UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-35A, T/N 12-005053

58TH FIGHTER SQUADRON

33RD FIGHTER WING
EGLIN AFB, FLORIDA

LOCATION: EGLIN AIR FORCE BASE, FLORIDA

DATE OF ACCIDENT: 19 MAY 2020

BOARD PRESIDENT: Colonel Bryan T. Callahan

Conducted IAW Air Force Instruction 51-307

EXECUTIVE SUMMARY

F-35A, T/N 12-005053
EGLIN AFB, FLORIDA
19 MAY 2020

On the night of 19 May 2020 at 2126L, the mishap aircraft (MA), an F-35A aircraft tail number (T/N) 12-005053 crashed on runway 30 at Eglin Air Force Base (AFB), Florida (FL). The MA was operated out of Eglin AFB, FL by the 58th Fighter Squadron (FS), 33rd Operations Group (OG), assigned to the 33rd Fighter Wing. The mishap pilot (MP) ejected safely but sustained nonlife threatening injuries. The MA, valued at $175,983,949, rolled, caught fire, and was completely destroyed.

The MP set and held 202 knots calibrated airspeed (KCAS) throughout the approach and landing. The aircraft touched down approximately 50 KCAS fast, and was approximately 8 degrees more shallow than desired for landing, at a 5.2 degree Angle of Attack. The aircraft landing lasted approximately five seconds before the MP ejected.

The nose of the aircraft drove down at a high rate of speed and the nose gear contacted the runway immediately after the main landing gear. Next, the MA experienced a significant nose-high bounce. After the initial bounce, the MP made stick inputs consistent with an attempt to recover and set a landing attitude. However, the MP's stick inputs quickly fell out of synch with the aircraft pitch oscillations and aircraft control cycles. Two seconds after touch down, the MP set and held aft stick, which would normally bring the nose of the aircraft up. Approximately one second after commanding aft stick the pilot also commanded full afterburner on his throttle. Both of those actions are consistent with an attempt to establish an attitude that would have allowed the aircraft to take off and go-around for another landing attempt. The horizontal stabilizers remained in full deflection down, which would tend to keep the nose of the aircraft down, despite the pilot holding aft stick for three seconds. After being unsuccessful in the attempt to go-around after multiple and progressively worsening bounces, the MP released the stick to eject.

The AIB President found, by a preponderance of the evidence, that the mishap was caused first, by the MA touching down at 202 KCAS, and second, by the MA flight control surfaces, namely the tail of the aircraft, conflicting with the MP inputs upon landing, resulting in the MP's inability to recover from the aircraft oscillation. The AIB President also found by a preponderance of the evidence that four additional factors substantially contributed to the mishap. The substantially contributing factors are: the MP landed with Speed Hold engaged and using an alternate crosscheck method, the MP Helmet Mounted Display misalignment distracted the MP during a critical phase of flight, MP experienced cognitive degradation due to fatigue, and the MP lacked systems knowledge on flight control logic.

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.

SUMMARY OF FACTS AND STATEMENT OF OPINION

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ACRONYMS AND ABBREVIATIONS

2vX	2 blue air versus unknown number of red air
33 FW	33rd Fighter Wing
33 OSS	33rd Operations Support Squadron
58 FS	58th Fighter Squadron
AB	After Burner
ACM	Air Combat Maneuvering
ADSC	Active Duty Service Commitment
AETC	Air Education and Training Command
AF	Air Force
AFB	Air Force Base
AFE	Air Flight Equipment
AFI	Air Force Instruction
AFRL	Air Force Research Laboratory
AFTO	Air Force Technical Order
AFTTP 3-3.F-35	Air Force Tactics, Techniques, and Procedures 3-3, Combat Aircraft Fundamentals for F-35
AGL	Above Ground Level
AIB	Accident Investigation Board
ALIS	Autonomic Logistics Information System
AOA	Angle of Attack
AP	Auto Pilot
APC	Approach Power Compensator
AT	Auto Throttle
ATCAA	Air Traffic Control Assigned Airspace
BFM	Basic Flight Manuevers
BOS	Before Operation Servicing
BR	Board Recorder
CAP	Commander’s Awareness Program
Capt	Captain
CAS	Close Air Support
CDM	Climb Dive Marker
CES	Civil Engineer Squadron
CLAW	Control Law
CIP	Core Integrated Processor
Col	Colonel
COVID-19	Corona Virus Disease 2019
CSMU	Crash Survivable Memory Unit
CT	Continuation Training
DAS	Distributed Aperture System
DD	Delayed Discrepancies
DLO	Desired Learning Objective
DME	Distance Measuring Equipment
DNIF	Duties Not Including Flying
DO	Director of Operations
DoD	Department of Defense
E-bracket	AOA Error-bracket
EFI	Electronic Flight Indicator
EP	Emergency Procedure
FAF	Final Approach Fix
FCS	Flight Control System
FL	Florida
FLIR	Forward Looking Infrared
FPM	Flight Path Marker
FS	Fighter Squadron
GCI	Ground Control Intercept
GM	Guidance Memorandum
G-TIMS	Graduate Training Integration Management System
HOTAS	Hands On Throttle and Stick
HSI	Horizontal Situation Indicator
HMD	Helmet Mounted Display
HMDS	Helmet Mounted Display System
HMOD	Hardware Modification
HUD	Heads-Up Display
IAW	In Accordance With
ICAW	Integrated Caution, Advisory and Warning
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IOS	Interim Operation Servicing
IPOR	Instructor Pilot of Record
IRC	Instrument Refresher Course
IRCM	Infrared Counter Measure
IP	Instructor Pilot
JCN	Job Control Number
JTD	Joint-Service Technical Data
KCAS	Knots Calibrated Airspeed
kts	Knots
L	Local Time
LA	Legal Advisor
LM	Lockheed Martin
LRIP	Low-Rate Initial Production
Lt Col	Lieutenant Colonel
MA	Mishap Aircraft
MADL	Multifunction Advanced Data Link
Maj	Major
MB	Martin Baker
MED	Medical Member
MF	Mishap Flight
MM	Maintenance Member
MP	Mishap Pilot
MPC	Mission Planning Cell
MSCM	Mission Systems Counter Measure
MW	Mishap Wingman
NCWILCCO	Navigation master mode, Combat, navigation and identification, Waveform, Instrument landing system, Localizer frequency, Course set, Configure aircraft, Off the wall and solid
NOTAMs	Notices to Airmen
NVG	Night Vision Goggles
OG	Operations Group
ORM	Operational Risk Management
PA	Power Approach
PAIR	Production Aircraft Inspection Requirement PAPI Precision Approach Path Indicators PFO Precautionary Flameout
PHA	Physical Health Assessment
PIO	Pilot Induced Oscillation
PM	Pilot Member
PMC	Partially Mission Capable
POS	Post Operation Servicing
PRD	Pilot Reported Discrepancy

PSI	Pounds per Square Inch
R2	Removal and Replacement
RFI	Request For Information
RNET	Report No Earlier Than
RTB	Return to Base
SAR	Search and Rescue
SATD	Sensor Aided Trail Departure
SFD	Standby Flight Display
SFS	Security Forces Squadron
SII	Special Interest Item
SOF	Supervisor of Flying
SOU	Standard Operating Units
TCTD	Time Compliance Technical Directives
TI	Tactical Intercepts
T/N	Tail Number
TO	Tech Order
TSgt	Technical Sergeant
TVE	Type Version Effectivity
vHUD	Virtual Heads-Up Display
VMC	Vehicle Management Computer
WOW	Weight on Wheels
Z	Zulu

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 21 May 2020, Lieutenant General Marshall B. Webb, the Commander of Air Education and Training Command (AETC), appointed Colonel Bryan T. Callahan to conduct an Accident Investigation Board (AIB) for a mishap that occurred on 19 May 2020, involving an F-35A aircraft, tail number (T/N) 12-005053, at Eglin Air Force Base (AFB), Florida (FL) (Tab Y-3). The investigation was conducted at Eglin AFB, FL from 29 June 2020 through 17 July 2020. Additionally, the following members were appointed to support the accident investigation: a Lieutenant Colonel legal advisor, a Lieutenant Colonel maintenance member, a Lieutenant Colonel medical member, a Captain pilot member, and a Technical Sergeant recorder (Tab Y-7).

b. Purpose

In accordance with AFI 51-307, *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 aircraft accident, prepare a publicly releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action.

