDI records, there was no indication that either of the two engines had signs of oil contamination, oil consumption, or negative trends (Tabs D2-4, D2-24 to D2-25, and U-114 to U-134).

Since the MA was not recovered, the 18th Wing personnel were prevented from conducting the post-mishap collection and analysis of fluids (Tab V-16.1 to V-16.5).

f. Unscheduled Maintenance

The last four flights flown by the MA prior to the mishap sortie occurred on 5 June 2018 and 6 June 2018 (Tab U-20).

On 5 June 2018, the MA landed code 3 (a major discrepancy, and not a flyable condition) for the Inertial Navigation System (INS), and code 2 (a minor discrepancy, but a flyable condition) for the environmental control system (ECS) and Joint Helmet Mounted Cueing System (JHMCS) discrepancies (Tab U-20). The INS and the JHMCS discrepancies were corrected, and the ECS discrepancy was on a three-flight watch, which was cleared on 6 June 2018 (Tab U-20).

On 6 June 2018, the MA landed code 2 for ECS, radio navigation, electronic countermeasure, and a radio 3 no transmit discrepancy (Tab U-20). Maintenance personnel corrected all of the code 2 conditions except for the radio 3 discrepancy (Tab U-20). The radio 3 discrepancy was still open in the active aircraft forms, which was a flyable condition (Tabs D2-3, D2-9, and U-20).

Captain PW2 flew the MA in a BFM sortie on 6 June 2018, and testified there was an uncommanded roll during the 3,000 feet engagement (Tabs R-46 to R-48, and V-5.5). Captain PW2 quickly recovered the MA and continued the mission with no further flight control abnormalities (Tab V-5.5 to V-5.6). After landing, because the Flight Manual does not classify an auto roll as a departure, Captain PW2 did not report this event to maintenance personnel (Tab V-5.6). On that same day, Major PW8 flew a BFM sortie in the MA after Captain PW2 (Tab V-11.3 to V-11.5). Major PW8 testified the MA flew normal (Tab V-11.3 to V-11.5).

If events such as "uncommanded roll" or "departure from controlled flight" are reported, maintenance personnel utilize TO F-15A-6 and/or 1F-15C-2-27FI-00-1 to troubleshoot (Tab BB-84 to BB-86). For an uncommanded roll, the aircraft is due an automatic flight control system operational checks, and possibly the directional control system operational test (Tab BB-85 to BB-86). For a departure situation, the TO states to impound the aircraft, debrief aircrew, complete the aircraft departure checklist, and perform a FCF, and possibly an OCF (Tab BB-84). There is no history of uncommanded rolls, and the last time the MA had a departure condition documented in the historical records was on 30 July 13 (Tab U-157 to U-158).

The following unscheduled maintenance actions were performed between 24 May 2017 to 11 June 2018 (Tab U-6 to U-20 and U-136 to U-140):

(1) 30 August 2017 - Removed and replaced dynamic pressure sensor
(2) 2 November 2017 - Removed and replaced the Air Data Computer (ADC)
(3) 9 November 2017 - Removed and replaced the ADC
(4) 13 November 2017 - Removed and replaced the pitch computer
(5) 14 November 2017- Removed and replaced the Inertial Navigation Unit (INU)
(6) 16 November 2017 - Removed and replaced the pitch computer
(7) 22 November 2017- Removed and replaced the Stick Force Sensor (SFS)
(8) 27 November 2017 - Removed and replaced the ADC
(9) 30 November 2017 - Removed and replaced the pitch computer
(10) 1 December 2017 - Removed and replaced the roll/yaw computer, Accelerometer Sensor Assembly (ASA), and RSA
(11) 6 December 2017 - Removed and replaced the ASA, RSA, pitch computer, roll/yaw computer, and AOA probe
(12) 7 December 2017 - Removed and replaced the pitch trim controller
(13) 14 December 2017 - Removed and replaced the PRCA and mode select assembly
(14) 29 December 2017 - Removed and replaced the AIC
(15) 10 January 2018 - Removed and replaced the ASA and SFS
(16) 7 February 2018 - Removed and replaced the L/R stab actuators
(17) 9 February 2018 - Removed and replaced the roll/yaw computer
(18) 26 February 2018 - Removed and replaced the RSA
(19) 26 March 2018 - Removed and replaced the stick grip
(20) 5 June 2018 - Removed and replaced the INU

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

The MA crashed into the Pacific Ocean and the majority of the wreckage remains on the ocean floor inaccessible (Tab V-16.2 to V-16.4). No flight control parts or flight control surfaces were retrieved during the MA recovery efforts (Tab V-16.2 to V-16.4). The crash survivable memory unit was recovered, but no flight data was recorded because of improper installation (Tabs V-16.4 and II-3).

b. Evaluation and Analysis

There was no engineering analysis completed for the flight control system, because there were no flight control parts recovered (Tab V-16.2 to V-16.4).

Without recovery of the MA, the possibility of an aircraft malfunction could not be ruled out with absolute certainty; however, engineering assessments (by the F-15 System Program Office (SPO) and manufacturer's subject matter experts (SME) analyzing the KITS data), MP testimony, and the Pilot Member simulator trials assessed that the MA trajectory can be explained by MP flight control inputs without an aircraft malfunction (Tabs J1-1 to J1-13, V-2.2 to V-2.10, DD-7 to DD-8, and EE-2 to EE-3).

