UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

F-35A, T/N 15-5197

421ST FIGHTER SQUADRON
388TH FIGHTER WING
HILL AFB, UTAH

LOCATION: HILL AIR FORCE BASE, UTAH

DATE OF ACCIDENT: 19 OCTOBER 2022

BOARD PRESIDENT: COLONEL KEVIN M. LORD

Conducted IAW Air Force Instruction 51-307

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND

OFFICE OF THE DEPUTY COMMANDER
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JUL 25 2023

ACTION OF THE CONVENING AUTHORITY

The report of the accident investigation board conducted under the provisions of Air Force Instruction 51-307, *Aerospace and Ground Accident Investigations*, that investigated the 19 October 2022 mishap at Hill Air Force Base, Utah, involving an F-35, T/N 15-5197, operated by the 388th Fighter Wing, complies with applicable regulatory and statutory guidance, and on that basis it is approved.

RUSSELL L. MACK
Lieutenant General, USAF
Deputy Commander

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

F-35A, T/N 15-5197
HILL AFB, UTAH
19 OCTOBER 2022

On 19 October 2022, at approximately 18:08:36 local (L), the mishap aircraft (MA), an F-35A aircraft, tail number (T/N) 15-5197, crashed after the final turn to land on Runway (RWY) 14 at Hill Air Force Base (AFB), Utah (UT). The MA was operated out of Hill AFB, UT by the 421st Fighter Squadron (FS) and assigned to the 388th Fighter Wing (FW). There were no fatalities. The mishap pilot (MP), assigned to the 388th FW, ejected safely before impact. He sustained minor injuries. The MA was destroyed upon impact, with a total loss valued at $166,340,000.00. The MA debris fanned out with most of the aircraft impacting within the airfield boundaries on Hill AFB.

The Mishap Flight consisted of four F-35A aircraft, with the MA flying as the #3 aircraft in the flight. After an uneventful training sortie, the MA returned to Hill AFB RWY 14, in a standard formation with the #3 aircraft in one nautical mile trail of the #1 aircraft. On final approach to landing, the MP experienced a slight rumbling to his aircraft due to wake turbulence from preceding aircraft. This air flow disturbance resulted in erroneous inputs to the air data application (ADA) of the F-35 flight control system. The erroneous inputs to the ADA resulted in a condition in which the aircraft flight controls did not respond correctly for the actual current conditions of the MA. Recognizing that the MA was not responding appropriately to control inputs, the MP selected full afterburner power to attempt to recover to controlled flight. Due to the low altitude, low airspeed, and sideslip flight path of the MA, the MP was unable to recover the aircraft and initiated ejection. The MP ejected before the MA impacted the ground and was destroyed. The MP landed just north of the base outside the Hill AFB airfield boundary fence and was recovered by emergency responders.

The accident investigation board (AIB) president found, by a preponderance of the evidence, the cause of the mishap was that the MA departed controlled flight due to air data system errors immediately prior to landing and there was no opportunity to recover the aircraft to controlled flight. The AIB President found one significantly contributing factor to the mishap: the MP did not increase landing spacing from preceding aircraft in accordance with wake turbulence procedures.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-35A, T/N 15-5197
HILL AFB, UTAH
19 OCTOBER 2022

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ACRONYMS AND ABBREVIATIONS

388 FW	388th Fighter Wing
421 FS	421st Fighter Squadron
ACC	Air Combat Command
ADA	Air Data Application
ADS	Air Data System
AFB	Air Force Base
AFE	Air Flight Equipment
AFI	Air Force Instruction
AFMAN	Air Force Manual
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Accident Investigation Board
ALIS	Autonomic Logistics Information System
AMXS	Aircraft Maintenance Squadron
AOA	Angle of Attack
AOSS	Angle of Side Slip
APC	Approach Power Compensator
ATIS	Automated Terminal Information System
BOS	Before Operation Servicing
C	Degrees Celsius
Ch	Channel
CLAW	Flight Control Law
CSMU	Crash Survivable Memory Unit
DEGD	Degrade
DO	Director of Operations
DoD	Department of Defense
EOTS	Electro-Optical Targeting System
ETR	Engine Throttle Request
FCS	Flight Control System
FGS	Fighter Generation Squadron
FLUG	Flight Lead Upgrade
FMC	Mull Mission Capable
FPM	Flush Port Module
FS	Fighter Squadron
Ft	Feet
G	Gravitational Force
HFACS	Human Factors Analysis and Classification System
HRC	Health Reporting Code
IAW	In Accordance With
ICAW	Integrated Caution and Warning
IOS	Interim Operation Servicing
JTD	Joint-Service Technical Data
K	Thousand
Kts	Knots
L	Local Time
MA	Mishap Aircraft
MC	Mission Capable
MEF	Mission Execution Forecast
MF	Mishap Flight
MFP	Multi-Function Probe
MP	Mishap Pilot
MW	Mishap Wingman
NM	Nautical Miles
NOTAMs	Notices to Air Missions
OBM	On-Board Model
ORM	Operational Risk Management
PA	Power Approach
PAO	Polyalphaolefin
POS	Post Operation Servicing
PRD	Pilot Reported Discrepancy
RTB	Return to Base
RTF	Return to Fly
RWY	Runway
SME	Subject Matter Expert
SMS	Store Management System
SOF	Supervisor of Flying
T-1	Tier 1 Waiver
TCTD	Time Compliance Technical Directives
T/N	Tail Number
UA	Up and Away
U.S.	United States
USAF	United States Air Force
UT	Utah
UTTR	Utah Test and Training Range
VFR	Visual Flight Rules
VMC	Vehicle Management Computer

B. SUMMARY OF FACTS.

AUTHORITY AND PURPOSE

a. Authority

On 1 December 2022, the Deputy Commander, Air Combat Command (ACC), appointed Colonel Kevin M. Lord to conduct an accident investigation of the 19 October 2022 crash of an F-35A, tail number (T/N) 15-5197, assigned to the 388th Fighter Wing (FW), Hill AFB, Utah (UT) (Tab Y-1.1). The investigation was conducted by an accident investigation board (AIB) pursuant to Air Force Instruction (AFI) 51-307, *Aerospace and Ground Accident Investigations* (Tab BB-11.1). The investigation was conducted at Hill AFB, UT, from 7 January 2023 to 5 February 2023 (Tab Y-1.1). A pilot member (Major), legal advisor (Major), maintenance member (Master Sergeant), and recorder (Technical Sergeant) were detailed as board members (Tabs Y-1.1 and Y-3.1). A medical subject matter expert (Major) was also appointed to advise the AIB (Tab Y-2.1).

b. Purpose

In accordance with (IAW) AFI 51-307, *Aerospace and Ground Accident Investigations*, this AIB conducted a legal investigation to inquire into all facts and circumstances surrounding this Air Force aerospace accident, prepare a publicly releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action (Tab BB-11.1).

2. ACCIDENT SUMMARY

On the evening of 19 October 2022, the mishap aircraft (MA), an F-35A, T/N 15-5197, operated by the 421st Fighter Squadron (421 FS), 388th Fighter Wing (388 FW), departed Hill AFB at 16:34:20 Local (L) for a Flight Lead Upgrade Sortie to the Utah Test and Training Range (UTTR) airspace (Tabs K-1.3, K-1.6, and CC-1.1). All preflight checks, ground operations, and the training portion of the mission occurred normally without any fault indications or issues with the MA (Tabs K-1.3, K-3.1, CC-2.1, and V-1.1.2 to V-1.1.3). The mishap pilot (MP) was fully qualified for the mission and to fly the MA (Tab K-1.5 to K-1.6). The mishap flight (MF) consisted of four F-35A aircraft, with the MA flying as the #3 aircraft in the flight (Tabs K-1.3 and K-1.6). After an uneventful training sortie, the MA returned to Hill AFB, in a standard tactical formation with #3 and #4 in one nautical mile trail (Tabs V-1.1.3 and CC-1.3). A mishap wingman (MW) received current weather information for landing at Hill AFB, including that wake turbulence procedures were in effect for Hill AFB, but did not pass the wake turbulence information on to the MF, including the MP (Tab CC-1.2 to CC-1.3). The MP failed to follow wake turbulence procedures when attempting to land (Tabs V-1.1.4 and CC-1.2). On final approach to landing, the MP experienced a slight “burble” (or rumbling) to his aircraft due to wake turbulence from the preceding aircraft (V-1.1.5). This atmospheric disturbance resulted in erratic inputs to the air data application (ADA) (Tabs J-1.42 and V-1.1.5). This, in turn, caused erroneous outputs from the ADA and resulted in a condition in which the aircraft flight controls

did not respond correctly to the actual current conditions of the MA (Tab J-1.42). Recognizing that the MA was not responding appropriately to control inputs, the MP selected full afterburner power to attempt to recover to controlled flight (Tab V-1.1.5). Due to the low altitude, low airspeed, and sideslip flight path of the MA, the MP was unable to recover the aircraft and initiated ejection (Tabs J-1.22 and V-1.1.6). The MP was able to eject at approximately 18:08:36 local (L) before the MA, valued at $166,340,000.00, impacted the ground and was destroyed (Tabs J-1.9 and P-1.1). The MA debris fanned out, with most of the aircraft impacting within the airfield boundaries (Tab J-1.9). Parts of the cockpit, canopy and ejection seat landed just outside the airfield boundary fence line (Tabs J-1.9, V-2.2.3, and V-5.2.6). The MP landed just north of the base fence line and was recovered by military and civilian emergency responders (Tab V-1.1.9 to V-1.1.10). Pre-mishap and post-mishap medical record checks showed nothing that would contribute to the mishap for any relevant party (Tab CC-3.1).

3. BACKGROUND

a. Air Combat Command

Air Combat Command (ACC) is one of ten major commands in the United States Air Force, headquartered at Joint Base Langley-Eustis, Virginia (Tab BB-4.8). As the lead command for fighter, command and control, intelligence, surveillance and reconnaissance, personnel recovery, persistent attack and reconnaissance, electronic warfare, and cyber operations, ACC is responsible for providing combat air, space, and cyber power and the combat support that assures mission success to America's warfighting commands (Tab BB-4.8). The Command operates more than 1,097 aircraft, 27 wings, 1,130 units and has 195 non-expeditionary locations, and an additional eight wings, 241 units at 47 locations supporting expeditionary operations for a total of 35 wings, 1,372 units at 242 locations, with 155,948 total force active-duty and civilian personnel (Tab BB-4.8 to BB-4.9).

b. 388th Fighter Wing

The 388th Fighter Wing (FW) is located on Hill Air Force Base, Utah and it's mission is to maintain combat readiness to deploy, employ, and sustain F-35A Lightning II aircraft worldwide in support of the national defense (Tab BB-4.4). The 388 FW is comprised of aproximately 2,000 airmen and civilain professionals and 78 F-35A Lightning II's (Tab BB-4.4).

c. 421st Fighter Squadron

The 421st Fighter Squadron (FS) is located on Hill Air Force Base, Utah and it's mission is to provide a lethal and survivable air superiority team, on-call and ready to solve emergent and complex problems for any Combatant Command (Tab BB-4.1). The 421 FS is comprised of 24 F-35A Lightning II's (Tab BB-4.1).

d. F-35A Lightning II

The F-35A is the U.S. Air Force's latest fifth-generation fighter (Tab BB-4.6). With its aerodynamic performance and advanced integrated avionics, the F-35A provides next-generation stealth, enhanced situational awareness, and reduced vulnerability for the United States and allied nations (Tab BB-4.6).