2. ACCIDENT SUMMARY

On the evening of 19 May 2020, the Mishap Aircraft (MA), an F-35A, T/N 12-005053, operated by the 58th Fighter Squadron (58 FS), 33rd Fighter Wing (33 FW), departed Eglin AFB at 2015L for a night Tactical Intercepts (TI) mission to the W151A airspace (Tabs K-3, K-5, K-11, and V-1.22). This type of training consists of a “Blue Air” flight with a student and instructor pilot engaging with simulated enemy aircraft, the “Red Air” (Tab V-1.22). The Mishap Flight (MF) was “Blue Air” and consisted of two F-35A aircraft with the MA flying as the Flight Lead (FL) (Tabs K-9, K-11, V-1.14 and V-1.22). At 2126L the MA touched down on runway 30 at Eglin AFB at 202 knots calibrated airspeed (KCAS) and 5.2 degrees angle of attack (AOA) and experienced significant pitch oscillations and bouncing (Tab J-8). After approximately five seconds of attempted landing rollout the MA lost control of the aircraft in close proximity to the ground (Tabs J-8, J-29, L-2, and L-6). The MP was able to successfully eject before the MA, valued at $175,983,949, rolled, caught fire, and was completely destroyed (Tabs J-83, P-3, R-31 and V-1.8 to V-1.9). The MA debris settled both on the runway and the infield to the north of the runway, while the MP landed on the south edge of the runway and was able to egress to the south before being recovered by the Emergency Responders (Tabs S-2 and V-1.9 to V-1.12).

3. BACKGROUND

a. Air Education and Training Command

Air Education and Training Command, with headquarters at Joint Base San Antonio-Randolph, Texas, was established and activated in January 1942, making it the second oldest major command in the Air Force (Tab BB-437 to BB-445). Its mission is to recruit, train and educate Airmen to deliver 21st Century Airpower (Tab BB-437 to BB-445).

b. 33rd Fighter Wing

The mission of the 33rd Fighter Wing is to train and graduate outstanding professionals (Tab BB-446 to BB-448). The vision of the 33 FW is to build the world's best communities: F-35, Air Battle Management and Intel (Tab BB-446 to BB-448). The 33 FW mission is accomplished by 944 assigned U.S. military, government civilian, and contract personnel (Tab BB-446 to BB-448).

c. 58th Fighter Squadron

The mission of the 58th Fighter Squadron is to train US Air Force operators and maintainers on employment and maintenance of the F-35 Lightning II "A" model, as part of the overall 33 FW mission of training American and international aircrews and maintainers of the US Air Force, Navy, Marine Corps, and international Air Forces (Tab BB-449 to BB-450).

d. F-35A Lightning II

The F-35A is the US Air Force's latest fifth-generation fighter. It will replace the aging fleet of F-16 Fighting Falcons and A-10 Thunderbolt II's, which have been the primary fighter aircraft for more than 20 years, and bring with it an enhanced capability to survive in the advanced threat environment in which it was designed to operate. With its aerodynamic performance and advanced integrated avionics, the F-35A will provide next-generation stealth, enhanced situational awareness, and reduced vulnerability for the United States and allied nations (Tab BB-451 to BB-452).

The F-35A airframe is inherently unstable (Tab BB-26). This instability provides excellent maneuverability and performance, but requires artificial stabilization and augmentation by the flight control system, also known as a fly-by-wire system (Tab BB-26). The flight control surfaces include horizontal stabilizers, trailing edge flaps, dual rudders and leading edge flaps (Tab BB-26). The pedals, stick, and throttle command the basic aircraft control functions through the flight control system. The control system maps the desired aircraft response into movement of the most optimum control surfaces to meet the pilot's request (Tabs V-12.1 and BB-26). Aircraft control is provided by execution of a defined set of control laws (CLAWs), which is essentially computer programming that determines how the combination of all aircraft inputs will be translated into changes to the flight control surfaces, based on the particular flight mode of the aircraft (Tab BB-27). The modes include power approach (PA) for takeoff and landing, and up-and-away (UA) when the gears are up (Tab BB-27). The PA CLAW provides precise control of glideslope, lineup, speed and angle of attack (AOA) during approach and landing (Tab BB-27). Below X degrees AOA, it is a pure pitch command system, which is good for aircraft turn performance and changing the flightpath at the sacrifice of stable attitudes (Tab BB-27). If a pilot touches down at less than X degrees AOA and attempts to use the stick to set landing attitude, the pitch rates will be significantly volatile and difficult to control (Tab BB-27). Above Y degrees the aircraft is in an AOA system, which is optimal for finer flight path changes prioritizing stable attitudes during a round out and flare (Tab BB-27).

On ground/weight on wheels (WOW) mode activates when the aircraft's sensors indicate weight on wheels (Tab BB-27). Ground handling CLAWs provide taxi capabilities using high and low gain nosewheel steering commanded through the pedals (Tab J-25). Pitch damping is provided through feedback that activates when wheel speed exceeds the knots groundspeed threshold (Tab BB-27). The CLAWs are specially tailored to provide excellent aerobraking capabilities using wheel speed and weight-on-wheel indications to provide good control of pitch attitude (Tab BB-27).

There are multiple transitional CLAWs, including PA Bounce Mode that is enabled momentarily during wheel spin up (Tab BB-27). These transitional modes and logic are typically transparent to the pilot. During a touch and go, the plane enters WOW mode, and the AOA reference is reset at touchdown from approach AOA (Y-Z degrees) to just below Y degrees (Tabs BB-27). The flight control system rapidly and continually captures new data about the state of the aircraft, the current mode, and pilot inputs in order to determine any errors between pilot inputs and the desired movement of flight control surfaces for stability (Tabs V-12.1 and BB-26). In situations where there is a large divergence between pilot inputs and the anticipated inputs, the flight control system resets in such a way that pilot inputs may have a minimal effect on flight control surfaces for a significant period of time (Tabs BB-27, J-32, and V-12).

4. SEQUENCE OF EVENTS

a. Mission

On Tuesday, 19 May 2020, the 58 FS director of operations (DO) scheduled and authorized the MF's mission as a two-ship formation conducting night TI with another two-ship formation (Tab V-3.1). The event was flown following the guidance for a night TI within the F-35A Combined Wingman Syllabus current as of July 2018 (Tabs K-5 and V-3.1).

b. Planning

The MP was originally scheduled to fly as Red Air in direct support of the student formation, meaning he would have been acting as a simulated adversary for the student formation instead of acting as an instructor pilot (IP) for a specific student (Tabs K-11 and V-1.13 to V-1.14). At approximately 1400L the MP was informed he was rescheduled to be the instructor for the MW via text message due to the original instructor pilot of record (IPOR) falling out as a precaution for coronavirus exposure (Tabs R-74 to R-75 and V-2.43). Flying as an IP for a TI is also known as "Blue Air" (Tab V-1.14, V-1.45 and V-2.34). The MP arrived at the 58 FS approximately 1600L (Tab X-21). MF members accomplished all required mission planning for the sortie, including, but not limited to, checking notices to Airmen (NOTAMs) for all applicable airfields, navigational aids, airspace, and weather for all applicable airfields and airspace including illumination data (Tabs K-12, R-74 and V-1.14 to V-1.15). Both the MP and MW completed an operational risk management (ORM) form, which is used to rate the level of risk for the particular flight, and was signed off by the appropriate level of supervision based on the risk level (Tab K-15). The MP's ORM was rated as medium risk (Tab K-15). The specific factors that contributed to this rating are discussed further in the Human Factors section. The MP reached out to the ground control intercept (GCI) training unit via phone to coordinate tactical support for the flight but did not reach anyone successfully and left a message (Tabs R-91 and V-1.14 to V-1.15). At 1800L, the mishap pilot (MP) conducted the flight and instructional briefing to the MW and covered all required items for the sortie during the allotted brief time (Tabs K-5, R-74, and V-1.46).

c. Preflight

The MF members donned their Aircrew Flight Equipment (AFE), which was inspected, current, and serviceable according to AFE records (Tabs H-30 to H-38, R-60, R-74). The MF received their tail numbers from the operations supervisor, and were briefed on all applicable aircraft forms data and hardware modifications (HMODs) (Tabs K-9, 60, R-74, and V-1.48). After engine start, but prior to taxi, GCI called the squadron operations supervisor requesting to support the MF for their student training (Tab R-60). The operations supervisor used the operations frequency to coordinate the GCI communication gameplan changes with the MF prior to their departure (Tab R-60).

d. Summary of Accident

At 2015L, the MF departed Eglin AFB on runway 12 with the MW in approximately two-mile trail behind the MA (Tabs K-5, R-75 and V-1.5). The MF departed to the south, entered the W151 A/C/E airspace, and conducted their training IAW the syllabus events (Tabs K-5, R-76, and V-1.5). At the completion of their tactical training and delay for a minor physiological event with the MW, the MF began their return to base (RTB) via radar vectors to the Instrument Landing System (ILS) approach to runway 30 at Eglin AFB as planned (Tab V-1.4 to V-1.9).