7. WEATHER

a. Forecast Weather

The weather forecast in Lion Airspace described sky conditions with multiple scattered layers from 2,000 feet to 6,000 feet and few clouds scattered from 7,000 feet to Flight Level (FL) 210 and few clouds from FL250 to FL320 layered (Tab F-2). Forecast visibilities were seven miles visibility out of clouds and four miles visibility in clouds (Tab F-2). Forecast winds aloft were from south/southwest/west at 5-15 knots from 5,000 feet to 25,000 feet (Tab F-2). The sea state was forecast to be 6 to 8 feet with a temperature of 79 degrees Fahrenheit and a drift of west to northwest (Tab F-2 and F-18). There was no forecast hazardous weather to and from or within Lion Airspace. From 30 to 60 miles southwest of the operating area there was a forecast for few (3-15%) thunderstorms with maximum tops of 55,000 feet (Tab F-5 to F-11).

b. Observed Weather

Video data observations from aircraft in the same airspace and at the same time as the mishap showed a broken cirrus layer at approximately 25,000 feet to 27,000 feet MSL and a broken cumulus layer between approximately 1,000 feet and 3,000 feet MSL with visual meteorological conditions (VMC) in between layers (Tab W-2). There were additional cirrus layers and cumulus clouds in the distance, more to the south than the north, but not in the localized airspace where fighter engagements were occurring (Tab W-2). Visibility was greater than five NM (Tab W-2). Post-mishap, the MW reported scattered clouds below 5,000 feet MSL (Tab R-4).

c. Space Environment - Not applicable.

d. Operations

Weather Requirements for VMC Operations are to maintain 2,000 feet vertical and one NM horizontal cloud clearance with five NM visibility and a discernible horizon (Tab BB-226). Based on observed weather at the engagement start altitude of 17,000 feet to 18,000 feet MSL, these requirements were met (Tab W-2). At lower altitudes and easterly headings, the ability to discern a clear horizon was obscured (Tab W-2).

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was a current, qualified, and experienced four-ship Flight Lead mission pilot with 500.1 total hours in the F-15C/D and 119.5 total hours of Ready Aircrew Program (RAP) F-15C simulator time (Tabs G-4, G-16, and BB-199 to BB-215). At the time of the mishap, all necessary flight currencies were up to date, and all required training for the planned mission was current in accordance with F-15 aircrew training manuals (Tab G-10 to G-15). A waiver was in place for the expiration of Crew Resource Management (CRM) training currency, which had expired on 31 May 2018 (Tab G-235). Low altitude step-down training (LASDT) currency provides the capability to execute tactical maneuvering down to 500 feet AGL instead of 1,000 feet AGL (Tab BB-261). The MP was non-current for LASDT, but this was not required for the mishap sortie since the planned fight floor was 5,000 feet AGL (Tabs G-12 and K-37). The MP's last mission evaluation was performed on 29 June 2017, and last instrument/qualification evaluation on 25 January 2018 (Tab G-17 to G-21). Evaluators rated the MP qualified with zero discrepancies on both evaluations (Tab G-18 to G-21).

The MP's flight time during the 90 days before the mishap was as follows (Tab G-6):

	Hours	Sorties
Last 30 Days	10.8	7
Last 60 Days	19.8	14
Last 90 Days	31.6	22

9. MEDICAL

a. Qualifications

At the MP's flight preventive health assessment (PHA) on 17 January 2018, the 18th Aerospace Medical Squadron (18 AMDS) medically qualified the MP for flying duties from 17 January 2018 to 16 April 2019 (Tabs X-2, BB-10, and BB-13 to BB-79). The examination did not reveal any potentially disqualifying medical conditions (Tabs X-2, BB-10, and BB-13 to BB-79). The MP did not convey any medical concerns or complaints at the time of MP's flight PHA (Tabs X-2, BB-10, and BB-13 to BB-79).

b. Health

A post-mishap review of the MP's medical records was conducted (Tab X-2). A post-mishap examination revealed the MP sustained significant poly-trauma following ejection from the MA (Tab X-2). All the subsequent injuries incurred were related to and consistent with a low altitude ejection (Tab X-2). At the time of the writing of this report, the patient is still undergoing extensive rehabilitation for the above injuries (Tab X-2).

c. Pathology

Immediately following the mishap, personnel involved in the MA sortie reported to Flight Medicine for toxicology testing (Tabs X-3, BB-81, and FF-2). Flight Medicine collected blood and urine samples used to identify any elevated levels of carbon monoxide, or the presence of ethanol or drugs (Tabs X-3, BB-81, and FF-2). A detailed Armed Forces Medical Examiner System analysis showed negative toxicology reports for associated aircrew and maintainers. (Tabs X-3, BB-81, and FF-2).

d. Lifestyle

There is no evidence to suggest lifestyle factors were a factor in the mishap (Tab X-3).

e. Crew Rest and Crew Duty Time

A review of the written 72-hour and 7-day history of the MP to evaluate for adequate crew rest and crew duty time was conducted (Tabs X-2, X-8 to X-15, and BB-4 to BB-8). There were no unusual habits, behaviors, stresses, or deviation from required work or rest cycles that contributed to the occurrence of this mishap (Tab X-2).

10. OPERATIONS AND SUPERVISION

a. Operations

Operations tempo for the 44 FS on 11 June 2018 was normal (Tab V-8.12). There were no squadron wide deployments, and operations included standard continuation training (Tab V-8.12). On 11 June 2018, the MP was an experienced Combat Mission Ready (CMR) pilot (Tab G-16). Per the Ready Aircrew Program (RAP) tasking memo, the MP's readiness level required eight flight missions and three simulator missions per month or 24 flight missions and six simulator missions in a three month period (Tab BB-199 to BB-215).

b. Supervision

44 FS personnel ensured all flight members were current and qualified for the mission (Tab K-9). The MP received a thorough briefing from a qualified flight lead, MB, in the mass briefing and the operations supervisor prior to stepping to the MA on the morning of the mishap (Tabs G-16, K-9, K-13 to K-43, and AA-2).

At the time of the mishap, the minimum altitude of 5,000 feet AGL for unlimited maneuvering was used as the minimum altitude for HABFM engagements (Tabs K-37 and BB-226). The minimum ejection altitude during out of control flight in the F-15C is 6,000 feet AGL (Tab BB-250). The risk of high AOA maneuvering up to aircraft flight manual limitations while below the minimum out of control ejection altitude was accepted (Tab K-37 and BB-250).

Out of control and departure situations and recoveries are briefed prior to every F-15C mission where high AOA conditions may be flown (Tabs V-6.5 and BB-228). Out of control/departure, recoveries are sometimes flown during quarterly Simulated Emergency Procedure Training (SEPT) simulator missions, but are not a required maneuver (Tab V-8.5). Negative G departures are prohibited in the aircraft and difficult to replicate in the simulator (Tab V-6.5). Since the simulator does not replicate any external force other than +1 G, the combined effect of negative and lateral G forces experienced in this mishap would be a first time occurrence for most F-15C pilots (Tab V-8.5).