The F-35A gives the U.S. Air Force and its allies the power to dominate the skies – anytime, anywhere (Tab BB-4.6). The F-35A is an agile, versatile, high-performance, 9g capable, multirole fighter that combines stealth, sensor fusion and unprecedented situational awareness (Tab BB-4.6).

The F-35A's advanced sensor package is designed to gather, fuse and distribute more information than any fighter in history, giving operators a decisive advantage over all adversaries (Tab BB-4.6). Its processing power, open architecture, sophisticated sensors, information fusion and flexible communication links make the F-35 an indispensable tool in future homeland defense, Joint and Coalition irregular warfare and major combat operations (Tab BB-4.6).

4. SEQUENCE OF EVENTS

a. Mission

On 19 October 2022, the 421st Fighter Squadron (FS) director of operations scheduled and authorized the mishap flight's (MF) mission as a four-ship formation conducting a flight lead upgrade flight for Legs 01 (Tabs K-1.3 and K-1.6). The MF was a flight of four F-35A aircraft (Tabs K-1.3 and K-1.6). The instructor pilot of record for the flight was Legs 02 (Tab K-1.6). The mishap pilot (MP), Legs 03, was fully qualified and certified to accomplish the mission (Tab K-1.5 to K-1.6). The MF flew to the South Utah Test and Training Range (UTTR) military training airspace and executed the training mission uneventfully before returning to Hill AFB for landing (Tab V-1.1.3).

b. Planning

MF members accomplished all required mission planning for the sortie, including, but not limited to, checking notices to air missions, navigational aids, airspace, and weather for all applicable airfields and airspace (Tabs K-2.4, K-3.1 to K-3.26, and V-1.1.2). The MF completed an operational risk management (ORM) form, which is used to rate the level of risk for the flight (Tab K-1.2). The MP's ORM was rated as low risk and was signed off by the appropriate level of supervision based on the risk level (Tab K-1.2).

c. Preflight

The MF members donned their Aircrew Flight Equipment (AFE), which was inspected, current, and serviceable according to AFE records (Tab J-5.15). The MF received their tail numbers from the operations supervisor, and were briefed an update to weather, airfield status, and forms data (Tabs K-1.3, V-1.1.2 to V1.1.3, and CC-2.1). Additionally, the MP completed a review of

applicable MA maintenance records, known as the bird book (Tab V-1.1.3). The MP then proceeded to the aircraft and completed a preflight inspection of the MA in accordance with aircraft guidance (Tab V-1.1.3). The MF started on time in accordance with the flight brief, and completed all normal ground procedures, without incident (Tab V-1.1.3).

d. Summary of Accident

Ground operations included an uneventful start, taxi, and takeoff (Tab V-1.1.3). The MF launched with four F-35s from Hill AFB RWY 14 at 16:34:20L (Tab CC-1.2). The MF flew west to their scheduled training airspace in the southern portion of the UTTR and executed the training mission uneventfully (Tab V-1.1.3). Throughout the mission there were no anomalies or issues noted with the MA by the MP (Tab V-1.1.3). At the completion of their tactical training, the MF returned to base in the traffic pattern for RWY 14 at Hill AFB (Tabs V-1.1.3 and CC-1.2).

At 17:55:35L, on the return to base, mishap wingman (MW), Legs 04, was directed to retrieve the current weather conditions at Hill AFB via radio (Tab CC-1.2 to CC-1.3). It is standard practice for only one flight member to check the weather and allow all other airplanes to remain on the control frequency (Tab BB-8.1). The winds retrieved in the weather report were from a north westerly direction at 5 knots (kts) and the Supervisor of Flying (SOF) declared that "wake turbulence procedures were in effect" (Tabs V-5.2.3 to V-5.2.4 and CC-1.3). The SOF is the focal point for command and control of flight operations in the control tower (Tab BB-10.1). According to wake turbulence procedures, "SOFs will declare Wake Turbulence Procedures in effect when a light crosswind (1-5 kts), tailwind, or light quartering tailwind condition is present. When Wake Turbulence Procedures are in effect, pilots will increase pitch-out spacing to 8 seconds for a minimum runway separation of 9,000 feet" (Tab BB-5.11). Increased formation spacing from the standard 3,000 feet runway separation to 9,000 ft is required in light quartering tailwind conditions to avoid the dangerous effects of wake turbulence (Tab CC-1.2).

At 17:56:26, Legs 04 relayed the weather information to the MF (Tab CC-1.3). When Legs 04 relayed the weather, Legs 04 did NOT state that wake turbulence procedures are in effect (Tab CC-1.3). While Legs 04 should have relayed this information, based on the reported light winds, all pilots in the MF should have known wake turbulence procedures were in effect and landing distances increased (Tab CC-1.3). Pilots are responsible for wake turbulence separation when maintaining visual separation or operating under visual flight rules (Tab BB-2.17).

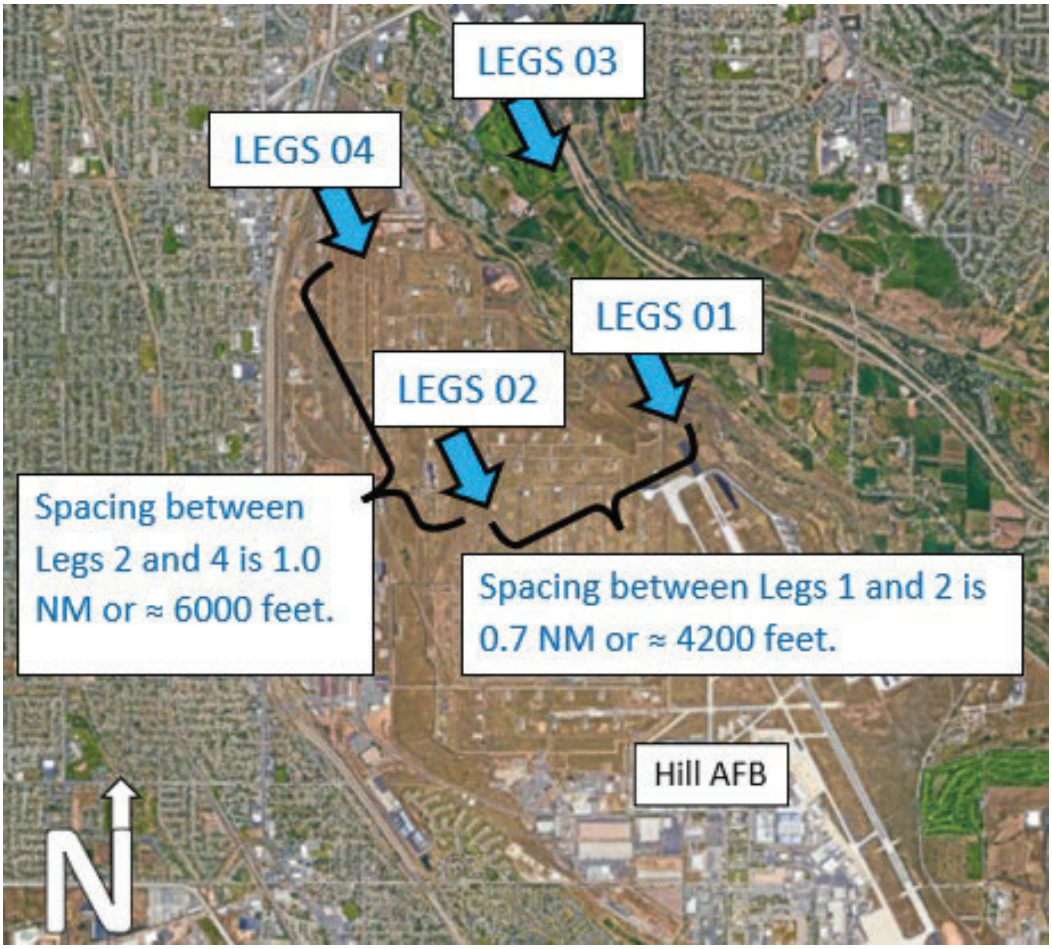

Figure 1: Formation Spacing arriving at Hill AFB (Tab Z-2.1)

Legs 02 and Legs 03 were not aware wake turbulence procedures were in effect (Tabs V-1.1.4 and V-3.2.4). As the MF announced the intention to land, the Hill AFB Tower noted to the entire MF at 18:07:29L that the current winds were at 5 knots (TAB CC-1.3). This is enough information for all pilots in the MF to know they must increase pattern and touchdown spacing in accordance with wake turbulence procedures (Tab CC-1.3). Legs 02 set the normal spacing (3,000 ft) behind Legs 01 (Tab V-3.2.3). According to available data, Legs 02 was approximately 5,000-6,000 ft behind Legs 01 (Tab CC-1.3). Legs 01 and Legs 02 did not encounter any wake turbulence or atmospheric disturbances and landed uneventfully (Tabs V-3.2.3 to V-3.2.4, and CC-1.3).

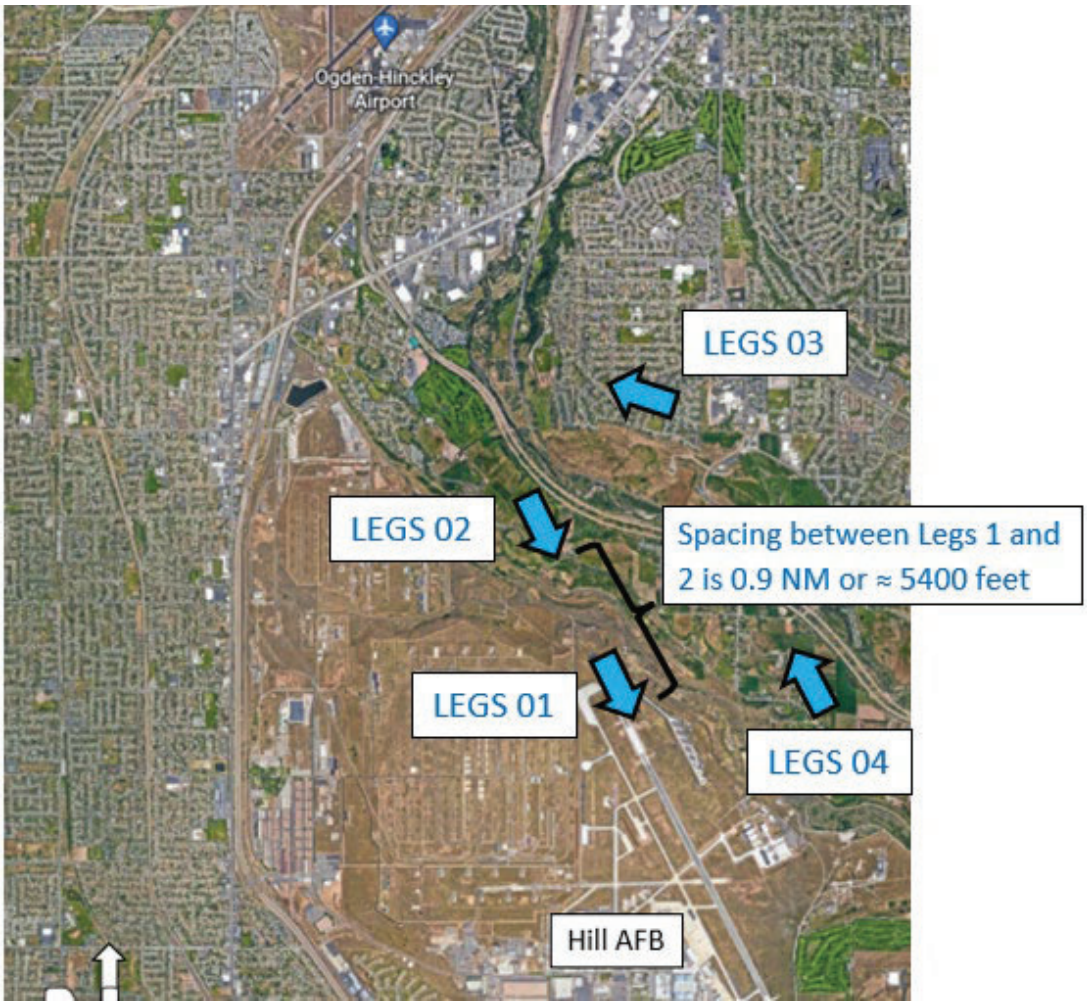

Figure 2: Approximate Aircraft Spacing at Legs 01 Touchdown (Tab Z-3.1)

Legs 03 initiated his normal landing procedures approximately 3000-4000 ft behind Legs 02 (Tabs V-1.1.4 and CC-1.3).