At 2125L, the MP reached the Final Approach Fix (FAF) and glide slope intercept with the gear down and locked, Auto Throttle (AT) enabled with Speed Hold set to hold 202 Knots Calibrated Airspeed (KCAS) IAW standard procedures and normal habit patterns (Tabs L-2, L-6, V-1.11 to V-1.12, and BB-360). In other words, he reached the point in his landing approach where he makes his final alignment of his aircraft for his descent to the runway. Therefore, the speed displayed would have shown CMD (Command) 202. Shortly after the FAF, which is the last part of the landing approach, the MP noticed a discrepancy in the alignment of his Helmet Mounted Display (HMD) (Tab V-1.6). After setting his CDM marker/aimpoint to the threshold of the runway, the MP expected to see it go below glideslope, or see the ILS glideslope indicator rise (Tabs L-6 and V-1.6). Instead, he observed the opposite, cueing him to the fact his HMD may be misaligned in relation to the horizon (Tab V-1.6 and V-1.32). The MP confirmed this by cross checking his virtual Heads Up Display (vHUD), and the ILS data continuing to show the MA getting higher in relation to the glideslope, again, opposite of what a pilot would expect to see after these inputs (Tabs L-6, V-1.6, and Z-27). The MP visually corrected his aimpoint and glide slope towards the threshold of the runway for the remainder of the approach and touchdown, approximately 103 seconds (Tabs L-6, V-1.6, and Z-27). The ILS glideslope data showed the aircraft high on glide path, forcing an increasingly nose low flight path correction (Tab V-1.6). Trying to correct for this error placed the HMD misaligned symbology further and uncomfortably short of the runway (Tab V-1.6). The MP described having to point into the black abyss, referring to how the area in front of the runway appeared at night (Tab V-1.6). The discomfort for the MP was aggravated by the lack of visual cues at night and particularly because of the low illumination (Tabs F-2, V-1.7 to V-1.8, V-1.33, and Z-27). The MP never cross-checked his airspeed or Angle of Attack (AOA) during the approach and touch down, meaning he did not look at the AOA and airspeed indicators to verify they were appropriate for landing (Tab V-1.52 and V-1.53). Additionally throughout the descent, the HMD projector brightness, or "green glow," that projects over the Field of Regard of the HMD, was increasingly distracting throughout the descent despite the MP manually adjusting brightness levels on final approach (Tabs V-1.7 and Z-27).

The HMD misalignment was undetectable during the sortie until this point (Tab V-1.6). However, once the MP pushed the nose of the aircraft down to set his aimpoint on the runway, the one degree nose low attitude could be clearly seen against the backdrop of the runway (Tab V-1.6). All this occurred during the final moments of flight, and coincided with the point in the approach when the MP normally engages APC and sets speed (Tab V-1.26). This was the first time the MP had experienced an HMD misalignment at night (Tab V-1.6 and V-1.34). The MP had also not experienced an HMD misalignment in a simulator before (Tab V-2.17).

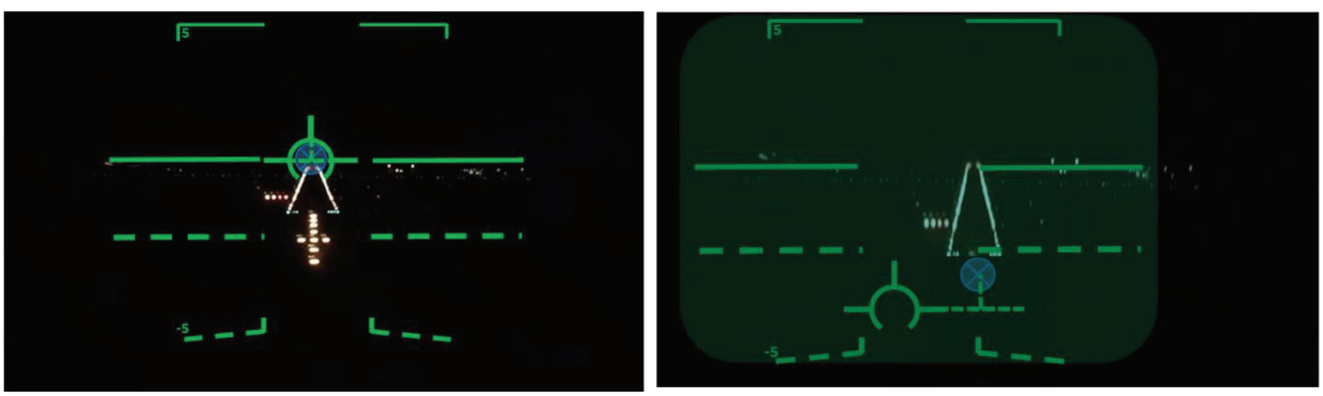

Figure 1
Side by Side representation of Aligned HMD vs. Misaligned HMD with L-R crosswind, "Hand of God" phenomenon, "Green Glow," and aimpoint in "black abyss" (Tab Z-7 and Z-27)

The MP uses the "Revised Control and Performance" scan method IAW Air Force Tactics, Techniques, and Procedures (AFTTP) 3-3, Combat Aircraft Fundamentals for F-35 (Tabs V-1.26 and BB-360). The Revised Method emphasizes maximum use of Auto-Throttle for airspeed control throughout the range of operation for this aircraft as a means of decreasing the cross-check burden between performance indications and deemphasizes traditional cross-check techniques such as known pitch and power combinations (Tab BB-360). According to AFTTP 3-3.F-35, once APC is engaged, the pilot can concentrate on situational and environmental factors instead of the performance instruments (Tab BB-360). The AFTTP 3-3.F-35 instructs the pilot to engage APC and then shift the cross-check to aimpoint and glide slope, with altitude as a secondary item to track (Tab BB-360). The AFTTP 3-3.F-35 deemphasizes AOA and airspeed as APC will be managing those aspects of the approach (Tab BB-360).

The MP touched down with Speed Hold engaged, a prohibited maneuver IAW the Joint-Service Technical Data (JTD) (Tab BB-27). This is approximately 50 KCAS faster and 8 degrees AOA shallower than the on speed parameters for the MA gross weight at the time of landing (Tabs J-32 and L-6). This speed forced the MP to input slight forward stick to enable touchdown resulting in the MA touching down in a three-point attitude, meaning both the main landing gear and nose landing gear impacted the ground at the same time (Tabs J-36, L-2, and V-1.7). As designed, upon initial weight on wheels (WOW) indication, the AT disengaged Speed Hold and the throttle back drive selected ground idle Engine Thrust Request (Tabs L-2 and BB-27). This three-point attitude and immediate nose gear bounce caused the nose of the aircraft to rise rapidly and excessively, which the MP attempted to stop with a forward stick input (Tabs J-36, L-2, and V-1.7).

Figure 2
MP's Landing Attitude (Tab Z-3)

This began a series of multiple and increasingly violent pitch oscillations on combinations of main landing gear only, nose landing gear only, and all three landing gear (Tabs J-36, L-2, and V-1.7). The MP attempted to stop these oscillations and pitch rates with forward and aft stick inputs during the first two seconds after touchdown attempting to set a landing/go around attitude of approximately 10 degrees nose high (Tabs J-36, L-2, and V-1.7). Attempting to set a landing attitude in this manner is consistent with common aviation habit patterns for post-bounce recovery (Tab V-16.1 and V-17.2). The MP's control inputs were quickly out of synch with commands from the Flight Control System (FCS) and, combined with nose gear bounce, resulted in the FCS becoming over-saturated (Tabs J-32, L-2 and V-12.1). Over-saturation in this context means the

FCS was effectively overwhelmed because a multitude of conflicting inputs were competing for limited processing power (Tabs J-32 and V-15.1). Over-saturation can result in latent or ignored flight control inputs (Tabs J-32 and V-15.1). This over-saturation cued FCS logic to direct the horizontal stabilizers to default to, and remain in, a trailing edge down position and caused the nose of the aircraft to go down (Tabs J-32, L-2, and V-12.1). With the horizontal stabilizers set in this trailing edge down position, the MP then input full aft stick for approximately three seconds and selected maximum afterburner (AB) in an unsuccessful attempt to set a go around attitude before successfully ejecting from the MA (Tabs J-32, J-36 to J-37, L-2, and V-1.7). The MA then departed the runway and crashed on the infield (Tabs J-8 and S-2).

e. Impact

The MA touched down at 202 KCAS and 5.2 AOA at 2126:43L approximately 2000 feet down runway 30 at Eglin AFB (Tabs J-8, J-10, L-2, and L-6). The ejection occurred at 2126:49L approximately 4600 feet down the runway slightly left of centerline (Tab J-12). The main body of the airframe departed the runway to the right (north) approximately 6000 feet down and came to stop approximately 6500 feet down in the infield on the northeast side of the runway just southeast of taxiway H approximately halfway between taxiways E and H1 (Tab S-8).

f. Egress and Aircrew Flight Equipment (AFE)