11. HUMAN FACTORS ANALYSIS

a. Introduction

A human factor is any environmental factor or psychological factor a human being experiences that contributes to or influences performance during a task (Tab BB-80 and BB-111 to BB-112).

Department of Defense Human Factors Analysis and Classification System (HFACS), Version 7.0 (Tab BB-80 and BB-111 to BB-112), establishes several potential human factors for assessment during a mishap investigation (Tab BB-80 and BB-111 to BB-112). The following human factors were relevant to the mishap:

b. PC508 Spatial Disorientation (SD)

This is a factor when an individual fails to correctly sense a position, motion, or attitude of the aircraft/vehicle/vessel or of oneself (Tab BB-122).

Contributing factors to spatial disorientation in this mishap were: workload (fixation), weather, misperception of the changing environment, and slowed instrument cross check, which led to the perception that the MP was turning parallel to the horizon (Tab DD-18).

SD occurred: (1) as the nose pitched up, (2) during the nose drop, and (3) during the roll and subsequent inverted, negative G spin of the MA (Tab DD-18).

In aviation, there are three distinct types of SD (Tab BB-103). Type I is unrecognized disorientation; the pilot is unaware that anything is wrong, and controls the aircraft in response to the false sensations of attitude and motion (Tab BB-103). Type II is recognized disorientation; the pilot is aware that something is wrong but may not realize that the source of the problem is SD (Tab BB-103). Type III is incapacitating disorientation; the pilot knows something is wrong, but the physiological or emotional responses to the disorientation are so great that the pilot is unable to recover the aircraft (Tab BB-103).

The MP was maneuvering defensively, in a high AOA turn (Tab V-2.8 and V-2.26). At some point after the level reversal to the right and attempting to continue in a right descending turn, the MP lost awareness of orientation to the horizon (Tab V-2.8). Specifically the MP testified that MP was in 80-90 degrees right bank (pulling across the horizon) in a parallel orientation when, in fact, the KITS data, MW flight data, and MW testimony confirmed that the MP reoriented to a 65 degrees nose-high climb perpendicular to the horizon (Tabs V-2.8 and J1-8). In the events leading up to out of control flight, the MP most likely experienced Type I, unrecognized SD (Tab DD-19). The MP was "unaware" of high pitch and slow airspeed (Tab V-2.21).

Causes of SD can be attributed to workload and phase of flight such as air-to-air maneuvering associated with Aerial Combat Maneuvering (ACM) and/or BFM (Tab BB-106). Because of the nature of an air-to-air mission, the pilot's attention is directed outside the aircraft, which increases the potential for channelized attention and slows effective instrument cross check (Tabs V-2.26 and BB-106). During the defensive posturing, the pilot was looking back over the shoulder to the belly of the MW (Tab V-2.9 and V-2.26). Simultaneously, utilization of a good crosscheck is required to avoid entering an unusual attitude (Tab BB-239). The MP was on a northeasterly heading at this time, where ragged clouds and sun glare obscured the horizon (Tab J1-9 and W-2). It is possible that this environmental factor could result in an incorrect assessment of pitch and roll relative to the horizon (Tab W-2).

Prior to the MP departing controlled flight, the MA went 65 degrees nose low with 110 degrees right bank (inverted) (Tab V-2.10). The MP had no recollection of the MA shifting from

65 degrees nose high to 65 degrees nose low, but only sensed the nose stopped tracking (Tabs J1-8 and V-2.3). The MP's lack of awareness that the MA was reversing from nose high to nose low was likely due to the observed weather conditions stated above, coupled with the MP's focus on maintaining sight with the MW (Tabs V-2.23 and W-2).

Furthermore, once in a negative G situation, the MP thought the MA was in an upright position and was unable to assess the negative AOA and negative G (Tabs J1-8, R-3, and V-2.34). The severe pitch and roll oscillations combined with negative and lateral Gs likely contributed to the SD (Tabs BB-252 and DD-19).

As the above examples illustrate, unrecognized SD had a significant impact on the MP, which contributed to the out of control flight and ejection from the MA (Tab DD-19). Some of the following sections will discuss the additional factors that contributed to the MP's SD: misperception of the changing environment, fixation, wrong choice of action, and external force or object impeded an individual's movement (Tab DD-19).

c. PC507 Misperception of the Changing Environment

This is a factor when an individual misperceives or misjudges altitude, separation, speed, closure, rate, and aircraft location within the performance envelope or other operational conditions (Tab BB-122). Misperception of an object, threat, or situation results in degraded sensory inputs (Tab BB-122). When present in an aircrew member, this can negatively affect situational awareness conditions (Tab BB-122).

Situational awareness (SA) is defined as an aircrew member's continuous perception of self and aircraft in relation to the dynamic environment of flight, threats, and mission, and the ability to forecast then execute tasks based on that perception (Tab BB-101).

While the MP did not recall any forecast weather related issues, the observed weather was significant for cloud cover both above and below the fight, in addition to the sun being displayed low on the horizon (Tabs W2 and BB-241). Added to this, the MP was flying in a vertical fight with reference to the other aircraft (i.e. the MW) (Tab BB-241). These conditions can result in disorientation and could have contributed to the MP's misperception of the MA's position relative to the horizon (Tabs W2 and BB-241).

The following sequence of events illustrate how the misperception of the changing environment by the MP lead to loss of SA of the MA's position relative to the horizon (i.e., the ground or in this case the ocean) along with the MA's energy state, pitch angle, and attitude (Tab DD-20).

The MP did not recall the MA's nose high position and perceived the MA was in a steep right hand turn (Tab V-2.24). However, the MP had oriented and maintained a lift vector on the MW resulting in a nose high attitude relative to the horizon and a subsequent decrease in airspeed (Tab J1-9). Further, the MP misperceived that the MA had decreased tracking during a right hand turn due to excessive AOA when KITS data showed that the MA was nose high for approximately 15 seconds (Tabs J1-8, V-2.11, and V-2.25,). At this point, the MA likely either stalled due to an excessive AOA spike as demonstrated in the simulator or the MP excessively unloaded and over a span of six seconds, the nose dropped from 65 degrees nose high to 65 degrees nose low (Tab J1-8).