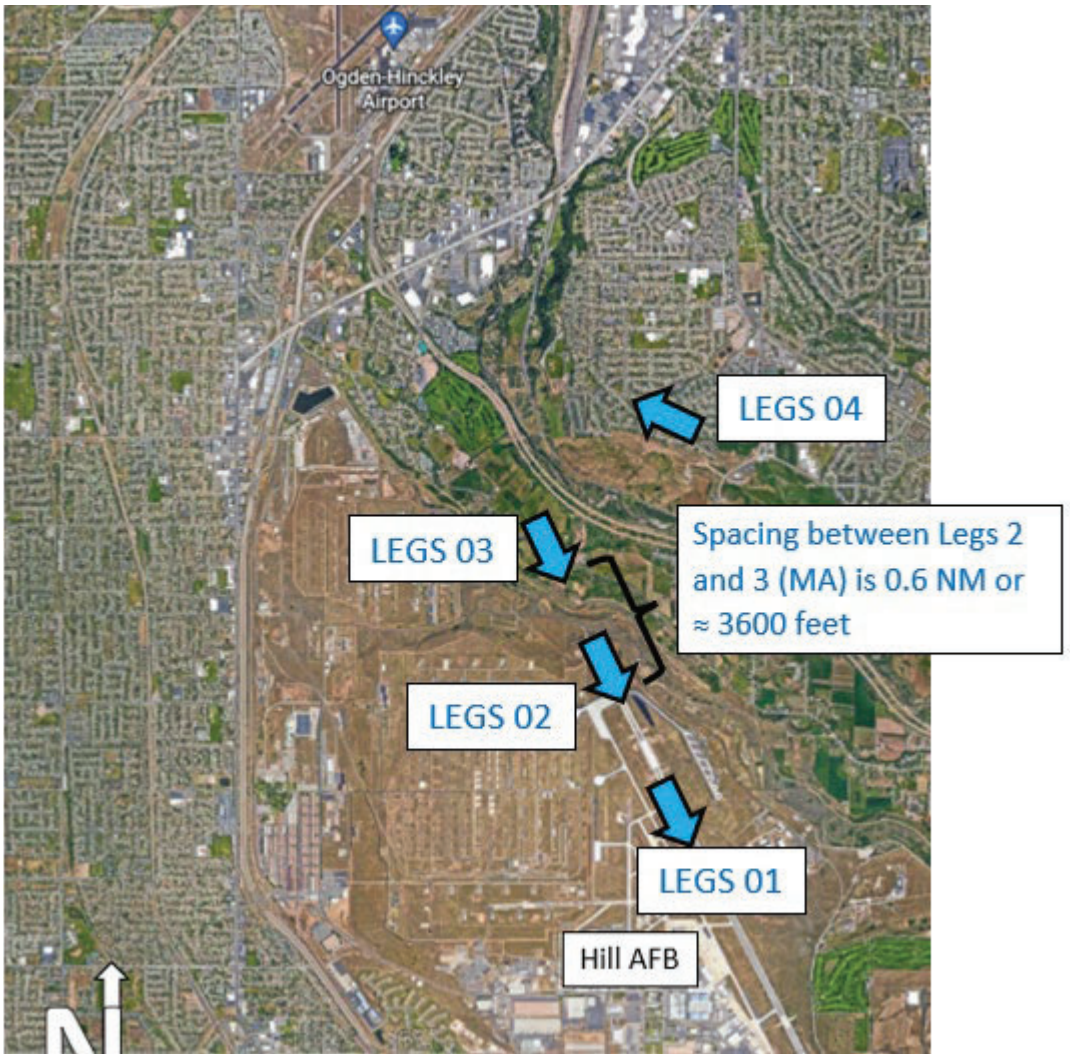

Figure 3: Approximate Aircraft Spacing just prior to Legs 02 Touchdown (Tab Z-4.1)

The MP extended the landing gear at 18:07:23L in preparation for landing (Tabs J-1.8 and V-1.1.4). According to the crash survivable memory unit (CSMU) (flight data recorder), the MA experienced two atmospheric disturbances during the approach and attempted landing (Tab J-1.8). The first disturbed air that the MA encountered was at 18:07:44L and is roughly coincident with the maneuver by the MA to establish spacing in the traffic pattern behind Legs 01 and Legs 02 (Tabs J-1.8 and CC-1.3).

At 18:08:18L, halfway through the turn to landing, the MP engaged the approach power compensator (APC) (Tabs J-1.16 and V-1.1.5). The APC is an additional power assist mode designed to reduce workload and to improve energy management and landing approach control during an approach to landing (Tab CC-1.2). With APC engaged, the aircraft automatically controls engine thrust request (ETR) to maintain desired landing conditions and reduce pilot workload (Tab J-1.16). At this time the aircraft recorded winds were the same as reported by ground sensors based on the tower weather radio call (Tabs J-1.8 and CC-1.3).

The MP testified that when he rolled out on final approach, he felt a distinct "burble" (or rumbling) on the MA (Tab V-1.1.5). Most F-35 pilots interviewed for this investigation and the AIB's F-35 Pilot Member, regularly experience wake turbulence while flying the aircraft (Tabs V-2.1.6, V-4.2.5, and CC-1.2). Based on available data, the MA was in disturbed air, called wake turbulence, for 3 seconds from 18:08:27L to 18:08:30L (Tab J-1.19).

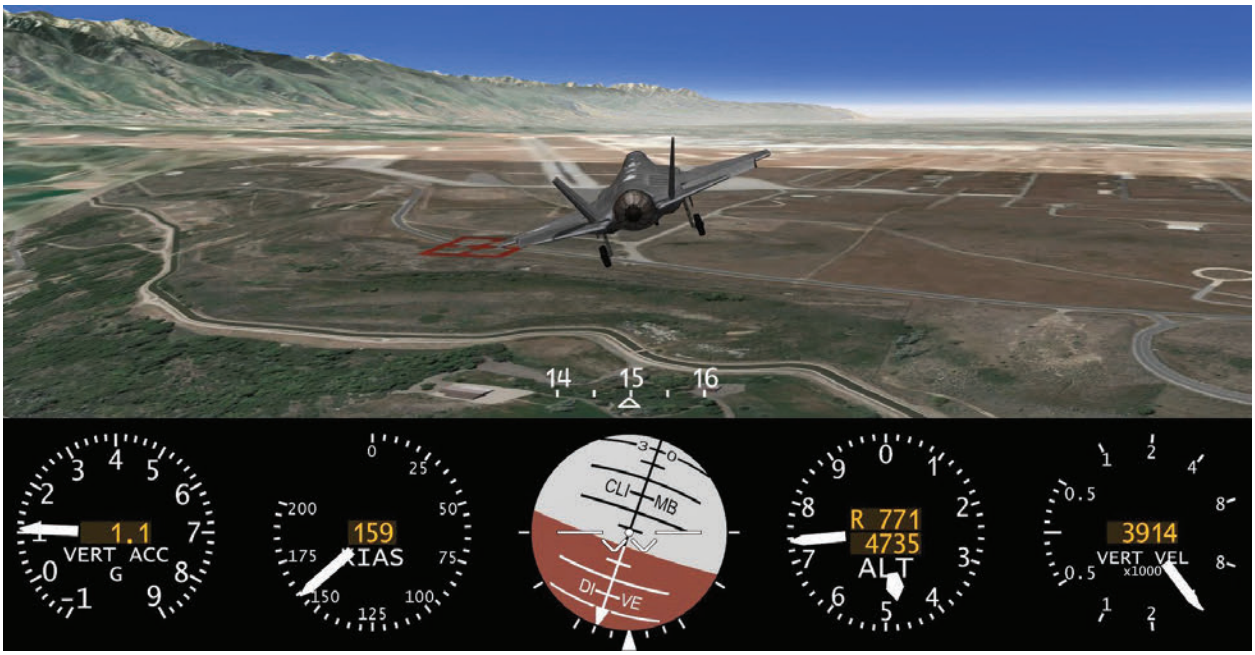

Figure 4: MA at 18:08:27 rolling out on final and felt "burble" (Tab S-6.1)

The MP noted, and the CSMU verified, an AIR DATA DEGD (degrade) integrated caution advisory or warning (ICAW) at 18:08:29L (Tabs J-1.42 and V-1.1.5). This ICAW, with a visual and audio notification to the MP, indicated one or more air data sources were degraded and was the first indication to the MP that there was something out of the ordinary occurring with the MA (Tabs J-1.42 and V-1.1.5). The F-35 enterprise has over 600,000 flight hours and this is the first known occurrence where wake turbulence had this impact on the air data system (ADS) (Tabs V-2.1.6 and CC-1.2).

Figure 5: MA at end of 18:08:30 (Tab S-6.1)

Following the AIR DATA DEGD ICAW, the MP noted that the MA was not responding appropriately to commanded control inputs (Tab V-1.1.5). In response, the MP selected full after burner power at 18:08:30L to abort the landing and set up for another landing attempt (Tab V-1.1.5).

After selecting full afterburner power, the MA continued to not respond as expected to MP inputs (Tab V-1.1.5). At approximately 18:08:33L, 3 seconds after the MA exited the wake turbulence, the MA banked sharply with the left-wing down (Tab J-1.22). The MP re-applied full roll stick at approximately 18:08:35L to counter the aggressive MA bank to the left (Tabs J-1.22 and V-1.1.5).

Figure 6: Wing drop at 18:08:33L (Tab S-6.1)

With the MA responding erratically to the inputs of the MP, the MP released control of the MA at approximately 18:08:36L to eject from the aircraft (Tabs J-1.22 and V-1.1.6).

Figure 7: MA flight condition at ejection initiation (18:08:36L) (Tabs J-1.22 and S-6.1)

e. Impact

The MP ejected at approximately 18:08:36L, the MA continued into the terrain just north of the approach end of RWY 14 at Hill AFB in full afterburner with the left wing striking the ground first (Tab J-1.22 and J-1.48).