The MP elected to eject and was able to use his right hand to release the stick and pull the ejection handle while his left hand remained near the throttle (Tab V-1.8). The MP ejected at 2126:49L at 202 knots close to ground level, heading 300, with a wind speed of 6-8 knots from 220-230, 4600 feet down the runway (Tab F-4 to F-8). The seat landed on the south side of runway 30 approximately 5800 feet down and the MP landed on the south side of the runway and egressed to the south infield (Tabs S-8 and V-1.9 to V-1.11). An Air Force Life Cycle Management Center comprehensive evaluation of all components of the ejection sequence showed the ejection event was successful with only minor issues identified, specifically the left arm restraint did not provide restraint against flailing injury, likely due to the position the MP left his left hand at the time he initiated ejection (Tabs J-106 and V-1.8). According to the report, the minor issues did not affect the MP's ejection sequence and no other abnormal indications were reported in regards to the condition of the applicable equipment, to include post-mishap analysis, and inspections were current (Tab J-99 to J-112 and J-121 to J-127).

g. Search and Rescue (SAR)

The ejection occurred at 2126:49L approximately 4600 feet down runway 30 at Eglin AFB (Tabs J-8 to J-12, L-2, and L-6). The MW slowed to approach speed at 700 feet Above Ground Level (AGL) or approximately 2.5 miles out from the runway and terminated its landing approach and began maneuvering itself so that it could get into a downwind position, and was then directed to the alternative runway 19 (Tab R-76 to 78). The crash was reported with the first rescue call from the control tower at 2127L (Tab X-27). The initial response team from the 96 SFS and 96 CES included fire response vehicles Battalion 1, Crash 51, 54, and 74, who were not certain of the MP's location and arrived at the MA wreckage and began firefighting at 2131L (Tabs R-17 to R-22, R63, R-69, and X-36). Police-3A was the first Security Forces vehicle to arrive followed by

Police1 and Police-2, which established the incident scene cordon (Tab X-27). The ejection sequence was not recorded in any witness statements, as the low illumination that night made it difficult to see anything besides the MA fireball that occurred (Tabs R-33 to R-34, and V-3.1). The MP, having egressed to the south side of the runway, recovered his radio and was able to contact the supervisor of flying (SOF) at approximately 2135L (Tabs R-34 and V-1.11). The SOF directed the MP to stay in the grass near the end of the runway holding area at taxiways B and F (Tabs R-34, S-9, and V-1.11). The MP used a flashlight to flag down Fire Response Vehicle Unit 61 and was picked up at approximately 2137L, transferred to Medic Vehicle 5, and then subsequently transported to the Eglin Emergency Room without incident (Tabs R-21 and V-1.11).

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

(1) The AIB reviewed all applicable Air Force Technical Order (AFTO) 781 and aircraft forms/documentation (Tab D) for the MA with the following notable item: MA was in a Partially Mission Capable (PMC) status for a previous pilot reported discrepancy (PRD) noted on 12 May 2020 (Tab D-90 to D-92). He indicated a Counter Measure (CM) degradation and failure after takeoff (Tab D-90 to D-92). Infrared Counter Measure (IRCM) and Mission Systems Counter Measure (MSCM) doors opened un-commanded during flight resulting in an Integrated Caution, Advisory and Warning (ICAW) (Tab D-90 to D-92). Pilot was able to cycle, close and clear the ICAW, and noted that the CM functioned as expected (Tab D-90 to D-92). Interview with the MP (Tab V-1.52) confirmed that he had the same ICAW during the mishap sortie, but it did not have any affect on his landing approach.

(2) The AIB reviewed all Time Compliant Technical Directives (TCTD) and noted the applicable issues in the next section (Tab U-3 and U-5).

(3) A six-month historical data review from the Autonomic Logistics Information System (ALIS) showed the MA had PRDs noted, but none were recurring issues (Tab U-3).

b. Inspections

(1) Post Operation Servicing (POS), Before Operation Servicing (BOS), and Interim Operation Servicing (IOS) inspections were all completed and signed off appropriately with no discrepancies noted (Tab V-1.52 and V-6 to V-8). Interviews with maintenance technicians and the MP all confirmed no defects noted (Tab V-1.52 and V-6.1 to V-8.1). The MA flew twice on the day of the mishap with the first sortie returning Code 2, which means it had a minor discrepancy that would not prevent operations, for a previous write up (the issue with the CM referenced above), but no other discrepancies noted (Tab D-90 to D-92). In addition to the IOS, the aircraft was refueled to the standard fuel load configuration (17,500 lbs) (Tab D-90).

(2) The AIB noted a high number of delayed discrepancies (DDs) in the aircraft forms, although none of the discrepancies were factors in the mishap. The following two delayed discrepancies are highlighted because they are the most relevant:

i. Modification of Helmet Mounted Display System (HMDS), deferred to next scheduled depot input (December 2020). This Hardware Modification (HMOD) would enable the pilot to perform fine alignment of the HMDS with Gen III helmets (Tab U-5). In accordance with Joint Program Office (JPO) Standard Operating Instruction (Tab U-5), this HMOD was given a rescission date of 2029 (Tab U-5). Although parts were available, TCTD posted in ALIS, completion required depot-level assistance (Tab U-5). Additionally, as the only LRIP-6 aircraft assigned to Eglin AFB, this specific TCTD applied only to the MA. MP mentioned during his interview (Tab V-2) that he had experienced HMD misalignments previously and that he reported these discrepancies to AFE personnel for repair. AFE personnel noted that they checked the MP's helmet on their alignment tester and there were no discrepancies noted (Tab H-4 to H-28). However, without the appropriate hardware (installed with the HMOD), the pilot could not accomplish any fine alignment in the MA (Tab U-5). Additionally, as noted in interviews with Test Pilots, HMDs are known to migrate out of alignment over time and are a known issue in the F-35 community (Tab V-4.1 and V-17.1).

ii. Modification of CM door operation, deferred to 13 October 2021. This modification would effectively upgrade Counter Measures Controller, Maintenance Interface Panel and aircraft harnesses to address the issue of the hydraulically latched CM Door opening during flight (Tab D-83 and D-84). This modification requires specialized equipment and engineering guidance thus requiring depot-level repair and was deferred to the next depot input (Dec 2020) (Tab D-83 and D-84).

(3) All Aircrew Flight Equipment (AFE) related inspections were reviewed with no discrepancies noted (Tab H-31).

c. Maintenance Procedures

In reviewing all applicable maintenance documentation and as noted in interviews with maintenance personnel and MP (Tabs V-1.52 and V-6 to V-8), it was determined that all procedures, practices, and performance were in accordance with governing maintenance directives (AFI 21-101) and applicable joint technical data (JTD).

d. Maintenance Personnel and Supervision

Training records validated that all 33 AMXS maintenance (Tab G-239) and 33 OSS AFE and MB contractor personnel (Tab H-31) who performed any servicing or inspections on the MA were fully trained and qualified. Review of the Maintenance shift schedule (3 shifts, Days/Swings/Mids) indicated that ample supervision was available on each shift (Tab R-54). Witness statements by senior maintenance leadership on duty during the mishap further corroborated that ample supervision was available (Tab R-54).

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

Review of all post-mishap fuel and hydraulic oil analysis came back normal with no discrepancies noted (Tab U-3) . All oxygen was expended or consumed during the mishap thus no samples were available for analysis (Tabs J-85).

f. Unscheduled Maintenance

There was no unscheduled maintenance accomplished following the first sortie and accomplishment of IOS prior to the mishap sortie (Tab V-7.1 to V-8.1). The aircraft was re-fueled with 17,500 pounds of fuel with no other servicing required (Tab D-90). Aircraft pre-flight pilot inspection and subsequent operations checks were normal with no other PRDs noted (Tab V-1.52). Interviews with maintenance ground personnel and MP validated no issues noted during the launch (Tab V-1.52 and V-7.1 to V-8.1). Review of all unscheduled maintenance going back 180 days revealed no link between maintenance and the mishap (Tab U-3). MP mentioned having identified to AFE that his helmet was having HMD issues and his helmet was run across the tester for realignment (Tab V-2.38). However, there were no records of this maintenance being accomplished (Tab U-3).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

(1) Aircraft Condition: Prior to the mishap, the MA was partially mission capable due to the previously mentioned CM door degrade (Tab D-90 to D-92). No discrepancies were noted that would have impacted safety of flight and the MP reported no issues on his pre-flight walk around or review of the aircraft forms other than the CM door discrepancy (Tab V-1.52). The MP did not identify his HMD as being misaligned until his approach on landing (Tab V-1.32). MP's successful egress from the aircraft indicated that all emergency egress systems were functioning as designed (Tab J-99 to J-112). This was further validated by LM's mishap technical report (Tab J-83). Following MP's ejection the MA's unrecoverable oscillations caused it to impact the runway and it sustained overwhelming damage during subsequent post-impact fire (Tab X-36). The recovery team was only able to retrieve fragmented portions of the MA's airframe and systems (Tab S-3 to S-8).