Then at some point during this nose high to nose low transition, the MP pushed the stick forward with full right rudder still engaged resulting in the snaproll (Tab J1-5). Abrupt forward stick inputs combined with a high roll or yaw rate may induce an auto roll/spin or cause a departure (Tab BB-247). The forward stick inputs when applied in this negative G situation caused the out of control flight (Tab J1-3 and J1-8). If the MP had recognized the negative G scenario and acted to use aft stick, this would have aided in recovery of the MA before it transitioned to a sustained departure situation (Tab BB-247).

d. PC102 Fixation

This occurs when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others (Tab B-123).

During the sequence of events, the MP performed the necessary defensive BFM to remain engaged with the MW (Tab V-2.8). This type of maneuvering requires the defensive player (i.e., the MP) to be looking outside of the aircraft over the shoulder through the top of the canopy (Tab BB-235). The MP was most likely channelized or fixated on the MW aircraft position, attitude, angle-off, and closure. (Tab DD-20). The combination of the cloud cover both above and below the fight, in addition to the sun located low on the horizon presented conditions where visual illusions in regards to the horizon were most likely to occur resulting in the loss of SA and misperception of the MA's positional relationship to the horizon (Tabs W2 and DD-20).

e. AE206 Wrong Choice of Action During Operation

This a factor when the individual, through faulty logic or erroneous expectations, selects the wrong course of action (Tab BB-116).

When there is a misperception of the current situation, the pilot cannot accurately predict the future status, which negatively affects decisions and subsequent actions (Tab BB-109). This misperception results in wrong choice of action (Tab DD-21). In the case of the MP, these wrong choices of action were the following: (1) unload of the stick with high AOA and full rudder, (2) not using aft stick to counter the negative Gs, and (3) maintaining full right rudder, which under negative G was a pro-left rolling input (Tabs J1-8, V-2.3 to V-2.38, BB-217 to BB-224, and BB-248). Where the first action led to the MA departure, the second and third actions sustained the MA departure condition (inverted, negative G spin) with negative AOA and negative Gs (Tabs BB-252 and DD-21).

In the events leading up to the first wrong choice of action, the MP stated the MA was tracking relatively parallel across the horizon, when KITS data showed the MA had transitioned to flying well above and perpendicular to the horizon (Tab V-2.21). The MP did not recall this change in flight path (Tab V-2.10).

Further, the MP did not recall executing a tree (vertical) maneuver when engaged in defensive BFM with the MW (Tab V-2.8). The MP misperceived the situation compared with the MW testimony and KITS data (Tabs J1-8, R-3, and V-2.7 to V-2.8). Since the MP was unaware of the

MA's high pitch attitude and resultant low airspeed, the MP failed to recognize the nose was falling down and to the right (Tabs J1-8 to J1-9, and V-2.34).

The MP thought excessive AOA was causing the MA to not track across the horizon (Tab V-2.24). This is consistent with the MP being unaware of the MA's high pitch attitude and decreasing airspeed (Tabs J1-8 to J1-9, V-2.8 and V-2.21). The MP assessed that by unloading pressure off the stick, it would help the MA's tracking (Tab V-2.3). While the exact moment the MP initiated the unload cannot be determined, once the MA's nose started falling it continued over a span of six seconds dropping from 65 degrees nose high to 65 degrees nose low (Tab J1-8).

At some point during this nose high to nose low transition, the MP executed the second wrong choice of action when continuing to apply full right rudder resulting in the snaproll (Tab V-2.11 and V-2.13). The MP recognized the MA's departure and executed the first two steps of the Out of Control/Departure Recovery Procedure; Smoothly Neutralize and Release Controls and Apply Rudder Smoothly and Opposite Roll/Yaw (Tab BB-217 to BB-224).

The MP recalled feeling light in the seat, a sensation of "eyeballs out," with a more significant force that pushed the MP to the right side of the cockpit (Tab V-2.14, V-2.34, and V-2.36). The MP sensed the forces as mostly yaw due to a perceived spin and was unaware of the negative G situation (Tab V-2.14). When the MP reapplied right rudder in the negative G condition it sustained the right yaw and left roll coupling of the MA rather than countering it (Tab BB-252). The MP, likely due to disorientation caused by the combined negative and lateral G forces, did not recognize the negative G condition and was unable to execute the last sentence of Step 2's warning to "counter any negative G with aft stick (Tabs BB-248 and DD-21).

Wrong choice of action is affected by numerous factors (Tab DD-21). One concept in particular, temporal or time distortion is worthy of discussion in this section as it refers to the MP. Temporal or time distortion occurs when our attentional capacities are highly taxed (Tab BB-116). Any high stress situation has the potential to create an environment that is conducive to temporal distortion (Tab DD-22). Due to the low ejection at the time of departure, the MP stated the time available to assess the situation was approximately three seconds (Tabs J1-8 and V-2.13).

Unlike the other HFACs, temporal/time distortion occurred at a point in the sequence of events where the MP reacted in a "fight or flight" response (Tab DD-22). In this case, fight would be defined as continuing to troubleshoot the issues with the MA and attempts to recover the aircraft through identification of the correct checklist with the immediate threat, given the low altitude, being both loss of life and the aircraft. Flight would be defined as ejecting from the aircraft because of the survival instinct (Tab DD-22).

The MP was aware that the altitude at the time of aircraft departure was below the minimum uncontrolled ejection altitude of 6,000 feet AGL (Tabs V-2.15 and BB-250). After application of right rudder failed to recover the aircraft to controlled flight, the MP focused on getting out of the aircraft (Tab V-2.15). Analysis of the KITS altitude data reveals that approximately 9-10 seconds expired while the MP assessed the situation and executed the out-of-control/departure recovery checklist prior to deciding to eject from the MA (Tabs J1-11 and BB-247). The MP recalled the challenges faced during this compressed time interval including both lateral and negative G forces pinning the MP to the right of the cockpit (Tab V-2.16.).