Figure 8: MA approach to attempt landing (Tab J-1.10)

The debris field fanned out with most of the aircraft disintegrating within airfield boundaries (Tab J-1.9). Parts of the cockpit, canopy and ejection seat were located just outside the airfield boundary fence line (Tab J-1.9).

Figure 9: MA at impact site (Tab S-4.1)

Figure 10: MA debris field on approach end to RWY 14 (Tab S-1.1)

f. Egress and Aircrew Flight Equipment (AFE)

All AFE performed its intended function, without incident or hindrance to pilot recovery (Tabs J-1.63 and J-5.15). The MP initiated ejection at approximately 4,900 above ground level or 200 ft above the ground (Tab J-2.7 and J-2.10). The MP initiated a successful ejection conducted at low speed and low altitude (Tab J-2.43). The ejection seat automatic sequencer functioned correctly, resulting in a successful ejection for the MP (Tab J-2.14).

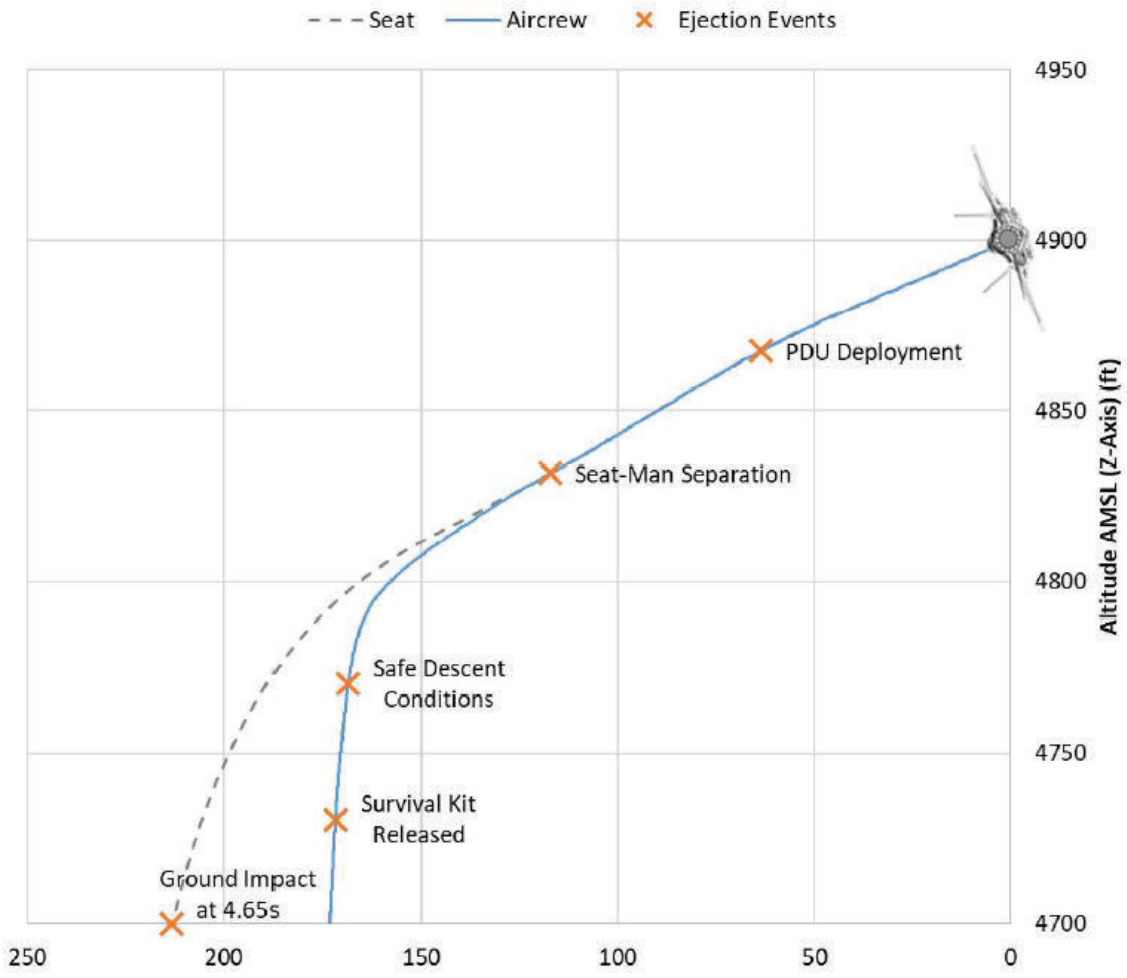

Figure 11: Ejection Trajectory (Tab J-2.10)

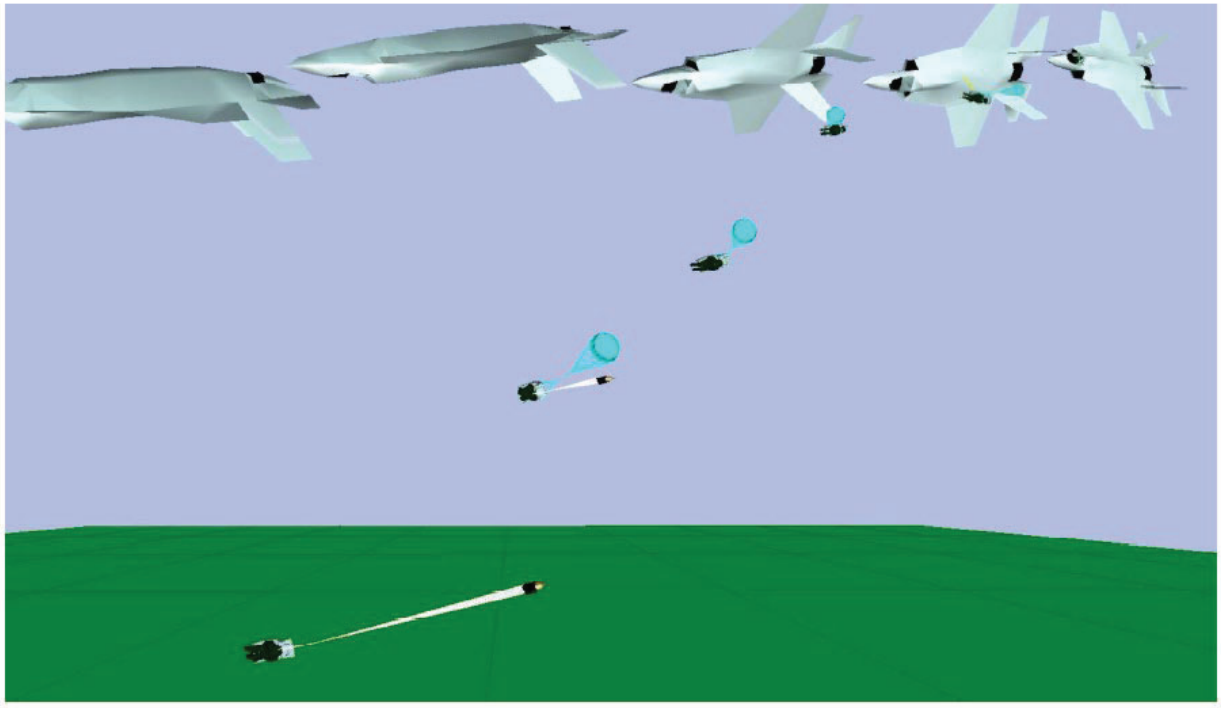

Figure 12: Representative Animation of the Stabilization Phase (Tab J-2.12)

Figure 13: Representative Animation of the Recovery Phase (Tab J-2.12)

g. Search and Rescue (SAR)

At 18:08:36L, the MP ejected on approach to landing on RWY 14 and parachuted to the ground just to the north of the Hill AFB airfield boundary (Tabs J-1.9, J-1.22, and V-1.1.6). The aircraft beacon was not heard on the radio by any witness who testified or on MF data recorders (Tabs V-5.2.5 and CC-1.4). Other than the beacon, all AFE operated correctly and was recovered for post mishap analysis (Tabs J-4.9 and J-5.15). Hill AFB tower personnel executed the quick reference checklists in response to the mishap (Tab V-5.2.5). Tower controllers directed Legs 04 and follow-on formations to divert to Salt Lake City Airport (Tab V-5.2.5). Legs 04 confirmed with tower personnel that a parachute was visible (Tab V-4.2.3). Hill AFB quick reaction forces were dispatched to the mishap site, to include firefighting and medical assets (Tab V-1.1.10 and V-5.2.5). The MP landed just outside the Hill AFB airfield fence line, just to the north of the aircraft impact area (V-1.1.8). The MP disconnected from his survival gear and ran away from the wreckage smoke and flames (Tab V-1.1.8). The MP's first action was to use his cell phone to call squadron operations (Tab V-1.1.9). The SOF called the MP on his cell phone and inquired into the status and location of the MP (Tab V-5.2.5). Shortly after impact, at approximately 18:20:00L, Hill AFB medical personnel were the first to examine the MP (Tab V-1.1.9). Shortly after impact at approximately 18:30:00L, civilian emergency response vehicles arrived on site where they transported the MP to a local hospital (Tab V-1.1.9 to V-1.1.10). The MP was treated for minor injuries sustained in the ejection (Tab V-1.1.10). Following the required tests and vital checks, the MP was released from the hospital that night (Tab V-1.1.10).

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The accident investigation board (AIB) reviewed all applicable Air Force Technical Order 781s and aircraft forms/documentation for the mishap aircraft (MA) (Tab D-5.1 to D-5.79).The MA was in a Full Mission Capable status and landed from its previous flight code 1, which means the aircraft was Mission Capable (MC) with no additional discrepancies (Tab D-5.4). The AIB reviewed all Time Compliant Technical Directives (TCTD) with no concerns to note (Tabs D-5.9 to D-5.30 and D-5.39 to D-5.62). A six-month historical data review from the Autonomic Logistics Information System showed the MA had Pilot Reported Discrepancies (PRD) and Health Reporting Codes noted, but no recurring issues pertinent to this mishap (Tab U-1.1 to U-1.62).

b. Inspections

Post Operation Servicing, Before Operation Servicing, and Interim Operation Servicing (IOS) inspections were all completed and signed off appropriately with no discrepancies noted (Tab U-2.1 to U-2.3). Maintenance documentation and an interview with the mishap pilot (MP) confirmed no defects were noted (Tabs U-2.1 to U-2.3 and V-1.1.3). The MA flew twice on the day of the mishap (Tab K-1.3D-5.6). Following the first flight of the day, an IOS inspection was

performed, which includes refueling the aircraft in preparation for its next flight (Tab U-2.3). The AIB reviewed all TCTDs and determined that none of the discrepancies were factors in the mishap (Tabs D-5.9 to D-5.30 and D-5.39 to D-5.62).

c. Maintenance Procedures

After reviewing all applicable maintenance documentation and after interviewing the MP, it was determined that all procedures, practices, and performance were in accordance with governing maintenance directives and applicable joint technical data (Tabs D-5.1 to D-5.79, U-1.1 to U-1.62, and V-1.1.3).

d. Maintenance Personnel and Supervision

Review of maintenance training records of any personnel who performed any servicing or inspections on the MA did not reveal anything that contributed to the mishap (Tab T-1.1 to T-1.270). Review of the maintenance shift schedule indicated that ample supervision was available on each shift (Tab CC-2.1).