(2) Control Law (CLAW) During Mishap: LM's report indicated that pilot inputs combined with FCS CLAW and landing gear characteristics, upon a three-point landing at 202 knots, led to the aircraft oscillation (bouncing between the nose and main gear) (Tab J-32). Large pitch rates, the toggling between different control modes due to the weight on wheels, large pilot inputs, and the high speed of the aircraft stressed the control system's ability to respond to pilot input and stabilize the aircraft (Tab J-32). In particular, the rate at which the horizontal tail could change was maximized and the flight controls were saturated (Tab J-32). The saturated flight controls then defaulted to a nose down position, preventing immediate response to the pilot's final attempt to abort the landing by pulling full aft stick and then commanding max AB at time 6315.7

seconds (21:26:45.189L) (Tab J-32). As a result, the pilot was unable to command nose-up horizontal tail deflection, despite holding full aft stick pitch inputs for three seconds (Tab J-32).

When questioned, neither the MP, AIB Pilot member (F-35 IP), or F-35A test pilots were familiar with some of the details of the control logic (Tab V-2.25, V-4.1, and V-17.3), and reference to some of the specific functions that came into play during the oscillation in this mishap could not be found in the F-35 Flight manual, TOs or JTD. Some of the control functions are reset when the aircraft exits PA mode and goes into PA bounce mode (Tab V-12.1). The CLAW is trying to remove steady state error between the pilot flight control commands and the actual status of the flight control surfaces to stabilize the aircraft (Tab V-12.1).

(3) The following structures and systems that survived the mishap were submitted to LM, Air Force Research Laboratory (AFRL) or Air Force Safety Center (AFSEC) for further analysis.

a. Main landing gear (MLG): The landing gear system on the F-35 is manufactured by Collins Aerospace (Tab J-150). It is equipped with a conventional, forward retracting tricycle landing gear arrangement (Tab J-45). The main gear is equipped with a single main wheel and retracts forward into a well at the forward edge of the wing outboard and above the main weapons bay (Tab J-45). Post-mishap analysis found that there were no pre-existing defects or material conditions that would predispose the landing gear to premature failure, but all fracture locations, modes, and propagation directions were consistent with a high speed landing and subsequent high impact event (Tab J-146 to J-202). Further AIB review of MA's weight and balance documents, and 180-day historical data from ALIS on all scheduled and unscheduled maintenance, found no discrepancies or maintenance accomplished that could have contributed toward the mishap (Tab U-3). MLG functioned as designed (Tab J-62).

b. Nose landing gear (NLG): Collins Aerospace is the primary manufacture of all landing gear components (J-150). The F-35 nose gear has a single wheel that retracts into a NLG wheel well immediately under the cockpit (Tab J-46). As stated above with the MLG, no discrepancies noted both by the post-mishap engineering evaluation, and in reviewing of all maintenance documents revealed any discrepancies that could have contributed to the mishap, and it is assessed that the NLG functioned as designed (Tab U-3).

c. Landing gear handle: No discrepancies were noted with the landing gear handle, which functioned as designed as validated by both the cockpit recorder and engineering evaluation (Tab J-50).

d. Crash-survivable Memory Unit (CSMU): The CSMU was retrieved successfully from the crash site with no structural damage noted (Tab J-28). Downloading and analysis of data revealed no discrepancies to any mission or aircraft systems that contributed to the aircraft mishap (Tab J-203).

e. MP's Helmet: The MP's helmet was evaluated by both Rockwell Collins (manufacture) and AFRL engineers (Tab J-128 to J-145). Although the extent of damage sustained was thoroughly documented, no evaluation was provided regarding the HMD to validate misalignment as identified in MP testimony (Tab J-132 to J-133). Although all scheduled AFE inspections (initial issue and 105 day functional checks) were signed off appropriately, AFE personnel had discontinued the process of tracking when any unscheduled maintenance (HMD misalignment) was requested (Tab H-31). AFE personnel had records of unscheduled maintenance (HMD alignment issues) from 2017-2018, but were unable to produce any records for 2019 and only resumed recording post-mishap (Tab H-31). The AIB found no USAF guidance/JTD requiring tracking of pilot reported HMD misalignments. MP acknowledged in his interview (Tab V-2.19 to V-2.22 and V-2.38 to V-2.40) that despite reporting HMD alignment issues previously and working with AFE to run his helmet on the tester, he continued to have issues with his HMD. AFE personnel are trained to use a Pilot Helmet tester to ensure HMD functionality and alignment (Tab H-31). However, the tester will not replicate fine alignment needed in each respective aircraft flown. Without the proper HMDS hardware installed in aircraft, pilots are unable to accomplish this type of fine alignment in the aircraft (Tab H-31 and Tab U-5). The AIB also discovered the helmet testers do not receive periodic calibration, but come from the factory (Rockwell-Collins) fully calibrated and able to recalibrate on built-in self-test (BIT) test prior to use (Tab H-31). The 33 OSS AFE flight has few testers with only fewer fully functioning. The testers were received at Eglin on 9 Oct 2015, and 8 Apr 2017 respectively. Since receipt from the factory, no other fine alignment, calibration, or inspection of the unit other than pre-use/BIT inspections have been accomplished (Tab H-31).

f. MP's Flight Suit: MP's flight suit was evaluated by LM and AFRL engineers. Damage was assessed to be consistent with a high-speed egress, to include imbedded fragments of the transparent portion of the canopy and exposure to propellants used in the ejection sequence (Tab J-128 to J-145). It was determined that all Pilot Flight Equipment (PFE) functioned as designed and provided physiological protection to the pilot during the full flight duration and through emergency escape (Tab J-128 to J-145).

b. Evaluation and Analysis: The items listed in paragraph a(3) were sent for engineering analysis with complete results available in Tab J. Structural analysis of aircraft components did not reveal anything relevant to the cause of the mishap (Tab J).

7. WEATHER

a. Forecast Weather

The 96th Test Wing weather forecasters provided the Mission Execution Forecast (MEF) for local flights to the surrounding training areas and ranges (Tab F-9 to F-12). On the night of the mishap, the forecasted weather for takeoff and landing was a few clouds at 2000 feet with scattered layers at 5000 and 9000 feet with winds out of the southwest at 9 knots and 7 miles or greater visibility (Tab F-9 to F-12). The forecasted illumination was 13%, or low illumination, for the duration of the sortie (Tab F-9 to F-12). Additionally, cloudy skies and rain showers were predicted to develop throughout the night due to the frontal boundary along the Mississippi River Valley area to the west (Tab F-9 to F-12).

b. Observed Weather

The observed weather at Eglin AFB at the time of the mishap was winds out of the southwest at 5 knots, scattered clouds at 6500 feet and overcast at 9000 feet with at least 10 miles of visibility with low illumination (Tab F-3 to F-8).

c. Space Environment

Not applicable.

d. Operations

No evidence suggests the MP was operating outside prescribed operational limits with respect to weather conditions (Tabs F-3 to F-12 and BB-364 to BB-466).

8. CREW QUALIFICATIONS

The MP was a current and qualified Instructor Pilot (IP) in the F-35A at the time of the mishap (Tab G-215 to G-229). In the F-35A, the MP had 137.8 total hours, 53.4 instructor hours, and 8.0 night hours (Tab G-215 to G-229). The MP obtained his initial F-35A instrument qualification on 29 January 2019 (Tab G-229). The MP's initial mission qualification as an instructor in the F35A is dated 7 August 2019 (Tab G-227). The MP was current and qualified as an F-35A instructor at night at the time of the mishap (Tab G-225 to G-228). Prior to qualification in the F-35A, the MP was qualified in the F-15E with 1272 hours, 374.9 night hours, and 410.3 combat hours (Tab G-219). Over his career he has a total of 1459 flight hours from 689 sorties (Tab G-219).

Recent flight time is as follows (Tab G-215):

	Hours	Sorties
30 days	5.9	4
60 days	11.4	8
90 days	27.4	19

9. MEDICAL

a. Qualifications

MP completed his most recent Periodic Health Assessment (PHA) and annual Flight Physical on 18 November 2019, and was issued a Medical Recommendation for Flying or Special Operational Duty (DoD Form 2992) on 23 January 2020, indicating that the MP was medically qualified for continued pilot duties (Tab G-3 to G-6). A review of the Aeromedical Information Management Waiver Tracking System indicated that MP required a medical waiver for one diagnosis, which was recently renewed through October 2022 (Tab X-3). MP was medically fit to fly (Tab X-3).

b. Health

The outpatient medical and dental records (paper and electronic) were reviewed for MP (Tab X-3). The MP overall was in good health (Tab X-3). He did have several medical appointments for a chronic ailment that did not affect his flight status in the weeks preceding the mishap, and these medical visits were, in general, properly treated by a flight surgeon (Tab X-3). The operations group had a medical professional physically imbedded within it, which, by design, increased utilization, and this is the therapy that the MP sought (Tab V-1.49). This condition was not the waived condition and the AIB determined that this medical condition was not relevant to the mishap (Tab X-3).