KITS data showed the MP had two seconds after the MA departure before falling below the 6,000 feet AGL ejection minimum (Tabs J1-11, V-2.12, V-2.32, and BB-250). The additional eight seconds spent fighting the MA (attempting to recover, giving it "the old college try,") likely contributed to an extremely low altitude ejection (1,100 feet AGL) (Tabs J1-11, V-2.12, V-2.32, and V-2.38). The ejection was further delayed by an unsuccessful first attempt as the MP's right hand gripped and pulled the emergency manual chute handle (Tabs V-2.15 to V-2.16 and Z-3). Furthermore, as the negative G situation progressed, the "ground rush" of the cloud deck at 1,000 feet to 3,000 feet MSL and seeing 3,000 feet to 3,500 feet MSL on the altimeter, the MP decided to eject (Tabs V-2.13 and W-2).

f. PE108 External Force or Object Impeded an Individual's Movement

This is a factor when acceleration forces greater than one second cause injury or prevent/interfere with the performance of normal duties (Tab BB-118).

Negative G flight characteristics are extremely disorienting (Tab BB-252). As described above, the MP was lifted out of the seat and pinned to the right side of the cockpit due to lateral and negative G forces (Tab V-2.16 and V-2.33 to V-2.34). Based on KITS data, the MP experienced negative longitudinal G forces ranging from -0.5 to -1.5 Gs for approximately 15 seconds (Tab J1-10). This contributed to the MPs inability to fly the MA with hands on stick and throttles as the MP had to brace with the right hand against the canopy and controlled the MA with left hand, which is not normal or expected operations (Tab V-2.11 and V-2.13).

These gravitational forces delayed the ejection by impeding the MP's ability to actuate the handles correctly (Tab V-2.15). Specifically, during the first ejection attempt the MP inadvertently grabbed the emergency manual chute handle with the right hand and applied insufficient force with the left hand to activate the ejection seat (Tab V-2.15 and V-2.31). Recognizing the error, the MP visually confirmed hands on the correct handles and ejected successfully by pulling both ejection handles (Tab V-2.15 and V-2.31).

g. OP004 Organizational (Formal) Training is Inadequate or Unavailable

This is a factor when initial training programs, upgrade programs, transition programs or other training conducted outside the local unit is inadequate or unavailable (Tab BB-130).

The MP experienced a negative G departure from controlled flight with a snap roll entry to the left that transitioned to an inverted, negative G spin condition (Tab DD-25 to DD-26). During F-15C initial qualification at the formal training unit (FTU), negative G scenarios are taught academically and briefed on every BFM sortie, but there is no practical hands-on simulator training specifically for negative G auto rolls or inverted spins (Tab V-15.4 to V-15.5). Positive G auto rolls/spins are taught but in only one simulator training flight in the initial qualification training (IQT) course (Tabs G-28 to G-175, V-15.4 to V-15.5). A review of MP's training records at the FTU revealed auto rolls/spins were only taught hands-on during one simulator training sortie each (Tab G-28 to G-175).

Through interviews with instructor pilots (IPs)/leadership from the 44 FS at Kadena AB, the board learned there is no requirement nor tracking mechanism during continuation training to ensure F-15 pilots are proficient to recover from a negative G auto roll or inverted, negative G spins (Tab V-6.5 to V-6.9, V-8.5 to V-8.7, and V-15.4 to V-15.5).

Specifically, negative G spins and negative G auto rolls are not tracked as individual required maneuvers in EP or tactical simulators (Tab V-6.5 to V-6.9, V-8.5 to V-8.7, and V-15.4 to V-15.5). Pilots testified they did not remember doing a negative G out of control departures recovery (Tab V-6.5 to V-6.9, V-8.5 to V-8.7, and V-15.4 to V-15.5). Additionally, actual accomplishments are not tracked in EP simulators, and monthly SEPT or BFM sortie briefs typically only cover positive G auto roll/spin situations and recoveries (Tab V-4.8 and V-8.5 to V-8.7). Pilots also testified the simulator is a poor replicator of the forces experienced (Tab V-6.5 to V-6.9, V-8.5 to V-8.7, and V-15.4 to V-15.5).

In this scenario the MP did not recognize the negative G aspect of the departure and therefore applied right rudder to counter the auto roll rather than left rudder (in the direction of the roll) as recommended in the Flight Manual to speed the recovery (Tabs BB-247, V-2.11, and V-2.13). Additionally, the MP did not counter the negative G with aft stick as recommended by the Flight Manual (Tab BB-248).

h. OP003 Provided Inadequate Procedural Guidance or Publications

This is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading or inappropriate (Tab BB-130).

Negative G flight characteristics, negative G auto rolls/spins, and recovery of the aircraft in negative G situations are included in the T.O. series for the F-15C (Tab BB-247, BB-254, and BB-254). However, the steps in the Out of Control/Departure Recovery checklist are written for a positive G auto roll or spin (Tab BB-217 to BB-224). In the handheld checklist, only a single warning mentions countering negative G with aft stick (Tab BB-217 to BB-224). There is no mention of negative G auto roll recovery considerations in the checklist (Tab BB-217 to BB-224).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 11-2F-15 Volume 1, *F-15-Aircrew Training,* 7 September 2010
(2) AFI 11-2F-15 Volume 3, *F-15-Operations Procedures,* 18 September 2014
(3) AFI 11-2F-15 Volume 3, *F-15 Operations Procedures*, *Kadena Air Base Supplement*, 10 November 2015
(4) AFI 11-202, Volume 3, *General Flight Rules*, 10 August 2016
(5) AFI 11-214, *Air Operations Rules and Procedures*, 14 August 2012, *Incorporating Change 1, 23 March 2016*
(6) AFI 11-290, *Cockpit/Crew Resource Management Program*, 15 October 2012
(7) AFPAM 11-417, *Orientation in Aviation*, 9 April *2015*
(8) AFI 48-123, *Medical Examinations and Standards*, 5 November 2013