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

Review of post-mishap fuel analysis came back normal with no discrepancies noted (Tabs D-1.1 to D-1.2, D-2.1 to D-2.2, D-3.1, and D-4.1 to D-4.2). Hydraulic, polyalphaolefin, oil, and oxygen samples were not available to be analyzed, however, all systems were functioning normally during the incident and not a contributing factor to this mishap (Tabs J-1.74 and CC-2.1).

f. Unscheduled Maintenance

The only maintenance performed on the MA after the first flight of the day and prior to the mishap sortie was an IOS which includes a refuel (Tab U-2.3). The aircraft was re-fueled with 2,284 gallons of fuel and no other servicing was required (Tab U-2.3). Aircraft pre-flight pilot inspection and subsequent operations checks were normal with no other PRD noted (Tab V-1.1.3). An interview with the MP validated no issues were noted during the launch procedures (Tab V-1.1.3). Review of all maintenance records going back 180 days revealed no link between maintenance and the mishap (Tab U-1.1 to U-1.62).

6. AIRFRAME SYSTEMS

a. Structures and Systems

Prior to the mishap, the mishap aircraft (MA) was fully mission capable (Tab CC-2.1). The mishap pilot (MP) reported no issues on his pre-flight walkaround of the MA or review of the aircraft forms (Tabs V-1.1.3 and CC-2.1). There were no identified discrepancies with the aircraft's flight control system until the MP's landing approach (Tab V-1.1.5). The MP's successful ejection, further validated by post mishap analysis, indicates that all emergency egress systems functioned as designed (Tab J-1.74). The following aircraft systems were relevant to the mishap sequence of events:

1) **Air Data Application (ADA) Software:** The ADA software analyzes inputs from various sensors on the aircraft to provide appropriate flight control inputs to the flight control surfaces (Tab CC-1.2). The ADA software utilizes external pressure and movement and movement rate sensors provided by the air data system to compute aircraft parameters (Tab J-1.17). The ADA also provides air data parameters to the aircraft control laws (CLAW) determining aircraft flight control surface movements (Tab J-1.17).

Air Data System (ADS): The ADS consists of sensors that collect information from outside of the aircraft and feed it into the ADA for use by other systems and the pilot (Tab CC-1.2). The F-35 ADS consists of one left hand and one right hand multi-function probe (MFP), and one left hand and one right hand flush port module (Tab J-1.39). The left-hand side and right-hand side are mirror images (Tab J-1.39).

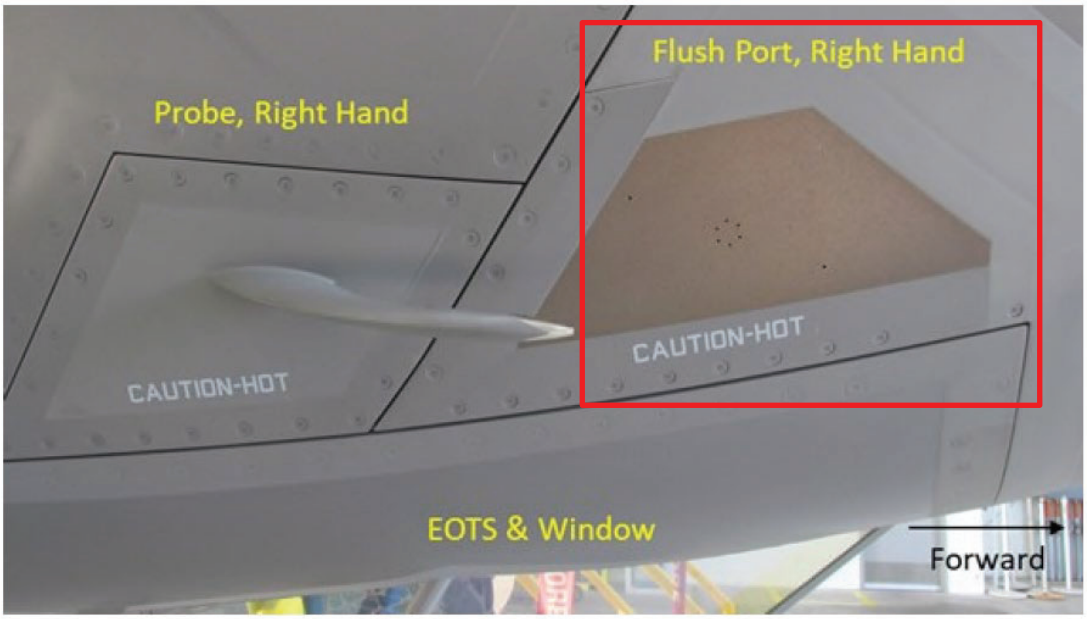

Figure 14: Flush Port (Tab J-1.39)

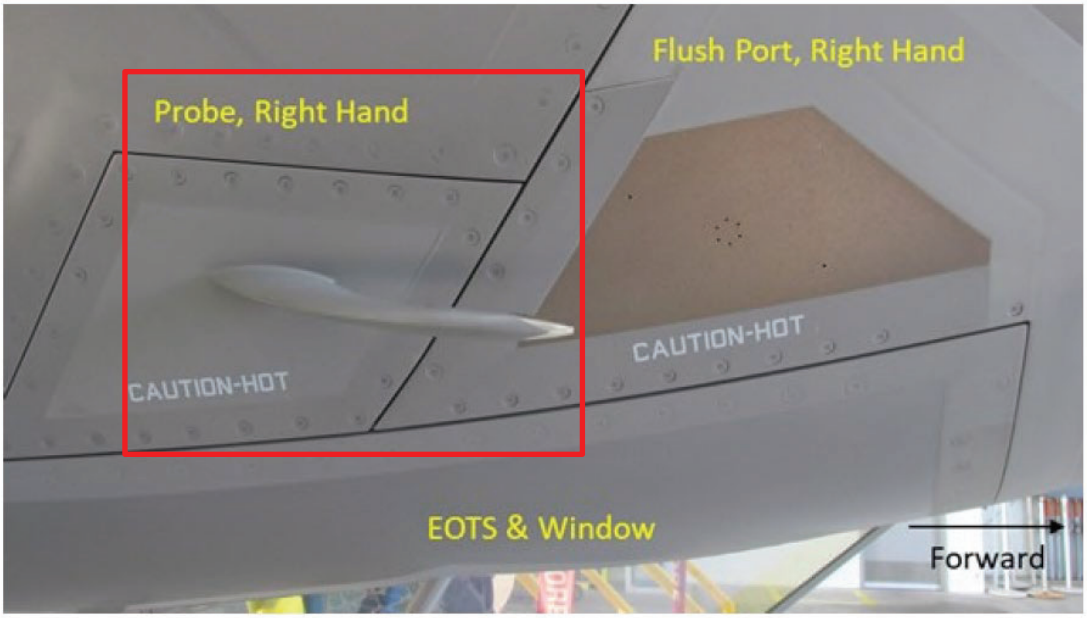

Figure 15: Probe (Tab J-1.39)

2) **Flight Control Law (CLAW):** Aircraft control is provided by execution of a defined set of algorithms, known as CLAWs, that reside in aircraft software, based on the flight mode of the aircraft (Tab J-1.15). Aircraft flight modes include power approach or takeoff and landing, and up-and-away (UA) when the landing gear is up (Tab J-1.15). The F-35 CLAW architecture is based on an on-board model (OBM) of the aerodynamics and propulsion system on the F-35A (Tab J-1.15). The OBM is used to estimate control surface effectiveness and predict expected aircraft response at the flight condition in which the aircraft is operating (Tab J-1.15). This model relies on flight condition information (Mach, altitude, angle of attack, angle of sideslip, dynamic pressure, etc.) provided by the ADA, and aircraft weight and center of gravity information that is provided by other aircraft subsystems (Tab J-1.15).

Flight Control System (FCS): The FCS brings together systems to provide pilot control of various parts of the aircraft (Tab CC-1.2).

Crash survivable memory unit (CSMU): The CSMU is designed to survive a catastrophic crash and acts as a flight data recorder (Tab J-1.11). The CSMU from the MA was retrieved successfully (Tab J-1.24). The CSMU begins recording data at engine start (or when external power is applied to aircraft) and records continuously through the mission (Tab J-1.11).

Figure 16: F-35 CSMU (Tab J-1.13)

b. Evaluation and Analysis

CSMU data analysis and integrity checks demonstrated the following: 1) the FCS operated as designed; 2) the ADS hardware and its associated firmware performed as designed; and 3) the propulsion system operated nominally and without issues throughout the flight (Tab J-1.74). According to CSMU data, there were two distinct atmospheric disturbances encountered during the approach and attempted landing that impacted data flow to the ADS (Tab J-1.8).

During both events, simultaneous pressure disturbances were observed on all ADS MFPs and flush port sensors resulting in fluctuations of the ADA output parameters (Tab J-1.8).

The first disturbance was observed between time 18:07:44L and 18:07:46L (Tab J-1.8). This disturbance was 41 seconds prior to the second and resulted in no cautions, warnings to the MP, or noticeable impact on the flying characteristics of the MA (Tabs J-1.8 and V-1.1.5).

The second disturbance was encountered between 18:08:27L and 18:08:30L as the MA maneuvered to land (Tabs J-1.8 and V-1.1.5). This disturbance resulted in a large enough disruption of airflow over the sensors that the ADA, based on system parameters, excluded data from the left side MFP (Tabs J-1.8 and V-1.1.5). Excluding data from the left side MFP resulted in a visual and audio AIR DATA DEGD (degrade) integrated caution advisory or warning (ICAW) to the MP at 18:08:29L (Tabs J-1.8 and V-1.1.5).

As captured by the CSMU, the disturbed air also caused the right-side probe to show readings outside input limits (Tab J-1.29). These readings did not trigger any ICAWs (Tab J-1.29). This intermittent disruption to the right side occurred multiple times over the next three seconds (18:08:27L to 18:08:30L) (Tab J-1.29). During each of these intermittent disruptions to the right side, with the left side inputs still excluded, the ADA stopped using primary readings until the right probe's readings came back to within acceptable parameters (Tabs J-1.29 and V-2.1.5).

Each time the right probe was intermittently excluded, the ADA switched between primary and back up sources to determine flight conditions (Tabs J-1.29 and V-2.1.5). With each transition, a value referred to as a "sump," was added to the on-board model to smooth flight control movements while switching between primary and backup (Tabs J-1.29 and V-2.1.7). "Sump" values nominally decay over four seconds, assuming there is a single transition between sources (Tab J-1.30). During the right probe's multiple, short-duration, readings outside of input limits, the ADA switched between primary and backup sources multiple times without time for the sump value to decay (Tab J-1.30). Each time this transition occurred the sump values added together (Tab J-1.30). The sum of the sump values from the multiple transitions resulted in the on-board model's estimation of aircraft conditions, differing from the aircraft's actual conditions to the point the MP was no longer able to control the MA (Tabs J-1.30 and CC-1.2). Based on CSMU data, the aircraft was not correctly responding to pilot inputs in the final seconds prior to ejection and departed controlled flight at 18:08:34 (Tab CC-1.2). This data is evidenced in the angle of sideslip (AOSS) values at 18:08:34 and after, approximately 2 seconds prior to MP ejection at 18:08:36L (Tabs J-1.15, J-1.22, and CC-1.2).