MP was evaluated by emergency room personnel at the Eglin AFB hospital in the hours following the mishap (Tab X-3). The MP sustained injuries during the process of the ejection. There were numerous small foreign bodies in the skin, especially in his forearms (Tab X-3). There was at least one foreign body in the eye (Tab X-3). Lastly, MP appears to have suffered a vertebral body compression fracture (Tab X-3). He reported that he was able to walk immediately afterward (Tab V-1.9), and was feeling wonderful to be alive (Tab X-3).

c. Pathology

The Defense Health Agency performed a Forensic Toxicology Examination on the blood and urine of the MP for the presence of abnormal levels of drugs of abuse, ethanol, and carbon monoxide (Tab G-238). None were detected (Tab G-238). Likewise, blood and urine of several maintenance personnel were also forensically tested (Tab G-230 to G-237). These specimens were also negative (Tab G-230 to G-237).

d. Lifestyle

There is no evidence to suggest lifestyle factors were a factor in the mishap (Tab X-8).

e. Crew Rest and Crew Duty Time

The AETC Supplement to AFI 11-202, Volume 3, *General Flight Rules*, states crew rest is compulsory for aircrew members and is a minimum of 12 non-duty hours before the Flight Duty Period (FDP) (Tab BB-362 to BB-363). Crew rest is free time and includes time for meals, transportation, and rest, as well as an opportunity for at least 8 hours of uninterrupted sleep (Tab BB-362 to BB-363). Aircrew may not exceed the FDP (Tab BB-362 to BB-363). The FDP for single seat aircraft is 12 hours (Tab BB-363), and is used to estimate the show time to the squadron (Tab BB-362 to BB-363). The FDP for single seat aircraft is 12 hours (Tab BB-363), and is used to estimate the show time to the squadron.

Based on the MP's 72-hour and 7-day history, he met crew rest requirements for all of his flights. On the day of the mishap, the MP reported that he arrived at work at 1600L (Tab X-5 to X-16). Take off time was 2015L, and the time of the mishap was 2126L (Tabs J-12 and K-11). The day prior, 18 May, the MP was scheduled to fly, but that flight was cancelled due to inclement weather

(Tab X-10). He arrived at home at 1700L the day prior to the mishap (Tab X-22). May 16 and 17 made up a weekend, and there was no duty on those days (Tab X-23).

10. OPERATIONS AND SUPERVISION

a. Operations

The 58 FS operations tempo was normal but slightly degraded due to coronavirus disease 2019 (COVID-19) operational precautions such as minimum or essential manning, mask wear and social distancing, and a lack of in person pilot meetings and phase briefs (Tab V-3.1). It had been six weeks since the squadron's last night week and the MP last flew at night 42 days prior on 7 April 2020 (Tabs G-215 to G-229 and V-3.1). The MP's most recent flight prior to the mishap was 11 days earlier on 8 May 2020 (Tab G-221).

b. Supervision

The mission was authorized by the 58 FS operations supervisor and a review of flight training records showed the MP and MW were current and qualified to participate in the scheduled sortie (Tab CC-3).

11. HUMAN FACTORS ANALYSIS

a. Introduction

As defined by AFI 91-204, Safety Investigations and Reports, a human factor is any environmental factor or psychological factor a human being experiences that contributes to or influences performance during a task. AFI 91-204, incorporating the most current Department of Defense Human Factors Analysis and Classification System, Version 7.0 (DoD HFACS), establishes several potential human factors for assessment during a mishap investigation (Tab BB-3 to BB-25).

b. Acts "Active Failures or Actions"

(1) AE103 Procedure Not Followed Correctly: is a factor when a procedure is performed incorrectly or accomplished in the wrong sequence. The MP did not follow guidance when MP failed to achieve final approach airspeed and announce airspeed change (Tab BB-360), and did not follow guidance when he failed to "slow to on-speed with a power reduction or by engaging Approach Power Compensator (APC)" for final approach (Tabs V-1.12 and BB-360).

(2) AE104 Over-controlled/Under-controlled Aircraft: is a factor when an individual responds inappropriately to conditions by either over- or under-controlling the aircraft. The error may be a result of preconditions or a temporary failure of coordination. The MP undercontrolled the aircraft when the MP did not switch out of Speed Hold (Tab V-2.5). Also, MP ineffectively attempted to stop the rapid MA pitch and subsequent oscillation in touchdown. (Tab V-1.7 to V-1.8 and V-12.1 to V-13.1).

(3) AE101 Unintended Operation of Equipment: is a factor when an individual's movements inadvertently activate or deactivate equipment, controls, or switches when there is no intent to operate the device. The stick inputs made by the MP after touching down, in an effort to control the pitch oscillations, caused the FCS to become saturated, such that an average "nose down" attitude was driven by the horizontal stabilizers (Tab J-36 and J-40). Given that the pilot was trying to achieve a landing/go-around AOA (Tab V-1.6), this was an unintended response from the FCS.

c. Preconditions "Latent Failures or Conditions"

(1) PE202 Instrumentation and Warning System Issues: is a factor when instrument factors such as design, reliability, lighting, location, symbology, size, display systems, auditory, tactile situational awareness or warning systems create an unsafe situation. The MP experienced an instrumentation system issue when the MP experienced an HMD misalignment (Tab V-1.32). Also, the MP was experiencing the green glow from the HMD projector video in his HMD during landing and especially just before touchdown, which was affecting his visibility (Tab V-1.6, V-1.24). The green glow was worse than normal due to the humidity (Tab V-1.7 and V-1.24). The MP had to adjust the settings to try to mitigate glow within a few hundred feet of the ground, and within several seconds of landing (Tab V-2.9).

(2) PC307 Fatigue: is a factor causing diminished physical/mental capability resulting from chronic or acute periods of prolonged wakefulness, sleep deprivation, jet lag, shift work or poor sleep habits. The MP was experiencing fatigue, as indicated on the MP's reported ORM (Tab K-16). The MP admitted to getting poor sleep with some frequency (Tab X-5 to X-14). Additionally, the MP noted that he usually feels more fatigued in the process of flying this aircraft than his previous aircraft, the F-15E (Tab V-1.46). It is known amongst the F-35 flying community that the oxygen delivery system is very different than legacy oxygen delivery systems, such as the one used in the F-15E (Tab V-4.1). It is a closed, feedback driven system, such that initiation of inhalation and exhalation actuate the delivery of airflow to the pilot with a slight change in pressure (Tab V-4.1). The pilot will experience, often imperceptibly, a delivered pressure of .01-.03 pounds per square inch, even when trying to exhale (Tab V-4.1). This means the pilot is breathing out against a pressure gradient (Tab V-4.1). Additionally, the feedback is initiated by the sensed change in pressure of the pilot by the system: each breath in and out is sensed and augmented by the feedback system (Tab V-4.1). However, this augmentation is not instantaneous, such that the pilot is subjected to slight delays in the pressure change delivered by the system with each breath in and out (Tab V-4.1). These features inherent to the F-35 closed feedback system cause many pilots across the F-35 platform to report feeling more fatigued than normal, when compared to their prior legacy aircraft (Tab V-4.1). This insidious increase in physical demand can translate into a degree of cognitive degradation (Tab V-4.1). On the night of the mishap, the MP reported feeling 50% more drained than a similar prior sortie, with a score on a cognitive degradation scale of a six out of ten versus his baseline of a four out of ten for a routine sortie (Tab V-2.36).

(3) PC102 Fixation: is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others. The MP was fixated on the

faulty symbology of the HMD at a critical phase of flight to the exclusion of a crosscheck of either AOA or airspeed (Tab V-1.34, V-2.5 to 2.10).

(4) PC103 Task Over-Saturation: is a factor when the quantity of information an individual must process exceeds their mental resources in the amount of time available to process the information. The MP had an aggregate of degrading factors to his mental processes leading up to the mishap.

i. First, the MP was a "contact of a contact" of an individual that tested positive for COVID-19 (Tab V-1.14). The first order contact of the positive case had a pending test, and if that individual tested positive, then the MP would be quarantined at home pending his own test result, which would cause operational and logistical disruption (Tab V-3).

ii. Second, the MP found out that he was switching from a less intensive (Red Air) sortie to an instructive, greater mentally intensive (Blue Air) sortie with a B-course student, and now had only four hours left until his pre-flight brief with his student started (Tab V-1.1 to V-1.14).

iii. Third, the Ground Control Intercept (GCI) was a late addition to the mission profile, which changed the mission plan (Tab V-1.16). Additionally, having GCI participate made the mission more difficult because they had a training mission as well (Tab V-1.30). They were added after the aircrew had left the building (Tab V-1.14 to V-1.15).

iv. Fourth, the nighttime ILS approach contributed to the over-saturation (Tab V-1.25, V-2.16 to V-2.18, and V-2.42). According to the MP and other witnesses, landing an F-35 at nighttime is not a mundane task, and is more difficult than a nighttime ILS landing in some of the legacy fighter aircraft (Tab V-1.25, V-2.16 to V-2.18, V-2.42, and V-3.1 to V-4.1).

v. The critical confounding item that ultimately resulted in over-saturation was the HMD misalignment (Tab V-2.6). At this moment, the MP, who was already fully taxed, now had to identify and navigate the HMD misalignment (Tab V-2.7). Correction of this error involved setting a flightpath that aimed short of the runway, essentially in the "black abyss," a term used to describe the featureless darkness of the space before the runway (Tab V-1.6). This is an uncomfortable place for which to aim, essentially because the aircraft is pointed at the dirt prior to the runway, or such is the illusion given the lack of usual daytime visual cues, which is a disconcerting feeling (Tab V-1.6 and V-17.1). This was opposed by the "Hand of God" phenomenon, which is a mental resistance or endpoint opposing a conscious physical action/input (Tab V-2.17). The MP had never had this HMD error before at nighttime (Tab V-1.34), and in this instance it occurred during a critical stage of flight (Tab V-2.7).