(9) AFI 51-503, *Aerospace and Ground Incident Investigations*, 14 April 2015
(10) AFI 91-204, *Safety Investigation and Hazard Reporting*, 27 April 2018
(11) TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*, 1 June 2018
(12) TO 00-20-2, *Maintenance Data Documentation*, 15 March 2016

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 and the Tinker Air Force Public Access site at http://www.tinker.af.mil/home/Technical-Orders.

b. Other Directives and Publications Relevant to the Mishap

(1) TO 1F-15A-6, *Inspection and Maintenance Requirements Manual*, 1 March 2011, Change 21 – 15 May 2018
(2) TO 1F-15C-2-27FI-00-1, *Fault Isolation,* 1 May 1995, Change 21 – 22 March 2017
(3) TO 1F-15A-1CL-1, *Flight Crew Checklist,* 15 February 2009, Change 15, 15 March 2018
(4) TO 1F-15A-1, *Flight Manual,* 15 February 2009, Change 15 – 1 February 2018
(5) AFTTP 3-3.F-15, *Combat Aircraft Fundamentals-F-15*, 17 June 2016
(6) Air Force Research Laboratory Handbook of Aerospace and Operational Physiology 2nd Edition, 1 November 2016
(7) Department of Defense Human Factors Analysis and Classification System (DOD HFACS) Version 7.0, 13 May 2014
(8) United States Air Force Medical Standards Directory, 25 September 2018
(9) Air Education and Training Command Syllabi, *Flying Training*, May 2013
(10) F-15C Ready Aircrew Programs Tasking Memorandum, *Aviation Schedule 2018*, 1 October 2018

c. Known or Suspected Deviations from Directives or Publications

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

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07 December 2018

HARMON S. LEWIS, JR., Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-15C, T/N 84-0008
NEAR KADENA AIR BASE, JAPAN
11 JUNE 2018

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 11 June 2018, the Mishap Pilot (MP) was flying the Mishap Aircraft (MA), an F-15C, Tail Number 84-0008, assigned to the 44th Fighter Squadron (44 FS), 18th Wing (18 WG), Kadena Air Base (AB), Japan. The MP was flying as lead of a two-ship formation during a dissimilar basic fighter maneuver (BFM) sortie with an F-22A, assigned to the 525th Fighter Squadron, 3rd Wing (3 WG), Joint Base Elmendorf-Richardson, Alaska. While maneuvering defensively in relationship to the Mishap Wingman (MW), at approximately 5,400 feet mean sea level (MSL) and 180 knots indicated airspeed (KIAS), the MP initiated a vertical maneuver climbing to 65 degrees nose high, 20 degrees of right bank, 39 degrees Angle-of-Attack (AOA), 1.2 Gs, and to approximately 6,300 feet MSL and 105 KIAS, before a significant nose drop occurred. The MP perceived the MA was not tracking as desired and initiated an unload of approximately one fist-width's forward stick with full right rudder. The nose pitched down and to the right to 65 degrees nose low, 110 degrees of right bank, -26 degrees AOA and G forces decreasing from 1.2 to -0.3 Gs. With right rudder still commanded, the MA experienced a negative G departure from controlled flight with a snap roll entry to the left that transitioned into an inverted, negative G spin. The MP received no indications of hydraulic, electrical, fuel, engine, structural, or flight control system malfunctions. The MP immediately experienced significant longitudinal and lateral G forces, high roll rates and pitch oscillations, and was below the F-15C Flight Manual's Uncontrolled Minimum Ejection Altitude of 6,000 feet above ground level. Unable to recover the MA, the MP ejected 15 seconds after the departure from controlled flight at approximately 1,100 feet MSL and sustained serious injuries. At approximately 0617 hours local time, 14 minutes after takeoff, the MA crashed into the Pacific Ocean approximately 70 miles south of Kadena AB. The MA broke apart upon impact with a loss valued at $42,360,014.00. There were no fatalities or damage to civilian property.

I find by a preponderance of the evidence the mishap was caused by the MP's improper application of forward stick with full right rudder, which resulted in a negative G departure from controlled flight due to the coupling of aerodynamic forces of yaw and roll.

I also find by a preponderance of the evidence that three additional factors substantially contributed to the mishap: spatial disorientation, lack of emergency procedure training for negative G departures from controlled flight, and limited time to analyze the situation and recover.

I developed my opinion by analyzing factual data from historical records, Air Force directives and guidance, engineering analyses, witness testimonies, flight trajectory data from the Kadena Instrument Training System (KITS) data, flight simulations, radio recordings, maintenance and inspection records, and information provided by medical and technical experts.

2. CAUSE

a. Improper Application of Forward Stick with Full Right Rudder

While the MP maneuvered defensively, the MP sensed the nose of the MA was not tracking at the desired rate and initiated a forward stick unload with full right rudder engaged. Comparing MP and MW testimony, engineering analysis of MA trajectory, and flight recreations in the simulator, I determined that the nose drop experienced by the MA was due to either (1) the MP demanding too much AOA; or (2) the MP's forward stick unload. With either of these precursors, from 65 degrees nose high pitch, approximately 39 degrees AOA, 6,300 feet MSL, and 105 KIAS, the MA experienced a nose high to nose low recovery described in the post-mishap engineering assessments as a sudden nose-down pitch below the horizon that led to a negative G excursion. While the precise moment the forward stick unload was executed by the MP could not be determined, KITS data showed the MA entered a region of low to neutral pitch stability for the F-15C (0 to -10 AOA) as the MA's nose fell through the horizon. Once the MA's nose was falling, the F-15C's lower pitch stability, assisted by gravity and forward stick input, contributed to the rapid nose down pitch rate that forced the MA into a negative AOA, negative G condition.