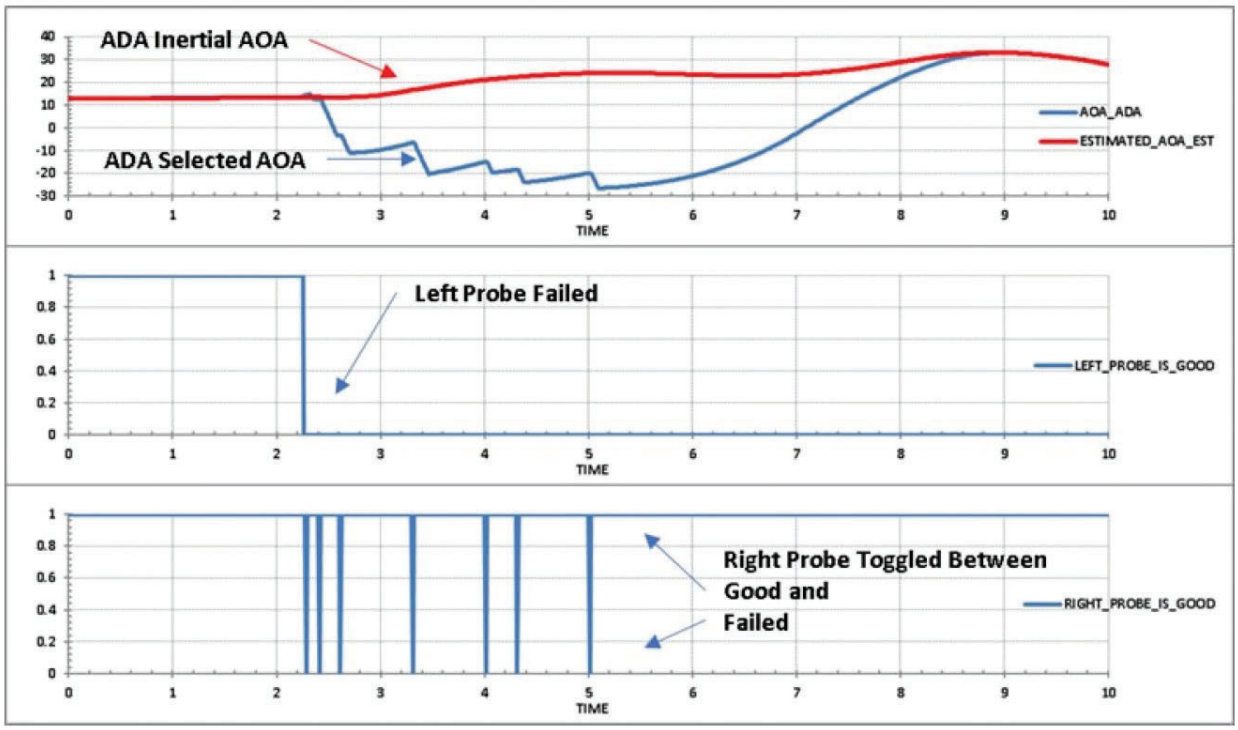

Figure 17: Post Flight Analysis Simulation of ADA divergence (Tab J-1.31)

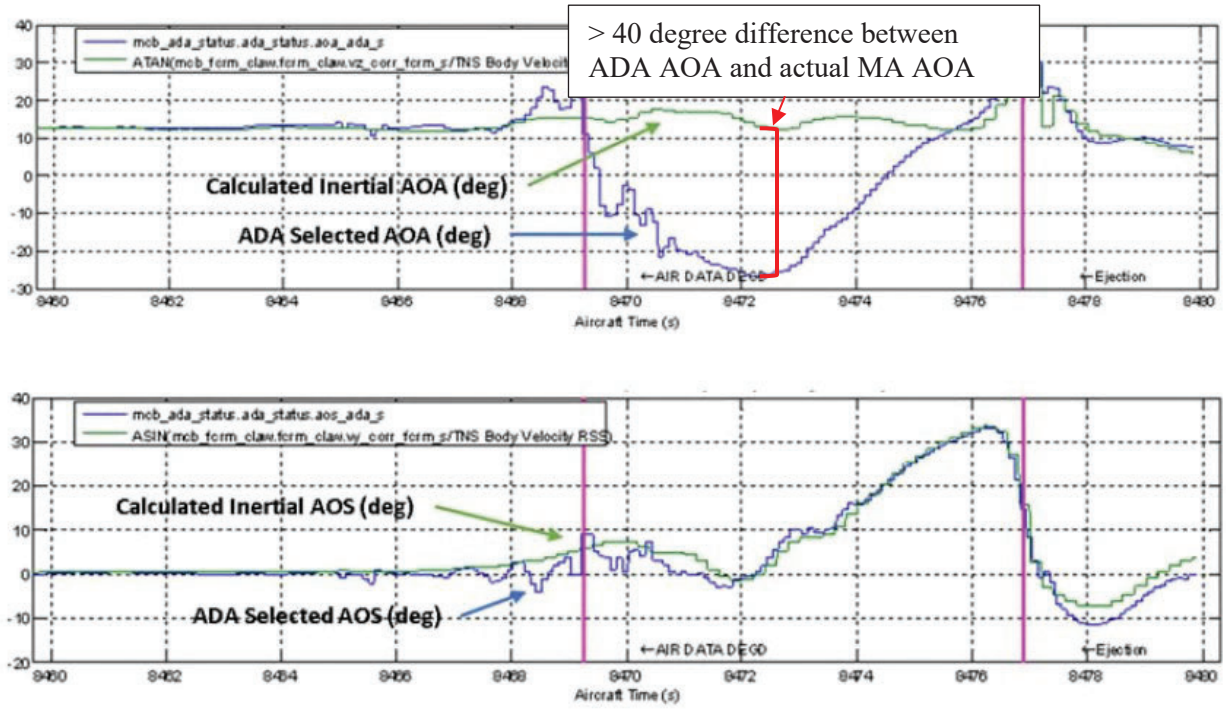

Figure 18: CSMU Recorded Evidence of ADA divergence (Tab J-1.26)

The control laws of the F-35 rely on receiving accurate air data, and with the on-board model predicted flight conditions and the physical flight conditions differing by more than 40 degrees, the flight control surface commands generated by the CLAW were incorrect for the current conditions (Tab J-1.31 to J-1.32).`

Ultimately, the inability to adequately control the MA, which forced the MP to eject, was due to erroneous flight condition parameters provided to the F-35 control laws from the ADA (Tabs J-1.32 and V-1.1.6).

A F-35 test pilot witnessed the mishap sequence from the ground and provided a statement to the AIB (Tab V-2.1.2). He testified that, "[the aircraft] looked like a totally normal F-35 before obviously going out of control…when the oscillations were happening, I did see really large flight control surface movements, stabs, trailing edge flaps, rudders all seem to be moving pretty rapidly like, probably at their rate limits, and huge deflections" (Tab V-2.1.3).

The witness further stated that the MA was sideways "by 30 to 40 degrees, which is far outside the normal flight envelope" (Tab V-2.1.3). The witness noted, "[t]here's virtually no chance of recovering from that…normally our sideslip command limit in power approach is 8 degrees. So, when I'm seeing 30 to 40 degrees, that's like you're flying sideways, there's no way [to recover the MA] and then of course it rolled off rapidly to the left" (Tab V-2.1.3).

While not an exact replication of the F-35A, the simulator at Hill AFB was placed into a similar state as the MA during the mishap sequence of events (Tab CC-1.4). Each attempt at replicating the mishap sequence resulted in the simulator departing controlled flight (Tab CC-1.4). This was accomplished by replicating the MA's exclusion of the left MFP and intermittent exclusion of

the right MFP during the MA's maneuver to land (Tab CC-1.4). All departures from controlled flight occurred independent of wake turbulence, which cannot be replicated in the simulator (Tab CC-1.5).

The following technical charts from the CSMU validates witness testimony, demonstrates the impact of the erroneous data supplied by the ADA, and verifies that the MA was out of control at the time the decision to eject was made (Tabs J-1.15, J-1.74, V-1.1.6, V-2.1.3, and CC-1.2).

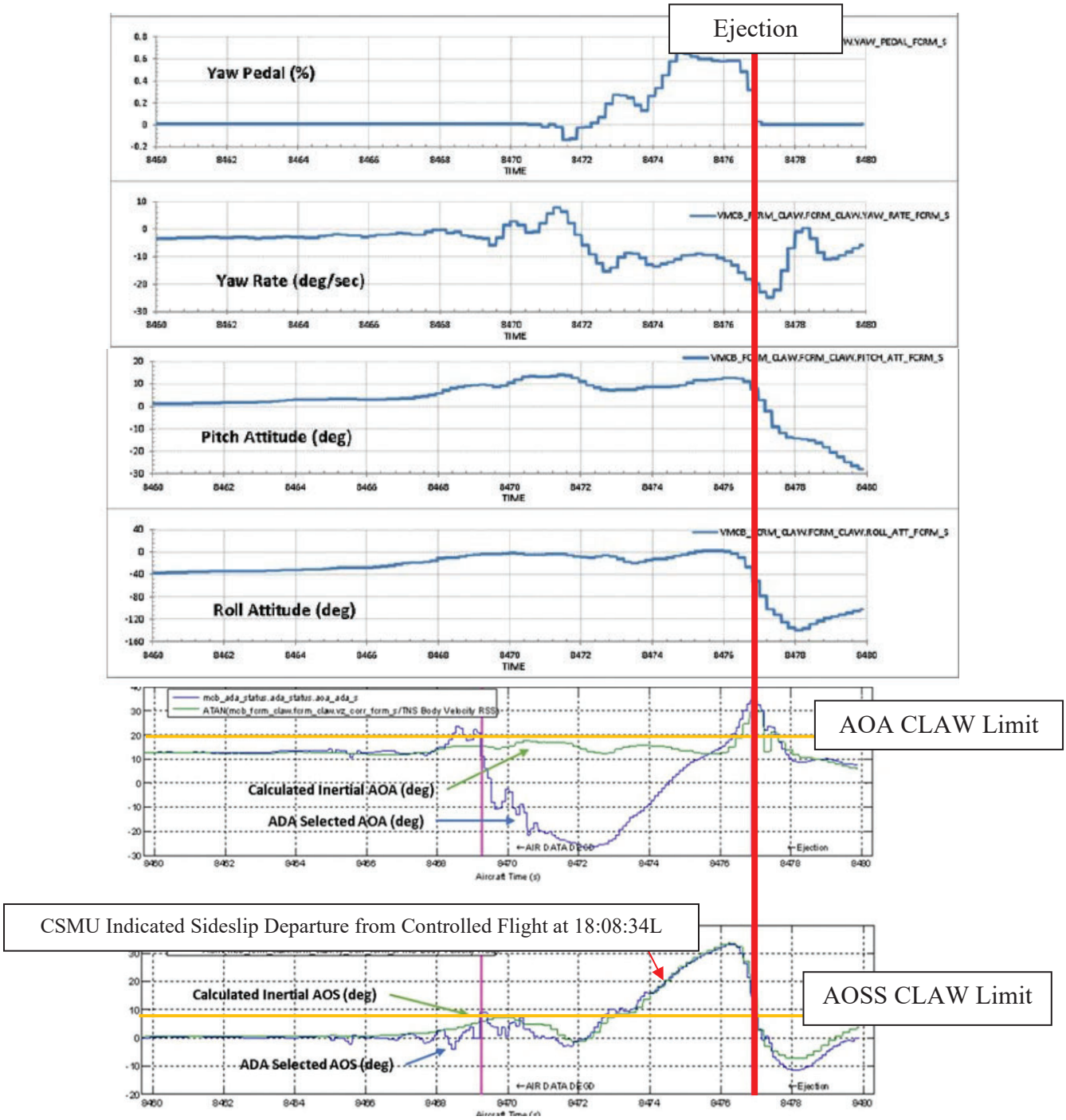

Figure 19: MA Parameters prior to 2nd Disturbed Air through Impact (Tabs J-1.21 and J-1.26)