(5) PC105 Negative Habit Transfer: is a factor when the individual reverts to a highly learned behavior used in a previous system or situation and that response is inappropriate for current task demands. The MP reverted to prior learned behaviors from his time in the F-15E when in a stressful moment (Tab V-2.39). As a prior F-15E pilot, he was not accustomed to using

the E Bracket to assess landing AOA because the F-15E did not have an AOA staple (Tab V-2.39). An E Bracket or AOA staple provides an easy to view indicator of the aircraft AOA.
Instead of using the staple, the MP used a digital display of the AOA, known as the alpha, which is more discrete in its display of the AOA (Tab V-2.39). Further, he had a negative habit transfer when he assessed his ground track (Tab V-1.11 and V-1.37). Based on his F-15E experience, he thought the ground rush effect, meaning the rate at which the ground was rising toward him during his landing descent, was within the realm of normal (Tab V-1.11 and V-1.37). He did not interpret that as indicating that he was fast (Tab V-1.11 and V-1.37). In addition, the MP had a negative habit transfer from the F-35A simulator (Tab V-2.30). He had landed the simulator at approximately the same speed he was traveling during the mishap (Tab V-2.30). The simulator did not replicate the oscillation he experienced (Tab V-2.30). In addition, two members of the AIB team were able to successfully land at the MA's speed and attitude (Tab Z-28). The LM mishap technical report stated, "the pitch rate sensitivity evident in flight was not observed in pilot simulation or initial attempts to match the maneuver with offline simulation" (Tab J-36). In addition, simulation did not reflect the divergence resultant from flight control saturation in efforts to recreate the mishap (Tab J-36).

(6) PC104 Confusion: is a factor when the individual is unable to maintain a cohesive and orderly awareness of the events and required actions and experiences a state characterized by bewilderment. The MP experienced confusion after the first two seconds of attempted landing, when his attempts to raise the nose and initiate a go-around sequence were fruitless (Tab V-1.38). The MP indicated that he felt like he was being ignored by the FCS (Tab V-1.38), and eventually felt helpless because the FCS was not doing what he commanded it to do (Tab V-1.8). This ultimately drove his decision to eject (Tab V-1.38).

(7) PC108 Interference/Interruption: is a factor when the individual is performing a highly automated/learned task and is distracted by another cue or event that results in the interruption and subsequent failure to complete the original task or results in skipping steps in the original task. The MP's normal habit patterns and procedures were interrupted by the misaligned HMD symbology (Tab V-1.6). The MP first became aware of this misalignment as he attempted to set his glide path visually with the symbology and the runway environment (Tab V-1.6, V-1.32). This occurred just inside the final approach fix, approximately 5 miles from touchdown (Tabs S-4, V-1.6, and V-1.32). The AFTTP 3-3.F-35 states "at the FAF or when the glide slope reaches 2.5 degrees, begin descent to capture the designed glide slop for the ILS. Engage the APC or slow to on speed no later than decision height" (Tab BB-360). The MP prioritized his glide path IAW this guidance, but the interference of the misaligned HMD resulted in a significant distraction for the remainder of the approach such that he never engaged APC or slowed to approach speed (Tab V-1.6). The AFTTP 3-3.F-35 guidance promotes the use of AT, AP, and APC to emphasize focus on FPM/CDM as a means to decrease pilot burden and increase situational awareness via the "revised cross-check" (Tab BB-360). The MP reported that he typically engages and verifies APC set and AOA on final after setting the aircraft glide path and aim point IAW AFTTP 3-3.F-35 guidance (Tab V-1.6 and V-1.53). After failing to set APC, the MP did not verify or cross-check speed or AOA for the remainder of the approach as it is generally de-emphasized in the revised cross-check method and normal habit patterns (Tabs V-1.53 and BB-360).

d. Organizational Influences "Upper-Level Management, Command Level"

OR001 Command and Control Resources are Deficient: is a factor when installation resources are inadequate for safe operations. This mishap occurred during the COVID-19 pandemic (Tab V-1.43). The pandemic has significant, immeasurable impacts on infrastructure, logistics, planning, and execution of the mission (Tab V-3.1). Week on-week off, or split-operations, has a deleterious effect on unit cohesion and flying operations (Tab V-3.1). As an example, it makes proper pilot meetings, such as phase briefs prior to the start of night flying, impossible in the conventional sense (Tab V-3). It relies on passive, disconcerted methods by which to pass critical information, as there are no physical all-pilot or instructor pilot meetings (Tab V-3.1). Individuals with perceived elderly, ill, or otherwise susceptible family members in the house, such as a newly pregnant wife, maintain a constant degree of vigilance and skepticism at work (Tab V-3.1). Threat mitigation of the coronavirus is a constant mental exercise, as when the MP was deciding when he would show up to work (Tab V-1.14 and V-1.16). The impact of this epidemic on flying operations, while impossible to quantify, cannot be overstated.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 21-101, Aircraft and Equipment Maintenance Management (16 January 2020)
(2) AFMAN 11-2F-35A Volume 1, F-35A Aircrew Training (13 February 2019)
(3) AFMAN 11-2F-35A Volume 1, AETC Supplement, F-35A Operations Procedures (11 April 2019)

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.

b. Other Directives and Publications Relevant to the Mishap

(1) DoD Human Factors Analysis and Classification System (HFACS) Version 7.0
(2) F-35A-FM, 001, F-35A Lightning II Flight Manual (8 October 2019) (FOUO)
(3) AFTTP 3-3.F-35, Combat Aircraft Fundamentals F-35 (6 December 2019) (FOUO)

c. Known Deviation

F-35A-FM, 001, F-35A Lightning II Flight Manual, pg. 1763, para. 4.1. Touching down for landing with Speed Hold engaged is a prohibited maneuver (Tab BB-27).

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11 September 2020

BRYAN T. CALLAHAN, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-35A, T/N 12-005053
EGLIN AFB, FLORIDA
19 May 2020

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 the night of 19 May 2020 at 2126L, the mishap aircraft (MA), an F-35A aircraft tail number (T/N) 12-005053 crashed on runway 30 at Eglin Air Force Base (AFB), Florida (FL). The MA was operated out of Eglin AFB, FL by the 58th Fighter Squadron, 33rd Operations Group, assigned to the 33rd Fighter Wing. The mishap pilot (MP) ejected safely but sustained non-life threatening injuries. The MA, valued at $175,983,949, rolled, caught fire, and was completely destroyed.

I find, by a preponderance of the evidence, that the mishap was caused first, by the MA touching down at 202 KCAS, and second, by the MA control surfaces conflicting with the MP inputs upon landing, resulting in the MP's inability to recover. Additionally I find by a preponderance of the evidence that four additional factors substantially contributed to the mishap. The substantially contributing factors are: the MP landed with Speed Hold engaged and using an alternate crosscheck method, the Helmet Mounted Display (HMD) misalignment distracted the MP during a critical phase of flight, the MP experienced cognitive degradation due to fatigue, and the MP lacked knowledge of the flight control system logic.

2. CAUSE

I find by a preponderance of the evidence, the causes of the mishap were the following:

a. MP landed at 202 KCAS.

The MP set and held 202 knots calibrated airspeed (KCAS) throughout the approach and landing. The aircraft touched down approximately 50 KCAS fast, and as a result of the increased speed, was approximately 8° Angle of Attack (AOA) more shallow than desired. The excess energy caused the nose to be driven down at a higher rate than the MP was accustomed to, and the shallow 5.2° AOA touch down caused the nose gear to contact the runway immediately after the main landing gear. This resulted in a rapid and excessive nose-high bounce.

Landing roll out became increasingly unstable after the first bounce for two reasons. First, the high-speed three-point landing caused the nose gear to compress and then rapidly extend. This forced the nose into the air at a rate inconsistent with the MP's previous landing experience. Second, the shallow (5.2°) AOA at touch down is below the recommended landing attitude of 13° AOA. Aircraft control logic is optimized for stability at the desired landing attitude. Landing at 5.2° AOA resulted in the MP managing the initial bounce in pure pitch rate as opposed to the more stable, and desired, AOA-driven rates the MP would have experienced if landing on speed. Ultimately, the high speed landing and resultant shallow AOA culminated in an out-of-control scenario developing on landing.

b. MA flight control system conflicted with MP inputs upon landing, resulting in the MP's inability to recover the aircraft.