Full right rudder, held by the MP during the nose drop, combined with the MA's negative AOA (between 0 and -0.5 G) resulted in extreme sideslip angles causing the aircraft to fly sideways with high in-the-cockpit lateral G loads. The KITS data showed the MA at -0.3 Gs during the nose drop and the MP recalled having full right rudder and right yawing differential throttle inputs throughout the intended minimum radius turn and during the forward stick unload. The F-15C Flight Manual states that as G is reduced, rudder inputs produce more and more yaw induced sideslip. Due to the stable dihedral effect of the F-15C design, the aerodynamic response to the left sideslip angles (developed as the MA pitched down with right yaw inducing flight control inputs) is a snap roll to the left in response to the coupling forces of yaw and roll. KITS data confirmed a six second nose drop to 65 degrees nose low, 110 degrees right bank (inverted), -26 degrees AOA, and -0.3 Gs, followed by a snap roll to the left. The MP recalled an abrupt, uncommanded nose low maneuver in the opposite direction (to the left) of the MP's flight control inputs (to the right) accompanied by departure warning tones. An uncommanded, abrupt flight path change is the definition of a departure from controlled flight, and engineering analysis of the MA's flight trajectory concluded this was a negative G departure with a snap roll to the left that transitioned to an inverted, negative G spin.

I determined that the MA was functioning in accordance with maintenance instructions and technical orders and concluded there were no aircraft malfunctions prior to flight or during the mishap sequence that contributed to the mishap. I arrived at this conclusion based on: a comprehensive review of aircraft maintenance records; testimony of maintenance witnesses; MP testimony of flight control inputs before the departure; MP testimony that there were no warning or caution lights or annunciations; MA flight trajectory (roll, pitch, and yaw) consistency with MP testimony of flight control inputs; simulator replications with and without malfunctions, and post-ejection trajectory analysis by subject matter experts. After the MP ejected, with flight controls neutral, the KITS data showed the MA was beginning to exit the spin (yaw rate decreasing, AOA and G forces increasing to positive, pitch oscillations getting smaller, pitch increasing more nose low, and airspeed increasing). The last KITS data showed the MA in a left rolling motion, 90 degrees nose low, accelerating past 260 KIAS, and with approximately 15 degrees positive AOA.

The MA was below the Flight Manual's Minimum Uncontrolled Ejection Altitude (6,000 feet AGL) in less than 2 seconds from the moment of departure. Although the MP did accomplish some recovery steps, approximately 8 seconds later, between 3,000 feet and 3,500 feet MSL with the ground rush of the low cloud layer, the MP focused on ejecting from the MA. Given the initial low altitude at the moment of departure, F-15C System Program Office engineers assessed it was unlikely the MA could have recovered before impacting the water. Therefore, I find that MP's misapplication of flight controls, that resulted in the departure and subsequent inverted, negative G spin, was causal.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

I find by a preponderance of the evidence that each of the following factors substantially contributed to the mishap.

a. Spatial Disorientation (SD)

A preponderance of the evidence suggests that the MP was spatially disoriented (Type 1) in Visual Meteorological Conditions (VMC) conditions due to misperception of the changing environment, fixation, and external forces (lateral and negative G forces) impeding MP's actions. This spatial disorientation occurred: (1) as the nose pitched up, (2) continued during the nose drop, and (3) during the negative G snaproll and inverted, negative G spin.

At some point after the level reversal to the right while attempting to continue in a right descending turn, the MP lost awareness of MA's orientation to the horizon. Specifically, the MP testified that MA was in 60-90 degrees right bank (pulling across the horizon) in a parallel orientation when in fact the KITS data, MW's aircraft data, and MW's testimony prove that the MP had reoriented to a 65-degree nose high climb perpendicular to the horizon, and according to MP testimony, MP was unaware of MA's high pitch and slow airspeed.

Due to the nature of BFM, the pilot's attention is directed outside the aircraft which increases the potential for channelized attention and slows an effective instrument cross check. The evidence suggests the MP was generally aware of MA's altitude, but during the latter portions of the engagement, the MP did not recognize the slow airspeed or high pitch attitude of the MA. The MP remembered 200 KIAS as the last airspeed, but the MA had slowed to 105 KIAS. During the moments that the MP initially became disoriented, the MP was not performing an effective cross-check. While looking back over the shoulder, through the top of the canopy, the MP was channelized mostly on the MW's aircraft position, attitude, angle-off, and closure. The MP was using mostly peripheral cues to maintain awareness of the horizon. In the portion of the sky that the MP was flying across, post-flight review of the Heads-Up Display (HUD) film from aircraft in the adjacent airspace (surge sector 7) at the same time showed high and low cloud layers, sun glare, and an obscured horizon to the east when flying at approximately 8,000 feet MSL. These environmental factors may have resulted in visual illusions leading to the MP's incorrect assessment of the MA's pitch and roll relative to the horizon.

The MP did not recall the MA's nose high position and perceived the MA was in a right hand turn. The MP oriented and maintained a lift vector on the MW (who was above and slightly aft) resulting in a nose high attitude relative to the horizon and a decrease in airspeed. Either during the nose drop or just before, the MP recognized the decreased nose rate, but believed it to be in a mostly level right hand turn. The KITS data showed the loss of nose track occurred after the MA had been in a nose high climb for approximately 15 seconds.

At this point, the MA's nose dropped because it either stalled (excessive AOA as demonstrated in the simulator) or because the MP initiated unload of forward stick. The MP does did not recall this excessive nose drop, but did recall executing a fist width unload in an attempt to break the AOA and get the nose tracking faster. Either precursor resulted in the same result: the MA nose began to drop from 65 degrees nose high.

At some point during this nose high to nose low transition, without awareness of the MA's orientation to the horizon, the MP executed another incorrect action by allowing the stick to remain forward of center with continued full right rudder, which resulted in the snaproll. Aerodynamically speaking, once the MA's nose was falling, the F-15C's lower pitch stability, assisted by gravity, caused the rapid nose down pitch rate that forced the MA into a negative AOA, negative G condition.

The MP's full rudder command throughout this excursion resulted in yaw induced sideslip and a snap roll to the left. The MP had no recollection of the MA shifting from 65 degrees nose high to 65 degrees nose low, but only sensed the nose stopped tracking. The MP's disorientation during this part of the sequence was likely due to the obscured horizon combined with the MP's focus on the MW.