7. WEATHER

a. Forecast Weather

The 388th Fighter Wing forecasters provide weather forecasts, or Mission Execution Forecast, for local flights to the Utah Test and Training Range (UTTR) (Tab CC-1.2). The day of the mishap, the forecast weather for takeoff and landing at Hill AFB was winds from 290 degrees at 6 knots (kts), with unlimited visibility, and few clouds at 25,000 feet above ground level with sunset at 18:42:00L (Tab F-4.1). The forecast for the training airspace used by the MF was surface winds from 240 degrees at 6 kts, with scattered clouds from 20,000 to 22,000 feet above sea level (Tab F-4.1). Winds aloft were 10 kts or less below 10 thousand feet above sea level (Tab F-4.1).

b. Observed Weather

The weather at Hill AFB at the time of the mishap was winds from 270 degrees at 5 kts, unlimited visibility, clear skies, and 19°C (Tab F-1.1).

c. Space Environment

Not applicable.

d. Operations

The only consideration for operations was that wake turbulence procedures were in effect at Hill AFB (Tab CC-1.2). This information was available on the Hill AFB Automated Terminal Information System (ATIS) and can be heard on a mishap wingman's (MW) tapes during the return to Hill AFB (Tab CC-1.2). However, the wingman, who retrieved the weather, did not include "wake turbulence procedures in effect" when relaying the ATIS via radio to the MF, including the mishap pilot (MP) (Tab CC-1.3). The criteria for wake turbulence procedures to be in effect is when a light crosswind (1-5 kts), tailwind, or light quartering tailwind condition is present (Tab BB-5.11). When wake turbulence procedures are in effect, pilots will increase pitch-out spacing to 8 seconds for a minimum runway separation of 9,000 ft (Tab BB-5.11). The MP did not follow this spacing or separation (CC-1.3).

e. Understanding Wake Turbulence

Every aircraft generates wake turbulence while in flight (Tab BB-7.1). Wake turbulence is a function of an aircraft producing lift, resulting in the formation of two counter-rotating vortices trailing behind the aircraft (Tab BB-7.1). Wake turbulence from an aircraft can affect other aircraft due to the strength, duration, and direction of the vortices (Tab BB-7.1). Pilots should always be aware of the possibility of a wake turbulence encounter when flying through the wake of another aircraft and adjust the flight path accordingly (Tab BB-7.1).

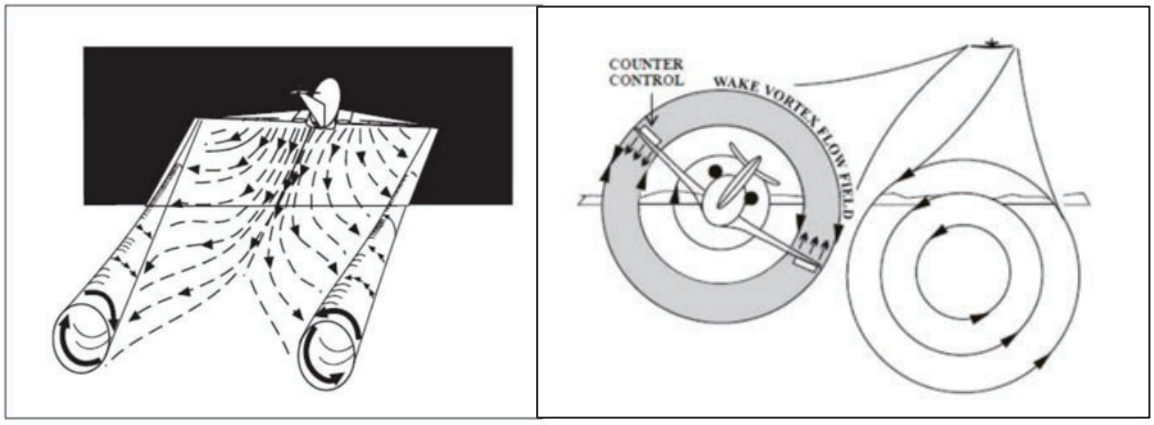

Figure 20: Wake vortex generation and impact on trailing aircraft (Tab BB-7.1 to BB-7.2)

Wake turbulence procedures at Hill AFB are intended to reduce the likelihood of following aircraft from entering wake turbulence vortices with the primary danger being an unexpected rolling motion close to the ground due to flight within the vortex, not because of an impact to the air data system of the F-35 (Tab CC-1.1 to CC-1.2). Most F-35 pilots interviewed for this investigation and the accident investigation board's F-35A Pilot Member, regularly experience wake turbulence while flying the aircraft (Tab CC-1.2). The F-35 has over 600,000 flight hours and this is the first known occurrence of wake turbulence having a catastrophic impact on the Air Data System (Tabs V-2.1.6 and CC-1.2).

8. CREW QUALIFICATIONS

a. Mishap Pilot (MP)

The MP was a current and qualified four-ship flight lead in the F-35A at the time of the mishap (Tab G-1.2). In the F-35A, the MP had 261.6 total hours (Tab G-3.1). The MP obtained his initial F-35A instrument qualification on 24 November 2020 (Tab G-2.1). The MP's initial mission qualification in the F-35A is dated 12 May 2021 (Tab G-2.1). The MP was certified as a flight lead on 20 May 2022 (Tab G-4.5). Prior to qualification in the F-35A, the MP graduated USAF pilot training with 174.0 hours student time (Tab G-3.1). Over his career he has a total of 438.9 flight hours from 284 sorties (Tab G-3.1). MP's recent flight time in the F-35A is as follows (Tab G-5.5):

	Hours	Sorties
30 days	13.3	9
60 days	20.3	14
90 days	21.4	15

Figure 21: MP's Supplemental 30/60/90 Day History (Tab G-5.5)

9. MEDICAL

a. Qualifications

The mishap pilot (MP) was "medically qualified" for flying duties, with no duty limiting conditions notated (Tab CC-3.1). The medical review revealed no other factors relevant to the mishap (Tab CC-3.1).

b. Health

The MP was in good health at the time of this mishap (Tab CC-3.1). A review of the MP's medical and dental records, did not reveal any illnesses or duty limiting conditions (Tabs V-1.2.1 to V-1.2.9 and CC-3.1). There is no evidence to indicate the MP's health was a factor in this mishap, as documented in his latest Physical Health Assessment (Tab CC-3.1).

c. Pathology

Toxicology samples were obtained and submitted to the Armed Forces Medical Examiner System for analysis (Tabs G-10.1 and CC-3.1). These tests identify drugs of abuse by immunoassay, along with ethanol, methanol, isopropanol, and acetone levels, found in the blood and urine (Tab CC-3.1). For all relevant parties, urine and blood specimen collected for forensic toxicology examination showed negative results for drugs of abuse panel, as well as ethanol, methanol, isopropanol and acetone (Tab CC-3.1).

d. Lifestyle

The 72-hours prior and 7-days prior histories were reviewed for MP (Tab V-1.2.3 to V-1.2.8). There was no evidence located to indicate lifestyle factors were relevant to the mishap (Tab V-1.2.3 to V-1.2.8).

e. Crew Rest and Crew Duty Time

Air Force pilots are required to have proper crew rest prior to performing inflight duties (Tab BB-13.1). Crew rest consists of a minimum 12-hour non-duty period before the designated flight duty period starts (Tab BB-13.1). During this time, aircrew may participate in meals, transportation, or rest, which allows for the opportunity for at least eight hours of continuous sleep (Tab BB-13.1). There is nothing to suggest that MP did not comply with published crew rest guidelines at the time of the mishap (Tab V-1.2.3).

10. OPERATIONS AND SUPERVISION

a. Operations

The 421 Fighter Squadron (FS) operations tempo was normal (Tab V-1.1.10). The mishap flight (MF) operational risk management for this sortie was low with no issues highlighted or identified that had any impact to this mishap (Tab K-1.2). There was no evidence to indicate that operations tempo or other operational factors impacted the mishap (Tabs K-1.2 and V-1.1.10).

b. Supervision

The mission was authorized by the 421 FS director of operations, and a review of flight training records showed the mishap pilot and other flight members were current and qualified to participate in the scheduled sortie (Tabs G-1.2 and K-1.3 to K-1.5).

11. HUMAN FACTORS ANALYSIS

a. Introduction

The accident investigation board (AIB) considered all human factors relevant to this mishap, as prescribed in the Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS) 7.0 (DoD HFACS 7.0) (Tab BB-3.2). The DoD HFACS 7.0 is a framework that identifies potential areas of assessment during an accident investigation and lists potential human factors that can play a role in an aircraft mishap (Tab BB-3.2). A human factor is any environmental, technological, physiological, psychological, psychosocial, or psychobehavioral factor a human being experiences that contributes to, or influences, performance during a task (Tab BB-3.2 to BB-3.23).

The framework is divided into four main categories: Acts, Preconditions, Supervision, and Organizational Influences (Tab BB-3.23). Each category is subdivided further into related human factor subcategories (Tab BB-3.23). The main categories allow for a complete analysis of all levels of human error, and demonstrate how such errors may interact together to contribute to a mishap (Tab BB-3.3). The AIB reviewed a substantial amount of evidence during its investigation, to include, but not limited to, cockpit voice recorder transcripts, crash survivable memory unit (CSMU) information, video recordings, and witness interviews (Tab CC-1.1). The human factors relevant to this mishap are defined below (Tabs BB-3.6, BB-3.10, BB-3.15, and BB-3.21).

b. Applicable Human Factors

The following four human factors contributed to the mishap: 1) inadequate procedural guidance or publications; 2) critical information was not communicated; 3) procedure not followed correctly; 4) automated system of the air data application created an unsafe situation (Tabs BB-3.6, BB-3.10, BB-3.15, and BB-3.21).

1. **OP003 Provided Inadequate Procedural Guidance or Publications**: is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading or inappropriate (Tab BB-3.21).

At the time of the mishap, the only reference to wake turbulence in procedural guidance or publications on wake turbulence for the F-35 was in *F-35A—OPERATIONS PROCEDURES,* AFMAN 11-2F-35AV3, 16 MAY 2022, paragraph 3.18.1 (Tab BB-12.1). It states, “Minimum pattern and touchdown spacing between landing aircraft is 3,000 feet for similar aircraft […] Increase spacing whenever wake turbulence is anticipated” (Tab BB-12.1). Given the impact of wake turbulence, as demonstrated in the analysis section on the air data application (ADA), this guidance is insufficient.

Furthermore, the insufficiency of existing guidance is evident when compared to the same volume for the F-16. F-16 guidance states, "When wake turbulence is expected due to calm winds (less than or equal to 5 knots) or when landing with a light tail wind, pilots will comply with increased pattern/touchdown spacing to 6,000 ft minimum (T-1)" (Tab BB-6.1). "Under these conditions, moderate to severe wake turbulence has been reported out to 7,000-foot touchdown spacing" (Tab BB-6.2).