MP attempted to reestablish a landing attitude after touch down. The aircraft landing lasted approximately five seconds before the MP elected to eject. Upon touch down the MP initially attempted to dampen the rapid rise of the nose produced by the first bounce. The MP's initial reaction was consistent with attempting to recover from a bounce and set a landing attitude. However, the MP's stick inputs quickly fell out of synch with the aircraft pitch oscillations and control cycles initiated by the weight on wheels. This resulted in multiple conflicting flight control inputs. In the presence of large and aggressive stick inputs the flight control system, based on its Control Law (CLAW) logic, became saturated and unresponsive, and ultimately biased the flight control surfaces toward nose down.

At the two second mark, the MP set and held aft stick to try to reestablish a landing attitude. The horizontal stabilizers trailing edges remained full deflection toward nose down despite the pilot holding aft stick. The MP was unable to overcome the nose-down bias in order to reestablish a landing attitude or execute a go-around. The MP reported feeling confused, helpless, and ignored. Three seconds of pilot flight control input was not enough time to overcome the saturation caused by two seconds of prior inputs. The flight control system failed to orient the aircraft to the appropriate attitude for a go-around, and thus avoid catastrophic loss of the aircraft. After three seconds of attempting to go-around, and after multiple and progressively worsening bounces, the MP released the stick to eject.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

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

a. MP landed with Speed Hold engaged. This is a prohibited maneuver IAW F-35A-FM-001. MP also used approved AFTTP 3-3.F-35 revised cross-check method.

Landing with Speed Hold (SH) engaged is not an authorized maneuver. The SH system has not been tested for landing performance. The MP failed to disengage SH at the normal point in his habit pattern (between Final Approach Fix (FAF) and 3 nautical miles). Failing to set Approach

Power Compensator (APC), and subsequently disengaging SH, resulted in the MP missing his airspeed and AOA cross-check habit pattern. The MP never verified he was flying the correct airspeed or AOA. The MP became aware of excess speed on short final when he noticed increased ground track, but given low illumination on 19 May, and pattern references learned in his previous major weapon system, the MP interpreted the fast ground track as acceptable. The MP's first realization of excess airspeed and incorrect AOA was upon touchdown.

The MP uses the approved "Revised Control and Performance" scan method ("Revised Method") IAW Air Force Tactics, Techniques, and Procedures (AFTTP) 3-3, Combat Aircraft Fundamentals for F-35. The MP had successfully used this method for all previous F-35 flights. However, the Revised Method's reliance on Auto-Throttle modes, and de-emphasis on performance instrument cross-check, resulted in the MP not habitually using alternate cues that he may be too fast or too shallow. The MP was distracted at his normal auto-throttle configuration point (see Helmet Mounted Display (HMD) misalignment Contributing Factor). The MP's preferred technique of landing in APC mode would not have clued him in to being in Speed Hold either, as neither mode requires pilot interaction with the throttle once set, and landing with Speed Hold engaged produces no audible warnings for a dangerous configuration. The MP flew the remainder of the final approach with auto-throttle engaged. The MP continued the approach unaware of the aircraft's incorrect configuration as there was no need for throttle interactions, no airspeed/AOA crosscheck, and no cueing system to alert the MP he's in the wrong throttle mode for touchdown.

b. MP HMD misalignment distracted the MP during a critical phase of flight.

The HMD misalignment, and subsequent conflict in flight data, consumed the MP's attention and was a source of distraction from the final descent through flare and touch down. The MP had never experienced HMD misalignment at night. Worse yet, the HMD was misaligned low as opposed to high. The low alignment resulted in the aircraft coming in too high for landing, which conflicted with ILS and visual data (see figure 1). The MP was relegated to using the HMD data to set his aimpoint as the F-35 lacks an alternate instrument such as the HUD found in legacy aircraft. The MP fought his own instincts to push further into the darkness short of the runway to correct his trajectory. This contributed to the steep approach. F-35A simulator profiles train F-35 crews to fly HMD-out approaches, but do not emphasize HMD-misaligned approaches, which aggravated the impact of the MP's HMD misalignment on the night of the mishap. The focus required to mentally filter the degraded symbology, green glow of the HMD projector, visually acquire nighttime runway cues, correct and then set the aimpoint, fight the "hand of God" effect of the darkness short of the runway, and monitor glide path trends, distracted the MP from engaging APC or slowing to final approach speed.

c. Cognitive degradation.

The MP reported feeling mentally drained during the night Tactical Intercepts portion of the sortie. Several factors contributed to the mental fatigue. The MP was preparing for a Red Air sortie but was switched to a Blue Air instructional sortie late in the planning cycle, and without proper coordination with GCI. The MP had been struggling with interrupted sleep and indicated as such on his ORM score. The MP was notified the day prior of exposure to COVID-19 and was awaiting a colleague's test results to determine his susceptibility.

The HMD's projection brightness, otherwise known as "Green Glow," became increasingly distracting as the approach continued. The MP attempted to dim the brightness but green glow feedback intensified as the MA approached the runway, peaking at approximately 300 feet AGL. The MP reported having to squint through the green glow in order to pick up on the environmental cues in the runway environment. This further contributed to the MP's level of distraction on final.

Lastly, the MP reported routine mental fatigue at the end of F-35A sorties. The MP's experiences are supported by emerging research into an F-35A physiological consideration called "work of breathing." There appears to be a physiological toll taken on a pilot's cognitive capacities as a result of breathing through the on-demand oxygen system. These degradations seem to impact pilots at varying levels toward the end of the sortie through post-flight events. The MP was asked where was his level of degradation on a one to ten scale. The MP reported a four out of ten on a routine basis, but on the night of the mishap he reported a six out of ten. Flying a night ILS in the F-35A has been described as "not a mundane task," and could have been made more challenging by the reported level of cognitive degradation. The degradation was a culmination of distractions, stress, lack of sleep, and work of breathing. These human factors are all manageable for an experienced fighter pilot. However, when taken cumulatively, these factors contributed to the MP's vulnerability to distractions during the mishap approach and landing.

d. Lack of knowledge on CLAW flight control logic.

There are multiple flight control logic modes that came into play during the landing roll. These logic modes toggled as Weight on Wheels (WOW) switches cycled with each bounce and MP stick inputs got out of sync with the physical flight controls. The conflicting inputs caused the flight control system to input a large bias value, which kept pushing the nose down. Three seconds was not enough time to null out the flight control system's efforts to keep the nose down.

There is minimal discussion, if any, of these CLAW logic functions in the F-35A Flight Manual (-1), the F-35A Flight Control/CLAW logic academics, or the AFTTP 3-3.F-35. The F-35A's flight control system is complex; there are too many sub-modes of the CLAW logic to describe in the aforementioned forums. Nonetheless, there exists a deficiency in the depth of CLAW logic and flight control systems knowledge in F-35A baseline manuals and academics.

Further contributing to the misperceptions on CLAW logic, pitch rates, and landing attitude recoveries is that F-35A simulator models do not accurately represent the aircraft flight dynamics seen in this scenario. The simulator allows for high-speed landings and the aircraft can be consistently recovered after bouncing in the simulator. The MP reported having been able to land the aircraft at the same parameters as seen during the mishap event. Two members of the AIB team were also able to successfully land the simulator at the MA's speed and attitude. The LM mishap technical report verified the disjoint between actual MA performance and the simulator model and stated, "the pitch rate sensitivity evident in flight was not observed in piloted simulation or initial attempts to match the maneuver with offline simulation." If the MP had a better understanding of the CLAW logic and how the aircraft would respond to inputs, and did not have the negative learning from the simulator, he might have been able to recover the aircraft despite the high speed landing, which is why this is a contributing factor to the mishap.

4. CONCLUSION

I find by a preponderance of the evidence that the causes of the mishap were a high speed landing and a lack of flight control response on landing. The MP landed at 202 KCAS, which was approximately 50 KCAS faster than the desired speed for the MA weight upon recovery. The increased landing speed resulted in a bounce that, coupled with MP and MA flight control conflicts, resulted in the MA departing controlled flight and the MP electing to eject. I further find by a preponderance of the evidence that the following were substantially contributing factors to the mishap. The HMD misalignment at night distracted the pilot at precisely the worst point in the approach timeline, and the F-35A reliance on auto-throttle modes and associated cross-checks played a part in the MP's failure to turn off the Speed Hold or recognize the fast approach and shallow landing attitude. A lack of sleep, coupled with post-mission cognitive degradation, further aggravated the MP's struggles with his instrumentation. Finally, a lack of systems knowledge and negative training from simulator experiences prevented him from appropriately responding to the high speed landing.

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