The evidence also illustrates that the disorientation continued after the negative G snaproll had transitioned to the inverted, negative G spin. The MP incorrectly assessed the MA was in an upright spin. Due to the extreme disorientation caused by the combined negative and lateral G forces, the MP did not recognize the negative G condition, and therefore did not execute the Flight Manual's associated warning to "counter any negative G with aft stick." Additionally, because the MP did not recognize the negative G, the MP's full right rudder to counter the left roll, caused a rolling moment in the opposite direction (to the left) and sustained the aerodynamic coupling perpetuating the MA in an out of control condition. The unrecognized SD during these phases of the mishap had a significant impact on the MP, which contributed to the negative G snaproll departure and inverted, negative G spin.

b. Lack of Emergency Procedure Training for Negative G Departures from Controlled Flight

Without aft stick to counter the negative G condition and split throttles still in AB, the initial steps of the checklist were not fully executed. Negative G flight characteristics, negative G auto rolls, negative G (inverted) spins, and considerations for recovery of the aircraft in negative G situations are included in the F-15C Flight Manuals (technical orders series). However, the steps in the Out of Control/Departure Recovery checklist were written for a positive G auto roll or spin. In the handheld checklist, only a single warning mentions countering negative G with aft stick. There is also no mention of negative G auto roll recovery considerations in the checklist, i.e., rudder with the roll will produce a faster recovery, or that rudder against the roll with negative G will actually worsen the situation by increasing the roll rate. The MP's application of right rudder was in accordance with the checklist step to "apply rudder smoothly opposite roll/yaw." However, this step in the Flight Manual was written for a positive G auto roll.

I also determined a lack of emergency procedure training for negative G scenarios during both initial qualification and continuation training significantly contributed to the MP's lack of familiarity with executing the Flight Manual's checklist in negative G scenarios. During the F-15C Initial Qualification Training (IQT) at the formal training unit (FTU), negative G scenarios are taught academically and briefed on every BFM sortie, but there is no practical hands-on simulator training specifically for negative G autorolls or negative G spins. A review of the course syllabus and MP's training records at the FTU revealed autorolls and spins are only required to be taught hands-on during one simulator training sortie each. According to testimony by the syllabus manager at the FTU, the emphasis during hands-on simulator training is not on negative G scenarios.

Through interviews with instructor pilots and leadership in the 44 FS at Kadena AB, I further determined that there is no requirement nor tracking mechanism during continuation training to ensure F-15 pilots are proficient to recover from a negative G departure or negative G spin. Although out of control and departure situations and recoveries are briefed prior to every mission where high AOA maneuvers may be flown, intentional spins are prohibited maneuvers in the aircraft. Spins and autorolls are sometimes flown in quarterly Emergency Procedures (EP) simulator training, but they are not a required maneuver nor are negative G scenarios tracked.

Although monthly Simulated Emergency Procedure Training (SEPT) cards track whether a pilot accomplished the EP via tabletop discussion or hands-on in the simulator, there is no requirement for pilot hands-on execution to complete SEPT training for these maneuvers. Most pilots testified they did not remember accomplishing a negative G departure recovery. Additionally, the simulator does not replicate any external force other than a +1 G environment, so the combined effect of negative and lateral G forces experienced in the mishap would probably be a first time occurrence for most F-15C pilots.

Given the aforementioned research, I find that there is no mechanism in initial qualification and continuation training to ensure that F-15C pilots are proficient at executing recoveries from negative G departure scenarios or negative G spins. Had the MP experienced negative G scenarios in training, MP may have been able to react and respond correctly to the developing negative G scenario and neutralized the rudder preventing the snaproll. Negative G training also may have prepared the MP to respond correctly to the negative G snaproll prior to transitioning to an inverted, negative G spin, from which subject matter experts agree the MA could not be recovered in the remaining altitude available.

c. Limited Time to Analyze the Situation and Recover

With a fight floor of 5,000 feet MSL, the MP had transitioned between 5,400 feet to 6,300 feet MSL in the moments preceding the departure. According to MP testimony and KITS data, the MA was below the Flight Manual's Minimum Uncontrolled Ejection Altitude (6,000 feet AGL) in less than 2 seconds from the moment of departure, which was rapid and disorienting. Due to the low altitude at that the time of departure, the MP recalled assessing the situation and executing an unsuccessful recovery attempt for approximately 3 seconds. The KITS data revealed the actual time elapsed before the MP's decision to eject, having sensed the ground rush of the low cloud layer and the ocean, was 9-10 seconds. Temporal or time distortion occurs when a person's attentional capacities are highly taxed. Any high stress situation has the potential to create an environment that is conducive to temporal distortion. This temporal or time distortion occurred at a point when the MP reacted to a "fight or flight" situation. In this case, *fight* was continuing to troubleshoot the situation and attempt to recover for the immediate threats of both loss of the aircraft and loss of life; whereas *flight* was the choice to eject from the aircraft because of the survival instinct.

The limited time available to correctly assess and recover the MA was a direct result of flying the engagement at an altitude insufficient to permit proper execution of the checklist recovery steps and verify if the MA was recovering before reaching 6,000 feet AGL, the minimum ejection altitude for out of control flight in the F-15C. At the time of the mishap, the minimum altitude of 5,000' AGL for unlimited maneuvering was utilized as the minimum altitude for high-aspect BFM engagements. Although unlimited maneuvering up to aircraft flight manual limitations was permissible down to 5,000 feet AGL, I find that it significantly reduced the time the MP had to assess, decide, and take the appropriate actions to recover the MA aircraft, which significantly contributed to the mishap.

4. CONCLUSION

I find by a preponderance of the evidence the mishap was caused by the MP's improper application of forward stick with full right rudder, which resulted in a negative G departure from controlled flight with a snap roll entry to the left that transitioned to an inverted, negative G spin due to the coupling of aerodynamic forces of yaw and roll. Furthermore, I find by a preponderance of the evidence that three additional factors substantially contributed to the mishap: spatial disorientation, lack of emergency procedure training for negative G departures from controlled flight, and limited time to analyze the situation and recover.

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07 DECEMBER 2018

HARMON S. LEWIS, JR., Colonel, USAF
President, Accident Investigation Board

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