2. **PP106 Critical Information Not Communicated**: is a factor when known critical information was not provided to appropriate individuals in an accurate or timely manner (Tab BB-3.15).

At 17:55:35L, on the return to Hill AFB, the mishap wingman (MW), Legs 04, retrieved the current weather conditions at Hill (Tab CC-1.3). Winds retrieved in the weather report were from the northwest at 5 knots (kts) and that the Supervisor of Flying had declared that "wake turbulence procedures were in effect" (Tab CC-1.3). At 17:56:26L Legs 04 relayed the weather information to the mishap flight (MF) (Tab CC-1.3). When the weather was relayed to the formation, Legs 04 did not state that "wake turbulence procedures are in effect" (Tab CC-1.3).

3. **AE103 Procedure Not Followed Correctly:** is a factor when a procedure is performed incorrectly or accomplished in the wrong sequence (Tab BB-3.6).

While Legs 04 did not relay that wake turbulence procedures were in effect, based on the reported winds, all pilots should have known that wake turbulence procedures were in effect and landing separation should be increased to 9,000 ft (Tabs BB-5.11 and CC-1.3). Hill AFB Instruction 13-204, *Airfield Operations*, states that pilots are responsible for wake turbulence separation when maintaining visual separation or operating under visual flight rules (VFR) (Tab BB-2.17). Legs 02 and Legs 03 (the mishap pilot) testified they did not remember wake turbulence procedures being in effect (Tab V-1.1.4 and V-3.2.4). Legs 02 testified that he was setting pattern spacing to be the standard 3,000 ft behind Legs 01 (Tab V-3.2.3). According to available data, Legs 02 was approximately 5,000-6,000 ft behind Legs 01 (Tab CC-1.3). Legs 02 did not encounter any wake turbulence and completed an uneventful pattern and landing (Tabs V-3.2.4 and CC-1.3). The mishap pilot (MP) also did not follow the wake turbulence procedures. The MP initiated normal landing procedures and followed approximately 3000-4000 feet behind Legs 02 instead of the required increased pattern spacing (Tabs V-1.1.4 and CC-1.1).

4. **PE205 Automated System Creates Unsafe Situation:** is a factor when the design, function, reliability, symbology, logic or other aspect of automated systems creates an unsafe situation (Tab BB-3.10).

As described in the analysis section, the ADA software provided faulty information to the flight controls based off the automated system adding in sump values (Tabs J-1.25 and J-1.31). The automated system then provided commands to flight control surfaces that were not appropriate for actual flight conditions, resulting in the MP's inability to maintain control of the mishap aircraft (Tabs J-1.25 and V-1.1.6).

The impact of the automated system was replicated in the F-35A simulator at Hill AFB as part of this investigation (Tab CC-1.4). Placing the simulator in a similar state to the mishap sequence of events resulted in the simulator departing controlled flight (Tab CC-1.4). There was no apparent warning of the automated system's impact to control of the aircraft until the simulator was out of control (Tab CC-1.4). Additionally, in the simulator, more aggressive pilot attempts to maintain control resulted in more aggressive departures from controlled flight (Tab CC-1.5). Lastly, in the simulator all departures from controlled flight occurred by replicating automated system errors, independent of wake turbulence, which cannot be replicated in the simulator (Tab CC-1.5).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publicly Available Directives and Publications Relevant to the Mishap

(1) AFMAN 11-2F-35A Volume 3, Operations Procedures (16 May 2022)
(2) AFI 11-2F-35A Volume 3, 388/419 Supplement, Operations Procedures (1 October 2018)
(3) HILLAFBI 13-204, Airfield Operations (18 September 2015)
(4) AFMAN 11-2F-16 Volume 3, Operations Procedures, Change 3 (13 September 2022)
(5) AFI 11-418, Operations Supervision (28 February 2028)
(6) AFMAN 11-202 Volume 3, Flying Operations, ACC Supplement, (8 November 2022)
(7) FAA Aeronautical Information Manual (17 June 2021)

NOTICE: All Air Force directives and publications listed above are available digitally on the Air Force Departmental Publishing Office website at: http://www.e-publishing.af.mil. FAA AIM is available at: https://www.faa.gov/air_traffic/publications/atpubs/aim_html/.

b. Other Directives and Publications Relevant to the Mishap

(1) DoD Human Factors Analysis and Classification System (HFACS) Version 7.0
(2) 388/419 FW F-35A Standards (29 September 2020)
(3) 388/419 FW Supervisor of Flying Checklist (18 October 2021)

c. Known Deviation from Directives or Publications

The MP violated AFI 11-2F-35A Volume 3, 388/419 Supplement, Operations Procedures, para. 8.1.4.14.1, by not increasing pattern spacing for a minimum runway separation of 9,000 ft (Tab BB-5.11). The MP was approximately 3,000-4,000 ft behind the aircraft in front of him (Tab CC-1.3).

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07 February 2023

KEVIN M. LORD, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-35A, T/N 15-5197
HILL AFB, UTAH
19 OCTOBER 2022

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 19 October 2022, at approximately 18:08:36 local (L), the mishap aircraft (MA), an F-35A, tail number 15-5197, crashed after the final turn to land on Runway (RWY) 14 at Hill Air Force Base (AFB), Utah (UT). The MA was operated out of Hill AFB, UT by the 421st Fighter Squadron and assigned to the 388th Fighter Wing (FW). There were no fatalities. The mishap pilot (MP), assigned to the 388th FW, ejected safely before impact and sustained minor injuries. The MA was destroyed upon impact, with a total loss valued at $166,340,000.00. MA debris fanned out, with most of the aircraft impacting within the airfield boundaries on Hill AFB.

The Mishap Flight (MF) consisted of four F-35As with the MA flying as the #3 aircraft in the formation. After an uneventful training sortie, the MA returned to land on RWY 14 at Hill AFB. The MF returned in a standard formation with #3 and #4 in one nautical mile trail of #1 and #2. On final approach to landing, the MP experienced a slight burble, or rumbling, due to wake turbulence from the preceding aircraft. This atmospheric disturbance resulted in erroneous inputs to the air data application (ADA). The erroneous inputs to the ADA resulted in a condition in which the aircraft flight controls did not respond correctly for the actual conditions of the MA. Recognizing that the MA was not responding appropriately to control inputs, the MP selected full afterburner power to attempt to recover to controlled flight. Due to the low altitude, low airspeed, and sideslip flight path of the MA, the MP was unable to recover the aircraft and initiated ejection. The MP ejected before the MA impacted the ground and was destroyed. The MP landed just north of the base, outside the Hill AFB fence line, and was recovered by Emergency Responders.

The recovery of the crash survivable memory unit (CSMU) accurately captured all relevant information to the cause of the mishap. While the MA mission data recordings were not available for review due to damage sustained in the post impact fire of the MA, flight member mission recordings were available. CSMU data analysis and integrity checks demonstrated that: 1) the flight control system operated as designed; 2) the Air Data System (ADS) hardware and its associated firmware performed as designed; and 3) the propulsion system operated nominally and without issues throughout the flight. In addition to CSMU data and formation member mission recordings, I relied on witness interviews and simulator reenactment to reach an evidence-based causal conclusion.

I find by a preponderance of the evidence the cause of the mishap was the MA departed controlled flight due to ADS errors immediately prior to landing in which there was no opportunity to recover to controlled flight. I find by a preponderance of the evidence one significantly contributing factor to the mishap: the MP did not increase landing spacing from preceding aircraft in accordance with wake turbulence procedures.

2. CAUSE

On final approach to landing, the MP experienced a slight "burble" (or rumbling) to his aircraft due to wake turbulence from preceding aircraft. The MA flew through the disturbed air for approximately three seconds. This disturbed air caused the MA ADS to exclude external readings from the left side multifunction probe (MFP). Due to this atmospheric disturbance, the MA ADS also intermittently disregarded right side MFP readings. Each time the right MFP was disregarded, the ADS would transition from the primary source to the backup source to assess its flight parameters. Each time the MA transitioned between primary and backup flight condition sources, the MA's assessment of its own flying conditions diverged further from actual flight conditions. Based on the erroneous information provided to the flight control system, the MA commanded incorrect movements of flight control surfaces and disregarded MP flight control inputs. Ultimately, the difference between actual flight conditions and system generated conditions resulted in a state where the MA could not be controlled by the MP. To recover the MA, the MP selected maximum afterburner power to increase airspeed and altitude. Due to the MA's low altitude and low airspeed in preparation for landing, the MP was unable to successfully regain control of the MA. The MP assessed that the aircraft had departed controlled flight, appropriately resulting in the decision to eject.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

The MP did not increase landing spacing from preceding aircraft in accordance with wake turbulence procedures.

Based on the current weather, with winds from a north westerly direction at 5 knots, the Supervisor of Flying declared that wake turbulence procedures were in effect in accordance with local guidance. This information was passed to the air traffic control tower to include on the automated weather system. Legs 04, the mishap wingman, retrieved arrival weather. In review of Legs 04 mission data video and audio, "wake turbulence procedures are in effect" is clearly heard on the audio recordings. However, when Legs 04 relayed the weather information, wake turbulence procedures were not relayed to the rest of the formation. The MP stated that he was not aware that wake turbulence procedures were in effect and planned to land with standard pattern spacing, which is approximately 3,000 feet. Legs 04 did not relay this critical information to the rest of the MF. The MP should have known to increase landing spacing because the light winds information was passed to the entire MF. Based on the data recorders of other members of the MF, the MA was approximately 3,600 feet behind the preceding aircraft.

Encountering wake turbulence is very common in aviation. Most F-35 pilots interviewed for this investigation testified that they had encountered wake turbulence multiple times in their career. The effects are often minimal and have little to no impact on continued flight. In contrast, wake

turbulence can have a significant impact on aircraft in the landing phase, thus the requirement for separation between aircraft becomes important for safety assurances. Wake turbulence procedures are intended to minimize the likelihood of encountering a rolling motion if flying within a vortex at low airspeeds close to the ground. This mishap was not caused by the traditional physical impacts of wake turbulence. Alternatively, the anomalous impact of the wake turbulence conditions encountered on this flight on the automated ADS of the F-35 led to the out-of-control state of the MA. At the time of this mishap, there have been over 600,000 flight hours in the F-35, with no known similar incidents of wake turbulence impacting the ADS. Furthermore, as part of this investigation we replicated the mishap conditions in the F-35 simulator at Hill AFB. By simulating the state of the MA's erratic ADS outputs, independent of wake turbulence, the simulator consistently became uncontrollable by the pilot and resulted in an ejection situation.

4. CONCLUSION

I find by a preponderance of the evidence the cause of the mishap was that the mishap aircraft departed controlled flight due to ADS errors immediately prior to landing in which there was no opportunity to recover to controlled flight. I also find by a preponderance of the evidence one significantly contributing factor to the mishap: the mishap pilot did not increase landing spacing from preceding aircraft in accordance with wake turbulence procedures.

LORD.KEVIN.M. Digitally signed by LORD.KEVIN.M. Date: 2023.07.01 12:17:50 +03'00'

07 February 2023

KEVIN M. LORD, Colonel, USAF
President, Accident Investigation Board

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